PUBLIC COMMENT

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSION REDUCTIONS AND REMOVALS FROM

IMPROVED FOREST MANAGEMENT ON NON-FEDERAL U.S. FORESTLANDS

VERSION 2.1

February 2024

ACR AT WINROCK INTERNATIONAL

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ABOUT ACR[SM]

ACR is a leading global carbon crediting program operating in regulated and voluntary carbon markets. Founded in 1996 as the first private voluntary greenhouse gas (GHG) registry in the world, ACR creates confidence in the integrity of carbon markets to catalyze transformational climate results. ACR ensures carbon credit quality through the development of environmentally rigorous, science-based standards and methodologies as well as oversight of GHG project verification, registration, and credit issuance and retirement reporting through its transparent registry system. ACR is governed by Environmental Resources Trust LLC, a wholly-owned nonprofit subsidiary of Winrock International.

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Acronyms

ATFS	American Tree Farm System
BIA	Bureau of Indian Affairs
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DBH	Diameter at breast height
ERR	Emission reductions and/or removals
ERT	Emission Reduction Ton
FIA	Forest Inventory and Analysis Program of the USDA Forest Service
FSC	Forest Stewardship Council
FVS	Forest Vegetation Simulator
GHG	Greenhouse gas
GIS	Geographic information system
GPG	Good Practice Guide
GPS	Global Positioning System
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
lb	pound
LULUCF	Land Use, Land Use Change and Forestry
NLCD	National Land Cover Database
NPV	Net present value

QA/QC	Quality assurance/quality control
SFI	Sustainable Forestry Initiative
SOP	Standard operating procedures
USDA	United States Department of Agriculture

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1 Methodology Description

1.1 Methodology Summary

This science-based methodology provides the quantification and accounting framework, including procedures for determining eligibility, assessing additionality, and quantifying, monitoring, reporting, and verifying greenhouse gas (GHG) emission reductions and removals (ERRs) for the creation of carbon credits from improved forest management (IFM) on non-federal U.S. forestlands.[1]

IFM encompasses a range of silvicultural activities which increase the carbon stored in forests remaining forests.[2] Sustained forest cover is the greatest contributor of GHG removals from land use and land use change in the U.S.[3] The potential GHG benefits from IFM in the U.S. are significant, estimated to be 279.4 million metric tons per year.[4]

Projects are assessed against a three-pronged additionality test, requiring the project activity to exceed legal requirements, to exceed common practice in the forestry sector and geographic region, and to overcome an implementation barrier. Projects exceeding the three-pronged additionality test may generate carbon credits that help to offset lost revenues associated with reduced harvest levels and retention of forest growth, compared to the absence of the project.

The baseline scenario represents an alternate harvest scenario in the absence of the project. Baseline carbon stock changes are projected based on Common Practice Silviculture, respecting all relevant constraints to forest management for the given ownership, and financial analysis. Projects then dynamically evaluate the baseline scenario using the *Tool for Dynamic Evaluation of Baselines for ACR*

[1] For a high-level overview of the improved forest management project type, please see our IFM Primer available under the Program Resources section of the ACR website.

[2] Kaarakka, L., Cornett, M., Domke, G., Ontl, T., & Dee, L. E. (2021). Improved forest management as a natural climate solution: A review. *Ecological Solutions and Evidence*, *2*(3), e12090. https://doi.org/10.1002/2688-8319.12090

[3] U.S. Environmental Protection Agency. (2023). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. U.S. Environmental Protection Agency, EPA 430-R-23-002. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021

[4] Fargione, J. E., Bassett, S., Boucher, T., Bridgham, S. D., Conant, R. T., Cook-Patton, S. C., ... & Griscom, B. W. (2018). Natural climate solutions for the United States. *Science Advances*, *4*(11), eaat1869. https://doi.org/10.1126/sciadv.aat1869

IFM Methodologies,[5] whereby the baseline is periodically compared against recently observed conditions throughout the Crediting Period, to ensure its continued validity prior to issuing credits.

Emission Reduction Tons (ERTs) are quantified on the basis of GHG Emission Reductions associated with forgone baseline timber harvests and GHG Removals associated with retention of with-project forest growth.

Project Proponents must adhere to sustainable forest management practices and demonstrate there is no activity-shifting leakage above the *de minimis* threshold. Market leakage must be assessed and accounted for in the quantification of project benefits.

1.2 Eligibility Conditions

In addition to satisfying the latest ACR program requirements, project activities must satisfy the following eligibility conditions:

- This methodology is applicable only on non-federally owned or managed[6] Forestland within the United States. Tribal lands in the United States meeting applicability conditions of this methodology and requirements of the relevant ACR Standard are eligible.[7]
- The methodology applies only to lands that can be legally harvested by entities owning or controlling timber rights on Forestland.
- Participating entities (e.g., Project Proponent, landowner) must demonstrate clear land title or control of timber rights for the entirety of the project area at the project Start Date and throughout the Crediting Period.
- Participating entities (e.g., Project Proponent, landowner) must document carbon credit title.
- The project must demonstrate an increase in with-project live biomass carbon and dead wood pools, in sum, relative to those pools in the baseline scenario by the end of the Crediting Period.
- Forestland that was converted from Native Species to non-Native Species within ten (10) years of the project Start Date is ineligible, and the planting of or management for non-Native Species is not permitted.

[5] Found on the Reference documents section of this methodology's website.

[6] Lands transferred or to be transferred and owned in-fee by the U.S. federal government are eligible for enrollment only when full control of timber and carbon rights have been retained and reside with a non-federal entity for the entirety of the ACR Minimum Project Term. The constraints and NPV discount rate of the entity retaining full control of timber and carbon rights must be employed for baseline setting.

[7] See also ACR Guidance for Carbon Project Development on Tribal Lands available under the Program Resources section of the ACR website.

- Manipulation of water tables or filling of wetlands is prohibited to negate the potential for related gaseous emissions from soil and chemical processes.

1.3 Sustainable Management Requirements

All projects must adhere to the following sustainable management requirements throughout the Crediting Period, subject to validation and verification.

Project areas subject to Commercial Harvesting at the project Start Date in the with-project scenario must adhere to at least one of the following:

Option 1 Be certified by Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), or American Tree Farm System (ATFS) or become certified within one year of the project Start Date;

Option 2 Be enrolled in a state or federally sanctioned forestry program with monitoring and enforcement mechanisms in place or become enrolled within one year of the project Start Date, and demonstrate compatibility with Montréal Process Criteria (per Section 1.3.1, subject to validation);

Option 3 (Option only available to private landowners owning less than 2,500 forested acres.) Provide a documented long-term forest management plan, demonstrating sustainable forest management compatible with the Montréal Process Criteria (per Section 1.3.1), prepared and signed by a Professional Forester; or

Option 4 (Option only available to tribal landowners.) Adhere to sustainable forest management practices informed by traditional knowledge. Where possible, practices informed by traditional knowledge should be evidenced by a document such as a traditional land use plan, but it is recognized that principles of traditional land use are often not documented and exist only in oral communication. In all cases, compatibilty with Montréal Process Criteria must be demonstrated per Section 1.3.1.

Evidence demonstrating adherence to one of these options must be provided at validation.

If the project is not subject to Commercial Harvest within the project area as of the project Start Date, but harvests occur later in the project term, the project area must adhere to at least one of the options above before Commercial Harvesting may occur. Evidence demonstrating adherence to one of these options must be provided at verification.

1.3.1 MONTRÉAL PROCESS COMPATIBILITY

Projects utilizing Options 2, 3, or 4 (Section 1.3) must demonstrate forest management compatibility with the Montréal Process Criteria.[8] Projects using the Montréal Process Criteria form found on the Reference documents section of this methodology's website must provide this as an appendix to either the GHG Project Plan (if demonstrating sustainable forest management at validation) or the Monitoring Report (if demonstrating sustainable forest management for harvests occurring later in the project term).

Projects using Option 2 must identify how forest management conforming to the requirements of the state or federally sanctioned forestry program is compatible with the Montréal Process Criteria using the form found on the Reference documents section of this methodology's website. Descriptions of how the state or federally sanctioned forestry program's requirements relate to each Criterion must be included.

Projects using Option 3 must provide a documented long-term forest management plan prepared and signed by a Professional Forester. Compatibility with the Montréal Process Criteria may be reported within the forest management plan or as an addendum using the form found on the Reference documents section of this methodology's website.

Projects using Option 4 with a written traditional land use plan may demonstrate compatibility with the Montréal Process Criteria within the plan itself or as an addendum using the form found on the Reference documents section of this methodology's website. Projects using Option 4 without a written land use plan must demonstrate compatibility of the traditionally informed forest management with the Montréal Process Criteria using the form found on the Reference documents section of this methodology's website.

For all Options, compatibility with Criteria 1 through 6 of the Montréal Process Criteria and Indicators must be demonstrated. Criterion 5 (Maintenance of forest contribution to global carbon cycles) is satisfied by listing the GHG Project. Criterion 7 (Legal, institutional and economic framework for forest conservation and sustainable management) is not relevant at the project scale and therefore not considered. References to specific Indicators from the Montréal Process may be provided but are not required.

[8] https://montreal-process.org/The_Montreal_Process/Criteria_and_Indicators/index.shtml

2 Boundaries, Additionality, and Permanence

2.1 Geographic Boundary

The Project Proponent must establish and record the geographic coordinates of the project boundary (and any stratification inside the boundary) by field mapping (e.g., GPS) or by using georeferenced spatial data (e.g., maps, GIS datasets, orthorectified aerial photography, or georeferenced remote sensing images).

The Project Proponent must then provide a detailed description of the geographic boundary of project activities, subject to validation. Note that the project activity may contain more than one discrete area of land provided that each area has a unique geographical identification and that each area meets the eligibility requirements. Information to delineate the project boundary must include the following:

- Project area map, delineated on a geographic information system (GIS);
- General location map; and
- Property parcel map.

Aggregation of forest properties with multiple landowners is permitted under the methodology consistent with the *ACR Standard* and the *ACR Aggregation and Programmatic Development Approach Guidance for IFM*,[9] which provide guidelines for aggregating multiple landholdings into a single project to reduce per-acre transaction costs of monitoring, reporting, and verification.

2.2 Temporal Boundary

The project Start Date may be denoted by one of the following:

- Land acquisition or self-imposed legal constraint (e.g., easement; Section 4.1.2.1) enactment date;
- The date the Project Proponent or associated landowner(s) began to apply the land management regime to increase carbon stocks and/or reduce emissions relative to the baseline; or

[9] Available under the Program Resources section of the ACR website.

- The date that the Project Proponent first demonstrated good faith effort to implement a GHG project. Such demonstrations must include documented evidence of:
  - The date the Project Proponent initiated a forest inventory for a GHG project;
  - The date that the Project Proponent entered into a contractual relationship or signed a corporate or board resolution to implement a GHG project; or
  - The date the project was submitted to ACR for listing review.

Other dates may be approved as the Start Date on a case-by-case basis.

In accordance with the *ACR Standard*, all projects will have a Crediting Period of twenty (20) years. The Minimum Project Term is forty (40) years. The Minimum Project Term begins on the project Start Date (not the first or last year of crediting). Projects must be validated within 3 years of the project Start Date.

2.3 Pools and Sources

The pools and sources relevant to this Methodology are listed below. Pools must be consistently included or excluded in both the baseline and with-project scenarios, unless otherwise noted.

Table 1: Carbon Pools

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Aboveground live biomass carbon	Included	Major carbon pool subject to the project activity.
Belowground live biomass carbon	Included	Major carbon pool subject to the project activity.
Aboveground standing dead wood	Optional	Project Proponents may elect to include the pool. Where included, belowground standing dead wood must also be included, and the pool must be estimated in both the baseline and with-project scenarios.

