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A Global Benchmark for Carbon

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Methodology for Improved Forest
Management: Conversion of Logged
to Protected Forest

About GCS

GreenCollar Consulting Solutions (GCS) is an environmental markets and project services consultancy with extensive experience in the development of agriculture, forestry and other land use (AFOLU) methodologies, policy and projects throughout Asia-Pacific. Our goal is to provide the tools and support services that will help land managers realize the full commercial potential of their environmental assets.

Our diverse work experience extends from agriculture and forest management methodology development and project development, to domestic and international policy advice. Our project experience includes work on some of the world's largest carbon forestry and agricultural projects and initiatives. GCS is based in Sydney and has strong strategic partnerships with firms in Europe, North America and Asia.

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Scope

This methodology is for estimating and monitoring greenhouse gas (GHG) emission reductions and removals from project activities that protect forests that would be logged in the absence of carbon finance.

Table of Contents

PART 1 - SOURCES, DEFINITIONS AND APPLICABILITY

1. Sources

- VCS Program Guidelines 2007.1

- VCS Tool for AFOLU Methodological Issues

- VCS Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities

- VCS methodology VM0007 REDD Methodology Modules (Avoided Deforestation Partners)

- VCS methodology VM0003 Methodology for Improved Forest Management through Extension of Rotation Age (Ecotrust)

- VCS methodology VM0005 Methodology for Conversion of Low-Productive Forests to High-Productive Forests (Silvestrum for Face the Future)

- Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination

- Tool for Calculation of the Number of Sample Plots for Measurements within A/R CDM Project Activities[1]

- Tool for testing significance of GHG emissions in A/R CDM project activities[2]

Note – All VCS program documents and approved VCS methodologies referenced in this methodology are available on the VCS website.

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

2. Definitions

This methodology uses all VCS approved definitions from the VCS Program Guidelines 2007.1 and the VCS Tool for AFOLU Methodological Issues.

The definitions in Table 1 are specific to this methodology.

Table 1. IFM-LtPF Methodology: definitions

Term	Explanation
Commercial timber harvest	Removal of merchantable trees from a forest to obtain income from the wood products.
Forest degradation	Direct human induced activity that leads to a long-term reduction in forest carbon stocks.
Forest Inventory	A system for measuring the extent, quantity, and condition of a forest by sampling through: a) a set of objective sampling methods designed to quantify the spatial distribution, composition, and rates of change of forest parameters within specified levels of precision for the purpose of management; b) the listing of data from such a survey.
Land parcel	The area of land within a forest specified for annual logging and timber extraction operations as defined in a timber harvest plan.
Planned timber harvest	Planned removal of merchantable trees from a forest to obtain income from the wood products under legal conditions for harvest and documented under a timber harvest plan.
Timber harvest plan	Description of the methods and operations needed to harvest timber from a forest under a given set of legal conditions for harvest, that includes: a) demarcation of non-harvest areas within the forest, b) division of the harvestable forest into annual operating areas (land parcels) presented as descriptions and maps, c) the design and presentation of the transport system for the removal of harvested timber products, d) a description of the harvest and transport machinery used for timber harvest.

3. Symbols and Notations

3.1 Physical quantities

In this section we present the symbols that are used throughout the methodology to represent physical quantities used in the accounting equations.

3.1.1 Flows of greenhouse gas(es)

The symbol GHG is the common identifier used throughout this methodology to represent flows of greenhouse gas(es) to/from the atmosphere.

For these flows, the absolute value represents the intensity of the flow, in tCO_2e $year^{-1}$, or the total amounts exchanged with the atmosphere, in tCO_2e.

3.1.2 Carbon stocks

The symbol C is the common identifier used throughout this methodology to represent carbon stocks. The values presented are either carbon stocks (in tC), or carbon stocks per unit area (in $tC \cdot ha^{-1}$) as indicated in the step-by-step methodology described under Part 2.

3.1.3 Carbon stock changes

The symbol ΔC is the common identifier used throughout this methodology to represent changes in carbon stocks. The values presented could be either total changes in carbon stocks (in tC), annual changes in carbon stocks (in $tC \cdot year^{-1}$), or annual changes in carbon stocks per unit area (in $tC \cdot ha^{-1} \cdot year^{-1}$), as indicated in the step-by-step methodology described under Part 2.

3.2 Scenario qualifiers

In this section we present the symbols that are used throughout the methodology as scenario qualifiers, for the physical quantities used in the accounting equations.

- Physical quantities referring to the **baseline scenario** feature the suffix $|BSL$;
- Physical quantities referring to the **project scenario** feature the suffix, $|PRJ$; and
- Physical quantities derived from baseline and project scenario accounting feature the suffix $|LtPF$

4. Applicability

Projects must fall within the AFOLU project category "IFM Logged to Protected Forest" as defined in the most recent version of the VCS AFOLU Guidance document. Specific conditions under which this methodology is applicable are:

- Forest management in the baseline scenario must be planned timber harvest;

- Under the project scenario, forest use is limited to activities that do not result in commercial timber harvest or forest degradation;

- Planned timber harvest must be estimated using forest inventory methods that determine allowable offtake as volume of timber ($m^3 ha^{-1}$);

- The boundaries of the forest land must be clearly defined and documented;

- Baseline condition cannot include conversion to managed plantations;

- Baseline scenario, project scenario and project case cannot include wetland or peatland.

PART 2 – STEP-BY-STEP METHODOLOGY DESCRIPTION

The *Logged to Protected Forest* (LtPF) methodology here presented is designed as a detailed *step-by-step* procedure enabling conservative estimation of net GHG emission reductions/removals resulting from the implementation of IFM projects aimed at the protection of forests that would be logged in the absence of carbon finance.

The methodology is organised into nine steps:

- STEP 0 – *Eligibility*, sets the criteria for eligibility of projects under the proposed LtPF methodology;

- STEP 1 – *Project Boundaries and Scope*, provides guidelines for defining the geographical and temporal boundaries of the project and lists the GHG emissions sources and carbon pools to be included in the project accounts;

- STEP 2 – *Baseline Selection, Additionality and Baseline Modelling*, provides guidelines to select the most conservative baseline scenario and to determine the additionality of the proposed project activities against the baseline selected;

- STEP 3 – *Baseline Scenario Greenhouse Gas Emissions*, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks as a result of planned timber harvest in the baseline scenario;

- STEP 4 – *Project Scenario Net Greenhouse Gas Emissions*, provides the detailed, step-by-step procedure to develop conservative estimates of net greenhouse gas emissions resulting from changes in carbon stocks in the project scenario;

- STEP 5 – *Project Leakage*, describes the methodology approach to account for leakage mechanisms arising from the implementation of project activities;

- STEP 6 – *Net Project Greenhouse Gas Emission Reductions*, provides the methodological approach to determine the amount of net greenhouse gas emission reductions/removals at the end of each year on the basis of the estimates of greenhouse gas emissions determined at steps 3 and 4 for the baseline and project scenarios respectively, and of the estimated amount of leakage determined at step 5;

- STEP 7 – *Project Verified Carbon Units*, provides the methodological approach to determine, on the basis of the amount of net greenhouse gas emission reductions/removals estimated at Step 6 and deductions to account for risk and uncertainty, the amount of carbon units that should be credited to the project each year over the project crediting period; and

- STEP 8 – *Project Monitoring*, provides guidelines for the implementation of a monitoring plan and identifies monitored parameters to assess carbon stock change and disturbance in the project case.

STEP 0 – Eligibility

Legal Right to Harvest

Legal right to harvest must pre-exist the implementation of the project.

The legal right to harvest must be issued by a relevant government body, define a legal allocation of rights to a forest timber resource, and include a plan for forest management that includes a definition of the spatial extent of the forest, the volume of the timber resource to be extracted and a description of harvesting practices.

Rights to forest management must be demonstrated by documentary proof of legal permissibility for timber harvest, intent to harvest and a description of the timber resource. This proof must be issued by the relevant (governmental) regulatory body that has designated, sanctioned or approved the project area (or areas) for forest management.

Intent to Harvest

Project proponents must demonstrate intent to harvest through the following forms of evidence originating prior to the date of all evidence in pursuit of carbon finance/consideration of IFM.

Projects shall provide either:

- Documented evidence demonstrating that:

   The project site is representative of other forestlands harvested in the country within the past two years; and

   The project site is within commercially viable distance to existing transport networks and a port for timber export or a mill for timber processing;

   or

- A valid and verifiable Government-approved timber management plan for harvesting the project area.

STEP 1 - Project Boundaries and Scope

Step 1.1 Geographical Boundaries

Project proponents shall clearly define the spatial boundaries of a project so as to facilitate accurate measuring, monitoring, accounting, and verifying of the project's emissions reductions and removals.

The IFM project activity may contain more than one discrete area of land.

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

- name of the project area (including compartment number, allotment number, local name);

- unique identifier for each discrete land parcel used in the timber harvest plan;

- map(s) of the area (preferably in digital format);

- geographic coordinates of each polygon vertex (preferably obtained from a GPS or from a geo-referenced digital map);

- total land area; and

- details of forest land rights holder and user rights.

The geographic boundaries of an IFM project are fixed and thus do not change over the project lifetime.

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

Step 1.2 Temporal Boundaries

The following temporal boundaries shall be defined:

Step 1.2.1 Start date and length of the project crediting period

The project crediting period is the period of time for which the net GHG emissions reductions or removals will be verified, which under the VCS AFOLU Guidance Document is equivalent to the project lifetime. The project must have an operating plan covering this period.

The project crediting period shall be set in accordance with the VCS rules for IFM LtPF projects. The duration of the project crediting period shall be reported in the VCS Project Document (VCS-PD).

Step 1.2.2 Duration of the monitoring periods

Issuance of Verified Carbon Units (VCUs) is subject to monitoring and verification. The minimum duration of a monitoring period is one year and the maximum duration is 10 years.

Project proponents are free to decide the periodicity of verifications, however, under the VCS AFOLU Guidance Document, if verification does not occur within 5 years, 50% of the buffer account credits are cancelled.

Baseline projections are calculated ex-ante and are not adjusted through-out the project lifetime.

Step 1.3 Carbon Pools

The carbon pools included or excluded from the project boundary are shown in Table 2.

Table 2: Carbon pools

Carbon pools	Included/Optional/ Excluded	Justification / Explanation of choice
Aboveground trees	Included	The stock change in the aboveground tree biomass shall be estimated
Aboveground non-tree	Excluded	Exclusion is always conservative when forests remains as forest
Belowground	Excluded	Unlikely to change significantly in forests remaining as forests and is difficult to measure - omission is conservative
Dead-wood	Included	Required under VCS Tool for AFOLU Methodological Issues
Harvested wood products	Included	Will be greater in baseline than project scenario and significant
Litter	Excluded	Insignificant and exclusion is conservative
Soil organic carbon	Excluded	Exclusion is always conservative when forests remains as forest

Step 1.4 Greenhouse Gases

The emissions sources included in or excluded from the project boundary are shown in Table 3.

Any one of these sources shall be neglected, i.e., accounted as zero, if the application of the most recent version of the "Tool for testing significance of GHG emissions in A/R CDM project activities" leads to the conclusion that the emission source is insignificant[3]. In addition, the sum of decreases in carbon pools and increases in emissions that may be neglected shall be less than 5% of the total project GHG benefits (VCS, 2007.1).

