Improved Forest Management

Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberlands

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FiniteCarbon
Connecting Forestry and Carbon Finance

CONTENTS

A. METHODOLOGY DESCRIPTION

A1. SCOPE AND DEFINITIONS

This methodology is designed to quantify GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline forest management practices. Removals are quantified for increased sequestration through retention of annual forest growth when project activities exceed the baseline.

Baseline determination is project-specific and must describe the harvesting scenario that would maximize net present value (NPV) of perpetual wood products harvests.

Project proponents must demonstrate there is no activity-shifting leakage above the *de minimus* threshold. Market leakage must be assessed and accounted for in the quantification of net project benefits.

Definitions and Acronyms

ACR	**American Carbon Registry**
ATF	**American Tree Farm**
Activity Shifting Leakage	**Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner**
Baseline	**Management scenario in the absence of project activities**
Carrying Costs	**Property taxes, mortgage interest, and insurance premiums**
Crediting period	**The period of time in which the baseline is considered to be valid and project activities are eligible to generate ERTs**
de minimus	**Threshold of 3% of the final calculation of emission reductions or removals**
ERT	**Emission Reduction Ton**
Ex-ante	**Prior to project certification**
FSC	**Forest Stewardship Council**
Forestland	**Forest land is defined as land at least 10 percent stocked by trees of any size, or formerly having such tree cover, and not currently developed for non-forest uses**
IPCC	**Intergovernmental Panel on Climate Change**
Minimum Project Period	**Time Period which project activities must be maintained and monitored through third-party verication**

Native Species	**Trees listed as native to a particular region by the Native Plant Society, SAF Forestry Handbook, or State adopted list**
Net Present Value (NPV)	**The difference between the present value of cash inflows and the present value of cash outflows over the life of the project**
SFI	**Sustainable Forestry Initiative**
Timberlands	**Forestlands managed for commercial timber production**
Tree	**A perennial woody plant with a diameter at breast height (1.37 m) >5 cm and a height of greater than 1.3 m**
VCS	**Voluntary Carbon Standard**

A2. APPLICABILITY CONDITIONS

- **The project must demonstrate an increase in on-site stocking levels above the baseline condition for the entire crediting period**
- **Methodology is applicable only on privately owned forestland within the USA**
- **The methodology applies only to timber rights owners who own or control timber rights on more than 1,000 acres. This is considered a conservative estimate of ownership profiles managing timberlands under economical optimal criteria under this methodology**
- **Use of non-native species is prohibited where adequately stocked native stands were converted for forestry or other land uses after 1997**
- **Draining or flooding of wetlands is prohibited**
- **There may be no leakage above de minimus levels through activity shifting to other lands owned, or under management control, by the timber rights owner outside the scope of the carbon project**

A3. POOLS AND SOURCES

Carbon pools	Included / Optional / Excluded	Justification / Explanation of choice
Above-ground biomass carbon	Included	Major carbon pool subjected to the project activity
Below-ground biomass carbon	Included	Major carbon pool subjected to the project activity

Harvested wood products	Included	Major carbon pool subjected to the project activity
Dead wood	Optional	Project proponents may elect to include the pool (where included, the pool must be estimated in both the baseline and with project cases)
Litter / Forest Floor	Excluded	Changes in the litter pool are considered de minimus as a result of project implementation
Soil organic carbon	Excluded	Changes in the soil organic carbon pool are considered de minimus as a result of project implementation

Emission Source	Gas	Included / excluded	Justification / Explanation of choice
Burning of biomass	CO_2	Excluded	However, carbon stock decreases due to burning are accounted as a carbon stock change
	CH_4	Included	Non-CO2 gas emitted from biomass burning
	N_2O	Excluded	Potential emissions are negligibly small

Leakage Source		Included / Optional / Excluded	Justification / Explanation of choice
Activity Shifting	Timber Harvesting	Excluded	Project proponent must demonstrate no activity-shifting leakage beyond the de minimus threshold will occur as a result of project implementation
	Crops	Excluded	Forestlands eligible for this methodology do not produce agricultural crops that could cause activity shifting
	Livestock	Excluded	Forestlands eligible for this methodology do not contain livestock that could cause activity

			shifting
Market Effects	**Timber**	**Included**	**Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.**

A4. METHODOLOGY SUMMARY

The following steps are required to quantify GHG removals and emission reductions from project activities:

1) **Describe project activity – the project proponent shall clearly describe the project activity**
2) **Screen project for eligibility –project must be screened to meet eligibility requirements**
3) **Collect stratified forest inventory data – forestland information from the project area must be gathered to establish stand structure and project stocking levels**
4) **Determine the baseline – the harvest schedule that maximizes net present value of perpetual wood products harvests must be determined**
5) **Projection of baseline and project activities – existing stocking levels must be projected over the entire crediting period for the baseline and project scenario.**
6) **Conduct non-permanence risk and leakage assessments – assessments are made to determine non-permanence mitigation strategies and to apply appropriate leakage deductions**
7) **Quantify ERTs – A GHG plan must be developed to document project conditions and quantify net project benefits. The plan must include ex-ante calculations for the entire project period**
8) **Undergo third-party verification – An independent GHG program approved verifier must conduct verification services in accordance with ISO 14064 (c) standards**
9) **Receive GHG program registration – ERTs are registered with GHG Program**
10) **Maintain project monitoring – On-going project monitoring is required and must follow the approved monitoring plan requirements**

B. ELIGIBILITY, BOUNDARIES, ADDITIONALITY AND PERMANENCE

B1. PROJECT ELIGIBILITY

This methodology applies to privately owned timberlands able to document clear land title or timber rights and offsets title and meets all other requirements of the GHG Program.