Belowground standing dead wood	Optional	Project Proponents may elect to include the pool. Where included, aboveground standing dead wood must also be included, and the pool must be estimated in both the baseline and with-project scenarios.
Lying 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 scenarios.
Harvested wood products	Included	Major carbon pool subject to the project activity.
Litter / Forest Floor	Excluded	Changes in the litter pool are considered *de minimis*.
Soil organic carbon	Excluded	Changes in the soil carbon pool are considered *de minimis*.

Table 2: Greenhouse Gases

GAS	SOURCE	INCLUDED / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
CO_2	Burning of biomass	Excluded	Carbon stock decreases due to burning are accounted as a carbon stock change.
CH_4	Burning of biomass	Excluded	Potential emissions are considered *de minimis.*[10]
N_2O	Burning of biomass	Excluded	Potential emissions are considered *de minimis.*

Table 3: Leakage Sources

[10] Regarding the *de minimis* determinations for CH_4 and N_2O from biomass burning, please see:
U.S. Environmental Protection Agency. (2022) AP-42, Air Pollutant Emission Factors, section 1.6.3.2. https://www.epa.gov/system/files/documents/2022-03/c1s6_final_0.pdf

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 minimis* threshold will occur as a result of project implementation (Section 5.3).
	Crops	Excluded	Forestlands eligible for this methodology do not produce agricultural crops that could cause activity shifting.
	Livestock	Excluded	Grazing activities, if occurring in the baseline scenario, are assumed to continue at the same levels under the with-project scenario and thus there are no leakage impacts.
Market	Timber Harvesting	Included	Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those CO_2 emissions must be included in the quantification of project benefits (Section 5.4).

2.4 Additionality

To be validated as additional, the GHG Project must apply the three-pronged additionality test, as described in the *ACR Standard*, to demonstrate:

- They exceed currently effective and enforced laws and regulations;
- They exceed common practice in the forestry sector and geographic region; and
- They face a financial implementation barrier.

The regulatory surplus test involves evaluating existing laws, regulations, statutes, legal rulings, deed restrictions, or other regulatory frameworks relevant to the project area that directly or indirectly affect GHG ERRs associated with a project action or its baseline candidates, and which require technical, performance, or management actions. Donor funding with specific restrictions on management activities must be considered. Legally binding conditions of self-imposed legal constraints which explicitly reinforce the project activity, put in place less than one year before or any time after the project Start Date, need not be considered. Regulatory surplus must be confirmed at each verification. Voluntary guidelines lacking an explicit enforcement mechanism are not considered in the regulatory surplus test.

The common practice test requires an evaluation of the predominant forest management practices in the project geographic region and a demonstration that the management activities of the with-project scenario will increase carbon sequestration compared to common practice. This includes: 1) describing the predominant forest management practices occurring on comparable sites of the region that have not been enrolled in a GHG project (e.g., similar forest type, ecological condition, species/product mixture), 2) providing a descriptive comparison of the expected carbon sequestration impacts of predominant forest management practices identified in step 1 in relation to with-project scenario management, and 3) demonstrating that carbon stocks under with-project scenario management will exceed those of the baseline scenario by the end of the Crediting Period. Section 4.1.2.5 provides a framework for determining Common Practice Silviculture, which may be incorporated into a project's common practice test demonstration.

The implementation barrier test examines factors that would prevent the adoption of the practice/activity proposed by the Project Proponent. Financial implementation barriers can include high costs, limited access to capital, or an internal rate of return in the absence of carbon credit revenues that is lower than the Project Proponents established and documented 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 shall include solid quantitative evidence such as net present value (NPV) and internal rate of return calculations. The results of the financial analysis for the baseline and with-project scenarios must be provided in the GHG Project Plan, demonstrating that the baseline is more profitable. Since carbon credit revenue incentivizes the otherwise less profitable project activity, the with-project scenario does not need to account for revenues associated with carbon credits. The project must face capital constraints that carbon credit revenues can potentially address; or carbon funding must reasonably be expected to incentivize the project's implementation; or carbon credit revenues must be a key element to maintaining the project action's ongoing economic viability after its implementation. Technological or Institutional barriers as referenced in the *ACR Standard* may also be relevant.

Application of the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies* may result in changes to the baseline scenario from validation. While there may be impacts to crediting due to new baseline carbon stock change calculations, the project itself will not be deemed ineligible or nonadditional during a previously validated Crediting Period.

2.5 Permanence

Project Proponents commit to a Minimum Project Term of 40 years. Projects must have effective risk mitigation measures in place to compensate fully for any Reversal, whether this occurs through an unforeseen natural disturbance or through a Project Proponent or landowners' choice to discontinue project activities. Such mitigation measures can include Buffer Pool Contributions and legally-binding reversal risk mitigation mechanisms, respectively, or an alternate risk mitigation measure approved by ACR.

The Project Proponent must conduct a Reversal Risk Analysis addressing both general and project-specific risk factors for Unintentional Reversals. 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 but 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.

Project Proponents must conduct their Reversal Risk Analysis using the *ACR Tool for Reversal Risk Analysis and Buffer Pool Contribution Determination*.[11] The output of this tool is a Buffer Pool Contribution Percentage for the project, an overall risk rating expressed as a percentage, which is applied at each issuance to determine the Buffer Pool Contribution that must be applied in the calculation of Net Emission Reductions and Removals (Equations 26 and 29). This deduction must be applied at each issuance (exceptions may apply if the Project Proponent uses an ACR-approved alternate risk mitigation mechanism).

[11] Available under the Program Resources section of the ACR website.

3 Stratification

Stratification may be used to improve the modeling of management scenarios and precision of carbon stock estimates. If stratification is used, a stratification standard operating procedures (SOP) document detailing relevant design, inputs, parameters, rules, and techniques must be provided as an attachment to the initial GHG Project Plan for validation. The stratification SOP document must contain sufficient information such that the stratification can be examined and duplicated as necessary to provide reasonable assurance of the validity of associated techniques and the absence of bias. The stratification must be the same for the baseline and with-project scenarios for the estimates of initial stocking levels. However, the number and boundaries of strata may change during the Crediting Period (*ex-post*) as baseline and with-project scenario management practices diverge. For estimation of initial carbon stocks, defining strata on the basis of parameters correlated to forest carbon stocking will generally reduce within-strata variability, improve sampling efficiency, and decrease the likelihood or magnitude of a required uncertainty deduction (Section 7.5), for example:[12]

- Size and density class
- Age class
- Management regime
- Forest cover types
- Site class

The *ex-post* stratification may be updated based on relevant changes to with-project scenario conditions, such as:

- Unexpected disturbances occurring during the Crediting Period (e.g., wildfire events, pest or disease outbreaks), affecting differently various parts of an originally homogeneous stratum;
- Forest management activities (e.g., planting, thinning, harvesting, coppicing, replanting), implemented in a way that affects the existing stratification; or
- Established strata may be merged if reason for their establishment is no longer relevant.

Any updates to stratification must be fully described in an addendum to the stratification SOP document.

[12] This list is not exhaustive and only includes examples of common stratification parameters.

4 Baseline Scenario

4.1 Identification of Baseline

The ACR IFM baseline represents a project-specific harvesting scenario that implements Common Practice Silviculture while respecting all relevant constraints to forest management (Figure 1). First, the project identifies the ownership scenario under which the baseline model is parameterized. Constraints are then identified for the ownership, broadly categorized as follows: legality, operability and access, financial feasibility, regional timber market capacity, and external approval. Common Practice Silviculture then establishes the baseline scenario's choice of silvicultural prescriptions and their Harvest Intensities, which must be substantiated with recent evidence from nearby Forestland. NPV analysis is then used to simulate a likely baseline harvest scenario in the absence of the project that generates a higher rate of return than the with-project scenario.

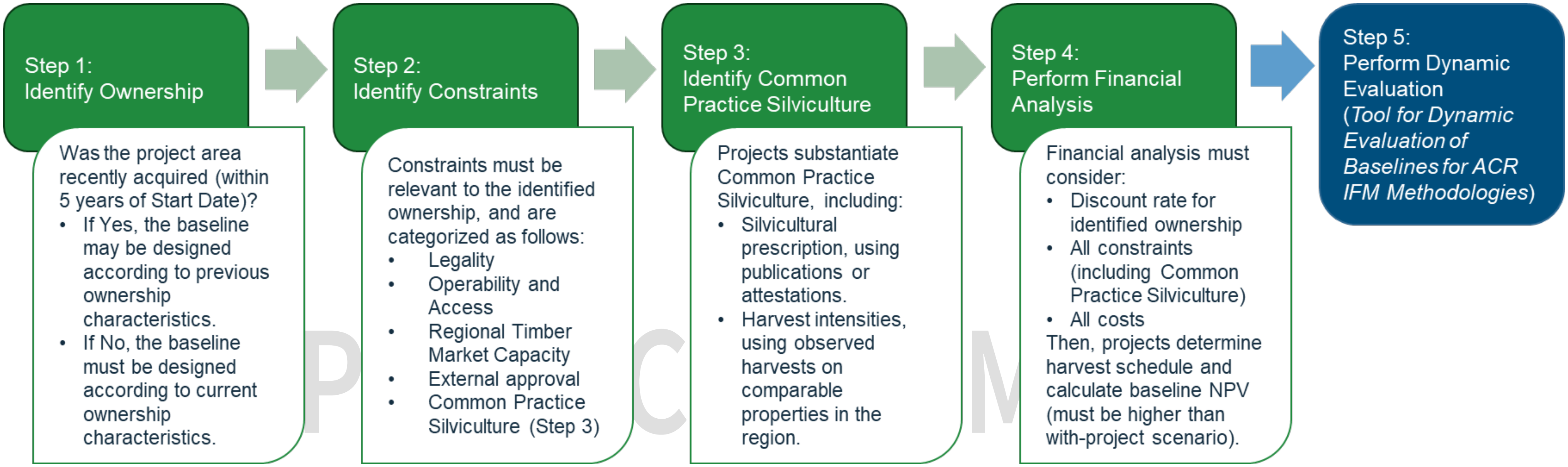
The GHG Project dynamically evaluates its baseline scenario over time using the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*,[13] whereby the baseline is periodically assessed against recently observed conditions throughout the Crediting Period, to ensure its continued validity prior to issuing credits. *Ex-ante* projections are periodically reassessed and remodeled as applicable.

Consideration shall be given to a range of reasonable baseline assumptions and the selected assumptions shall be feasible and plausible for the duration of the Crediting Period.

The ISO 14064-2 principle of conservativeness must be applied for the determination of the baseline scenario.[14] In particular, the conservativeness of the baseline is established with reference to the choice of approaches, assumptions, methods, parameters, data sources, and key factors so that GHG baseline emissions are more likely to be under-estimated rather than over-estimated, and that reliable results are maintained over a range of probable assumptions. Using the conservativeness principle does not always imply the use of the "most" conservative choice of assumptions or methods.

[13] Found on the Reference documents section of this methodology's website.
[14] ISO 14064-2:2019. https://www.iso.org/standard/66454.html.

Figure 1: Identification of Baseline



4.1.1 OWNERSHIP

The first step in parameterizing the baseline model is identifying the timber rights ownership of the project area. A project may identify multiple timber rights ownerships if it is aggregated or employs the Programmatic Development Approach. The selection of ownership impacts the choice of constraints (Section 4.1.2) and discount rate used in the financial analysis (Section 4.1.3).

If the timber rights of the project area were recently acquired (within less than 5 years of project Start Date), the baseline model may be parameterized using the previous ownership. Otherwise, the current ownership must be used. Ownership is fixed for the duration of the project term and is only subject to dynamic evaluation in verifications in which the timber rights transition to a new ownership.