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

Table 3: Emission sources other than resulting from changes in stocks in carbon pools

Gas	Sources	Included/ Excluded	Justification/explanation of choice
Carbon dioxide (CO_2)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Excluded	Conservative as emissions will be greater in the baseline scenario than in the project case.
	Removal of herbaceous vegetation	Excluded	Based on CDM EB decision reflected in paragraph 11 of the report of the 23rd session of the board: cdm.unfccc.int/Panels/ar/023/ar_023_rep.pdf
Methane (CH_4)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Excluded	Conservative as emissions will be greater in the baseline scenario than in the project case.
	Burning of Biomass	Included	Included as CO_2 equivalent emission
Nitrous oxide (N_2O)	Combustion of fossil fuels (in vehicles, machinery and equipment)	Excluded	Potential emissions are negligible
	Nitrogen based fertilizer	Excluded	Potential emissions are negligible. Following the VCS update to the Tool for AFOLU Methodological Issues and Guidance for AFOLU Projects emissions through the use of fertilizer are considered insignificant and are not considered here
	Burning of Biomass	Excluded	Potential emissions are negligible

STEP 2 – Baseline Selection, Additionality and Baseline Modelling

Step 2.1 Selection of baseline

The project proponent shall apply criteria and procedures for identifying and assessing potential baseline scenarios in accordance with rule 6.3 VCS (2007.1) and the specific requirements for IFM projects in the VCS Tool for Methodological Issues (paragraph 14 and footnote 13) when constructing the baseline.

The project proponent shall use the current version of the VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities" to assess which of the baseline alternatives shall be excluded from further consideration.

As per the applicability conditions, the project must demonstrate a baseline of planned timber harvest. If such a baseline cannot be demonstrated then this methodology cannot be applied.

Step 2.2 Modelling the baseline scenario

Once the baseline scenario of planned timber harvest is demonstrated project proponents must determine how to model the baseline management scenario. A Historical Baseline Scenario (Step 2.2.1) must be used where data is available, otherwise a Common Practice Baseline Scenario (Step 2.2.2) shall be used.

Step 2.2.1   Historical Baseline Scenario

A baseline scenario and timber harvest plan (see Box 1) derived from the historical practices of the baseline agent of timber harvest must be modelled as the project baseline if the following documents exist for the project proponent as the baseline land manager for forests in the same region as the project area:

1. Historical records of forest management exist for a minimum of 5 or more years preceding the project start date

2. Historical records indicate that the management practices have surpassed the legal requirements provided by conforming with all local and regional forest legislation

3. Historical records that indicate that the historical management surpasses financial barriers by providing above average financial returns

Step 2.2.2   Common Practice Baseline Scenario

All other cases must model baseline harvest based on common practice.

Common practice will be timber harvest under the legal requirements for forest management and will be determined from a timber harvest plan (see Box 1) developed from:

1. The project area through scenario modelling as though the legal requirements were implemented in the project area; and

2. A reference area[4] (or multiple reference areas) already under timber harvest management that complies with legal requirements for forest management and selected to be representative of local common practice for timber harvest.

Common practice cannot contradict management of the baseline agent except where common practice represents a lower harvest intensity (in m³/ha) than management by the baseline agent.

Where there is limited capacity to generate the baseline scenario using a reference site in the region of the project area, multiple reference areas may be selected to cover a country so long as the reference area criteria regarding forest types, climate and elevation are met.

Box 1. Timber Harvest Plan

The description of harvesting in the form of a timber harvest plan forms the basis of the baseline scenario for greenhouse gas accounting.

The timber harvest plan describes the harvest of timber products and must:

a. reference the forest volume inventory (see Step 3.1 – parameter $V_{j,i/BSL}$) to identify the relative number of trees per hectare potentially available for harvest by species in each stratum;
b. demarcate all non-harvest areas within the forest based on legally required exclusions for environmental features such as slope, swamp areas or conservation buffers;
c. divide the harvestable forest into annual operating areas (referred to throughout this methodology as *land parcels*) using common practice;
d. include a design and presentation of the transport system to move harvested timber products from the land parcels to downstream processing or market entry points; and
e. list necessary harvest and transport machinery.

The timber harvest plan must follow local best practice for timber harvest and the timber resource volume and extraction quotas defined in the legal requirements.

For the purpose of estimating the net annual changes in carbon stocks resulting from planned timber harvest in the baseline scenario a detailed *planned timber harvesting schedule* will be developed from the timber harvest plan, spelling out details of harvest for

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[4] Reference areas must be in the same region as the project area and must match the project area in terms of forest types, climate and elevation (identical mix of forest types ±20%; identical annual precipitation ±20%; elevation classes (500m classes) in the reference region shall be in the same proportion as in the project area (+/- 20%))

each land parcel in the project area in terms of the following:

  a. the species to be harvested[5];

  b. the year (*1,2,3...*) in which timber harvest of each land parcel is scheduled to occur;

  c. the number of years each land parcel is in a post-harvest state during the project crediting period;

  d. the maximum and minimum diameters at breast height (DBH), at stump and at top for tree harvesting;

  e. the planned harvesting regime (clearfelling, specie/stratum-selective logging, area-selective logging);

  f. technical specifications for the categories of wood products to be harvested; and

  g. the total volumes or fractions to be harvested, broken down by categories of wood products defined as sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other.

The planned timber harvest schedule is determined *ex ante* to reflect the timber harvesting plan as stipulated in the legal right to harvest. The *planned timber harvesting schedule* will be developed for the Project Area to include all land parcels within the project boundary for the proposed IFM activity.

The output of the timber harvest plan shall be the mean extracted volume per unit area by species in each stratum in each year ($V_{EX,j,i|BSL}$).

The planned timber harvesting schedule will be submitted by project proponents as part of the VCS-PD.

Step 2.3 Stratification

If the proposed project area contains different forest types or forests with different carbon density, stratification must be carried out in order to improve the accuracy and precision of carbon stock estimates.

For estimation of base year 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. Strata will include either forest type, vegetation type and/or target timber species.

Based on the availability of data regarding the nature and composition of forest stocks in the project area, stratification will be developed on the basis of either:

  a. existing vegetation mapping or stratification, where these are documented in the legal right to harvest; or

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[5] Species selected to be harvested in the forest management plan shall be subset of species commercially harvested in the region

b. estimates developed from sampling the project area using standard forest assessment protocols specific to the forest region where the project area is located.

Baseline stratification is developed *ex ante*.

Project proponents will submit as part of the VCS-PD a detailed description of the stratification adopted for the project area.

Step 2.4 Additionality

The project proponent shall demonstrate the additionality of the project using the most recent version of the VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities".

STEP 3 - Baseline Scenario Greenhouse Gas Emissions

Calculation of baseline scenario greenhouse gas emissions requires the application of the equations presented at this step to complete the greenhouse gas accounts for all land parcels in the baseline case.

The following table lists the baseline emissions modelled by this methodology:

Included in modelling
Emission from wood product conversion
Decomposition of deadwood from harvested trees
Emissions from wood product retirement
Stock change due to regrowth following timber harvest
Conservatively excluded from modelling
Decomposition of trees incidentally killed during tree felling
Decomposition of trees killed through skid trail creation
Decomposition of trees killed through road construction
Emissions through fossil fuels burned in baseline harvesting practices
Emissions through subsequent forest re-entry

Baseline projections are calculated ex-ante and are not adjusted through-out the project lifetime.

The baseline net greenhouse gas emissions are determined from calculation of deadwood generated in the process of timber harvest (Step 3.2), the emissions resulting from production and subsequent retirement of wood products derived from the timber harvesting (Step 3.3), minus the rates of forest regrowth post timber harvest (Step 3.4).

Baseline commercial timber volumes must be derived (Step 3.1) for development of the timber harvest plan and for ex-post accounting of emissions resulting from natural forest disturbance.

The equations calculate the total emissions across the project crediting period for each emission source. Total emissions are averaged across the crediting period to give annual emissions and are multiplied by t*, time elapsed since the start of project activity (Step 3.5). Ex-

post, t* is updated so baseline projections are available for each proposed future verification date.

Data for input into these carbon stock change calculations for the baseline scenario shall be established from the same data used to create the timber harvesting plan.

Step 3.1 Calculation of carbon stocks in commercial timber volumes

This step calculates $C_{HB,j,i|BSL}$, the mean carbon stock in total harvested biomass in tC·ha^{-1} and $C_{EX,j,i|BSL}$, the mean carbon stock in extracted timber (merchantable timber that leaves the forest) in tC·ha^{-1} .

The following calculation of merchantable volume of timber per unit area ($V_{j,i|BSL}$) that is potentially available for harvest shall be based on data from field measurements in sample plots.

It is acceptable to use pre-existing forest inventory data[6] for this purpose, provided that the pre-existing data:

    a. represents the project strata;

    b. is not more than 10 years old; and

    c. where forest inventory data is more than 10 years old, that the volume estimate derived from the pre-existing data has been validated with limited sampling within the project area.

Validation of pre-existing forest inventory data must be carried out by field surveys. For each strata, mean volume is estimated from sample plots/points measured within the project area using standard forest inventory assessment methods. The number of sample plots will be determined from application of the most recent version of the Tool for Calculation of the Number of Sample Plots for Measurements within A/R CDM Project Activities[7].

If the validated estimate of volume is within the 90% confidence interval of the corresponding estimate or is greater than the estimate calculated from pre-existing forest inventory data, the pre-existing forest inventory data may be used. If the validation estimate is less than the corresponding estimate calculated from pre-existing forest inventory data, the estimate from pre-existing data cannot be used.

Estimation of the merchantable volume of trees must be based on locally derived allometric equations or yield tables. If locally derived equations or yield tables for each species are not available it is acceptable to use relevant regional, national or default data.

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[6]   Standard quality control / quality assurance procedures for forest inventory including field data collection and data management shall have been applied to the forest inventory assessment. Sampling data and methods shall be available for verification. Sample sizes shall have been sufficient to ensure inventory estimates are within the 95% confidence intervals with the estimated variance within +/- 15 percent from the mean.

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

Yield tables or allometric equations shall be used to convert field measurements of diameter (*DBH*, at typically 1.3 m [4.3 ft] aboveground level or above buttress where they exist), and total height H of each tree in the sample plots to merchantable volume, $V_{l,j,i,sp}$.

It is acceptable to combine *DBH* and allometric equations if field instruments (e.g. a relascope) that measure the volume of each tree directly have been used.

The estimate of merchantable volume for each species *j* at the sample plot level will be calculated as:

$$V_{j,i,sp} = \sum_{l=1}^{L} V_{l,j,i,sp} \tag{1}$$

Where:

$V_{j,i,sp}$ merchantable volume for species *j* in stratum *i* in sample plot *sp*, m³;

$V_{l,j,i,sp}$ merchantable volume for tree *l* of species *j* in stratum *i* in sample plot *sp*; m³ [8]

l   1, 2, 3 …*L* sequence of individual trees in sample plot;

i   1, 2, 3 …*M* strata;

sp   1, 2, 3 …*SP* sample plots; and

j   1, 2, 3 …*J* tree species.

Therefore, the merchantable volume per unit area of species *j* in stratum *i* will be calculated as the mean merchantable volume in all sample plots in stratum *i*:

$$V_{j,i|BSL} = \frac{1}{SP} * \sum_{sp=1}^{SP} \frac{V_{j,i,sp}}{A_{sp}} \tag{2}$$

Where:

$V_{j,i|BSL}$ mean merchantable volume per unit area of species *j* in stratum *i* in the baseline scenario, m³·ha⁻¹;

$V_{j,i,sp}$ merchantable volume for species *j* in stratum *i* in sample plot *sp*; m³;

A_{sp} area of sample plot *sp*, ha; [9]

i   1, 2, 3 …*M* strata;

sp   1, 2, 3 …*SP* sample plots; and

j   1, 2, 3 …*J* tree species.