Proponents must use the U.S. Forest Service Forest Inventory & Analysis Program definition to demonstrate the project area meets the definition of Forestland conditions. Forestland is defined as land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for non-forest uses.

B2. PROJECT GEOGRAPHIC BOUNDARY

The project proponent must provide a detailed description of the geographic boundary of project activities. Note that the project activity may contain more than one discrete area of land, that each area must have a unique geographical identification, and that each area must meet the eligibility requirements. Information to delineate the project boundary must include:

- **Project area delineated on USGS topographic map**
- **General location map**
- **Property parcel map**

Aggregation of forest properties with multiple landowners is permitted under the methodology with aggregated areas treated as a single project area.

B3. PROJECT TEMPORAL BOUNDARY

Projects with a start date of November 1, 1997 or later are eligible[1]. The start date is when the project proponent began to apply the land management regime to increase carbon stocks and/or reduce emissions.

In accordance with the American Carbon Registry's Forest Carbon Project Standard v2.0, all projects will have a crediting period of twenty (20) years. The minimum project period is forty (40) years. The minimum period begins on the start date (not the first or last year of crediting).

If the project start date is more than one year before submission of the GHG plan, the project proponent shall provide evidence that GHG mitigation was a project objective from inception.

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[1] **American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.0.* Winrock International, Little Rock, Arkansas.**

B4. ADDITIONALITY

Projects must apply a three-prong additionality test[2] to demonstrate that they exceed currently effective and enforced laws and regulations; exceed common practice in the forestry sector and geographic region; and face a financial implementation barrier.

The regulatory surplus test involves existing laws, regulations, statutes, legal rulings, or other regulatory frameworks that directly or indirectly affect GHG emissions associated with a project action or its baseline candidates, and which require technical, performance, or management actions. Voluntary guidelines are not considered in the regulatory surplus test.

The common practice test requires project proponents to evaluate the predominant forest industry technologies and practices in the project's geographic region. The Project Proponent shall demonstrate that the proposed project activity exceeds the common practice of similar landowners managing similar forests in the region. Projects initially deemed to go beyond common practice are considered to meet the requirement for the duration of their crediting period. If common practice adoption rates of a particular practice change during the crediting period, this may make the project non-additional and thus ineligible for renewal, but does not affect its additionality during the current crediting period.

An implementation barrier represents any factor or consideration that would prevent the adoption of the practice/activity proposed by the Project Proponent. Financial barriers can include high costs, limited access to capital, or an internal rate of return in the absence of carbon revenues that is lower than the Proponent's established minimum acceptable rate. Financial barriers can also include high risks such as unproven technologies or business models, poor credit rating of project partners, and project failure risk. When applying the financial implementation barrier test, project proponents should include solid quantitative evidence such as NPV and IRR calculations.

B5. PERMANENCE

Project proponents commit to a minimum project period of 40 years. Projects must have effective risk mitigation measures in place to compensate fully for any loss of sequestered carbon whether this occurs through an unforeseen natural disturbance or through a project proponent or landowner's choice to discontinue forest carbon project activities. Such mitigation measures can include contributions to the buffer pool, insurance, or similar measures. Effective and complete mitigation of losses provides permanence.

To assess the risk of reversal, project proponents must conduct a risk assessment addressing both general and project-specific risk factors. General risk factors include risks such as financial failure, technical failure, management failure, rising land opportunity costs, regulatory and social instability, and natural disturbances. Project-specific risk factors vary by project type can include land tenure, technical capability and experience of the project developer, fire potential, risks of insect/disease, flooding and extreme weather events, illegal logging potential, and others.

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[2] **American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.0.* Winrock International, Little Rock, Arkansas.**

Project proponents must conduct their risk assessment using the *ACR Tool for Risk Analysis and Buffer Determination or* the *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination.* The output of either tool is an overall risk category, expressed as a fraction, for the project translating into the buffer deduction that must be applied in the calculation of net ERTs (section G1). This deduction must be applied unless the project proponent uses an ACR approved insurance product or other program-approved mitigation mechanism.

C. BASELINE

C1. IDENTIFICATION OF BASELINE

The IFM baseline is the legally-permissible harvest scenario that would maximize net present value (NPV) of *perpetual* wood products harvests. The baseline management scenario shall be based on silvicutural prescriptions recommended by published state or federal agencies to perpetuate existing on-site timber producing species while fully utilizing available growing space. The resulting harvest schedule is used to establish baseline stocking levels through the life of the project. Required inputs for the NPV calculation include the results of a recent timber inventory of the project lands, prices for wood products of grades that the project would produce, costs of logging, reforestation and related costs, silvicultural treatment costs, and carrying costs. Project proponents shall include roading and harvesting costs as appropriate to the terrain and unit size. Project proponents must model growth of forest stands through the crediting period. Project proponents should use an optimization program that calculates the maximum net present value for the harvesting schedule. The discount rate for modeling shall be 6% per year, in real (without inflation) terms. Wood products must be accounted.

Consideration shall be given to a reasonable range of feasible baseline assumptions for the baseline determination and the selected scenario should be plausible over a range of assumptions for the duration of the baseline application. The Baseline scenarios shall cover the same period of time as the project.

The ISO 14064-2 principle of conservativeness must be applied for the determination of the baseline scenario. In particular, the conservativeness of the baseline is established with reference to the choice of assumptions, parameters, data sources and key factors so that project emission reductions and removals are more likely to be under-estimated rather than over-estimated, and that reliable results are maintained over a range of probable assumptions. However, using the conservativeness principle does not always imply the use of the "most" conservative choice of assumptions or methodologies[3].