4.1.2 CONSTRAINTS

The next step in parameterizing the baseline model is identifying constraints to forest management. All relevant constraints for the identified ownership (Section 4.1.1) must be incorporated into the modeling of the baseline scenario. These are broadly categorized as legality, operability and access, regional timber market capacity, external approval, and Common Practice Silviculture. Except for external approval, constraints are subject to dynamic evaluation using the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*.

4.1.2.1 Legality

All legally binding constraints to forest management must be considered in baseline modeling. These include all existing laws, regulations, legal rulings, deed restrictions, and other regulatory frameworks relevant to forest management (e.g., legally binding terms and conditions associated with the land acquisition, donor funding with specific restrictions on allowable management activities). Best management practices to protect water, soil stability, forest productivity, wildlife, and other sensitive resources, as published or prescribed by applicable federal, state, or local government agencies are also considered legally binding constraints.

The only exceptions to modeling legal constraints, which are not required to be considered in baseline modeling if enacted less than one year before or any time after the project Start Date, are the following self-imposed legal constraints explicitly reinforcing the project action:

- Conservation easements;

- Deed restrictions;
- Contracts limiting forest management of existing and/or new timber owners; and
- Constraints associated with voluntary state or federally sanctioned forestry programs (e.g., enrollment in a forest management tax incentive program).

Any of the above exceptions must be considered in baseline modeling if enacted prior to one year before the project Start Date. Demonstrations of explicit reinforcement of the project action must include attestations and or other verifiable evidence, produced and dated within one year of when the constraint was enacted, that references the GHG Project.

4.1.2.2 Operability and Access

Baseline management activities must be demonstrably operable and harvested timber must be physically accessible considering the terrain of the unit and the availability of existing and potential infrastructure, such as roads and any improvements and/or expansions required to access timber. Access limitations (e.g., seasonal road conditions and restrictions; timing associated with potential infrastructure improvements and/or expansions) must be considered as well as land ownership, tenure, and any other conditions relevant to physically accessing timber and performing baseline management activities.

4.1.2.3 Regional Timber Market Capacity

The baseline scenario's harvested timber output must not exceed regional timber market (i.e., mills, ports, rail yards, and other markets for timber) capacity for the species, size, and grade forest products produced. Regional timber markets are those within hauling distances that allow the baseline's forest management activities to be profitable considering transport costs (e.g., drive and unloading time, fuel costs) and prices for forest products. The feasibility of the baseline harvest regime must be demonstrated with timber market reports, testimony from a Professional Forester, published literature from an applicable state or federal agency, or other verifiable evidence (Section 4.2).

4.1.2.4 External Approval

Baseline management activities must consider any required external approval (i.e., oversight or endorsement) by third-party entities that are not directly involved in the project implementation but have influence on the project area management (e.g., public agencies required approval of forest management plans). Mission statements, management plans, and other internal guiding documents need not be considered unless they require external approval. Both donor funding without specific restrictions on management activities and internal board approval are not considered external approval barriers for project implementation. To verifiably demonstrate that potential external approval constraints have been adequately considered, projects must provide attestations from relevant third-party entities, examples of the participating entities or similar landowners gaining the relevant external approval, or other verifiable evidence. This constraint type is not subject to dynamic evaluation.

4.1.2.5 Common Practice Silviculture

The next step in parameterizing the baseline model is identifying eligible silvicultural prescriptions and Harvest Intensities for the project area. Both the choice of silvicultural prescriptions and Harvest Intensities must be substantiated (per this section) to be eligible for modeling in the baseline scenario. Once both the silvicultural prescriptions and Harvest Intensities are substantiated, baseline silviculture is deemed Common Practice Silviculture.

Baseline silvicultural prescriptions must fully utilize available growing space and must perpetuate existing onsite timber producing species, unless it is demonstrated that their replacement (e.g., conversion of natural forests to plantations, replacing existing onsite timber producing species) is feasible and substantiated. Each baseline silvicultural prescription[15] must be substantiated by at least one of the following:

- Publication, statement, or attestation from an applicable state or federal agency;
- Written statement or attestation from a Professional Forester(s); or
- Peer-reviewed or academic publication.

4.1.2.5.1 SUBSTANTIATION OF HARVEST INTENSITY

For the purposes of this methodology, Harvest Intensity is an expression of percent biomass removed per acre per year, relative to a property's relevant stratum size. Substantiation of baseline Harvest Intensities is performed when developing initial *ex-ante* projections to be included in the GHG Project Plan (Section 4.2) and when performing dynamic evaluations (*Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*) throughout the Crediting Period.

To substantiate the Harvest Intensities employed by the baseline, projects must first identify comparable properties with harvest treatments occurring within the 5-year lookback period. Projects

[15] Silvicultural prescriptions are inclusive of regeneration treatments (e.g., artificial planting, seed tree retention), intermediate treatments (e.g., pre-commercial thinning), and harvest treatments (e.g., clearcutting, single-tree selection, shelterwood).

then stratify by forest cover type. Once stratified, the Harvest Intensities of harvests observed on comparable properties within each forest cover stratum are calculated. Projects then develop constraints based on the Harvest Intensities of the observed harvests, to guide baseline development. Lastly, projects must check that baseline harvests occurring both in each single year and cumulatively during the Crediting Period do not exceed the intensity of observed harvests. This process is further described in the following sections.

The following sections refer to the Harvest Intensity Calculator,[16] and tables found therein. The Harvest Intensity Calculator must be utilized for substantiating Harvest Intensity.

COMPARABLE PROPERTIES IDENTIFICATION

Projects must identify at least two comparable properties with harvest treatments occurring within the 5-year lookback period (i.e., 5 years preceding the project Start Date; Table 1 of Harvest Intensity Calculator). Comparable properties must meet the following specifications:

- Located within 150 road miles of the perimeter of the project area;[17]
- Owned (or timber controlled) by a non-federal entity;[18]
- At least the greater of either: 25% of the geographic size (in acres) of the project area, or 1000 acres;[19]
- No greater than 200% of the geographic size (in acres) of the project area; and
- Containing similar ecological condition(s) and/or species/product mixture.

A single comparable property may be used to substantiate Harvest Intensities on more than one forest cover stratum, but this is not required (i.e., a project may have unique sets of comparable properties for substantiating Harvest Intensities within each forest cover stratum).

FOREST COVER STRATIFICATION

[16] Found on the Reference documents section of this methodology's website.

[17] 150 miles is used to demonstrate a maximum hauling distance in: Pokharel, R., & Latta, G. S. (2020). A network analysis to identify forest merchantability limitations across the United States. Forest policy and economics, 116, 102181. https://www.sciencedirect.com/science/article/abs/pii/S1389934119301765. In regions where roads are not a primary mode of transportation, 150 linear miles may be used. If a project can verifiably demonstrate that there are no comparable properties not already enrolled in a GHG project within the specified distance, the perimeter may be expanded until comparable properties are identified.

[18] Properties owned by the participating entity/entities but outside the project area are eligible comparable properties.

[19] Only Forestland needs to be considered when determining whether a comparable property meets the geographic size specifications.

Since silvicultural practices vary across ecological conditions, Harvest Intensities must be substantiated for each forest cover type. Projects must stratify the project area and comparable properties, consistently applying the same methods and datasets (Tables 1 and 3 of Harvest Intensity Calculator). At minimum, forest cover strata must use the classifications of the National Land Cover Database (NLCD),[20] which include Deciduous Forest, Evergreen Forest, Mixed Forest, Shrub/Scrub, Woody Wetlands, and others. More refined forest cover stratifications (e.g., by species or FIA forest type) are permitted when the project justifies the stratification with verifiable evidence supporting the accuracy of the proposed stratification system. This process is distinct from stratification for the purpose of carbon stock estimation (Section 3), although the same stratification may be used for both purposes as applicable.

Harvest Intensity Calculation

Once comparable properties are stratified, projects must determine the Harvest Intensity of observed harvest treatments (Table 2 of Harvest Intensity Calculator). The following general steps are followed when calculating the Harvest Intensity of a harvest treatment within a given forest cover stratum.

Step 1 **Identify the number of acres affected in each stratum.** The number of acres affected must consider all harvest treatments of similar percent biomass removed per acre.

Step 2 **Identify the average percent biomass removed per acre.** The percent biomass removed is relative to the sum of the above and belowground live biomass carbon and above and belowground standing dead wood (if included) pools. Harvest treatments may be separated by distinct treatment type or may be grouped together and averaged for each forest cover stratum.

Step 3 **Divide the number of acres affected by the total stratum acres to calculate the percent stratum area affected.** The stratum acres must consider the forest cover stratification determined according to Section 4.1.2.5.1.

Step 4 **Divide the percent stratum area affected by the number of years to calculate an annual harvest rate for each stratum.**

Step 5 **Multiply the percent biomass removed per acre by the percent stratum area affected per year to calculate Harvest Intensity.** Harvest Intensity is expressed as a percentage.

[20] The most recent NLCD data (as of this methodology publication) is available here: https://www.mrlc.gov/data/nlcd-2021-land-cover-conus. For a general overview of the NLCD, please visit: https://www.usgs.gov/centers/eros/science/national-land-cover-database#overview

These steps are applied to at least two comparable properties per stratum, which results in a determination of Harvest Intensity for each forest cover stratum on each comparable property. Within each forest cover stratum, the lesser (i.e., more conservative) Harvest Intensity for each forest cover stratum (among the minimum two comparable properties identified) is determined, which is then used in constraint development.

Forest cover loss alone is insufficient evidence of harvest treatments on comparable properties, and projects must verifiably demonstrate that forest loss can be attributed to harvest activities (i.e., natural disturbances resulting in forest loss such as wildfire cannot be used). Sources of data to be used as inputs for the calculation of Harvest Intensity on comparable properties may include:

- Management records from a participating entity (e.g., Project Proponent, landowner) or another landowner/forest manager;
- Aerial imagery, remote sensing products, or a geospatial analysis demonstrating forest loss consistent with harvest treatments; or
- Other verifiable evidence.

CONSTRAINT DEVELOPMENT

To develop constraints for parameterizing the baseline model based on the Harvest Intensities of comparable properties, projects must first identify the baseline's average percent biomass removed per acre (Table 4 of Harvest Intensity Calculator). Projects then develop constraints by applying the inverse operations of the general steps for Harvest Intensity calculation (Table 5 of Harvest Intensity Calculator).

Constraining baseline harvests in a single year to comparable property's Harvest Intensities may be inappropriate on smaller areas, which may be subject to periodic harvests of higher intensity. To account for the effect of averaging time in the Harvest Intensity calculation for small landowners, projects must calculate a scaling factor to be used in determining the annual constraint. The Annual Small Landowner Harvest Intensity Factor may range from 1 to 3, depending on the total project area.

Equation 1: Annual Small Landowner Harvest Intensity Factor

$$\text{if } [\text{Area}_{\text{project}} < 5{,}000] \text{ then } \text{HI}_{\text{SF}} = \left(\left[\frac{(5{,}000 - \text{Area}_{\text{project}})}{5{,}000}\right] \times 2\right) + 1$$

or

$$\text{if } [\text{Area}_{\text{project}} \geq 5{,}000] \text{ then } \text{HI}_{\text{SF}} = 1$$

WHERE

HI_{SF}	Annual Small Landowner Harvest Intensity Factor (unitless).
$Area_{project}$	Total project area (acres).

This factor is multiplied by the acres affected per year (based on the lesser comparable property Harvest Intensity and the baseline percent biomass removed per acre) to calculate the annual constraint (Table 5 of Harvest Intensity Calculator). The cumulative constraint is calculated by multiplying the acres affected per year by the number of years in the Crediting Period (20).