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[8] See *Data and parameters not monitored (default or possibly measured one time)* list for information on data selection (p 47).

[9] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

$V_{j,i|BSL}$ will be used to develop the timber harvest plan (Box 1). The timber harvest plan sets the allowable mean extracted volume ($V_{EX,j,i|BSL}$) from this merchantable volume based on legal limits.

Once the timber harvest plan is complete and $V_{EX,j,i|BSL}$ is calculated the Biomass Conversion and Expansion Factors (BCEF) method[10,11] shall be used to determine the carbon stock in harvested biomass.

This method is appropriate as forest inventory data and allowable harvest must be based on volume estimates to which expansion factors can be readily applied. The selected BCEF must have a minimum DBH compatible with the minimum DBH defined in the timber harvest plan (Box 1).

Therefore, the carbon stock of timber harvested per unit area for species *j* in stratum *i* will be calculated from this mean volume of extracted timber:

$$C_{HB,j,i|BSL} = V_{EX,j,i|BSL} * BCEF_R * CF_j \qquad (3)$$

Where:

$C_{HB,j,i|BSL}$ mean carbon stock of harvested biomass per unit area for species *j* in stratum *i*, $tC \cdot ha^{-1}$;

$V_{EX,j,i|BSL}$ mean volume of extracted timber per unit area for species *j* in stratum *i*, $m^3 \cdot ha^{-1}$;

$BCEF_R$ biomass conversion and expansion factor applicable to wood removals in the project area, $t.d.m \ m^{-3}$; [12]

CF_j carbon fraction of biomass for species *j*, $tC \ t \ d.m.^{-1}$; [13]

i   1, 2, 3 ...*M* strata; and

j   1, 2, 3 ...*J* tree species.

Not all of the harvested biomass leaves the forest because the timber harvested has two components: 1) wood removed to market (extracted timber) and, 2) wood remaining in the forest as a result of harvest (see Step 3.2).

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[10] Somogyi, Z., E. Cienciala, R. Mäkipää, P. Muukkonen, A. Lehtonen and P. Weiss. (2006) Indirect methods of large-scale forest biomass estimation, Eur. J. Forest Res. 126 (2) pp. 197–207. http://dx.doi.org/10.1007/s10342-006-0125-7.

[11] IPCC. (2006) IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. In: Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. (Eds.). IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[12] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[13] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

Therefore, the mean carbon stock of extracted timber per unit area for species j in stratum i will be calculated from the mean volume of extracted timber multiplied by density and carbon fractions:

$$C_{EX,j,i|BSL} = V_{EX,j,i|BSL} * D_j * CF_j \qquad (4)$$

Where:

$C_{EX,j,i|BSL}$ mean carbon stock of extracted timber per unit area for species j in stratum i; tC·ha^{-1};

$V_{EX,j,i|BSL}$ mean volume of extracted timber per unit area for species j in stratum i; in m^3·ha^{-1};

D_j basic wood density of species j; t d.m. m^{-3}; [14]

CF_j carbon fraction of biomass for species j; tC t d.m.$^{-1}$;

i 1, 2, 3 ...M strata; and

j 1, 2, 3 ...J tree species.

Step 3.2 Calculation of dead wood generated in the process of timber harvest

This step calculates $\Delta C_{DW,i,p|BSL}$, the change in carbon stock in dead wood resulting from timber harvest in stratum i in land parcel p, using $C_{EX,j,i|BSL}$ and $C_{HB,j,i|BSL}$ as calculated in Step 3.1.

The simplifying assumption is made that dead wood created during timber harvest is emitted in the year of harvest.

Therefore, the change in carbon stock in the dead wood pool in stratum i in land parcel p will be calculated as the difference between the total carbon stock of the harvested biomass and the carbon stock of the extracted timber:

$$\Delta C_{DW,i,p|BSL} = A_{i,p} * \sum_{j=1}^{J} \left(C_{HB,j,i|BSL} - C_{EX,j,i|BSL} \right) \qquad (5)$$

Where:

$\Delta C_{DW,i,p|BSL}$ change in carbon stock of dead wood resulting from timber harvest per unit area in stratum i in land parcel p, in tC;

$A_{i,p}$ the area of stratum i in land parcel p, ha; [15]

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[14] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[15] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

$C_{HB,j,i|BSL}$	mean carbon stock of harvested biomass per unit area for species j in stratum i, tC·ha^{-1};
$C_{EX,j,i|BSL}$	mean carbon stock of extracted timber per unit area for species j in stratum i, tC·ha^{-1};
j	1, 2, 3 ...J species;
i	1, 2, 3 ...M strata; and
p	*1, 2, 3 ...P* land parcels.

Step 3.3 Calculation of baseline carbon sequestered in wood products

This step calculates $\Delta C_{WP,i,p|BSL}$ net carbon stock change resulting from wood product conversion and retirement.

In all cases where wood is harvested for conversion to wood products, carbon stock in the wood products pool must be included in the baseline case.

Carbon stocks treated here are those stocks remaining in wood products after 100 years because the bulk of emissions associated with timber harvest, processing and waste, and eventual product retirement occur within this timeframe. This methodology employs the simplifying assumption that the proportion remaining after 100 years is effectively "permanent."

Accounting for wood products shall take place at the time of timber harvest.

The conceptual framework detailed in Winjum *et al* (1998)[16] is used here, applying the simplifying assumption that all extracted biomass not retained in long-term wood products after 100 years is emitted in the year harvested, instead of tracking annual emissions through retirement, burning and decomposition.

All factors are derived from Winjum *et al* (1998).

Therefore, the carbon stock of extracted timber across species is calculated as:

$$C_{EX,i|BSL} = \sum_{j=1}^{J} C_{EX,j,i|BSL} \qquad (6)$$

Where:

$C_{EX,i|BSL}$	mean carbon stock of extracted timber per unit area in stratum i, tC·ha^{-1};
$C_{EX,j,i|BSL}$	mean carbon stock of extracted timber per unit area for species j in stratum i, tC·ha^{-1};
i	1, 2, 3 ...M strata; and

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

j 1, 2, 3 ...J species.

The wood product class(es), k, (sawnwood, wood-based panels, other industrial roundwood, paper and paper board, and other) that are the anticipated end use of the extracted timber must now be selected. It is acceptable practice to assign gross percentages of volume extracted to wood product classes on the basis of local expert knowledge of harvest activities and markets.

Therefore, the proportion of mean carbon stock of extracted timber that remains sequestered in long-term wood products after 100 years is calculated as:

$$C_{WP,i|BSL} = \sum_k \left(C_{EX,i,k|BSL} * (1 - WW_k) * (1 - SLF_k) * (1 - OF_k) \right) \tag{7}$$

Where:

$C_{WP,i|BSL}$ carbon stock sequestered in wood products in stratum i as a result of planned timber harvest in the baseline scenario, in tC·ha^{-1};

$C_{EX,i|BSL}$ mean carbon stock of extracted timber per unit area in stratum i, for wood product type k, tC·ha^{-1};

WW_k fraction of biomass carbon from wood waste immediately emitted as a by product of milling operations for wood product k, dimensionless; [17]

SLF_k fraction of biomass carbon for wood product k that will be emitted to the atmosphere within 5 years of timber harvest, dimensionless; [18]

OF_k fraction of biomass carbon for wood product type k that will be emitted to the atmosphere between 5 and 100 years of timber harvest, dimensionless; [19]

i 1, 2, 3 ...M strata; and

k wood product classes (1. sawnwood, 2. wood-based panels, 3. other industrial roundwood, 4. paper and paper board, and 5. other).

Therefore, the carbon stock change resulting from wood product conversion and retirement is calculated as the difference between the mean carbon stock of extracted timber minus the carbon sequestered in wood products:

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[17] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[18] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[19] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

$$\Delta C_{WP,i,p|BSL} = A_{i,p} * (C_{EX,i|BSL} - C_{WP,i|BSL}) \qquad (8)$$

Where:

$\Delta C_{WP,i,p|BSL}$	change in carbon stock resulting from wood product conversion and retirement from stratum i in land parcel p, tC;
$A_{i,p}$	the area of stratum i in land parcel p, ha; [20]
$C_{EX,i|BSL}$	mean carbon stock of extracted timber per unit area in stratum i, tC·ha^{-1};
$C_{WP,i|BSL}$	carbon stock sequestered in wood products in stratum i as a result of planned timber harvest in the baseline scenario, in tC·ha^{-1};
i	1, 2, 3 …M strata; and
p	1, 2, 3 …P land parcels.

Step 3.4 Change in carbon stocks due to forest regrowth after harvest

This step calculates $\Delta C_{RG,i,p|BSL}$, the carbon sequestration resulting from forest regrowth after timber harvest in stratum i in land parcel p; tC.

The carbon sequestration in the baseline resulting from forest regrowth after timber harvest up to year t is equal to the forest regrowth rate multiplied by the number of years since timber harvest multiplied by the area of each stratum in each land parcel.

Therefore, carbon sequestration resulting from forest regrowth after timber harvest is calculated as:

$$\Delta C_{RG,i,p|BSL} = A_{i,p} * (RGR_i * TH_{i,p}) \qquad (9)$$

Where:

$\Delta C_{RG,i,p|BSL}$	carbon sequestration resulting from forest regrowth after timber harvest in stratum i in land parcel p, tC;
$A_{i,p}$	the area of stratum i in land parcel p, ha; [21]
RGR_i	regrowth rate of forest post timber harvest for stratum i, tC·ha^{-1} yr^{-1}; [22]
$TH_{i,p}$	number of years since timber harvest in stratum i in land parcel p, years; [23]

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[20] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[21] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[22] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

i 1, 2, 3 ...M strata; and

p *1, 2, 3 ...P* land parcels.

Step 3.5 Calculation of baseline scenario greenhouse gas emissions from change in carbon stocks

This step calculates $GHG_{NET|BSL}$, the net greenhouse gas emissions in the baseline scenario, in tCO$_2$e.

The net carbon stock change to be converted to emissions is equal to the carbon stock change as a result of timber harvest plus the carbon stock change resulting from conversion and retirement of wood products minus carbon sequestration from forest regrowth after harvest.

Therefore, the net change in carbon stock in each land parcel is calculated as:

$$\Delta C_{NET,p|BSL} = \sum_{i=1}^{M} \left(\Delta C_{DW,i,p|BSL} + \Delta C_{WP,i,p|BSL} - \Delta C_{RG,i,p|BSL} \right) \tag{10}$$

Where:

$\Delta C_{NET,p|BSL}$ net change in carbon stock in the baseline scenario in parcel p, in tC;

$\Delta C_{DW,i,p|BSL}$ change in carbon stock from dead wood resulting from timber harvest per unit area in stratum i in land parcel p, in tC;

$\Delta C_{WP,i,p|BSL}$ change in carbon stock resulting from wood product conversion and retirement from stratum i in land parcel p, tC;

$\Delta C_{RG,i,p|BSL}$ carbon sequestration resulting from forest regrowth after timber harvest in stratum i in land parcel p, tC;

i 1, 2, 3 ...M strata; and

p *1, 2, 3 ...P* land parcels.