C 1.1 Confidentiality of Proprietary Information

While it remains in the interest of the general public for project proponents to be as transparent as possible regarding GHG reduction projects, the project proponent may choose at their own option to designate any information regarded as confidential due to proprietary considerations. If the project proponent chooses to identify information related to financial performance as confidential, the project proponent must submit the confidential baseline and project documentation in a separate file marked "Confidential" to the GHG Program and this information shall not be made available to the public. The GHG Program authorities and verification body shall utilize this information only to the extent required to register the ERTs. If the project proponent chooses to keep financial information confidential, a publically available project summary must be prepared and provided to the GHG Program.

[3] **ISO 14064-2:2006(E)**

C2. BASELINE STRATIFICATION

If the project activity area is not homogeneous, stratification must be carried out to improve the precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy and precision of the estimates of net GHG emissions reductions or GHG removal by sinks. For estimation of baseline carbon stocks, strata must be defined on the basis of parameters that are key variables for estimating changes in managed forest carbon stocks, for example:

a. Management regime
b. Species or cover types
c. Size and density class
d. Site class

C3. BASELINE NET REDUCTIONS AND REMOVALS / EMISSIONS FOR FIXED BASELINES

Baseline carbon stock change must be calculated for the entire crediting period. The baseline stocking level used for the stock change calculation is derived from the baseline management scenario developed in section C1. This methodology requires annual baseline stocking levels to be projected for the entire crediting period and a stabilized long-term average baseline stocking level be calculated for the crediting period.

Annual projected stocking levels are used for the baseline stock change calculation until the projected stocking level reaches the stabilized long-term average. Thereafter, the long-term average stocking level is used in the baseline stock change calculation for the entire project period. The project proponent shall provide a graph of the projected baseline stocking levels and the long-term average baseline stocking level for the entire project period (see figure 1. Sample Baseline Stocking Graph).

The following equations are used to construct the baseline stocking levels using models described in section 3.1 and wood products calculations described in section 3.2:

<u>Annual projected baseline stocking</u>

$$C_{BSL,PROJ} = C_{BSL,AG/BG} + C_{BSL,DW} + C_{BSL,WP} \quad (1)$$

where:

$C_{BSL,PROJ}$	**Sum of all carbon stocks in the baseline scenario projection for year t; t C**
$C_{BSL,AG/BG}$	**Carbon stock in baseline above-ground and below-ground portions of trees for all strata for year t; t C**
$C_{BSL,DW}$	**Carbon stock in baseline dead wood pools for all strata for year t; t C**
$C_{BSL,WP}$	**Carbon stock in baseline wood products pool for year t; t C**

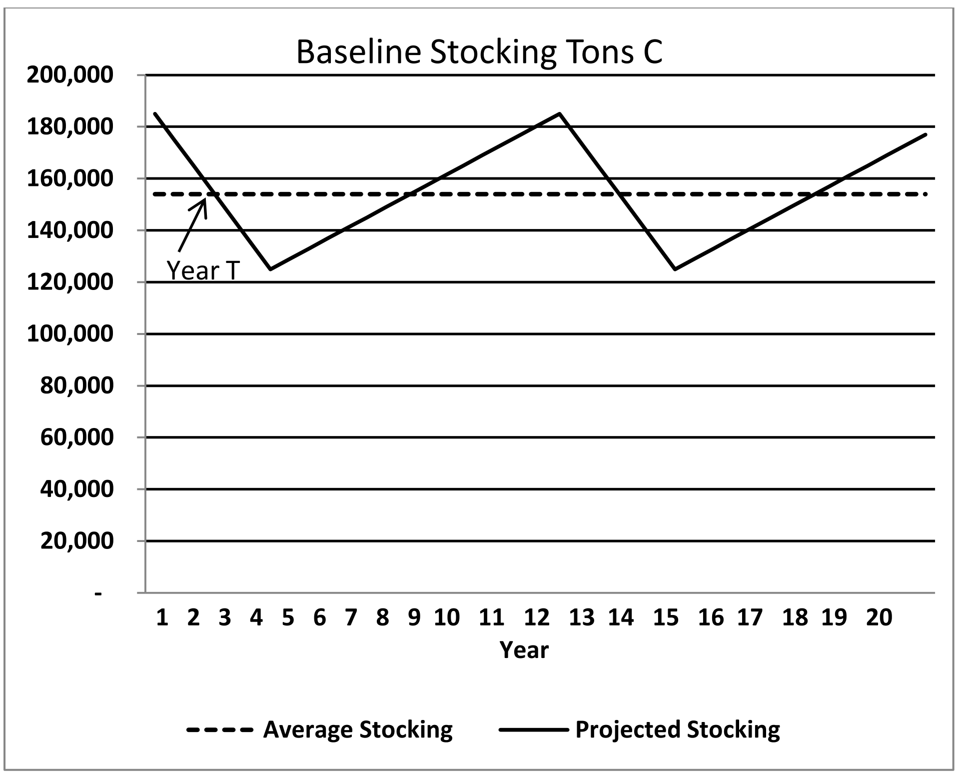
<u>Stabilized long-term average baseline stocking</u>

$$C_{BSL,AVE} = (\sum C_{BSL,AG/BG} + \sum C_{BSL,DW} + \sum C_{BSL,WP})/20 \quad \textbf{(2)}$$

where:

$C_{BSL,AVE}$	**Average carbon stocks in the baseline scenario for year t; t C**
$C_{BSL,AG/BG}$	**Summed annual carbon stock in baseline above-ground and below-ground portions of trees for all strata (summed over the 20 year modeled baseline); t C**
$C_{BSL,DW}$	**Summed annual carbon stock in baseline dead wood pools for all strata (summed over the 20 year modeled baseline); t C**
$C_{BSL,WP}$	**Summed annual carbon stock in baseline wood products pool (summed over the 20 year modeled baseline); t C**

Figure 1. Sample Baseline Graph



If years elapsed since the start of the IFM project activity is ≤ T (T=year projected stocking reaches the long-term baseline average) use projected stock change equation (4), otherwise for long-term average stock change use Δ bsl = 0 **(3)**

Projected stock change equation:

$$\Delta C_{BSL} = \Delta C_{BSL,P} - GHG_{BSL,E} \quad (4)$$

where:

ΔC_{BSL}	**Baseline greenhouse gas removals by sinks; t CO2-e**
$\Delta C_{BSL,P}$	**Stock changes in above and below -ground biomass, dead wood, and wood products in the baseline scenario; t CO2-e**
$GHG_{BSL,E}$	**Increase in GHG emissions as a result of the implementation of the baseline scenario within the project boundary; t CO2-e**

$$\Delta C_{BSL,P} = \Delta C_{BSL,TREE} + \Delta C_{BSL,DW} + C_{BSL,WP} \quad (5)$$

where:

$\Delta C_{BSL,P}$	**Stock changes in tree biomass, dead wood, and wood products in the baseline scenario; t CO2-e**
$\Delta C_{BSL,TREE}$	**Carbon stock change in biomass of trees in the baseline scenario; t CO2-e**
$\Delta C_{BSL,DW}$	**Carbon stock change in dead wood pools in the baseline scenario; t CO2-e**
$C_{BSL,WP}$	**Carbon stock in wood products in the baseline scenario; t CO2e**

$$\Delta C_{BSL,TREE} = (C_{BSL,AG/BG,t} - C_{BSL,AG/BG,t-1}) * 44/12 \quad (6)$$

where:

$\Delta C_{BSL,TREE}$	**Carbon stock change in biomass of trees in the baseline scenario; t CO2-e**
$C_{BSL,AG/BG}$	**Sum of carbon stock in above-ground and below-ground biomass for all strata in the baseline for year t; t C**
t	**Years elapsed since start of project**

$$\Delta C_{BSL,DW} = (C_{BSL,SD/LD,t} - C_{BSL,SD/LD,t-1}) * 44/12 \quad (7)$$

where:

$\Delta C_{BSL,DW}$	**Carbon stock change in dead wood pools for all strata in the baseline; t CO2-e**
$C_{BSL,SD/LD}$	**Sum of carbon stock in standing dead and lying dead pools for all strata in the baseline for year t; t C**
t	**Years elapsed since start of project**

$$C_{BSL,WP} = (\sum C_{BSL,AWP}/20) * 44/12 \quad (8)$$

where:

$C_{BSL,WP}$	Carbon stock in wood products in the baseline for year t; t CO2-e
$C_{BSL,AWP}$	Summed annual carbon stored in wood products during crediting period; t C

$$GHG_{BSL,E} = BS_{BSL} * ER_{CH4} * \frac{16}{12} * GWP_{CH4} \quad (9)$$

where:

$GHG_{BSL,E}$	Increase in GHG emissions as a result of the implementation of the baseline scenario within the project boundary for year t; t CO2-e
BS_{BSL}	Carbon stock in logging slash subject to burning as part of forest management for year t; t C
ER_{CH4}	Emission ratio for CH4 (if local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value, 0.01211); kg C as CH4 (kg C burned)-1
GWP_{CH4}	Global warming potential for CH4 (IPCC default: 21 for the first commitment period of the Kyoto Protocol); t CO2-e (t CH4)-1

Carbon stock calculation for logging slash burned (BS_{BSL}) shall use the method described in Section 3.1.1 for bark, tops and branches, and Section 3.1.2 if dead wood is selected.

3.1 Stocking Level Projections in the Baseline

$C_{BSL,AG/BG}$ and $C_{BSL,DW}$ must be estimated using models of forest management across the baseline period. Modeling must be completed with a peer reviewed forestry model that has been calibrated for use in the project region. The GHG Plan must detail what model is being used and what variants have been selected. All model inputs and outputs must be available for inspection by the verifier. The baseline must be modeled over a 20-year period.

Examples of appropriate models include:

· FVS: Forest Vegetation Simulator
· SPS: Stand Projection System
· FIBER: USDA, Forest Service
· FPS: Forest Projection System by Forest Biometrics
· CRYPTOS and CACTOS: California Conifer Timber Output Simulator

Models must be:

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

The output of the models must include projected volume in live aboveground tree biomass, or appropriate unit, by strata in the baseline scenario through the duration of the project. Where model projections produce changes in volume over five year periods, the numbers shall be annualized to give a stock change number for each year.

If the output for the tree is the volume then this must be converted to biomass and carbon using equations in Section 3.1.1. If processing of alternative data on dead wood is necessary, equations in section 3.1.2 may be used.

3.1.1 Tree Carbon Stock Calculation

The mean carbon stock in aboveground biomass per unit area is estimated based on field measurements in sample plots. A sampling plan must be developed that describes the inventory process including sample size, determination of plot numbers, plot layout and locations, and data collected. Plot data used for biomass calculations may not be older than 10 years. Plots may be permanent or temporary and they may have a defined boundary or use variable radius sampling methods. Biomass for each tree is calculated from its merchantable volume using a component ratio method. The project proponent must use the same set of equations for ex-ante and ex-post baseline and project projections through the entire project period.