HARVEST INTENSITIES CHECK

Once a baseline harvest schedule has been developed (Section 4.1.3), final checks must be performed to ensure proper implementation and standardize validation/verification. For *ex-ante* projections at initial validation, checks ensure that Harvest Intensities of comparable properties were not exceeded, both in each single year (Table 6 of Harvest Intensity Calculator) and cumulatively during the Crediting Period (Table 7 of Harvest Intensity Calculator).

These checks are also performed as part of the dynamic evaluation (according to the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*). Harvest Intensities for the Reporting Period are checked during the Observed Conditions Assessment (Table 8 of Harvest Intensity Calculator). Harvest Intensities for the remainder of the Crediting Period are checked during the Periodic Modeling Assessment (Table 9 of Harvest Intensity Calculator).

To prepare for these checks, Harvest Intensities of multiple harvest treatments (i.e., percent biomass removed per acre) in the same forest cover stratum must be combined, which calculates the total Harvest Intensity per forest cover stratum.

When checking annual or Reporting Period Harvest Intensities, the lesser comparable property Harvest Intensity must be multiplied by the Annual Small Landowner Harvest Intensity Factor (Equation 1; Tables 6 and 8).

When checking cumulative Harvest Intensities, percent stratum area affected must be divided by the number of years remaining in the Crediting Period (20 years at validation, or less during a Periodic Modeling Assessment; Tables 7 and 9) to calculate an annual harvest rate prior to calculating Harvest Intensity.

If the lesser comparable property Harvest Intensity (Table 2) exceeds the total Harvest Intensity per forest cover stratum (Tables 6 and 7), then the baseline Harvest Intensities applied to that forest cover stratum are substantiated. For any forest cover stratum that cannot be substantiated, the baseline

Harvest Intensities must be reduced such that they are equal to or less than the lesser comparable property Harvest Intensity per forest cover stratum.

4.1.3 FINANCIAL ANALYSIS

The final step in parameterizing the baseline model is performing a financial analysis to determine an appropriate harvest schedule. An NPV discount rate of 3 – 6% is assigned as an indicator for how a given landowner within a particular Forestland timber ownership class would base their forest management decisions (Table 4).[21] The project must employ the discount rate values in Table 4 for the ownership class corresponding to the selected ownership(s) (Section 4.1.1). NPV discount rates are assigned and weighted based upon timber rights ownership across the entirety of the project area.

Table 4: Discount Rates for Net Present Value Determinations by U.S. Forestland Timber Ownership Class

TIMBER OWNERSHIP CLASS	ANNUAL DISCOUNT RATE
Private Industrial	6%
Private Non-Industrial	5%
Tribal	5%
Non-Federal Public	4%
Non-Governmental Organization	3%

Required inputs for the project NPV calculation include the results of a recent forest inventory of the project area, prices for forest products of grades that the project would produce, logging and transport costs, reforestation and site rehabilitation costs, silvicultural prescription 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 and harvests of the baseline scenario for 100 years from the project Start Date.

Project Proponents must determine the NPV of the baseline scenario while considering all costs, utilizing Common Practice Silviculture and meeting any other constraints, including legal

[21] Description of NPV discount rates for ACR's IFM methodology v2.0 (2022). Found on the Reference documents section of this methodology's website.

requirements, operability and access constraints, regional timber market capacity, and external approval constraints. The baseline scenario must generate a higher NPV from timber revenue than the with-project scenario, without consideration for carbon credit revenue (Section 2.4).

Project Proponents may use a constrained optimization program to calculate the NPV for the harvest schedule. The annual real (without inflation) discount rate for each non-federal timber ownership class given in Table 4 must be applied. The resulting harvest schedule is used to establish baseline stocking levels throughout the Crediting Period, which is used for *ex-ante* projections reported in the GHG Project Plan. Wood products must be accounted for and included in the calculation of ERRs (Equation 25).

4.1.4 DYNAMIC EVALUATION

The baseline scenario is subject to dynamic evaluation using the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*,[22] which establishes a framework for evaluating specific categories relating to baseline validity during a Crediting Period and on an *ex-post* basis. It also provides the necessary steps to adjust quantification of baseline carbon stock changes, and hence ERRs, if the evaluation finds that adjustments are necessary. Please see the tool for further details.

4.2 Baseline Reporting

The GHG Project Plan must include the following baseline reporting:

- A general description of the baseline management scenario over the Crediting Period.
- Identification of the timber rights ownership used in the baseline model (Section 4.1.1). If the baseline model is parameterized using the previous ownership, evidence of the recent acquisition (within less than 5 years of the project Start Date) must be provided.
- A list and description of any and all constraints affecting baseline forest management, including:
    - Legal constraints. Each legal constraint description must include the following:
        - A general description of each legal constraint;
        - The geographic extent of each legal constraint;
        - The governing agency or body associated with each legal constraint;
        - A description of how each legal constraint is considered in the baseline scenario; and

[22] Found on the Reference documents section of this methodology's website.

  - A list of any self-imposed legal constraints explicitly reinforcing the project action which are not considered in the baseline scenario.
- Operability and access constraints. Each operability or access constraint description must include the following:
  - A general description of each operability or access constraint;
  - The type of terrain impacted and an explanation of that impact on forest management;
  - The specific areas within the project that are constrained; and
  - A description of how each operability or access constraint is considered in the baseline scenario.
- Regional timber market capacity. Each timber market capacity constraint description must include the following:
  - A general description of each timber market capacity constraint;
  - Timber markets considered, and their locations and transport costs relative to the project area;
  - Species, sizes, and volumes accepted over time;
  - A description of how each timber market capacity constraint was determined using one of the following sources: timber market reports, testimony from a Professional Forester, published literature from a state or federal agency, or other verifiable evidence; and
  - A description of how each timber market capacity constraint is considered in the baseline scenario.

- External approval constraints. Each external approval constraint description must include the following:
  - A general description of each external approval constraint;
  - The third-party entity whose approval would be required for implementation of baseline management activities;
  - A description of the demonstration of the baseline gaining external approval and the verifiable evidence provided; and
  - A description of how each external approval constraint is considered in the baseline scenario.
- Common Practice Silviculture.
  - Each baseline silvicultural prescription must be substantiated according to Section 4.1.2.5 and fully described, including:
    - A general description of the silvicultural prescription;
    - Trees retained (e.g., residual volumes, species, size limits);
    - Harvest frequency or thresholds;

    - Regeneration assumptions; and
    - A description of the verifiable evidence substantiating the choice of silvicultural prescription as Common Practice Silviculture according to Section 4.1.2.5, including any sources, qualifications of people involved, and the applicability to the project area;
  - Baseline Harvest Intensities must be substantiated according to Section 4.1.2.5.1 and fully described, including:
    - The Harvest Intensity Calculator, including all required inputs and calculations of annual and cumulative Harvest Intensity for both comparable properties and the project area;
    - A description of how each comparable property qualifies per the specifications in Section 4.1.2.5.1, including:
      - Approximate location relative to the project area;
      - Confirmation of non-federal ownership;
      - Property size, including its size relative to the project area (%); and
      - Forest cover strata, ecological condition(s), and/or species/product mixture.
    - A description of the verifiable evidence and methods used to determine Harvest Intensity on comparable properties, including the exact data sources, stratification methods asn, and quantification approaches utilized (information that identifies comparable properties may be anonymized). Projects utilizing verifiable evidence that visually and/or quantifiably displays harvest treatments with Harvest Intensities equal to or greater than the baseline harvest treatments must present this evidence. Projects utilizing remote sensing models for harvest treatment identification to determine Harvest Intensity on comparable properties must report the following:
      - GHG Projects that utilize an internally-developed remote sensing model must provide details that summarize the methodology, the type of algorithm used (e.g., random forest, support vector machine), the training and validation data and processes, and the source data (e.g., satellite, Lidar, SAR, IFSAR). In addition, a metadata document with further details about the model methodology and assessment must be provided.
      - GHG Projects that utilize an externally-developed remote sensing model must provide documentation on the models utilized, including the authors, affiliation, model methodology, source data (e.g., satellite, Lidar, SAR, IFSAR), model performance, associated publication (if available), and other relevant details on the applicability for biomass change detection.
      - All GHG Projects that utilize a remote sensing model must report on the accuracy of the model using stardardized approaches to accuracy assessment (e.g., error matrix) based on ground-truthed validation data.
- A description of the finanical analysis, including:

- Discount rate(s) applied;
- Summary of timber prices and associated sources;
- A list of all costs considered and associated sources;
- NPV of the baseline scenario;
- NPV of the with-project scenario (without consideration for carbon credit revenue); and
- Description of methods used to determine the baseline harvest schedule, including any optimization programs utilized.

- A graph depicting the projected baseline and with-project stocking levels, with time (40 years) in the x-axis and metric tons CO_2e in the y-axis, for the following pools:
  - Standing live trees;
  - Standing dead trees, if included;
  - Lying dead wood, if included; and
  - Harvested wood products.

4.3 Estimation of Baseline Emission Reductions

The following sections and equations are used to compute the baseline net reductions and removals resulting from baseline carbon stock changes and long-term storage in harvested wood products. This methodology requires the following:

- Baseline stocking levels to be determined for the entire Crediting Period;
- The long-term average baseline stocking level to be calculated for the Crediting Period;
- The change in baseline live tree and dead wood (if included) carbon stocks to be computed for each time period, t;[23] and
- The long-term average value of baseline carbon stored in wood products 100 years after harvest to be calculated following Section 4.3.4 and Equation 4 for the calculation of ERRs (Equation 25).

The following equations are used to construct the baseline stocking levels using the models described in Section 4.3.1 and wood products calculations described in Section 4.3.4:

[23] Throughout this methodology, **t** is used to mean time in years and may be fractional (i.e., more or less than one year).

Equation 2: Change in Baseline Live Tree Stocks

$$\Delta C_{BSL,TREE,t} = (C_{BSL,TREE,t} - C_{BSL,TREE,t-1})$$

WHERE

t	Time in years.
$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock in above and belowground live trees (in metric tons CO_2e) during year **t**.
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Equation 3: Change in Baseline Dead Wood Stocks

$$\Delta C_{BSL,DEAD,t} = (C_{BSL,DEAD,t} - C_{BSL,DEAD,t-1})$$

WHERE

t	Time in years.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock in dead wood (in metric tons CO_2e) during year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2e) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Any projected reductions in live tree and dead wood carbon stocks due to harvests, disturbances, or slash burning in the baseline must be properly accounted for in Equations 2 and 3.

Equation 4: Baseline Average Harvested Wood Products Value

$$\bar{C}_{BSL,HWP} = \frac{\sum_{t=1}^{20} C_{BSL,HWP,t}}{20}$$

WHERE

t	Time in years.

$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e).
$C_{BSL,HWP,t}$	Baseline carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.

NOTE: Please see Section 4.3.4 for detailed instructions on baseline wood products calculations.

To calculate long-term average baseline stocking level for the Crediting Period, based on stocking from year 0 to year 20, use:

Equation 5: Baseline Average Long-term Stocking

$$C_{BSL,AVE} = \frac{\sum_{t=0}^{20}(C_{BSL,TREE,t} + C_{BSL,DEAD,t})}{21}$$

WHERE

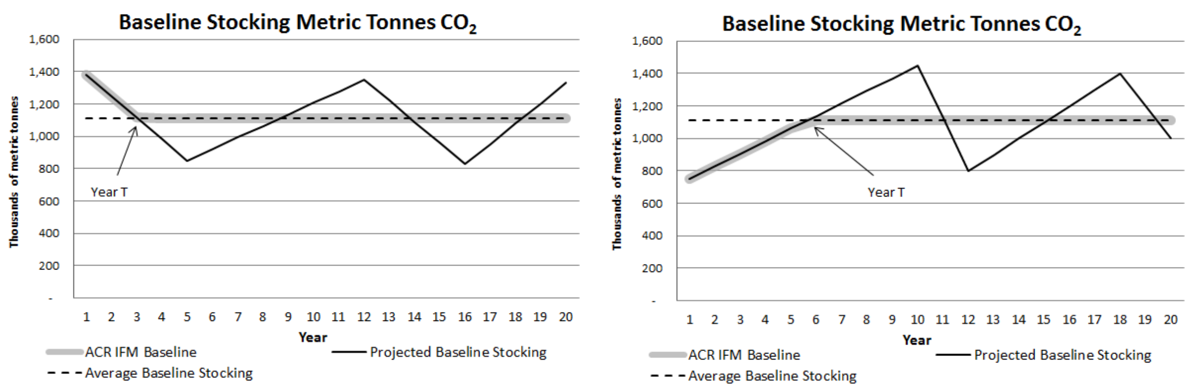
t	Time in years.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2e) including the initial value (i.e., **t** =0).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2e) at the end of year **t**.