In order to generate the annual carbon stock change in the baseline scenario, the total net change in carbon stocks across all parcels harvested within the project crediting period is divided by the project crediting period.

This annual net change in carbon stocks is multiplied by the time elapsed since the start of the project activity to determine the net change in carbon stock across all parcels in the baseline scenario since the start of the project activity.

Therefore, net change in carbon stock across all parcels harvested within the project crediting period in the baseline scenario since the start of the project activity is calculated as:

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[23]   See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

$$\Delta C_{NET|BSL} = \frac{\left(\sum_{p=1}^{P} \Delta C_{NET,p|BSL} \right)}{IFM_{CP}} * t^{*}$$ (11)

Where:

$\Delta C_{NET|BSL}$ net change in carbon stock across all parcels in the baseline scenario since the start of the project activity, in tC;

$\Delta C_{NET,p|BSL}$ net change in carbon stock in the baseline scenario in parcel p, in tC;

IFM_{CP} project crediting period for the IFM project, in years;

t*   time elapsed since the start of the project, in years; and

p *1, 2, 3 ...P* land parcels harvested within the crediting period.

The net carbon stock change in the baseline scenario since the start of the project activity must be converted to net greenhouse gas emissions and is calculated as:

$$GHG_{NET|BSL} = \Delta C_{NET|BSL} * \frac{44}{12}$$ (12)

Where:

$GHG_{NET|BSL}$ net greenhouse gas emissions in the baseline scenario since the start of the project activity, tCO_2e;

$\Delta C_{NET|BSL}$ net change in carbon stock across all parcels in the baseline scenario since the start of the project activity, tC; and

44/12   ratio of molecular weights of carbon dioxide and carbon, $tCO_2\text{-e } tC^{-1}$.

STEP 4 – Project Scenario Net Greenhouse Gas Emissions

This step calculates $GHG_{NET|PRJ}$, the net greenhouse gas emissions in the project scenario, in tCO$_2$e.

Greenhouse gas emissions from Improved Forest Management (IFM) activities implemented in the project scenario must be accounted subject to application of the *de minimis* rule, as prescribed by the VCS AFOLU Guidance Document.

The type and extent of the activities implemented in the project scenario will be described by the project proponents as part of the documentation submitted with the VCS-PD.

In accordance with the applicability conditions the project scenario does not allow commercial timber harvest. As a result, carbon stock changes due to vegetation management and fuel removal will be negligible.

Thus net greenhouse gas emissions in the project scenario will be equal to carbon sequestration through ongoing forest growth minus any emissions resulting from forest disturbance (both illegal logging and natural disturbances).

Ex-ante and ex-post estimations of natural disturbance for the project scenario shall be estimated following step 4.2.1.[24]

The potential for illegal extraction of trees from the project area shall be assessed ex-ante and ex-post through a participatory rural appraisal (PRA) of the communities in and surrounding the project area following step 4.2.2.[25]

At all subsequent verifications, data collected for monitored parameters for natural disturbance and illegal logging must be included using the equations given at steps 4.2 and 4.3 below.

It is not a requirement of this methodology for project proponents to estimate carbon stock change from forest growth in the project scenario of undisturbed forest.

However, where project proponents choose to determine stock change from forest growth in the project scenario a detailed sampling plan must be provided in the VCS-PD and follow the equations in step 4.1 below.

Step 4.1 Ongoing forest growth in the project scenario

This step calculates $\Delta C_{AB,t|PRJ}$ annual carbon stock change in aboveground biomass of trees in the project scenario, in tCO$_2$e.

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[24]   *Ex ante* estimations of areas burned and naturally disturbed shall be based on historic incidence of fire and natural disturbance in the Project region.

[25]   If the belief is that zero illegal logging will occur within the project boundaries then ex-ante this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent illegal logging.

Step 4.1.1

Select or develop an appropriate allometric equation for forest type/group of species j (e.g. tropical humid forest or tropical dry forest) or for each species or family j (group of species) found in the inventory (hereafter referred to as species group) that converts tree dimensions from field timber inventories on sample plots to aboveground biomass of trees.

Equation selection or development must follow the criteria described for $f_j(X,Y...)$, the aboveground biomass of trees based on allometric equation for species group j based on measured tree variable(s), in the parameters section below.

Step 4.1.2

Only the individual trees, species and strata which were to be harvested in the baseline scenario are to be measured. The tree dimensions and minimum diameter at breast height (*DBH*) specified by the selected allometric equation in Step 4.1.1 must apply to these trees.

Any minimum values employed in inventories are held constant for the duration of the project.

Step 4.1.3

The carbon stock in aboveground biomass for each individual tree of species group j in the sample plot located in stratum i will be estimated using the selected or developed allometric equation applied to the tree dimensions resulting from Step 4.1.2.

Therefore, the sum of the carbon stock in each sample plot will be calculated as:

$$C_{AB,j,i,t,sp|PRJ} = \sum_{l=1}^{L_{j,i,sp,t}} f_j(X,Y...) * CF_j \qquad (13)$$

Where:

$C_{AB,j,i,t,sp|PRJ}$	carbon stock in aboveground biomass of trees of species j in plot sp in stratum i at time t in the project scenario, tC
CF_j	carbon fraction of biomass for tree group j, tC t d.m.$^{-1}$; [26]
$f_j(X,Y...)$	aboveground biomass of trees based on allometric equation for species group j based on measured tree variable(s), t. d.m. tree^{-1}; [27]
i	1, 2, 3, …M strata;
j	1, 2, 3 … J tree species;

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[26] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

[27] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

l 1, 2, 3, ... $L_{j,i,t,sp}$ sequence number of individual trees of species group j in stratum i at time t in sample plot sp;

t 0, 1, 2, 3, ...t^* years elapsed since start of the project activity; and

sp 1, 2, 3 ...SP sample plots.

Step 4.1.4

The total carbon stock in the aboveground biomass of all trees present in sample plot sp in stratum i at time t, shall be calculated as:

$$C_{AB,i,t,sp|PRJ} = \sum_{j=1}^{J} C_{AB,j,i,t,sp|PRJ} \tag{14}$$

Where:

$C_{AB,i,t,sp|PRJ}$ aboveground biomass carbon stock of all trees of stratum i at time t in sample plot sp in the project scenario, tC;

$C_{AB,j,i,t,sp|PRJ}$ carbon stock in aboveground biomass of trees of species j in stratum i at time t in plot sp in the project scenario, tC;

i 1, 2, 3, ...M strata;

j 1, 2, 3 ... J tree species; and

t 0, 1, 2, 3 ...t^* years elapsed since the start of the project activity.

Step 4.1.5

Therefore, the mean carbon stock in aboveground biomass for each stratum per unit area is calculated as:

$$C_{AB,i,t|PRJ} = \frac{1}{SP} * \sum_{sp=1}^{SP} \left(\frac{C_{AB,i,t,sp|PRJ}}{A_{sp}} \right) \tag{15}$$

Where:

$C_{AB,i,t|PRJ}$ mean aboveground biomass carbon stock of trees in stratum i at time t, tC·ha^{-1};

$C_{AB,i,t,sp|PRJ}$ aboveground biomass carbon stock of trees in stratum i at time t in sample plot sp, tC;

$A_{,sp}$ area of sample plot sp, ha; [28]

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[28]   See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

sp   *1, 2, 3 … SP* sample plots;

i   *1, 2, 3 … M* strata; and

t   *0, 1, 2, 3 … t** years elapsed since the start of the project activity.

Step 4.1.6

The annual carbon stock change in aboveground biomass of trees in year t is the difference in mean carbon stock in aboveground biomass between sampling events and, when expressed in tCO_2e, is calculated as:

$$\Delta C_{AB,t|PRJ} = \left(\sum_{i=1}^{M} \left(A_i * \frac{C_{AB,i,t2|PRJ} - C_{AB,i,t1|PRJ}}{T} \right) \right) * \frac{44}{12} \qquad (16)$$

Where:

$\Delta C_{AB,t|PRJ}$ annual carbon stock change in aboveground biomass of trees in year t, $tCO_2e \cdot yr^{-1}$;

$C_{AB,i,t|PRJ}$ mean aboveground biomass carbon stock of trees in stratum i at time t, $tC \cdot ha^{-1}$;

A_i area covered by stratum i, ha;

T number of years between monitoring time $t1$ and $t2$ ($T = t2 - t1$); years;

i *1, 2, 3 … M* strata;

t *1, 2, 3 … t** years elapsed since the start of the project activity; and

44/12   ratio of molecular weights of carbon dioxide and carbon, $tCO_2e \cdot tC^{-1}$.

The carbon stock change in aboveground biomass of trees ($\Delta C_{AB,t|PRJ}$) is the output of this step necessary to calculate net greenhouse gas emissions in the project scenario.

Step 4.2 Forest disturbance in the project scenario

This step calculates $\Delta C_{DIST\_FR,t|PRJ}$, carbon stock change due to fire disturbance in the project scenario; tCO_2-e, $\Delta C_{DIST,t|PRJ}$, carbon stock change due to non-fire natural disturbance in the project scenario; tCO_2-e and $\Delta C_{DIST\_IL,i,t|PRJ}$, the net carbon stock changes as a result of illegal logging in stratum i at time t; in tCO_2e.

4.2.1 Natural disturbance

It is a requirement that any greenhouse gas emissions from natural disturbance above de minimis that may occur in the project area are monitored.

Estimation of emissions from natural disturbance shall be calculated depending on the type of disturbance event. Disturbance due to fire is calculated following Step 4.2.1.1, and all non-fire natural disturbance (e.g. wind, disease, pest events) is calculated following Step 4.2.1.2.

Step 4.2.1.1

For fire damage it is assumed that a fire burning in the project scenario would also have burned in the baseline. Project emissions are therefore equal to the fire damage to biomass absent in the baseline case (harvested and removed) but present in the project case.

Where fires occur *ex post* in the project area, the area burned shall be delineated.

Therefore, based on the IPCC 2006 Inventory Guidelines, estimation of greenhouse gas emissions from biomass burning shall be calculated as:

$$\Delta C_{DIST\_FR,t|PRJ} = \sum_{i=1}^{M}(A_{burn,i,t} * B_{i,t|PRJ} * COMF_i * G_{g,i} * 10^{-3} \cdot GWP_{CH4}) \qquad (17)$$

Where:

$\Delta C_{DIST\_FR,t|PRJ}$	net greenhouse gas emissions resulting from fire disturbance in year t, tCO_2e ;
$A_{burn,i,t}$	area burnt for stratum i at time t, ha; [29]
$B_{i,t|PRJ}$	average aboveground biomass stock present in the project scenario but absent in the baseline scenario before burning stratum i, time t; t d. m. ha^{-1};
$COMF_i$	combustion factor for stratum i, dimensionless; [30]
$G_{g,i}$	emission factor for stratum i for methane, g kg^{-1} dry matter burnt; [31]
GWP_{CH4}	global warming potential for CH_4 (IPCC default: 21), tCO_2e tCH_4 $^{-1}$;
i	1, 2, 3 ...M strata; and
t	1, 2, 3, ... $t*$ years elapsed since the start of the IFM project activity.