The following steps are used to calculate tree biomass:

Step 1: Determine the biomass of the merchantable component of each tree based on appropriate volume equations published by USDA Forest Service (if locally derived equations are not available use regional or national equations as appropriate) and oven-dry tree specific gravity for each species

Step 2: Determine the biomass of bark, tops and branches, and below-ground biomass as a proportion of the bole biomass based on component proportions from Jenkins and others (2003)[4]

Step 3: Using the sum of the biomass for individual trees, determine the per plot estimate of total tree biomass for each plot

Step 4: Determine the tree biomass estimate for each stratum by calculating the mean biomass estimate from plot level biomass derived in step 3

Step 5: Determine total project carbon by summing the biomass of each stratum for the project area and converting biomass to dry metric tons of Carbon

$$C_{AG/BG} = \text{total project area biomass (kg)} * .5 * .001 \qquad (10)$$

where:

$C_{AG/BG}$	Carbon stock in above-ground and below-ground biomass of tree; t C for both baseline and project projection

3.1.2 Dead Wood Calculation (if selected)

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[4] Jenkins, J.; Chojnacky, D.C.; Heath, L.S.; Birdsey, R.A. 2003. National Scale Biomass Estimators for United States Tree Species. Forest Science. 49(1): 12-35

Dead wood included in the methodology comprises two components only – standing dead wood and lying dead *wood* (that is, below-ground dead wood is conservatively neglected). Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components.

3.1.2.1 Standing Dead Wood

Step 1: Standing dead trees shall be measured using the same criteria and monitoring frequency used for measuring live trees. The decomposed portion that corresponds to the original above-ground biomass is discounted.

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

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

Step 3: Biomass must be estimated using the component ratio method used for live trees in the decomposition class. When the bole is in decomposition classes 2, 3 or 4, the biomass estimate must be limited to the main stem of the tree. If the top of the standing dead tree is missing, then the top diameter may be assumed to be zero. Tops may be measured if reachable or the broken top is identifiable on the ground.

Step 4: The biomass of dead wood is determined by using the following dead wood density classes deductions: Class 1 – same as live tree biomass; Class 2 – 95% of live tree biomass; Class 3 – 90% of live tree biomass; Class 4 – 80% of live tree biomass.

Step 5: Determine total project standing dead carbon by summing the biomass of each stratum for the project area and converting biomass to dry metric tons of Carbon

$$C_{SD} = \text{total project area biomass (kg)} * .5 * .001 \quad (11)$$

where:

C_{SD}	**Carbon stock in standing dead biomass of tree; t C for both baseline and project projection**

3.1.2.2 Lying Dead Wood

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

Step 1: Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996)[56]. Two 50-meter lines (164 ft) are established bisecting each plot and the diameters of the lying dead wood (≥ 10 cm diameter [≥ 3.9 inches]) intersecting the lines are measured.

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

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

Step 3: The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[7] as modified by Van Wagner (1968)[8] separately for each density class.

$$V_{LDW} = \pi^2(\sum D^2)/(8 * L) \quad \textbf{(12)}$$

where:

V_{ldw}	**Volume of lying dead wood per unit area;** m^3
D	**Diameter of each piece along the transect; cm**
L	**Length of transect; m**

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

$$B_{LDW} = A * V_{LDW} * D_{WD} \quad \textbf{(13)}$$

where:

B_{LDW}	**Biomass of lying dead wood per unit area**
A	**Area**
D_{WD}	**Basic wood density of dead wood in the density class – sound (1), intermediate (2), and rotten (3); t d.m. m-3**

Step 5: Determine total project lying dead carbon by summing the biomass of each stratum for the project area and converting biomass to dry metric tons of Carbon

C_{LD} **= total project area biomass (kg) * .5 * .001** **(14)**

where:

C_{LD}	**Carbon stock in standing dead biomass of tree; t C for both baseline and project projection**

3.2 Wood Products Calculation

Wood products shall be calculated using the US DOE 1605(b) method. The following steps must be followed to determine the amount of carbon in harvested wood:

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[6] A variant on the line intersect method is described by Waddell, K.L. 2002. Sampling coarse wood debris for multiple attributes in extensive resource inventories. Ecological Indicators 1: 139-153. This method may be used in place of Steps 1 to 3.

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

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

Step 1: Calculate the annual biomass of the total volume extracted from within the project boundary with extracted timber differentiated into sawnwood and pulpwood classes.

Step 2: Calculate the proportion of extracted timber that remains sequestered after 100 years. Instead of tracking annual emissions through retirement, burning and decomposition, the methodology calculates the proportion of wood products that have not been emitted to the atmosphere 100 years after harvest and assumes that this proportion is permanently sequestered. The method uses Table 1.6 from the Forestry Appendix of the Technical Guidelines of the US Department of Energy's Voluntary Reporting of Greenhouse Gases Program (known as Section 1605b)[9]. Users will determine the region the project is located in (using Figure 1.1 of the same document) and whether the timber is softwood or hardwood. The proportions defined as "In Use" and "Landfill" 100 years after production will be used.

C4. MONITORING REQUIREMENTS FOR BASELINE RENEWAL

A project's crediting period is the finite length of time for which the baseline scenario is valid and during which a project can generate offsets against its baseline.