Change in baseline carbon stock is computed for each time 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 Crediting Period (see Figure 2). The year that the projected stocking levels reach the long-term average (time $t = T$) is determined by either Equation 6 or 7, depending on initial stocking levels. Prior to time T, the projected stocking levels are used for the baseline stock change calculation, as determined by Equation 8. In the year that the projected stocking levels reach the long-term average (time $t = T$), the baseline stock change calculation is determined by Equation 9. Thereafter, the long-term average stocking level is used in the baseline stock change calculation, as determined by Equation 10.

Figure 2: Sample Baseline Stocking Graph

FOR PROJECT BEGINNING:

a) Above 20-year average baseline stocking   b) Below 20-year average baseline stocking



When initial baseline stocking levels (at year 0) are higher than the long-term average baseline stocking for the Crediting Period, use the following equation to determine when year t equals T:

Equation 6: Baseline Intersection with Higher Initial Stocking

$$\textbf{if } \left[\left(C_{BSL,TREE,t} + C_{BSL,DEAD,t}\right) \leq C_{BSL,AVE}\right] \textbf{ then } t = T$$

WHERE

t	Time in years.
T	Time at which baseline reaches the twenty-year average carbon stock.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2e).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2e) at the end of year **t**.

When initial baseline stocking levels (at year 0) are lower than the long-term average baseline stocking for the Crediting Period, use the following equation to determine when year t equals T:

Equation 7: Baseline Intersection with Lower Initial Stocking

$$\textbf{if } \left[\left(C_{BSL,TREE,t} + C_{BSL,DEAD,t}\right) \geq C_{BSL,AVE}\right] \textbf{ then } t = T$$

WHERE

t	Time in years.
T	Time at which baseline reaches the twenty-year average carbon stock.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2e).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year t.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2e) at the end of year t.

If the years elapsed since the start of the IFM project activity (t) is less than T, use the following equation to compute baseline stock change:

Equation 8: Change in Baseline Total Stocks before Intersection

$$\Delta C_{BSL,t} = \Delta C_{BSL,TREE,t} + \Delta C_{BSL,DEAD,t}$$

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year t.
$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock in above and belowground live trees (in metric tons CO_2e) during year t.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock in dead wood (in metric tons CO_2e) during year t.

Prior to year T the value of $\Delta C_{BSL,t}$ will most likely be negative for projects with initial stocking levels higher than $C_{BSL,AVE}$ or positive for projects with initial stocking levels lower than $C_{BSL,AVE}$.

If the years elapsed since the start of the IFM project activity (t) equals T, use the following equation to compute baseline stock change:

Equation 9: Change in Baseline Total Stocks at Intersection

$$\Delta C_{BSL,t} = C_{BSL,AVE} - (C_{BSL,TREE,t-1} + C_{BSL,DEAD,t-1})$$

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t**.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2e).
$C_{BSL,TREE,t-1}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of the year prior to year **t**.
$C_{BSL,DEAD,t-1}$	Baseline carbon stock in dead wood (in metric tons CO_2e) at the end of the year prior to year **t**.

If the years elapsed since the start of the IFM project activity (t) is greater than T, use the following equation to compute baseline stock change:

Equation 10: Change in Baseline Total Stocks after Intersection

$$\Delta C_{BSL,t} = 0$$

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t**.

4.3.1 STOCKING LEVEL PROJECTIONS IN THE BASELINE

$C_{BSL,TREE,t}$ and $C_{BSL,DEAD,t}$ 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 and approved by ACR. The GHG Project Plan must detail what model is being used and what variants and calibration processes have been selected. All model inputs and outputs (e.g., plot data, model selection, geographic variant, calibration for site-specific conditions, tree list outputs) must be available for inspection by the verifier, and the verifier shall document the methods used in validating the growth model in the validation report.

Forest Vegetation Simulator (FVS) is an approved growth model.

Other appropriate growth models may be used upon approval by ACR and demonstration of the following criteria:

- 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; and
- Parameterized for the specific conditions of the site.

The output of the models must include either projected total aboveground and belowground carbon per acre, volume in live tree biomass, or another appropriate unit by strata in the baseline. If the model output is volume, then this must be converted to biomass and carbon using the equations in Section 4.3.2. Where model projections are output in multi-year increments, the numbers shall be annualized to give stocking values for each year. The same model and calibration must be used in the baseline and with-project scenario stocking projections.

If including dead wood and processing of alternative data on dead wood is necessary, the steps in Section 4.3.3 must be used. Estimations of dead wood in the with-project scenario may remain static between measurement events or may be estimated using an approved growth model that predicts dead wood dynamics. Estimations of dead wood in the baseline scenario must be estimated using an approved growth model that predicts dead wood dynamics, if available. If a growth model approved for use by ACR does not predict dead wood dynamics, the baseline harvesting scenario may not decrease dead wood more than 50% through the Crediting Period. If included, standing dead wood must use the same biomass estimation technique (Section 4.3.2.1) as live trees.

4.3.2 TREE CARBON STOCK CALCULATION

The mean carbon stock in aboveground biomass per unit area is estimated based on field measurements in sample plots.[24] Professionally accepted principles of forest inventory must be

[24] Other potential sampling techniques are subject to review and approval by ACR prior to use.

applied. An inventory SOP document must be developed and attached to the GHG Project Plan for validation that describes the inventory process, including the following:

- Sample size;
- Determination of plot locations and numbers;
- Plot size and design, in-field location procedures, and monumentation;
- Whether plots are permanent or temporary;
- Data collected and measurement tools used;
- Detailed measurement procedures such that measurements are repeatable;
- Decay classification of standing dead wood, if an included pool;
- Process for recording missing volume, or tree class code as applicable, and how corresponding deductions for unsound wood were applied;
- Biomass estimation technique (Section 4.3.2.1);
- Components of the tree selected for biomass quantification;
- Data management systems and processes, including quality assurance / quality control (QA/QC) procedures;
- Procedures for updating the forest inventory, including following harvests or disturbances; and
- Equations and steps used to calculate uncertainty in each included carbon pool and emission source.

Use or adaptation of inventory SOPs already applied in national forest monitoring systems such as the United States Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) program,[25] available from published handbooks, or from the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance (GPG) for Land Use, Land Use Change and Forestry (LULUCF)[26] is recommended. 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 (i.e., fixed radius) or use variable radius sampling methods.

[25] U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2022) Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.2. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf

[26] Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Wagner, F. (2003) Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

Biomass for each tree is calculated using one of three estimation techniques (Section 4.3.2.1). The Project Proponent must use the same set of equations, diameter at breast height thresholds, and selected biomass components for *ex-ante* and *ex-post* baseline and with-project estimates.

To ensure accuracy and conservative estimation of the mean aboveground live biomass per unit area within the project area, projects must account for visibly missing and rotten portions of the tree in both the *ex-ante* and *ex-post* baseline and with-project scenarios. Determine missing volume deductions with cull attribute data (noting defects affecting carbon, not just merchantability) collected during field measurement of sample plots. Cull attribute data must be collected as percent missing from each third of the tree.

The following steps are used to estimate carbon in the aboveground portion of standing live trees:

Step 1 Determine the biomass of each tree based on appropriate volume and/or biomass equations (see Section 4.3.2.1).

Step 2 Adjust the calculation of biomass in standing live trees (from a 1 foot stump to the maximum height of the tree) to account for visibly missing and rotten portions of each third of the tree (i.e., cavities, broken tops, or other missing wood) using the distribution in Table 5.[27]

Cull attribute data must be based on the entire volume of each portion of the tree and assign a deduction (0-100%) for the missing and rotten volume. This method must also be applied to live trees with broken tops to account for the missing portion of snapped trees.

Table 5: Biomass Distribution by Thirds of the Tree

PORTION OF TREE	PERCENTAGE BIOMASS
Bottom-third	64.5%
Middle-Third	28.6%
Top-Third	6.9%

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

[27] Table 5 based on an analysis performed by Dehai Zhao, PhD, of Dahai Analytics LLC

Step 4 Determine the tree biomass estimate for each stratum by calculating a mean biomass per acre estimate from plot level biomass derived in Step 3 multiplied by the number acres in the stratum.

Step 5 Determine total project carbon (in metric tons CO_2e) by summing the biomass of each stratum for the project area and converting biomass to carbon by multiplying by 0.5, kilograms to metric tons by dividing by 1000, and finally carbon to CO_2e by multiplying by 3.664.

4.3.2.1 Biomass Estimation

One of the following biomass estimation techniques must be used:

Option 1 Generalized allometric regression equations for estimating biomass from 10 species groups (Jenkins et al. 2003; Table 4).[28] Appendix A assigns species to species groups. Biomass of above and belowground components must be estimated according to their component ratios (table 6);

Option 2 Biomass algorithms based on the regional volume equations from the USDA Forest Service National Volume Estimator Library,[29] as employed by default in the FVS Fire and Fuels Extension (Rebain et al. 2010).[30] The belowground biomass must be estimated using the Jenkins method (option 1 above). The correct variant for the project area must be selected; or

Option 3 Species specific volume and biomass estimators according to geographic region:[31]

[28] Jenkins, Jennifer C.; Chojnacky, David C.; Heath, Linda S.; Birdsey, Richard A. (2003). National scale biomass estimators for United States tree species. Forest Science. 49: 12-35

[29] U.S. Department of Agriculture, Forest Service, National Volume Estimator Library: https://www.fs.fed.us/forestmanagement/products/measurement/volume/nvel/

[30] Rebain, Stephanie A. comp. (2010, revised February 2022). The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. https://www.fs.usda.gov/fmsc/ftp/fvs/docs/gtr/FFEguide.pdf

[31] Adapted from the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects, June 25, 2015. https://ww3.arb.ca.gov/cc/capandtrade/protocols/usforest/forestprotocol2015.pdf.

Projects outside CA, OR, WA and AK must use the component ratio method described in Appendix K of the FIA Database Description and User Guide.[32] The methods described in Woodall et al. (2011)[33] are used to calculate gross and sound volumes by region and species.[34] Projects located in IA, IL, IN, KS, MI, MO, MN, ND, NE, SD, and WI must calculate sound volume using the equations specified in Table 5 of Appendix A.[35] For other states, gross volume must be converted to sound volume by subtracting rotten and missing volume. Other components, including belowground live and dead biomass, are estimated and adjusted according to Appendix K (Burrill et al. 2021). Aboveground components are summed for total aboveground biomass.