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[29] See *Data and parameters used in monitoring* parameter list for information on data selection (p59).
[30] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).
[31] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

The average aboveground biomass stock present in the project scenario but absent in the baseline scenario before burning for a particular stratum shall be calculated as:

$$B_{i,t|PRJ} = \sum_{j=1}^{J} \left(V_{EX,i,j|BSL} * BCEF_R \right) \tag{18}$$

Where:

$B_{i,t|PRJ}$ average aboveground biomass stock present in the project scenario but absent in the baseline before burning for stratum i, time t, t d. m. ha^{-1};

$V_{EX,j,i|BSL}$ mean volume of extracted timber per unit area for species j in stratum i, m^3·ha^{-1};

$BCEF_R$ biomass conversion and expansion factor applicable to wood removals in the project area, t.d.m m^{-3};[32]

i 1, 2, 3 ...M strata;

j 1, 2, 3 ...J tree species; and

t 1, 2, 3, ... t^* years elapsed since the start of the IFM project activity.

Step 4.2.1.2

For non-fire natural disturbance it is assumed that a disturbance event in the project scenario would also have occurred in the baseline. Project emissions are therefore equal to the non-fire natural disturbance to biomass absent in the baseline case (harvested and removed) but present in the project case.

It is conservatively assumed that the natural disturbance is a stand-replacing disturbance, and that the biomass change as a result of the natural disturbance ($\Delta C_{DIST,t|PRJ}$) is emitted in the year of disturbance.

Where non-fire natural disturbances occur *ex post* in the project area, the area disturbed shall be delineated.

$$\Delta C_{DIST,t|PRJ} = \sum_{i=1}^{M} \left(A_{dist,i,t} * \sum_{j=1}^{J} C_{HB,j,i|BSL} \right) * \frac{44}{12} \tag{19}$$

Where:

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[32] See *Data and parameters not monitored (default or possibly measured one time)* parameter list for information on data selection (p 47).

$\Delta C_{DIST,t|PRJ}$ net greenhouse gas emissions resulting from non-fire natural disturbance in year t, tCO$_2$e ;

$A_{dist,i,t}$ area disturbed for stratum i at time t, ha; [33]

$C_{AGB,i|BSL}$ carbon stock in aboveground biomass per unit area in stratum i, tC·ha^{-1};

$44/12$ ratio of molecular weights of carbon dioxide and carbon, tCO$_2$e·tC^{-1};

i 1, 2, 3 …M strata;

j 1, 2, 3 …J tree species; and

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

4.2.2 Illegal logging

It is a requirement that any greenhouse gas emissions from illegal logging above *de minimis* that may occur in the project area ($\Delta C_{DIST\_IL,i,t|PRJ}$) are monitored.

At the time of methodology approval, remote sensing technology using optical sensors is not capable of direct measurements of biomass and changes thereof[34] but has some capability to identify forest strata that have undergone a change in biomass[35].

As remote methods for monitoring illegal logging are not available at the time of methodology approval, the following ground-based methods must be used.

Step 4.2.2.1

A participatory rural appraisal (PRA) of the communities surrounding the project area shall be completed to determine if there is the potential for illegal extraction of trees from the project area. If this assessment finds no potential pressure for these activities then illegal logging ($\Delta C_{DIST\_IL,i,t|PRJ}$) can be assumed to be zero and no monitoring is needed.

The PRA must be repeated every 2 years.

Step 4.2.2.2

If the results of the PRA suggest that there is a potential for illegal logging activities, then limited field sampling must be undertaken.

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[33] See *Data and parameters used in monitoring* parameter list for information on data selection (p59).

[34] However, technology is developing rapidly, including techniques such as RADAR, SAR, or LiDAR.

[35] For example, a multi-temporal set of remotely sensed data can be used to detect changes in the structure of the forest canopy. A variety of techniques, such as Spectral Mixture Analysis (Souza et al. 2005), SAR or LiDAR, can be used under this approach but no specific technology is prescribed here. Some of the newer technologies can estimate carbon contents of forest types, if supported by field information such as sample plots to calibrate the technology and fieldwork leading to allometric equations of key species. Project proponents should use techniques that are suitable to their specific situation and that have been published in peer-reviewed papers.

The area that is potentially subject to degradation $(A_{DIST\_IL,i})$ uses the distance of illegal logging penetration from all access points (access buffer), such as roads and rivers or previously cleared areas, to the project area determined from the PRA.

The area subject to illegal logging shall be delineated $(A_{DIST\_IL,i})$ based on an access buffer from all access points, such as roads and rivers or previously cleared areas, to the project area, with a width equal to the distance of degradation penetration.

$A_{DIST\_IL,i}$ shall be sampled by surveying several transects of known length and width across the access-buffer area (equal in area to at least 1% of $A_{DIST\_IL,i}$) to determine the presence or absence of new tree stumps. The CDM tool for significance[36] shall be applied to determine significance where there is evidence that trees are being harvested.

Where application of the CDM tool demonstrates that illegal logging is insignificant then illegal logging can be assumed to be zero and no monitoring is needed.

This limited sampling must to be repeated each time the PRA indicates a potential for illegal logging.

Where limited sampling provides evidence that trees are being removed in the buffer area, then systematic sampling must be implemented based on a detailed sampling plan. The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone $(A_{DIST\_IL,i})$. The diameter of all tree stumps will be measured and conservatively assumed to be the same as the DBH. Where the stump is a large buttress, several individuals of the same species nearby shall be located and a ratio of the diameter at DBH to the diameter of buttress at the same height above ground as the measured stumps shall be determined. This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree.

The aboveground carbon stock of each harvested tree will be estimated using the allometric regression equations chosen for forest growth in the project scenario[37]. The mean aboveground carbon stock of the harvested trees $(C_{DIST\_IL,i,t|PRJ})$ is conservatively estimated to be, the total emissions and, consequently all emissions enter the atmosphere.

This sampling procedure shall be repeated every 5 years and the results annualised by dividing the total emissions by five.

Therefore, where the PRA or the limited sampling indicate no illegal logging occurring:

$$\Delta C_{DIST\_IL,t|PRJ} = 0$$

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[36] http://cdm.unfccc.int/EB/031/eb31_repan16.pdf

[37] If species-specific equations are used and species cannot be identified from stumps then it shall be assumed that the harvested species is the species most commonly harvested. A PRA shall be used to determine the most commonly harvested species.

Where the PRA and the limited sampling indicate degradation is occurring, net carbon stock changes as a result of illegal logging shall be calculated as:

$$\Delta C_{DIST\_IL,t|PRJ} = \sum_{i=1}^{M}\left(A_{DIST\_IL,i} * \frac{C_{DIST\_IL,i,t|PRJ}}{AP_i} \right) \qquad (20)$$

Where:

$\Delta C_{DIST\_IL,t|PRJ}$	net carbon stock changes as a result of illegal logging at time t, tCO$_2$e;
$A_{DIST\_IL,i}$	area potentially impacted by illegal logging in stratum I, ha; [38]
$C_{DIST\_IL,i,t|PRJ}$	biomass carbon of trees cut and removed through illegal logging in stratum i at time t, tCO$_2$e;
AP_i	total area of illegal logging sample plots in stratum i, ha; [39]
i	1, 2, 3 …M strata in the in the project case; and
t	1, 2, 3, … t years elapsed since the projected start of the project activity.

Step 4.3 Net greenhouse gas emissions in the project scenario

This step calculates $\Delta C_{NET,t|PRJ}$, the net greenhouse gas emissions in the project scenario in year t, in tCO$_2$e.

The net greenhouse gas emissions in the project scenario are the sum of net greenhouse gas emissions resulting from fire and non-fire forest disturbance, plus any carbon stock changes that occur as a result of illegal logging, minus the annual carbon stock change in the aboveground biomass of trees due to forest growth.

Therefore, net greenhouse gas emissions in the project scenario in year t, is calculated as:

$$\Delta C_{NET,t|PRJ} = (\Delta C_{DIST\_FR,t|PRJ} + \Delta C_{DIST,t|PRJ} + \Delta C_{DIST\_IL,t|PRJ}) - \Delta C_{AB,t|PRJ} \qquad (21)$$

Where:

$\Delta C_{NET,t|PRJ}$	net greenhouse gas emissions in the project scenario in year t, tCO$_2$-e;
$\Delta C_{DIST\_FR,t|PRJ}$	net greenhouse gas emissions resulting from fire disturbance in year t, tCO$_2$e ;
$\Delta C_{DIST,t|PRJ}$	net greenhouse gas emissions resulting from non-fire natural disturbance in year t, tCO$_2$e ;
$\Delta C_{DIST\_IL,t|PRJ}$	Net carbon stock changes as a result of illegal logging at time t, tCO$_2$e;

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[38] See *Data and parameters used in monitoring* parameter list for information on data selection (p59).
[39] See *Data and parameters used in monitoring* parameter list for information on data selection (p59).

$\Delta C_{AB,t|PRJ}$ annual carbon stock change in aboveground biomass of trees in year t, tCO$_2$e·yr^{-1}; and

t 1, 2, 3, … t^* years elapsed since start of the project activity.

The net greenhouse gas emissions across in the project scenario since the start of the project activity is calculated as:

$$GHG_{NET|PRJ} = \sum_{t=1}^{t^*} \Delta C_{NET,t|PRJ} \qquad\qquad (22)$$

Where:

$GHG_{NET|PRJ}$ net greenhouse gas emissions in the project scenario since the start of the project activity, tCO$_2$e;

$\Delta C_{NET,t|PRJ}$ net greenhouse gas emissions in the project scenario in year t, tCO$_2$e; and

t 1, 2, 3, … t^* years elapsed since start of the project activity.

STEP 5 – Project Leakage

Step 5.1 Activity shifting leakage

There may be no leakage due to activity shifting.

Where the project proponent controls multiple parcels of land within the country the project proponent must demonstrate that the management plans and/or land-use designations of other lands they control have not materially changed as a result of the planned project (designating new lands as timber concessions or increasing harvest rates in lands already managed for timber) because such changes could lead to reductions in carbon stocks or increases in GHG emissions.

This must be demonstrated through:

- historical records showing trends in harvest volumes paired with records from the with-project time period showing no deviation from historical trends;

- forest management plans prepared ≥24 months 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.

At each verification, documentation must be provided covering the other lands controlled by the project proponent where leakage could occur, including, at a minimum, their location(s), area and type of existing land use(s), and management plans.

Where activity shifting occurs or a project proponent is unable to provide the necessary documentation at first and subsequent verification, the project shall not meet the requirements for verification. Therefore, the project shall be subject to the conditions described in the VCS AFOLU Guidance Document on projects which fail to submit periodic verification after the commencement of the project. Project proponents may optionally choose to submit a methodology deviation with their future verifications to address activity shifting leakage.

Where the project proponent has control only over resource use in the project area and has no access to other forest resource, then the only type of leakage emissions calculated is GHG emissions due to market effects that result from project activity.

Step 5.2 Market leakage

Leakage due to market effects is equal to the net emissions from planned timber harvest activities in the baseline scenario multiplied by an appropriate leakage factor:

$$GHG_{LK|LtPF} = LF_{me} * GHG_{NET|BSL} \qquad (23)$$

Where:

$GHG_{LK|LtPF}$ is total market leakage as a result of IFM LtPF activities, tCO2e;

LF_{ME} is the dimensionless leakage factor for market-effects calculations;

$GHG_{NET|BSL}$ net greenhouse gas emissions in the baseline scenario since the start of the project activity, tCO_2e.

The leakage factor (see Box 2) is determined by considering where in the country logging will be increased as a result of the decreased timber supply caused by the project.

If the ratio of merchantable biomass to total biomass is higher in the project area, it is likely that additional logging will be performed in these areas as a result of reduced logging in the project area in the project scenario.