A Project Proponent may apply to renew the crediting period by[10]:

- **Re-submitting the GHG Project Plan in compliance with then-current GHG Program standards and criteria**
- **Re-evaluating of the project baseline**
- **Demonstrating additionality against then-current regulations, common practice and implementation barriers**
- **Using GHG Program-approved baseline methods, emission factors, tools and methodologies in effect at the time of crediting period renewal**
- **Undergoing verification by an approved verifier**

C5. ESTIMATION OF BASELINE UNCERTAINTY

It is assumed that the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), or estimates based of sound statistical sampling. Uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools shall always be quantified. Indisputably conservative estimates can also be used instead of uncertainties, provided that they are based on verifiable literature sources. In this case the uncertainty is assumed to be zero. However, this module provides a procedure to combine uncertainty information and conservative estimates resulting in an overall project scenario uncertainty.

It is important that the process of project planning consider uncertainty. Procedures including stratification and the allocation of sufficient measurement plots can help ensure low uncertainty. It is

[9] **http://www.pi.energy.gov/enhancingGHGregistry/documents/PartIForestryAppendix.pdf**
[10] **American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.0.* Winrock International, Little Rock, Arkansas.**

good practice to consider uncertainty at an early stage to identify the data sources with the highest risk to allow the opportunity to conduct further work to diminish uncertainty. Estimation of uncertainty for pools and emissions sources for each measurement pool requires calculation of both the mean and the 90% confidence interval. In all cases uncertainty should be expressed as the 90% confidence interval as a percentage of the mean.

The uncertainty in the baseline scenario should be defined as the square root of the summed errors in each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products use the confidence interval of the stocks of extracted timber. The 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.

therefore, **(15)**

$$UNCbsl = \sqrt{[(\sqrt{\sum (E_{ag/bg,i}{}^2)}) * \bar{x}_{ag/bg} / \bar{x}_z]^2 + [(\sqrt{\sum (E_{dw,i}{}^2)}) * \bar{x}_{op} / \bar{x}_z]^2 + [(\sqrt{\sum (E_{wp,i}{}^2)}) * \bar{x}_{wp} / \bar{x}_z]^2}$$

where:

UNC_{bsl}	**Uncertainty in the baseline scenario**
$E_{ag/bg}$	**90% confidence interval of the above-ground and below-ground pool expressed as a percentage of the mean**
E_{dw}	**90% confidence interval of the dead wood pools expressed as a percentage of the mean**
E_{wp}	**90% confidence interval or the wood products pool expressed as a percentage of the mean**
$\bar{x}$	**Sample mean of given pool**
i	**Stratum**
z	**Largest measured pool**

D. WITH-PROJECT SCENARIO

D1. WITH-PROJECT STRATIFICATION

If the project activity area is not homogeneous, stratification must be carried out to improve the precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy and precision of the estimates of net GHG emissions reductions or GHG removal by sinks. For estimation of baseline carbon stocks strata must be defined on the basis of parameters that are key variables in any method used to estimate changes in managed forest carbon stocks, for example:

a. Management regime
b. Species or cover types
c. Size and density class
d. Site class

Project participants must present in the GHG Plan an ex-ante stratification of the project area or justify the lack of it. The number and boundaries of the strata defined ex-ante may change during the crediting period (ex-post).

The *ex-post* stratification shall be updated due to the following reasons:

- **Unexpected disturbances occurring during the crediting period (e.g. due to fire, pests or disease outbreaks), affecting differently various parts of an originally homogeneous stratum**
- **Forest management activities (e.g. cleaning, planting, thinning, harvesting, coppicing, re-planting) may be implemented in a way that affects the existing stratification**
- **Established strata may be merged if reason for their establishment has disappeared**

D2. MONITORING PROJECT IMPLEMENTATION

Information shall be provided, and recorded in the GHG Plan, 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 can be achieved by field mapping (e.g. using GPS), or by using georeferenced spatial data (e.g. maps, GIS datasets, orthorectified 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 form the *IPCC GPG LULUCF 2003*, is recommended**
- **The forest management plan, together with a record of the plan as actually implemented during the project shall be available for validation and verification, as appropriate**

D3. MONITORING OF CARBON STOCKS IN SELECTED POOLS

Information shall be provided, and recorded in the GHG Plan, to establish that 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 form the *IPCC GPG LULUCF 2003*, is recommended. The forest management plan, together with a record of the plan as actually implemented during the project shall be available for verification, as appropriate.

The 90% statistical confidence interval of sampling can be no more than +/- 10% of the mean estimated amount of the carbon stock. If the project proponent cannot meet the targeted +/- 10% of the mean at 90% confidence, then the reportable amount shall be the lower bound of the 90% confidence interval.

At a minimum the following data parameters must be monitored:

- **Project area**
- **Sample plot area**
- **DBH**
- **Tree height**
- **Wood products volume**
- **Dead wood pool, if selected**

D4. MONITORING OF EMISSION SOURCES

Emissions from biomass burning must be monitored during project activities. When applying all relevant equations provided in this methodology for the *ex-ante* calculation of net anthropogenic GHG removals by sinks, project participants shall provide transparent estimations for the parameters that are monitored during the crediting period. These estimates shall be based on measured or existing published data where possible. In addition project proponents must apply the principle of conservativeness. 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.