Projects in CA, OR or WA must use regional volume and biomass equations provided by the USDA FIA program. The Project Proponent must first estimate volume using the models and associated coefficients within “Volumetric Equations for California, Oregon, and Washington” (2014).[36] Biomass is then estimated using the equations within “Biomass Equations for California, Oregon, and Washington” (2014).[37] The CA, OR and WA volume models from Woodall et al. (2011) must not be used. Sum the aboveground standing live and aboveground standing dead tree carbon stocks and apply the methods described in Cairns et al. (1997; Table 3)[38] at the plot level to estimate belowground biomass density based on aboveground biomass density in tons per hectare. The live

[32] Burrill, Elizabeth A.; DiTommaso, Andrea M.; Turner, Jeffery A.; Pugh, Scott A.; Menlove, James; Christiansen, Glenn; Perry, Carol J.; Conkling, Barbara L. (2021). The Forest Inventory and Analysis Database: database description and user guide version 9.0.1 for Phase 2. U.S. Department of Agriculture, Forest Service. Appendix K: Biomass Estimation in the FIADB, K-1–K-8 p. https://www.fia.fs.usda.gov/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2_9-0-1_final.pdf

[33] Woodall, Christopher W.; Heath, Linda S.; Domke, Grant M.; Nichols, Michael C. (2011). Methods and equations for estimating aboveground volume, biomass, and carbon for trees in the U.S. forest inventory, 2010. Gen. Tech. Rep. NRS-88. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://www.nrs.fs.usda.gov/pubs/gtr/gtr_nrs88.pdf

[34] See the REF_SPECIES table, prepared by the Forest Inventory and Analysis Database, to determine correct coefficients, by downloading the accompanying files at: https://www.fs.usda.gov/research/treesearch/39555

[35] See the Sound Cubic Foot Volume Equation Coefficients, found on the Reference documents section of this methodology’s website, to determine correct coefficients.

[36] U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2014) Volume Estimation for the PNW-FIA Integrated Database. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2014/volume_equations.pdf

[37] U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2014) Regional Biomass Equations Used by FIA to Estimate Bole, Bark, and Branches. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2014/biomass_equations.pdf

[38] Cairns, M. A., Brown, S., Helmer, E. H., & Baumgardner, G. A. (1997). Root biomass allocation in the world's upland forests. *Oecologia*, *111*, 1-11. https://www.jstor.org/stable/4221653

and dead belowground pools may be separated by multiplying the belowground biomass density by each pool's respective proportion of total aboveground biomass. Calculation of belowground biomass must be consistent for both baseline and with-project scenarios.

Projects in AK must use regional biomass equations provided by the USDA FIA program.[39] The AK volume models found in Woodall et al. (2011) must not be used. Sum the aboveground standing live and aboveground standing dead tree carbon stocks and apply the methods described in Cairns et al. (1997) at the plot level to estimate belowground biomass density based on aboveground biomass density in tons per hectare. Calculation of belowground biomass must be consistent for both baseline and with-project scenarios.

Note that the same components must be calculated for *ex-ante* and *ex-post* baseline and with-project estimates.

4.3.3 DEAD WOOD CALCULATION

Dead wood included in the methodology comprises two components –standing dead wood (above and belowground) and lying dead wood. 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.

4.3.3.1 Standing Dead Wood (if included)

Step 1 Standing dead tree biomass shall be measured and estimated using the same criteria, monitoring frequency, and technique used for measuring and estimating biomass of live trees. The decomposed portion that corresponds to the original biomass is discounted in Step 2.

[39] U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2002) Alaska Biomass Equations. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2015/alaskabiomassequations.pdf

Step 2 Adjust the calculation of carbon to account for structural loss (i.e., cavities, broken tops, or other missing wood) and density reductions. Decay classes must be collected during field measurements according to the classification system of the USDA FIA program.[40]

For projects using Options 1 or 2 of 4.2.2.1:

Standing dead tree biomass must be adjusted for density reduction and structural loss using the Domke (2011) method.[41] Density reduction factors shall be based on either the hardwood/softwood default values found in Table 6 of Harmon et al. (2011)[42] or the species-specific values found in Appendix B. This choice must be applied consistently across the with-project and baseline scenarios. When applying density reduction factors from Appendix B and species are not available, Project Proponents must identify an appropriate decay class from the same genus (Appendix D). With either choice, class 5 standing dead wood must receive the density reduction factor for class 4. Structural loss factors for all species are found in Table 2 of Domke et al. (2011) for decay classes 1-5 for top, bark, bole, stump, and roots. The aboveground biomass must be adjusted for structural loss using either the component-specific factors in Domke et al. (2011) or Table 5's distribution by thirds in combination with field-collected cull attribute data (per Step 2 of Section 4.3.2.1); this choice must be applied consistently across the whole project. In either case, the structural loss adjustment factor for roots, found in Domke et al. (2011), must be applied to belowground biomass.

For projects using Option 3 of 4.2.2.1:

Projects outside AK, CA, OR, and WA: Standing dead tree biomass must be adjusted for density reduction and structural loss using the Domke (2011) method. Species-specific decay class and density reduction factors are found in Appendix B of Harmon et al. (2011). Where species are not found in Appendix B, Project Proponents must identify an appropriate decay class from the same genus (Appendix D). If not possible, use the hardwood/softwood default values found in Table 6 of Harmon et al. (2011). Class 5

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[40] U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2022) Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.2. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf.

[41] Domke, G. M., Woodall, C. W., & Smith, J. E. (2011). Accounting for density reduction and structural loss in standing dead trees: Implications for forest biomass and carbon stock estimates in the United States. *Carbon Balance and Management*, *6*, 1-11. https://link.springer.com/article/10.1186/1750-0680-6-14

[42] Harmon, M. E., Woodall, C. W., Fasth, B., Sexton, J., & Yatkov, M. (2011). Differences between standing and downed dead tree wood density reduction factors: a comparison across decay classes and tree species. *USDA For. Serv. Res. Pap. NRS-15*, 40. https://www.fs.usda.gov/research/treesearch/38699

standing dead wood must receive the density reduction factor for class 4. Structural loss factors for all species are found in Table 2 of Domke et al. (2011) for decay classes 1-5 for top, bark, bole, stump, and roots. The aboveground biomass must be adjusted for structural loss using either the component-specific factors in Domke et al. (2011) or Table 5's distribution by thirds in combination with field-collected cull attribute data (per Step 2 of Section 4.3.2.1); this choice must be applied consistently across the whole project. In either case, the structural loss adjustment factor for roots, found in Domke et al. (2011), must be applied to belowground biomass.

Projects in AK, CA, OR, and WA: Apply density conversion factors based on decay classes from Harmon et al. (2011).

Step 3 Using the sum of the selected biomass components for individual trees, determine the per plot estimate of total standing dead tree biomass for each plot.

Step 4 Determine the tree biomass estimate for each stratum by calculating a mean biomass per acre estimate from plot level biomass derived in Step 3 multiplied by the number acres in the stratum.

Step 5 Determine total project standing dead carbon (in metric tons CO_2e) by summing the biomass of each stratum for the project area and converting biomass to carbon by multiplying by 0.5, kilograms to metric tons by dividing by 1000, and finally carbon to CO_2e by multiplying by 3.664.

4.3.3.2 Lying Dead Wood (if included)

Accounting of carbon in the lying dead wood pool is optional, and stocks may or may not increase as the stands age (depending on previous and projected forest management). Where included, the following steps are required:

Step 1 Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996).[43, 44] At least two 50-meter lines (164 ft) are established bisecting each plot and the

[43] Harmon, M.E. and J. Sexton. (1996) Guidelines for measurements of wood detritus in forest ecosystems. U.S. LTER Publication No. 20. U.S. LTER Network Office, University of Washington, Seattle, WA, USA. https://andrewsforest.oregonstate.edu/sites/default/files/lter/pubs/webdocs/reports/detritus/publications/Guidelines%20for%20Measurements%20of%20Woody%20Detritus%20in%20Forest%20Ecosystems.pdf

[44] A variant on the line intersect method is described by Waddell, K. L. (2002). Sampling coarse woody debris for multiple attributes in extensive resource inventories. *Ecological indicators, 1*(3), 139-153.

diameters of the lying dead wood (≥ 10 cm diameter [≥ 3.9 inches]) intersecting the lines are measured.

Step 2 The dead wood is assigned to one of the three density states (sound, intermediate, and rotten) by species using the "machete test", as recommended by IPCC GPG LULUCF.[45] The following dead wood density class deductions must be applied to the three decay classes: For hardwoods, sound—no deduction, intermediate - 0.45, rotten - 0.42; for softwoods, sound—no deduction, intermediate - 0.71, rotten - 0.45.[46]

Step 3 The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[47] as modified by Van Wagner (1968)[48] separately for each density class.

Equation 11: Volume of Lying Dead Wood

$$V_{LDW,DC} = \pi^2 \left(\sum_{n=1}^{N} D_{n,DC}{}^2 \right) \div (8 \times L)$$

WHERE

$V_{LDW,DC}$	Volume (in cubic meters per hectare) of lying dead wood in density class DC per unit area.
$D_{n,DC}$	Diameter (in centimeters) of piece number n, of N total pieces in density class DC along the transect.
L	Length (in meters) of transect.

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

https://www.sciencedirect.com/science/article/abs/pii/S1470160X01000127. This method may be used in place of Steps 1 to 3.

[45] Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Wagner, F. (2003) Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

[46] USDA FIA Phase 3 proportions.

[47] Warren, W., & Olsen, P. F. (1964). A line intersect technique for assessing logging waste. *Forest science, 10*(3), 267-276. https://academic.oup.com/forestscience/article-abstract/10/3/267/4746187

[48] Van Wagner, C. E. (1968). The line intersect method in forest fuel sampling. *Forest science, 14*(1), 20-26. https://academic.oup.com/forestscience/article-abstract/14/1/20/4709615

Equation 12: Biomass of Lying Dead Wood

$$B_{LDW} = A \sum_{DC=1}^{3} V_{LDW,DC} \times WD_{DC}$$

WHERE

B_{LDW}	Biomass (in kilograms per hectare) of lying dead wood per unit area.
A	Area (in hectares).
$V_{LDW,DC}$	Volume (in cubic meters per hectare) of lying dead wood in density class DC per unit area.
WD_{DC}	Basic wood density (in kilograms per cubic meter) of dead wood in the density class — sound (1), intermediate (2), and rotten (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 by multiplying by 0.5, kilograms to metric tons by dividing by 1000, and finally carbon to CO_2e by multiplying by 3.664.

4.3.4 HARVESTED WOOD PRODUCTS

There are five steps required to account for the harvesting of trees and to determine carbon stored in wood products in the baseline and with-project scenarios:[49]

1. Determining the amount of carbon in trees harvested that is delivered to mills (bole without bark);
2. Accounting for mill efficiencies;
3. Estimating the carbon remaining in in-use wood products 100 years after harvest;
4. Estimating the carbon remaining in landfills 100 years after harvest; and
5. Summing the carbon remaining in in-use and landfill wood products 100 years after harvest.

[49] Adapted from Appendix C of the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects, June 25, 2015. https://ww3.arb.ca.gov/cc/capandtrade/protocols/usforest/forestprotocol2015.pdf.

Step 1 DETERMINE THE AMOUNT OF CARBON IN HARVESTED WOOD DELIVERED TO MILLS

The following steps must be followed to determine the amount of carbon in harvested wood if the biomass model does not provide metric tons carbon in the bole, without bark. If it does, skip to Step 2.