The leakage factor is thus defined as a dimensionless number with values between 0 and 1 assigned *ex ante* on the basis of a comparison between the ratio of merchantable biomass to total biomass across all strata in the base year, and the ratio of merchantable biomass to total biomass of the country's forest estate where harvesting would likely be displaced to.

Box 2. Leakage factor calculation

The leakage factor is determined by considering where in the country logging will be increased as a result of the decreased supply of the timber caused by the project. If the areas liable to be logged have a higher ratio of merchantable biomass to total biomass higher than the project area it is likely that the proportional leakage is higher and vice versa:

Therefore,

$$LF_{ME} = 0$$

if it can be demonstrated that no market-effects leakage will occur within national boundaries, that is if no new concessions are being assigned AND annual extracted volumes cannot be increased within existing national concessions AND illegal logging is absent (or *de minimis*) in the host country.

The amount of leakage is determined by where in the country's forest estate harvesting would likely be displaced. If harvesting is displaced to forests where a lower proportion of forest biomass is merchantable material from harvestable species than in the project area, then in order to extract a given volume higher emissions should be expected as more trees will need to be cut to supply the same volume.

In contrast if a higher proportion of the total biomass of commercial species is merchantable in the displacement forest than in the project forests, then a smaller area would have to be harvested and lower emissions would result.

Therefore, each project shall calculate within each stratum the ratio of merchantable biomass to total biomass (PMP_i). This shall then be compared to the ratio of merchantable biomass to total biomass for each forest type (PML_{FT}).

The following deduction factors (LF_{ME}) shall be used:

PML_{FT} is equal (± 15%) to PMP_i LF_{ME} = 0.4
PML_{FT} is > 15% less than PMP_i LF_{ME} = 0.7
PML_{FT} is > 15% greater than PMP_i LF_{ME} = 0.2

Where:
PML_{FT} mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type, %;

PMP_i merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries, %; and

LF_{ME} Leakage factor for market-effects calculations; dimensionless.

Where sufficient variation exists in PMP_i relative to PML_{FT} that multiple values of LF_{ME} result, then an area weighted final value for LF_{ME} shall be calculated. The area of stratum i as a proportion of the total project area shall be multiplied by LF_{ME}. All values are then summed to arrive at the area weighted final value of LF_{ME}.

STEP 6 – Net Project Greenhouse Gas Emission Reductions

Knowledge of the greenhouse gas emission level calculations at steps 3, 4 and 5 for baseline scenario, project scenario and leakage allows an *ex-ante* estimation of the level of net GHG emission reductions resulting at the end of each year over the project crediting period from the implementation of the proposed Logged to Protected Forest (LtPF)-IFM project.

Therefore, the project GHG credits are calculated as:

$$GHG_{CREDITS|LtPF} = GHG_{NET|BSL} - GHG_{NET|PRJ} - GHG_{LK|LtPF} \qquad (24)$$

Where:

$GHG_{CREDITS|LtPF}$ project greenhouse gas credits associated with the implementation of improved forest management (IFM) activities in the project scenario, tCO_2e;

$GHG_{NET|BSL}$ net greenhouse gas emissions in the baseline scenario since the start of the project activity, tCO_2e;

$GHG_{NET|PRJ}$ net greenhouse gas emissions in the project scenario since the start of the project activity, tCO_2e; and

$GHG_{LK|LtPF}$ total greenhouse gas emissions due to leakage arising outside the project boundary as a result of the implementation of improved forest management (IFM) activities in the project scenario, tCO_2e.

STEP 7 – Project Verified Carbon Units

The number of Verified Carbon Units (VCUs) for each year t in the project crediting period is the greenhouse gas emission reductions and removals adjusted for uncertainty and risk.

Step 7.1 Adjustment for uncertainty

Estimated greenhouse gas emissions and emission reductions from IFM activities have uncertainties associated with parameters and coefficients including estimates of area, carbon stocks, regrowth and expansion factors. It is assumed that the uncertainties associated with input data are available, either as default uncertainty values given in most recent IPCC guidelines, or as statistical estimates based on sampling.

Uncertainty at all times is defined at the 95% confidence interval where the estimated variance exceeds +/- 15 percent from the mean. Procedures including stratification and the allocation of sufficient measurement plots will help ensure that low uncertainty results and ultimately full crediting can result.

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

Uncertainties arising from the measurement and monitoring of carbon pools and greenhouse gases shall always be quantified. Errors in each pool shall 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.

For both the baseline and the with-project case the total uncertainty is equal to the square root of the sum of the squares of each component uncertainty and is calculated at the time of reporting through propagating the error in the baseline stocks and the error in the project stocks.

Therefore, total uncertainty for LtPF project is calculated as:

$$U_{TOTAL|LtPF} = \sqrt{U^2_{|PRJ} + U^2_{|BSL}}$$ (25)

Where:

$U_{total|LtPF}$ total uncertainty for LtPF Project, dimensionless;

$U_{|PRJ}$ total uncertainty for the improved forest management activities in the project scenario, dimensionless; and

$U_{|BSL}$ total uncertainty for the baseline scenario, dimensionless.

Project proponents must justify the selection of uncertainty propagation in the VCS-PD.

If $U_{total|LtPF} \leq 0.15$ then no deduction will result for uncertainty.

If $U_{total|LtPF}>0.15$ then the amount of greenhouse gas emission credits associated with IFM activites will be deducted as follows:

$$Credits_{total|LtPF} = GHG_{credits|LtPF} \cdot \left(1 - U_{total|LtPF`}\right) \qquad (26)$$

Where**:**

$Credits_{total|LtPF}$ total greenhouse gas credits adjusted for uncertainty for each year t in the project crediting period;

$GHG_{credits|LtPF}$ project greenhouse gas credits associated with the implementation of improved forest management (IFM) activities in the project scenario, $tCO_2e\cdot year^{-1}$; and

$U_{total|LtPF}$ total uncertainty for LtPF Project, dimensionless.

Step 7.2 Calculation of verified carbon units

The amount of greenhouse gas credits estimated at Step 7.1 above shall be adjusted to account for risk.

They shall be subject to deductions based on application of the most recent version of the VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination.

Therefore, the amount of VCU's that can be issued at time t=t2 (the date of verification) for monitoring period T=t2-t1, is calculated as:

$$VCU_{net|LtPF} = \left(Credits_{total,t2|LtPF} - Credits_{total,t1|LtPF}\right) - Bu_{|IFM-VCS} \qquad (27)$$

Where:

$VCU_{net|LtPF}$ number of verified carbon units; dimensionless;

$Credits_{total.t1|LtPF}$ net anthroprogenic greenhouse gas removals by sinks, as estimated for t*=t1 in tCO_2e;

$Credits_{total.t2|LtPF}$ net anthroprogenic greenhouse gas removals by sinks, as estimated for t*=t2 in tCO_2e; and

$Bu_{|IFM-VCS}$ total number of credits withheld in VCS buffer account.

STEP 8 – Project Monitoring

The following parameters must be monitored in this methodology:

- Illegal logging PRA
- Result of limited illegal logging survey
- Area burnt in stratum i at time t ($A_{burn,i,t}$)
- Area potentially impacted by illegal logging in stratum i ($A_{DIST\_IL, i}$)
- Total area of illegal logging sample plots in stratum i (AP_i)
- Merchantable biomass as a proportion of total aboveground tree biomass for stratum i (PMP_i)
- Area covered by stratum i (A_i)
- Diameter at breast height of tree (DBH)

These parameters will be required at each verification and are used in equations 16, 17, 19 at Step 4 and in Step 5.

Step 8.1 Scope of monitoring and the monitoring plan

Monitoring is required to

a. determine changes in forest carbon stocks and greenhouse gas emissions from project activity;

b. confirm project activity; and

c. determine changes in forest carbon stocks and greenhouse gas emissions from disturbance and illegal logging.

In some project cases monitoring may also be implemented to update stratification.

It is a requirement that the monitoring plan presented in the VCS-PD shall address the monitoring of project implementation, the monitoring of actual carbon stock changes from project activity, and estimation of *ex-post* net carbon stock changes from disturbance and illegal logging.

The description of the monitoring plan in the VCS-PD will include the following for each of these monitoring tasks:

a. technical description of the monitoring task;

b. a list of data and parameters to be collected;

c. overview of data collection procedures;

d. quality control and quality assurance procedure;

e. data archiving; and

f. organisation and responsibilities of the parties involved in all the above.

Step 8.2 General requirements for monitoring

All data collected as part of monitoring will be archived electronically and be kept at least for 2 years after the end of the project crediting period. All measurements will be conducted according to relevant standards.

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

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

The archives shall include:

- copies of all original field measurement data, laboratory data, data analysis spreadsheets;

- estimates of the carbon stock changes in all pools and non-CO_2 GHG and corresponding calculation spreadsheets;

- GIS products; and

- copies of the measuring and monitoring reports.

Step 8.3 Monitoring of project implementation

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

- the geographic position of the project boundary is recorded for all areas of land;

- the geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This will be achieved by field survey (e.g. using GPS) or by using georeferenced spatial data (e.g. maps, GIS datasets, aerial photography, or georeferenced remote sensing images);

- commonly accepted principles of forest inventory and management are implemented;

- standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of SOPs already applied in national forest monitoring or available from published handbooks or from the IPCC GPG LULUCF 2003 is recommended; and

- the project plan, together with a record of the plan as actually implemented during the project, shall be available for validation or verification as appropriate.

Step 8.4 Stratification

This methodology requires that an *ex ante* stratification of the project area in the project scenario is described in the VCS-PD as documented in the timber harvest plan, or developed by project proponents through sampling in the project area.

The monitoring plan may include sampling to adjust the number and boundaries of the strata defined *ex ante* where an update is required because of

a) unexpected disturbances occurring during the project crediting period affecting differently various parts of an originally homogeneous stratum and/or

b) forest management activities that are implemented in a way that affects the existing stratification in the project scenario.

Established strata may also be merged if the reasons for their establishment have disappeared.

Step 8.5 Monitoring of actual carbon stock changes

Carbon stocks will be measured according to the stock assessment equations in this methodology with field sampling based on forest inventory methods. Various sources exist to assist with the design of a verifiable forest field inventory based on best practice for sampling, data management and analysis (Box 3).

In the project area (or areas) the inventory plan must be specified in the VCS-PD and include:

a) adequate forest stratification, sample size estimation methods and consider uncertainty; and

b) a sampling framework including sample size, plot size, plot shape and information to determine plot location.

To determine the sample size and allocation among strata, this methodology uses the most recent version of the tool for the "Calculation of the number of sample plots for measurements within A/R CDM project activities"[40] approved by the CDM Executive Board.

Carbon stock changes over time shall be estimated by taking measurements in plots at each monitoring event. Monitoring events shall take place at intervals of 5, or preferably 3 years. For intermittent years it is good practice to use extrapolations of trends as they have occurred up till that moment. Monitoring reports can use such extrapolated parameter values for the determination of net emissions by sources and removals resulting from the project.

The design of the sampling regime will be determined by the number of strata and timber harvest the baseline case.

Step 8.6 Conservative approach and uncertainty

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

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

An uncertainty analysis is required for all estimates from monitoring related to change in area, change in carbon stocks and emissions for both the baseline and project case.

Box 2. Resource material for the design of forest field inventories.