D5. ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS

This section describes the steps required to calculate ΔC_P (Sum of the carbon stock changes and greenhouse gas emissions under the project scenario up to time t, in t CO_2e).

$$\Delta C_P = \Delta C_{ACT} - GHG_{P,E} \quad (16)$$

where:

ΔC_P	**Project scenario net greenhouse gas removals by sinks; t CO2-e**
ΔC_{ACT}	**Sum of stock change in above and below -ground biomass, dead wood pools, and wood products in the project scenario; t CO2-e**
$GHG_{P,E}$	**Increase in GHG emissions as a result of the implementation of the project scenario within the project boundary for year t; t CO2-e**

$$\Delta C_{ACT} = (C_{PP,t} - C_{PP,t-1}) * 44/12 \quad (17)$$

where:

C_{PP}	**Carbon stock in all selected pools in the project scenario for year t; t C**
t	**Years elapsed since start of project**

$$C_{PP} = C_{AG/BG} + C_{DW} + C_{WP} \quad (18)$$

where:

$C_{AG/BG}$	**Sum of carbon stock in above-ground and below-ground portions of trees for all strata for year t**
C_{DW}	**Sum of carbon stock in dead wood pools for all strata for year t; t C**
C_{WP}	**Sum of carbon stock in wood products for all strata for year t; t C**

$$GHG_{P,E} = BS_P * ER_{CH4} * \frac{16}{12} * GWP_{CH4} \quad (19)$$

where:

$GHG_{P,E}$	**Increase in GHG emissions as a result of the implementation of the project scenario within the project boundary for year t; t CO2-e**
BS_P	**Carbon stock in logging slash subject to burning as part of forest management for year t; t C**
ER_{CH4}	**Emission ratio for CH4 (if local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value, 0.01211); kg C as CH4 (kg C burned)-1**
GWP_{CH4}	**Global warming potential for CH4 (IPCC default: 21 for the first commitment period of the Kyoto Protocol); t CO2-e (t CH4)-1**

Carbon stock calculation for logging slash burned (BS_P) shall use the method described in Section 3.1.1 for bark, tops and branches, and Section 3.1.2 if dead wood is selected.

5.1 Tree Biomass, Dead Wood Carbon Calculation, Wood Products

The project proponent must use the same set of equations used in Section C3.1.1, C3.1.2, and C3.2 to calculate carbon stocks in the project scenario.

D6. MONITORING OF ACTIVITY SHIFTING LEAKAGE

As per the applicability conditions, there may be no leakage beyond *de minimus* levels through activity shifting to other lands owned, or under management control, by the timber rights owner outside the scope of the carbon project. If leakage from activity shifting is discovered, project proponents must estimate the associated leakage amount and deduct ERTs to fully compensate for emissions resulting from activity shifting leakage.

If the project decreases wood product production by >5% relative to the baseline then the project developer and all associated land owners must demonstrate that there is no leakage within their operations – i.e., on other lands they manage/operate outside the bounds of the ACR carbon project. Such a demonstration may include:

- **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 and no deviation from management plans**
- **Entity-wide management certification that requires sustainable practices (programs can include FSC, SFI, or ATF). Management certification shall be required on all entity owned lands with active timber management programs.**

D7. ESTIMATION OF EMISSIONS DUE TO MARKET LEAKAGE

If the project is able to demonstrate that any decrease in total wood products produced by the project relative to the baseline is less than 5% over the life of the project period then:

$$LK = 0 \quad (20)$$

Where project activities decrease total wood products produced by the project relative to the baseline by more than 5% but less than 25% over the life of the project, market leakage deduction is 10%. (according to VCS AFOLU Guidance Document[11])

$$LK = 0.1 \quad (21)$$

Where project activities decrease total wood products produced by the project relative to the baseline by 25% or more over the life of the project, the amount of leakage is determined by where harvesting would likely be displaced to. If in the forests to which displacement would occur a lower proportion of forest biomass in commercial species is in merchantable material than in 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

[11] **http://www.v-c-s.org/docs/AFOLU%20Guidance%20Document.pdf**

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.

Each project thus shall calculate within each stratum the proportion of total biomass in commercial species that is merchantable (*PMP*). This shall then be compared to mean proportion of total biomass that is merchantable for each forest type (*PML*).

Merchantable biomass is defined as: "Total gross biomass (including bark) of a tree 5 inches (12.7 cm) DBH or larger from a 1 foot (30.48 cm) stump to a minimum 4 inches top DOB of the central stem" *Definition from US Forest Service FIA Program*

The following deduction factors (*LK*) shall be used:

Where:

PML is equal (± 15%) to PMP:	***LK=***	**0.4**	**(22)**
PML is > 15% less than PMP:	***LK=***	**0.7**	**(23)**
PML is > 15% greater than PMP:	***LK=***	**0.2**	**(24)**

where:

PML_{FT}	**Mean merchantable biomass as a proportion of total aboveground tree biomass for each forest type; % (see default values below)**
PMP	**Merchantable biomass as a proportion of total aboveground tree biomass for each stratum within the project boundaries; %**
LK	**Leakage factor for market-effects calculation**

Default values for PML:

Forest Type Group	Merchantable Biomass as Proportion of Total Biomass
White Red Jack Pine	77%
Spruce Fir	58%
Longleaf Slash Pine	73%
Loblolly Shortleaf Pine	73%
Ponderosa Pine	64%
Oak Pine	71%
Oak Hickory	73%
Oak Gum Cypress	72%
Elm Ash Cottonwood	73%
Maple Beech Birch	76%
Aspen Birch	61%
Douglas Fir	70%
Western White Pine	62%
Fir-Spruce/Mountain Hemlock	62%
Lodgepole Pine	64%
Hemlock/Sitka Spruce	67%
Western Larch	66%
Redwood	43%
Western Oak	69%

D8. ESTIMATION OF WITH-PROJECT UNCERTAINTY

It is assumed that the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), or estimates based of sound statistical sampling. Uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools shall always be quantified. Indisputably conservative estimates can also be used instead of uncertainties, provided that they are based on verifiable literature sources. In this case the uncertainty is assumed to be zero. However,

this module provides a procedure to combine uncertainty information and conservative estimates resulting in an overall project scenario uncertainty.