I. Determine the amount of wood harvested (actual or baseline) that will be delivered to mills, by volume (cubic feet) or by green weight (lbs.), and by species for the current year (y). In all cases, harvested wood volumes and/or weights must exclude bark.
   A. Baseline harvested wood quantities and species are derived from modeling a baseline harvesting scenario using an approved growth model.
   B. Actual harvested wood volumes and species must be based on verified third party scaling reports, where available. Where not available, documentation must be provided to support the quantity of wood volume harvested.
      i. If actual or baseline harvested wood volumes are reported in units besides cubic feet or green weight, convert to cubic feet using the following conversion factors:

Table 6: Volume Multipliers for Converting Timber and Chip Units to Cubic Feet or Cubic Meters

UNIT	FT^3 FACTOR	M^3 FACTOR
Bone Dry Tons	71.3	2.0
Bone Dry Units	82.5	2.3
Cords	75.0	2.1
Cubic Feet	1.0	0.0
Cubic Meters	35.3	1.0
Cunits-Chips (CCF)	100.0	2.8
Cunits-Roundwood	100.0	2.8
Cunits-Whole tree chip	126.0	3.6
Green tons	31.5	0.9
MBF-Doyle	222.0	6.3

MBF-International 1/4"	146.0	4.1
MBF-Scribner ("C" or "Small")	165.0	4.7
MBF-Scribner ("Large" or "Long")	145.0	4.1
MCF-Thousand Cubic Feet	1000.0	28.3
Oven Dried Tons	75.8	2.1

II. If a volume measurement is used, multiply the cubic foot volume by the appropriate green specific gravity by species from table 5-3a of the USFS Wood Handbook.[50] This results in pounds of biomass with zero moisture content. If a particular species is not listed in the USFS Wood Handbook, it shall be at the verifier's discretion to approve a substitute species. Any substitute species must be consistently applied across the baseline and with-project calculations.

III. If a weight measurement is used, subtract the water weight based on the moisture content of the wood. This results in biomass with zero moisture content.

IV. Multiply the dry weight values by 0.5 pounds of carbon/pound of wood to compute the total carbon weight.

V. Divide the carbon weight by 2,204.6 pounds/metric ton and multiply by 3.664 to convert to metric tons of CO_2e. Sum the CO_2e for each species into saw log and pulp volumes (if applicable), and then again into softwood species and hardwood species. These values are used in the next step (accounting for mill efficiencies). Please note that the categorization criteria (upper and lower DBH limits) for hardwood/softwood saw log and pulp volumes must be the same between the baseline and with-project scenarios.

Step 2 ACCOUNT FOR MILL EFFICIENCIES

Multiply the total carbon weight (metric tons of carbon) for each group derived in step 1 by the mill efficiency identified for the project's mill location(s) in the Wood Product Reference File.[51] This output represents the total carbon transferred into wood products. The

[50] U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. (2021). *Wood handbook - Wood as an engineering material*. General Technical Report FPL-GTR-282. https://www.fs.usda.gov/research/treesearch/62200

[51] Found on the Reference documents section of this methodology's website.

remainder (sawdust and other byproducts) of the harvested carbon is considered to be immediately emitted to the atmosphere for accounting purposes.

Step 3 ESTIMATE THE CARBON STORAGE 100 YEARS AFTER HARVEST IN IN-USE WOOD PRODUCTS

The amount of carbon that will remain stored in in-use wood products for 100 years depends on the rate at which wood products decay. Decay rates depend on the type of wood product that is produced and its end use. Thus, in order to account for the decomposition of harvested wood over time, a decay rate is applied to wood products according to their product class and destination. To approximate the climate benefits of carbon storage, this methodology accounts for the amount of carbon stored 100 years after harvest. Thus, decay rates for each wood product class have been converted into “storage factors” in the table below.

Table 7: 100-Year Storage Factors[52]

WOOD PRODUCT CLASS	IN-USE	LANDFILLS
Softwood Lumber	0.234	0.405
Hardwood Lumber	0.064	0.490
Softwood Plywood	0.245	0.400
Oriented Strandboard	0.349	0.347
Non-Structural Panels	0.138	0.454
Miscellaneous Products	0.003	0.518
Paper	0	0.151

STEPS TO ESTIMATE CARBON STORAGE IN IN-USE PRODUCTS 100 YEARS AFTER HARVEST

To determine the carbon storage in in-use wood products after 100 years, the first step is to determine what percentage of a project area’s harvest will end up in each wood product

[52] Smith, J. E. (2006). *Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States* (No. 343). United States Department of Agriculture, Forest Service, Northeastern Research Station. https://www.fs.usda.gov/research/treesearch/22954

class for each species (where applicable), separated into hardwoods and softwoods. This must be conducted by either:

- Obtaining a verified report from the mill(s) where the project area's logs are sold indicating the product categories the mill(s) sold for the year in question; or
- If a verified report cannot be obtained, looking up default wood product classes for the project's Supersection, as given in the Wood Product Reference File. A project's Supersection is determined using the GIS shapefiles,[53] for either the lower 48 states or Alaska respectively. Projects spanning multiple Supersections should use a weighted average wood product class distribution.

If breakdowns for wood product classes are not available from either of these sources, classify all wood products as "miscellaneous".

Once the breakdown of in-use wood product categories is determined, use the 100-year storage factors to estimate the amount of carbon stored in in-use wood products 100 years after harvest:

1. Assign a percentage to each product class for hardwoods and softwoods according to mill data or default values for the project.
2. Multiply the total carbon transferred into wood products by the % in each product class.
3. Multiply the values for each product class by the storage factor for in-use wood products.
4. Sum all the resulting values to calculate the carbon stored in in-use wood products after 100 years (in metric tons CO_2e).

Step 4 ESTIMATE THE CARBON STORAGE 100 YEARS AFTER HARVEST FOR WOOD PRODUCTS IN LANDFILLS

To determine the appropriate value for landfill carbon storage, perform the following steps:

1. Assign a percentage to each product class for hardwoods and softwoods according to mill data or default values for the project.
2. Multiply the total carbon transferred into wood products by the % in each product class.
3. Multiply the total carbon transferred into wood products (derived in step 3) for each product class by the storage factor for landfill carbon.

[53] Wood Product Reference File and Supersection shapefiles are found on the Reference documents section of this methodology's website.

4. Sum all the resulting values to calculate the carbon stored in landfills after 100 years (in metric tons CO_2e).

Step 5 DETERMINE TOTAL CARBON STORAGE IN WOOD PRODUCTS 100 YEARS AFTER HARVEST

The total carbon storage in wood products after 100 years for a given harvest volume is the sum of the carbon stored in landfills after 100 years and the carbon stored in in-use wood products after 100 years. This value is used for the calculation of ERRs (Equation 25). The value for the with-project harvested wood products will vary every year depending on the total amount of harvesting that has taken place. The baseline value is the twenty-year average value as calculated in Equation 4 and does not change from year to year, unless dynamic evalutations have affected quantification.

4.4 Monitoring Requirements for Crediting Period Renewal

A project's Crediting Period is the finite length of time for which a GHG Project Plan is valid, and during which a GHG Project can generate carbon credits against its baseline scenario. GHG projects will review and potentially adjust their baseline scenario according to the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*.

A Project Proponent may apply to renew the Crediting Period by performing the following:

- Re-submitting the GHG Project Plan in compliance with then-current *ACR Standard* and program rules and criteria;
- Re-evaluating the project baseline and generating *ex-ante* projections for the renewed Crediting Period;
- Demonstrating additionality against then-current regulations, common practice, and implementation barriers. Self-imposed legal constraints which explicitly reinforce the project activity put in place less than one year before or any time after the project Start Date are not considered legally binding for baseline constraint modeling or Crediting Period renewal.
- Using ACR-approved baseline methods, emission factors, and tools in effect at the time of Crediting Period renewal; and
- Undergoing validation and verification by an approved validation/verification body.

4.5 Estimation of Baseline Uncertainty

It is assumed that uncertainties associated with the estimates of the various carbon pools are available, either as default values given in IPCC Guidelines,[54] IPCC GPG LULUCF,[55] or estimates based on sound statistical sampling . Uncertainties arising from the measurement and monitoring of carbon pools and changes in carbon pools must be quantified. Indisputably conservative estimates of uncertainty may also be employed, provided they are justified with relevant verifiable literature and approved by ACR.

Stratification and the allocation of sufficient measurement plots can help minimize uncertainty. It is good practice to consider uncertainty at an early stage in project development to identify highly variable data pools and allow the opportunity to conduct further work to diminish uncertainty. Estimation of uncertainty for each measurement pool requires calculation of both the mean and the width of the 90% confidence interval.

Uncertainty in the baseline scenario should be defined as the weighted average uncertainty of each of the included pools. For measured or modeled live tree and dead wood (both standing and lying) carbon stock estimates, use the confidence interval of the input inventory data. Wood products also use the live tree inventory data. The uncertainty 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,

Equation 13: Baseline Uncertainty

$$\mathbf{UNC_{BSL}} = \sqrt{\frac{\left[\left(\mathbf{C_{BSL,TREE,0}} \times \mathbf{e_{BSL,TREE,0}}^2\right) + \left(\mathbf{C_{BSL,DEAD,0}} \times \mathbf{e_{BSL,DEAD,0}}^2\right) + \left(\bar{\mathbf{C}}_{\mathbf{BSL,HWP}} \times \mathbf{e_{BSL,TREE,0}}^2\right)\right]}{\left(\mathbf{C_{BSL,TREE,0}} + \mathbf{C_{BSL,DEAD,0}} + \bar{\mathbf{C}}_{\mathbf{BSL,HWP}}\right)}}$$

WHERE

[54] Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K. (2006). 2006 IPCC guidelines for national greenhouse gas inventories. https://www.osti.gov/etdeweb/biblio/20880391

[55] Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Wagner, F. (2003) Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

t	Time in years.
UNC_{BSL}	Percentage uncertainty in the combined carbon stocks in the baseline.
$C_{BSL,TREE,0}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2e) for the initial inventory at year 0.
$C_{BSL,DEAD,0}$	Baseline carbon stock in dead wood (in metric tons CO_2e) for the initial inventory at year 0.
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e).
$e_{BSL,TREE,0}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in above and belowground live trees (in metric tons CO_2e) for the initial inventory at year 0.
$e_{BSL,DEAD,0}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in dead wood (in metric tons CO_2e) for the initial inventory at year 0.

5 With-Project Scenario

5.1 Monitoring of Carbon Stocks in Selected Pools

With-project scenario stocks are determined by periodically remeasuring plots (data cannot be older than 10 years) according to the inventory SOP document and modeling carbon stocks to a discrete point in time. For sampling, information shall be provided and recorded in the GHG Project Plan to establish that professionally accepted principles of forest inventory and management are implemented. SOPs and 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 systems such as the USDA FIA program,[56] available from published handbooks, or the IPCC GPG LULUCF[57] is recommended. The inventory SOP document must describe how the project will update the forest inventory data following harvests or disturbances. Any changes to inventory practices from the originally validated inventory SOP document are subject to verification, must maintain or increase accuracy (in terms of the amount of relevant data collected, not necessarily the confidence interval of the mean), and shall be described in an updated inventory SOP document to be submitted to ACR.

Mill receipts or other harvest records for with-project harvests occurring within the Reporting Period must be provided for verification purposes.

The 90% statistical confidence interval of sampling can be no more than ±10% of the mean estimated amount of the combined carbon stock at the project area level.[58] If the Project Proponent cannot

[56] U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2022) Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.2. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf

[57] Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Wagner, F. (2003) Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

[58] For calculating a pooled confidence interval of carbon pools across strata, see equations in Shiver, B. D., & Borders, B. E. (1996). *Sampling techniques for forest resource inventory*. John Wiley and Sons. https://www.cabdirect.org/cabdirect/abstract/19970604413

meet the targeted ±10% of the mean at 90% confidence, then an uncertainty deduction is applied as determined by Section 7.5.

At a minimum, the following data parameters must be monitored:

- Project area;
- Sample plot area;
- Tree species;
- Tree biomass;
- Wood products volume; and
- Dead wood pool, if selected.

5.2 Estimation of With-Project Removals

This section describes the steps required to calculate $\Delta C_{P,t}$ (carbon stock change under the with-project scenario; metric tons CO_2e). This methodology requires:

- Carbon stock levels to be determined at the end of each Reporting Period, t;
- The change in with-project live tree and dead wood, if included, carbon stock to be computed from the end of the prior Reporting Period, t-1; and
- The Reporting Period value of with-project carbon stored in wood products 100 years after harvest to be calculated following Section 4.3.4 for the calculation of ERRs (Equation 25).