IPCC Good Practice Guidance on Land Use. Land Use Change and Forestry (IPCC 2003) http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

The Sourcebook for Land Use Change and Forestry Projects (Pearson et al. 2005) http://www.winrock.org/feature_ecosystem_200802.asp

Measurement guidelines for the sequestration of forest carbon (Pearson et al. 2007) http://www.nrs.fs.fed.us/pubs/3292

Field Measurements for Forest Carbon Monitoring A Landscape-Scale Approach (Hoover. 2008)

The Winrock sampling calculator http://www.winrock.org/Ecosystems/tools.asp?BU=9086

The CDM A/R Methodological Tool "Calculation of the number of sample plots for measurements within A/R CDM project activities" (Version 02) http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

The California Climate Action Reserve Registry Forest Project Protocol (Version 2) 2009 http://www.climateactionreserve.org/how-it-works/protocols/adopted-protocols/forest/forest-project-protocol-update/

Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States (Smith et al. 2006)http://nrs.fs.fed.us/pubs/8192

A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Projects (MacDicken. 1997) http://www.winrock.org/fnrm/publications.asp?BU=9058

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

In addition to the parameters listed in the tables presented in the following pages, the provisions on data and parameters not monitored in the tools referred to in this methodology apply. In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, project participants must retain a conservative approach; that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

Data / parameter:	$V_{l,j,i,sp}$
Data unit:	m^3
Used in equations:	(1)
Description:	Merchantable volume for tree l of species j in sample plot sp in stratum i
Source of data:	Calculated from volume tables or equations linking diameter at breast height (DBH, at typically 1.3 m aboveground level), and/or merchantable height (MH), to commercial (merchantable) volume of trees in the sample plots above the minimum DBH set in the timber harvest plan.
	If locally derived equations or yield tables are not available use relevant regional, national or default equations from IPCC literature, national inventory reports or published peer-reviewed studies– such as those provided in Tables 4.A.1 to 4.A.3 of the GPG-LULUCF (IPCC 2003).
Measurement procedures (if any):	N/A
Any comment:	It is necessary to verify the applicability of equations used.
	Allometric equations can be verified by both:
	1. Verification of equation conditions
	Justification should be provided for the applicability of the equation to the project locations. Such justification should include identification of climatic, edaphic, geographical and taxonomic similarities between the project location and the location in which the equation was derived. Any equation used should have an r^2 value of greater than 0.5 (50%) and a p value that is significant (<0.05 at the

95% confidence level).

2. Additional field verification

The following Limited measures method must be used for field verification:

- select at least 10 trees per species distributed across the age range (but excluding trees less than 15 years old for which there is rarely a great relative inaccuracy in equations) ;
- measure DBH, and height to a 10 cm diameter top or to the first branch;
- calculate stem volume from measurements; and
- plot the estimated volume of all the measured trees along with the curve of volume against diameter as predicted by the allometric equation.

If the estimated volume of the measured trees are distributed both above and below the curve (as predicted by the allometric equation) the equation may be used. The equation may also be used if the measured individuals have a volume consistently higher than predicted by the equation. The equation may not be used if >75% of the measured trees have a volume lower than the predicted curve. In this instance another equation must be selected.

Data / parameter:	CF_j
Data unit:	tC·t d.m.$^{-1}$
Used in equations:	(3), (4), (13), (18)
Description:	Carbon fraction of dry matter for species j
Source of data:	Either the default value 0.5 tC·t d.m.$^{-1}$ or species specific values from the literature shall be used. The same value, however, must be used in all instances where this parameter is used.
Measurement procedures (if any):	N/A
Any comment:	

Data/ parameter:	D_j
Data unit:	t d.m. m^{-3}

Used in equations:	(4)
Description:	Basic wood density of species j in t d.m. m^{-3}
Source of data:	Shall be chosen with priority from higher to lower preference as follows: a) National species-specific or group of species-specific values (e.g. from National GHG inventory); b) Species-specific or group of species-specific values from neighbouring countries with similar conditions. When species-specific data from neighbouring countries is of higher quality, being more representative of the species in the project scenario, it may be preferable to use these values than lower quality national data; c) Global species-specific or group of species-specific (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Tables 4.13 and 4.14). Species-specific wood densities may not always be available, and may be difficult to apply with certainty in the typically species rich forests of the humid tropics, hence it is acceptable practice to use wood densities developed for forest types or plant families or species groups.
Measurement procedures (if any):	N/A
Any comment:	Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	$f_j(X,Y...)$
Data unit:	t d.m. tree^{-1}
Used in equations:	(13)
Description:	Allometric equation(s) for species j linking measured tree variable(s) to aboveground biomass of living trees
Source of data:	Equations must have been derived using a wide range of measured variables (e.g. DBH, Height, etc.) based on datasets that comprise at least 30 trees. Equations must be based on statistically significant regressions and must have an r^2 that is ≥ 0.8. The source of equation(s) shall be chosen with priority from higher to lower preference, as available, as follows: a) National species-, genus-, family-specific; b) Species-, genus-, family-specific from neighbouring countries with similar conditions (i.e. broad continental regions); c) National forest-type specific;

	d) Forest-type specific from neighbouring countries with similar conditions (i.e. broad continental regions); e) Forest type-specific such as those provided Tables 4.A.1 to 4.A.3 of the GPG-LULUCF (IPCC 2003); or in Pearson, T., Walker, S. and Brown, S. 2005. Sourcebook for Land Use, Land-Use Change and Forestry Projects. Winrock International and the World Bank Biocarbon Fund. 57pp.; or in Chave, J., C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J.-P. Lescure, B. W. Nelson, H. Ogawa, H. Puig, B. Riera, T. Yamakura. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145: 87-99. Species-, genus- and family-specific allometric equations may not always be available, and may be difficult to apply with certainty in the typically species rich forests of the humid tropics. Hence it is acceptable practice to use equations developed for regional forest types, provided that their accuracy has been validated with direct site-specific data following guidance given below. If a forest-type specific equation is used, it should not be used in combination with species-specific equation(s) (i.e. it must be used for all tree species[41]).
Measurement procedures (if any):	N/A
Any comment:	It is necessary to validate the applicability of equations used. Source data from which equation(s) was derived should be reviewed and confirmed to be representative of the forest type/species and conditions in the project and covering the range of potential independent variable values. Allometric equations can be validated either by: 1. Limited Measurements • select at least 30 trees (if validating forest type-specific equation, selection should be representative of the species composition in the project area, i.e. species representation in roughly in proportion to relative basal area). Minimum diameter of measured trees shall be 20cm and maximum diameter shall reflect the largest trees present or potentially present in the

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[41] Note that forest type specific and pantropical equations will typically not include palm species or hollow-stem species (e.g. Cecropia) and so specific equations for these growth forms will be needed

future in the project area (and/or leakage belt);

- measure DBH, and height to a 10 cm diameter top or to the first branch;

- calculate stem volume from measurements and multiplying by species-specific density to gain biomass of bole;

- apply a biomass expansion factor to estimate total aboveground biomass from stem biomass[42]; and

- plot the estimated biomass of all the measured trees along with the curve of biomass against diameter as predicted by the allometric equation.

If the estimated volume of the measured trees are distributed both above and below the curve (as predicted by the allometric equation) the equation may be used. The equation may also be used if the measured individuals have a biomass consistently higher than predicted by the equation. If >75% of the measured trees have a biomass lower than the predicted curve, destructive sampling must be undertaken or another equation must be selected.

2. Destructive Sampling

- select at least 5 trees (if validating forest type-specific equation, selection should be representative of the species composition in the project area, i.e. species representation in roughly in proportion to relative basal area) at the upper end of the range of independent variable values existing in the project area;

- measure DBH and commercial height and calculate volume using the same procedures/equations used to generate commercial volumes to which BCEFs will be applied;

- fell and weigh the aboveground biomass to determine the total (wet) mass of the stem, branch, twig, leaves, etc. Extract and immediately weigh subsamples from each of the wet stem and branch components, followed by oven drying at 70 degrees C to determine dry biomass;

- 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; and

- plot the estimated biomass of all the measured trees along with the curve of biomass against diameter as predicted by the allometric equation.

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[42]   See IPCC 2006 INV GLs AFOLU Chapter 4 Table 4.5

If the estimated volume of the measured trees are distributed both above and below the curve (as predicted by the allometric equation) the equation may be used. The equation may also be used if the measured individuals have a biomass consistently higher than predicted by the equation. If >75% of the measured trees have a biomass lower than the predicted curve another equation must be selected.

Details of destructive sampling measurements are given in:
Brown, S. 1997. Estimating biomass and biomass change of tropical forests: a primer. FAO Forestry Paper 134, Rome, Italy.
Available at http://www.fao.org/docrep/W4095E/W4095E00.htm

If using species-specific equations, and new species are encountered in the course of monitoring, new allometric equations must be sourced from the literature and validated, if necessary, as per requirements and procedures above.

Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	$BCEF_R$
Data unit:	t.d.m m^{-3}
Used in equations:	(3) (18)
Description:	Biomass conversion and expansion factor applicable to wood removals in the project area
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: a) Existing local forest type-specific; b) National forest type-specific or eco-region-specific (e.g. from national GHG inventory); c) Forest type-specific or eco-region-specific from neighbouring countries with similar conditions. Sometimes (c) might be preferable to (b); d) Global forest type or eco-region-specific (e.g. IPCC 2006 INV GLs AFOLU Chapter 4 Table 4.5). Alternatively: $BCEF_R = BEF_R * D$

	Where BCEF values are not directly available, they can be calculated as Biomass Expansion Factor (BEF)* basic wood density (D).
	Application of this equation requires caution because basic wood density and biomass expansion factors tend to be correlated. If the same sample of trees was used to determine D, BEF or BCEF, conversion will not introduce error, therefore, it is acceptable to use this equation. If, however, basic wood density is not known with certainty, transforming one into the other might introduce error, as BCEF implies a specific but unknown basic wood density, therefore, all conversion and expansion factors must be derived or their applicability checked locally.
Measurement procedures (if any):	N/A
Any comment:	When selecting a $BCEF_R$ the minimum DBH in the allometric equation must be compatible with the minimum DBH specified in the timber harvest plan. Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	$COMF_i$
Data unit:	Dimensionless
Used in equations:	(17)
Description:	Combustion factor for stratum i (vegetation type)
Source of data:	Default values in Table 2.6 of IPCC, 2006
Measurement procedures (if any):	N/A
Any comment:	The combustion factor is a measure of the proportion of the fuel that is actually combusted, which varies as a function of the size and architecture of the fuel load (i.e., a smaller proportion of large, coarse fuel such as tree stems will be burnt compared to fine fuels, such as grass leaves), the moisture content of the fuel and the type of fire (i.e., intensity and rate of spread). Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	G_{gi}
Data unit:	g kg^{-1} dry matter burnt
Used in equations:	(17)
Description:	Emission factor for stratum i for gas g
Source of data:	Defaults can be found in Volume 4, Chapter 2, of the IPCC 2006 Inventory Guidelines in table 2.5
Measurement procedures (if any):	N/A
Any comment:	Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	OF, SLF, WW
Data unit:	kg kg^{-1}
Used in equations:	(7)
Description:	OF = Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years after production;
	SLF = Fraction of wood products that will be emitted to the atmosphere within 5 years of production; and
	WW = Fraction of extracted biomass effectively emitted to the atmosphere during production
	Wood waste fraction (WW):
	Winjum et al 1998 indicate that the proportion of extracted biomass that is oxidized (burning or decaying) from the production of commodities to be equal to 19% for developed countries, 24% for developing countries.
	Short-lived fraction (SLF)
	Winjum et al 1998 give the following proportions for wood products with short-term (<5 yr) uses (applicable internationally):
	Sawnwood 0.2
	Woodbase panels 0.1
	Other industrial roundwood 0.3
	Paper and Paperboard 0.4
	Additional oxidized fraction (OF)
	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 the 5th and 100th years after initial harvest:

Wood Product Class	Boreal	Temperate	Tropical
Sawnwood	0.36	0.60	0.84
Woodbase panels	0.60	0.84	0.97
Other industrial roundwood	0.84	0.97	0.99
Paper and paperboard	0.36	0.60	0.99

Source of data:	The source of data is the published paper of Winjum et al. 1998[43]
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	PML_{FT}
Data unit:	%
Used in equations:	STEP 5 - Leakage, Box 2.
Description:	Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type.
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: a) peer-reviewed published sources (including carbon/biomass maps or growing stock volume[44] maps with a scale of at least 1km); b) official Government data and statistics ; or c) original field measurements. The forest types considered shall be only those relevant for the specific market effects leakage, that is, only forest types with active timber production. An appropriate source of data will be Government records on annual allowable cuts for the areas of commercial forests.