As with baseline uncertainty, it is important that the process of project planning consider uncertainty. Procedures including stratification and the allocation of sufficient measurement plots can help ensure low uncertainty. It is good practice to consider uncertainty at an early stage to identify the data sources with the highest risk to allow the opportunity to conduct further work to diminish uncertainty. Estimation of uncertainty for pools and emissions sources for each measurement pool requires calculation of both the mean and the 90% confidence interval. In all cases uncertainty should be expressed as the 90% confidence interval as a percentage of the mean.

The uncertainty in the project scenario should be defined as the square root of the summed errors in each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products use the confidence interval of the stocks of extracted timber. The errors in each pool can be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

Therefore, **(25)**

$$UNCp = \sqrt{[(\sqrt{\sum (E_{ag/bg,i}{}^2)})*\bar{x}_{ag/bg}/\bar{x}_z]^2 + [(\sqrt{\sum (E_{dw,i}{}^2)})*\bar{x}_{op}/\bar{x}_z]^2 + [(\sqrt{\sum (E_{wp,i}{}^2)})*\bar{x}_{wp}/\bar{x}_z]^2}$$

Where

UNC_P	**Uncertainty in the project scenario**
$E_{ag/bg}$	**90% confidence interval of the above and below ground pool expressed as a percentage of the mean**
E_{dw}	**90% confidence interval of the dead wood pools expressed as a percentage of the mean**
E_{wp}	**90% confidence interval or the wood products pool expressed as a percentage of the mean**
$\bar{x}$	**Sample mean of given pool**
i	**Stratum**
z	**Largest measured pool**

E. EX-ANTE ESTIMATION

E1. EX-ANTE ESTIMATION METHODS

The project proponent must make an ex ante calculation of all net anthropogenic GHG removals and emissions for all included sinks and sources for the entire project period. Project participants shall provide estimates of the values of those parameters that are not available before the start of monitoring activities. Project participants must retain a conservative approach in making these estimates.

Uncertainties arising from, for example, biomass expansion factors or wood density, could result in unreliable estimates of both baseline net GHG removals by sinks and the actual net GHG removals by sinks especially when global default values are used. Project proponents shall identify key parameters that would significantly influence the accuracy of estimates. Local values that are specific to the project circumstances must then be obtained for these key parameters, whenever possible. These values must be based on:

- **Data from well-referenced peer-reviewed literature or other well-established published sources; or**
- **National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; or**
- **In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value must be briefly noted in the GHG plan. For any data provided by experts, the GHG Plan shall also record the expert's name, affiliation, and principal qualification as an expert– plus inclusion of a 1-page summary CV for each expert consulted, included in an annex**

When choosing key parameters based on information that is not specific to the project circumstances, such as in use of default data, project proponents must select values that will lead to an accurate estimation of net GHG removals by sinks, taking into account uncertainties. If uncertainty is significant, project participants must choose data such that it tends to under-estimate, rather than over-estimate, net GHG removals by sinks[12].

[12] **AR-ACM0001**

F. QA/QC AND UNCERTAINTY

F1. METHODS FOR QUALITY ASSURANCE

Standard operating procedures (SOPs) and quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be documented. 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.

F2. METHODS FOR QUALITY CONTROL

Project Proponents shall consider all relevant information that may affect the accounting and quantification of GHG reductions/removals, including estimating and accounting for any decreases in carbon pools and/or increases in GHG emission sources. This methodology sets a *de minimus* threshold of 3% of the final calculation of emission reductions. For the purpose of completeness any decreases in carbon pools and/or increases in GHG emission sources must be included if they exceed the *de minimus* threshold. Any exclusion using the *de minimus* principle shall be justified using fully documented *ex ante* calculations.

F3. CALCULATION OF TOTAL PROJECT UNCERTAINTY

The following equation must be applied:

$$UNC = \sqrt{UNC_{BSL}^{\ 2} + UNC_{P}^{\ 2}} \qquad \textbf{(26)}$$

where:

UNC	**Total project Uncertainty, in %**
UNC_{BSL}	**Baseline uncertainty, in % (Section C5)**
UNC_{P}	**With-project uncertainty, in % (Section D8)**

If calculated UNC in equation (26) is <10%, then UNC shall be considered 0% in equation (27).

G. CALCULATION OF ERTs

G1. CALCULATION OF ERTs

$$C_{ACR,t} = (\Delta C_p - \Delta C_{bsl}) * (1 - LK) * (1 - UNC) \quad \textbf{(27)}$$

Where:

$C_{ACR,t}$	**Total net greenhouse gas emission reductions at time *t* (t CO_2e)**
ΔC_P	**Carbon stock changes and greenhouse gas emissions under the project scenario at time *t,* in t CO_2e (Section D5)**
ΔC_{bsl}	**Carbon stock changes and greenhouse gas emissions under the baseline scenario at time *t,* in t CO_2e (Section C3)**
LK	**Leakage discount (Section D7)**
UNC	**Total project uncertainty, in % (Section F3)**

$$ERT_t = (C_{ACR,t} - C_{ACR,t-1_1}) * (1 - BUF) \quad \textbf{(28)}$$

Where:

$ERT_{,t}$	**Number of Emission Reduction Tons at year t**
BUF	**The non-permanence buffer deduction as calculated by the *ACR Tool for Risk Analysis and Buffer Determination or* the *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination* (no deduction if an ACR approved insurance product is used); fraction (Section B5)**

For questions or comments please contact:

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