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[43] Winjum, J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. Forest Science 44: 272-284 31

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

	Where volumes are used the source of data wood density is required to convert to merchantable biomass. The source of data on wood densities shall be chosen as per the species specific density parameter, D_j.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	RGR_i
Data unit:	$tC.ha^{-1}.yr^{-1}$
Used in equations:	(9)
Description:	Forest regrowth rate post timber harvest for stratum i
Source of data:	Regrowth rate shall be calculated from either a) data generated in a reference area using measurements of timber volume in a chronosequence of replicated sample plots; or b) published data on forest growth after timber harvest of the same forest type within the same region as the project; or c) the IPCC default values for aboveground net biomass growth in natural forests[45].
Measurement procedures (if any):	
Any comment:	Default values shall be updated whenever new guidelines are produced by the IPCC

Data / parameter:	$V_{EX,j,i|BSL}$
Data unit:	$m^3.ha^{-1}$
Used in equations:	(3), (4)

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[45] IPCC Guidelines for National Greenhouse Gas Inventories (2006), Table 4.9

Description:	Mean volume of extracted timber per unit area for species j in stratum i
Source of data:	The timber harvest plan sets the allowable mean extracted volume from the merchantable volume of timber in the forest inventory ($V_{j,i|BSL}$), based on legal limits.
Measurement procedures (if any):	N/A
Any comment:	

Data / parameter:	$TH_{i,p}$
Data unit:	Years
Used in equations:	
Description:	Number of years since timber harvest in stratum i in land parcel p
Source of data:	The timber harvest schedule specifies the year (*1,2,3...*) timber harvest in each land parcel is scheduled to occur and the number of years each land parcel is in a post harvest state during the project crediting period.
Measurement procedures (if any):	
Any comment:	

Data / parameter:	$A_{i,p}$
Data unit:	Ha
Used in equations:	(5), (8), (9)
Description:	Area covered by stratum *i* over land parcel *p*
Source of data:	GPS coordinates and/or Remote Sensing data and/or legal parcel records
Measurement procedures (if any):	
Any comment:	It shall be assumed ex-ante that land parcel boundaries and strata areas shall not change through time

Data / parameter:	A_{sp}

Data unit:	Ha
Used in equations:	(2), (15)
Description:	Area of sample plot *sp*
Source of data:	Recording and archiving of size of sample plots
Measurement procedures (if any):	Standard procedures for plot delineation in forest timber inventory surveys shall be used (see references in Box 3 for example procedures)
Any comment:	*Ex-ante* the size of the plots shall be defined and recorded in the monitoring plan.

Data and parameters used in monitoring

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

Data / parameter:	*Illegal Logging PRA Results*
Data unit:	
Used in equations:	STEP 4
Description:	
Source of data:	PRA
Measurement procedures (if any):	The PRA shall evaluate whether timber harvest may be occurring in the project area and shall consist of semi-structured interviews / questionnaires. If ≥ 10% of those interviewed/surveyed believe that illegal logging may be occurring within the project boundary then the limited on-the-ground illegal logging survey shall be triggered. An additional output of the PRA shall be a depth of penetration of illegal logging pressure. A maximum distance shall be recorded for penetration into the forest from access points (such as roads, rivers, already cleared areas) for the purpose of harvesting timber.
Measurement Frequency	Every two years
QA/QC Procedures	
Any comment:	*Ex ante* estimation shall be made of illegal logging in the with-project case. If the belief is that zero illegal logging will occur within the project boundaries then this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent illegal logging.

Data/ parameter:	*Result of Limited Illegal Logging Survey*
Data unit:	
Used in equations:	STEP 4
Description:	

Source of data:	Limited on-the-ground illegal logging survey
Measurement procedures (if any):	Sampled by surveying multiple transects of known length and width across the access-buffer area to check whether new tree stumps are evident or not. The access-buffer area shall be equal in area to at least 1% of $A_{DIST\_IL,i}$
Measurement Frequency	Must to be repeated each time the PRA indicates a potential for illegal logging.
QA/QC Procedures	
Any comment:	*Ex ante* an estimation shall be made of illegal logging in the with-project case. If the belief is that zero illegal logging will occur within the project boundaries then this parameter may be set to zero if clear infrastructure, hiring and policies are in place to prevent illegal logging.

Data/ parameter:	$A_{burn,i,t}$
Data unit:	Ha
Used in equations:	(17)
Description:	Area burnt in stratum *i* at time *t*
Source of data:	GPS coordinates and/or Remote Sensing data
Measurement procedures (if any):	N/A
Monitoring Frequency:	Areas burnt shall be monitored at least every five years
QA/QC procedures:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	*Ex ante* estimations of areas burned shall be based on historic incidence of fire in the Project region

Data/ parameter:	$A_{dist,i,t}$
Data unit:	Ha
Used in equations:	(17)
Description:	Area disturbed in stratum *i* at time *t*
Source of data:	GPS coordinates and/or Remote Sensing data
Measurement procedures (if	N/A

any):	
Monitoring Frequency:	Areas disturbed shall be monitored at least every five years
QA/QC procedures:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	*Ex ante* estimations of areas disturbed shall be based on historic incidence of natural disturbance in the Project region

Data/ parameter:	$A_{DIST\_IL,i}$
Data unit:	Ha
Used in equations:	(19)
Description:	Area potentially impacted by illegal logging in stratum *i*
Source of data:	GIS delineation and ground truthing
Measurement procedures (if any):	$A_{DIST\_IL,i}$ shall be composed of a buffer from all access points (access buffer), such as roads and rivers or previously cleared areas. The width of the buffer shall be determined by the depth of degradation penetration as defined as a PRA output
Measurement Frequency	Repeated each time the PRA indicates a potential for degradation
QA/QC Procedures	
Any comment:	*Ex ante* a limited survey can be used to determine a likely depth of degradation penetration

Data / parameter:	$C_{DIST\_IL,i,t|PRJ}$
Data unit:	tCO$_2$-e
Used in equations:	20
Description:	biomass carbon of trees cut and removed through illegal logging in stratum *i* at time *t*
Monitoring interval:	Repeated each time limited sampling of $A_{DIST\_IL,}$ indicates illegal logging
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone ($A_{DIST\_IL,i}$). The diameter of all tree stumps will be measured and conservatively assumed to be the same as the DBH. Where the stump is a large buttress, several individuals of the same species nearby shall be located and a ratio of the diameter at DBH to

	the diameter of buttress at the same height above ground as the measured stumps shall be determined. This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree. The aboveground carbon stock of each harvested tree will be estimated using the allometric regression equations chosen for forest growth in the project scenario. The mean aboveground carbon stock of the harvested trees is conservatively estimated to be the total emissions and to all enter the atmosphere
QA/QC procedures:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	If species-specific equations are used and species cannot be identified from stumps then it shall be assumed that the harvested species is the species most commonly harvested. A PRA shall be used to determine the most commonly harvested species.

Data / parameter:	AP_i
Data unit:	Ha
Used in equations:	(19)
Description:	Total area of illegal logging sample plots in stratum i
Source of data:	Ground measurement
Measurement procedures (if any):	A sampling plan must be designed using multiple sample plots systematically placed across the buffer zone so that they sample at least 3% of the area of the buffer zone.
Measurement Frequency	Not more than five years
QA/QC Procedures	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	*Ex ante* estimation should be made of area of plots. This should be set to exactly 3% of the buffer zone $A_{DIST\_IL,i}$

Data / parameter:	PMP_i
Data unit:	%

Used in equations:	STEP 5 - Leakage, Box 4.
Description:	Merchantable biomass as a proportion of total aboveground tree biomass for stratum i within the project boundaries
Source of data:	Within each stratum divide the summed merchantable biomass (defined as total gross biomass of a tree 15cm DBH or larger) by the summed total of aboveground tree biomass.
Monitoring interval:	Not more than five years
Measurement procedures (if any):	
QA/QC procedures:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	*Ex-ante* a time zero measurement shall be made of this factor. The timber harvest plan sets the allowable mean extracted volume from the merchantable volume of timber in the forest inventory ($V_{j,i|BSL}$), based on legal limits.

Data / parameter:	$A_{i,}$
Data unit:	Ha
Used in equations:	(16)
Description:	Area covered by stratum i
Source of data:	GPS coordinates and/or Remote Sensing data and/or legal parcel records
Measurement procedures (if any):	
Measurement Frequency	
QA/QC Procedures	
Any comment:	In the baseline scenario strata areas shall not change through time.

	In the project scenario it shall be assumed *ex-ante* that stand boundaries and strata areas shall not change through time. *Ex post* adjustments of the project scenario strata may be needed if unexpected disturbances occur during the project crediting period, severely affecting different parts of an originally homogenous stratum. This disturbance will be delineated as a separate stratum for the purpose of monitoring the carbon stock changes.

Data / parameter:	*DBH*
Data unit:	Cm
Used in equations:	Step 4.1.2
Description:	Diameter at breast height of a tree in cm
Monitoring interval:	Not more than 5 years
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	Typically measured 1.3m aboveground. Measure all trees above some minimum *DBH* in the sample plots. The minimum *DBH* varies depending on tree species and climate; for instance, the minimum *DBH* may be as small as 2.5 cm or as high as 20 cm, but for humid tropical forests 10 cm is commonly used. Minimum DBH employed in inventories is held constant for the duration of the project.
QA/QC procedures:	Standard quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of QA/QCs already applied in national forest monitoring, or available from published handbooks, or form the *IPCC GPG LULUCF 2003*, is recommended.
Any comment:	QA/QC procedures apply not only to DBH but to all tree or non-tree vegetation dimension variables measured, as may be identified by allometric equations employed but not specifically identified here.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	11 Feb 2011	Initial version released
v1.1	10 Nov 2011	Updates (all effective on issue date): 1. In Equation 7 parameter $C_{EX,i,k|BSL}$ was clarified to be the mean carbon stock of extracted timber per unit area in stratum I, for wood product type k. 2. Step 4.1.2, was clarified that only individual trees, species and strata which were to be harvested in the baseline scenario may be modeled for on-going forest growth in the project scenario. 3. Equation 21 was modified to be clear that net greenhouse gas emissions in the project scenario are a result of the sum of emission from disturbance minus the annual carbon stock change in the aboveground biomass of trees due to forest growth. 4. Parameter $BECF_R$ was clarified to have the unit t.d.m m^{-3}.