The following equations are used to construct the with-project stocking levels using models and forest inventory measurements described in Sections 4.3.1 and 4.3.2, respectively:

Equation 14: Change in With-Project Live Tree Stocks

$$\Delta C_{P,TREE,t} = \left(C_{P,TREE,t} - C_{P,TREE,t-1}\right)$$

WHERE

t	Time in years.
$\Delta C_{P,TREE,t}$	Change in the with-project carbon stock in above and belowground live trees (in metric tons CO_2e) during year **t**.
$C_{P,TREE,t}$	With-project carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Equation 15: Change in With-Project Dead Wood Stocks

$$\Delta C_{P,DEAD,t} = \left(C_{P,DEAD,t} - C_{P,DEAD,t-1}\right)$$

WHERE

t	Time in years.
$\Delta C_{P,DEAD,t}$	Change in the with-project carbon stock in dead wood (in metric tons CO_2e) during year **t**.
$C_{P,DEAD,t}$	With-project carbon stock in dead wood (in metric tons CO_2e) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Any reductions in carbon stocks due to harvests, disturbances, or slash burning that occurred during the Reporting Period must be accounted in Equations 14 and 15.

Use the following equation to compute change in the with-project carbon stock:

Equation 16: Change in With-Project Total Stocks

$$\Delta C_{P,t} = \Delta C_{P,TREE,t} + \Delta C_{P,DEAD,t}$$

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t**.
$\Delta C_{P,TREE,t}$	Change in the with-project carbon stock in above and belowground live trees (in metric tons CO_2e) during year **t**.
$\Delta C_{P,DEAD,t}$	Change in the with-project carbon stock in dead wood (in metric tons CO_2e) during year **t**.

5.2.1 TREE BIOMASS, DEAD WOOD, AND WOOD PRODUCTS

The Project Proponent must use the same set of equations used in Sections 4.3.2, 4.3.3, and 4.3.4 to calculate carbon stocks in the with-project scenario.

5.3 Monitoring of Activity-Shifting Leakage

Project Proponents and all associated landowners must demonstrate that there is no activity shifting leakage beyond *de minimis* within their operations – i.e., on other lands they manage/operate outside the boundaries of the GHG Project. This demonstration is not required if the Project Proponent and associated landowner(s) enroll all their forested landholdings, owned and under management control, within the GHG Project.

Such a demonstration must include one or more of the following:

- Entity-wide adherance to one or a combination of the sustainable management options specified in Section 1.3, covering all entity owned lands subject to Commercial Harvesting, including one or more of the following:
  - Management certification that requires sustainable practices (FSC, SFI, or ATFS);
  - Enrollment in a state sanctioned forestry program with monitoring and enforcement mechanisms in place and demonstration of compatibility with the Montréal Process Criteria (per Section 1.3.1);

- For private landowners owning less than 2,500 forested acres, provision of a documented long-term forest management plan, demonstrating sustainable forest management compatible with the Montréal Process Criteria (per Section 1.3.1), prepared and signed by a Professional Forester; or
- For tribal landowners, adherance to sustainable forest management practices informed by traditional knowledge (as specified in Section 1.3) and demonstration of compatibility with the Montréal Process Criteria (per Section 1.3.1).

- Forest management plans prepared ≥24 months prior to the start of the project showing harvest plans on all owned/managed lands compared with records from the with-project time period showing no unanticipated increase in harvests outside the project area;
- Historical records covering all ownership trends in harvest volumes compared with records from the with-project time period showing no deviation from historical trends over most recent 10-year average; or
- Verifiable evidence of no harvesting in a given Reporting Period for all lands owned or managed by participating entities (e.g., Project Proponent, landowner) and not enrolled in the GHG Project.

5.4 Estimation of Emissions Due to Market Leakage

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. Market leakage shall be quantified by one of the following:

- Applying the appropriate default market leakage discount factor (Equations 17, 18, 19, or 20):
  - Where project activities decrease total wood products produced by the project relative to the baseline by less than 5% over the Crediting Period, the market leakage deduction is 0%.

Equation 17: Less than 5% Market Leakage

$$\mathrm{LK} = 0$$

- 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 Crediting Period, the market leakage deduction is 10%.[59]

Equation 18: 5% to 25% Market Leakage

$$\mathbf{LK = 0.1}$$

- Where the project consists of multiple small private landowners (each owning less than 5,000 forested acres) and project activities decrease total wood products produced by the project relative to the baseline by more than 25%, the market leakage deduction is 20%.[60]

Equation 19: Small Landowner Market Leakage

$$\mathbf{LK = 0.2}$$

- Where the project consists of one or more large private landowners (owning more than 5,000 forested acres) or any non-private landowners and project activities decrease total wood products produced by the project relative to the baseline by more than 25%, the market leakage deduction is 30%.

Equation 20: General Market Leakage

$$\mathbf{LK = 0.3}$$

- Directly accounting for market leakage associated with the project activity:

Where directly accounting for leakage, market leakage shall be accounted for at the regional scale, applied to the same general forest type as the project (i.e., forests containing the same or substitutable commercial species as the forest in the project area), and must be based on verifiable methods for quantifying leakage. Methods and summary results must be provided in the GHG Project Plan and/or subsequent Monitoring Reports. It is at the verifier and ACR's discretion to determine whether the method for quantifying market leakage is appropriate for the project.

[59] We assume that any decrease in production would be transferred to forests of a similar type.

[60] Based on ACR's *Methodology for the Quantification, Monitoring, Reporting, and Verification of Greenhouse Gas Emission Reductions and Removals from Improved Forest Management on Small Non-Industrial Private Forestlands* and citations therein supporting a 20% market leakage deduction for small private landowners.

5.5 Estimation of With-Project Uncertainty

Uncertainty in the with-project scenario is defined as the weighted average error of each of the measurement pools, including live trees and, if included, standing dead wood and lying dead wood. If the with-project carbon stocks in live trees and dead wood are derived from modeling (Section 4.3.1), use the confidence interval ($e_{P,TREE/DEAD,t}$) of the input inventory data. For wood products with measured and documented harvest volume removals use zero as the confidence interval (instead of $e_{P,TREE,t}$; Equation 21). For estimated wood product removal use the confidence interval of the live tree inventory data ($e_{P,TREE,t}$). 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,

Equation 21: With-Project Uncertainty

$$UNC_{P,t} = \sqrt{\frac{\left[\left(C_{P,TREE,t} \times e_{P,TREE,t}{}^2\right) + \left(C_{P,DEAD,t} \times e_{P,DEAD,t}{}^2\right) + \left(C_{P,HWP,t} \times e_{P,TREE,t}{}^2\right)\right]}{\left(C_{P,TREE,t} + C_{P,DEAD,t} + C_{P,HWP,t}\right)}}$$

WHERE

t	Time in years.
$UNC_{P,t}$	Percentage uncertainty in the combined carbon stocks in the project for year **t**.
$C_{P,TREE,t}$	With-project carbon stock in above and belowground live trees (in metric tons CO_2e) at the end of year **t**.
$C_{P,DEAD,t}$	With-project carbon stock in dead wood (in metric tons CO_2e) at the end of year **t**.
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.
$e_{P,TREE,t}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the carbon stock in above and belowground live trees (in metric tons CO_2e) for the most recent inventory used to estimate stocking at the end of year **t**.

$e_{P,DEAD,t}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the carbon stock in dead wood (in metric tons CO_2e) for the most recent inventory used to estimate stocking at the end of year **t**.

6 Ex-ante Estimation

The Project Proponent must make an *ex-ante* calculation of GHG ERRs for all included sinks and sources for the entire Crediting Period. These projections must be included in the GHG Project Plan. Project Proponents shall provide estimates of the values of those parameters that are not available before the start of monitoring activities. Project Proponents must retain a conservative approach in making these estimates.

Ex-ante projections must be based on best available knowledge of expected with-project management as of the project Start Date. However, *ex-ante* projections do not bind the with-project scenario forest management over the Crediting Period.

The methods required by this methodology will primarily dictate how *ex-ante* projections are calculated. However, when selecting values not dictated by this methodology, *ex-ante* projections must be based on:

- Data from well-referenced peer-reviewed literature or other well-established published sources;
- 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 Project Plan. For any data provided by experts, the GHG Project Plan shall also record the expert's name, affiliation, and principal qualification as an expert.

When selecting values based on data 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 GHG ERRs, taking into account uncertainties. Project Proponents must choose data such that it tends to underestimate, rather than overestimate, net GHG ERRs and include data sources in the description of methods and assumptions within the GHG Project Plan.

7 QA/QC, Validation, Verification, and Uncertainty

7.1 Methods for Quality Assurance

An inventory SOP document, including data management systems and processes and QA/QC procedures, must be developed according to the requirements of this methodology (Section 4.3.2). These systems, processes, and procedures are subject to validation and subsequent verifications. Use or adaptation of SOPs already applied in national forest monitoring systems such as the USDA FIA program,[61] available from published handbooks, or the *IPCC GPG LULUCF 2003* is recommended. A stratification SOP document must also be developed (Section 3).

7.2 Methods for Quality Control

Project Proponents shall consider all relevant information that may affect the accounting and quantification of GHG ERRs, including estimating and accounting for any decreases in carbon pools and/or increases in GHG emission sources. This methodology sets a *de minimis* threshold of 3% of the final calculation of ERRs. 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 minimis* threshold. Any exclusion using the *de minimis* principle shall be justified using fully documented *ex-ante* calculations.

7.3 Validation

In accordance with the *ACR Standard* and the *ACR Validation and Verification Standard*, projects must be validated by an ACR-approved validation/verification body prior to its first ERT issuance. Validation may be conducted in conjunction with the project's initial full verification or as a stand-alone

[61] Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.1. 2021. U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf.

validation activity. Projects must be validated in accordance with the *ACR Standard* and by deadlines established therein (generally, within three years of the project Start Date).

In addition to the scope set out by the *ACR Standard* and the *ACR Validation and Verification Standard* Scope, validation shall assess:

- Conformance with eligibility, applicability, and sustainable forest management requirements;
- Compatibility of the forest management plan with the Montréal Process Criteria (if applicable; Section 1.3.1);
- Project geographic boundaries;
- Physical infrastructure, activities, technologies, and processes;
- GHGs, sources, and sinks within the project boundary;
- Project temporal boundary;
- Stratification procedures and implementation, if applicable;
- Description of and justification of the baseline scenario, including the selection of ownership and constraints, the substantiation of Common Practice Silviculture, the methods and results of the financial analysis (Section 4.1), and all required reporting (Section 4.2);
- Methodologies and calculation procedures used to generate estimates of baseline and with-project scenario stocks, emission reductions, and removals (including growth model selection and parameterization);
- Procedures for measuring carbon stocks (inventory SOPs);
- Data management systems and QA/QC procedures;
- Processes for estimating, calculating, and accounting for project-level uncertainty; and
- Roles and responsibilities of participating entities (e.g., Project Proponent, landowner).

The Project Proponent must provide sufficient documentation and data to enable required validation activities.

7.4 Verification

Projects developed with this methodology must undergo verification by an ACR-approved validation/verification body at each request for issuance of ERTs. As further described by the *ACR Standard*, for the initial Reporting Period, and no less frequently than every 5 years of reporting thereafter, projects must conduct a full verification including a site visit to the project site. Projects may choose to perform desk-based verifications more frequently in interim years.

In addition to the scope set out by the *ACR Standard* and the *ACR Validation and Verification Standard*, verification shall assess:

- Continued regulatory surplus and conformance with eligibility, applicability, and sustainable forest management requirements;
- Project geographic boundary updates;
- Temporal boundary of the Reporting Period;
- Stratification updates;
- Application and results of the *Tool for Dynamic Evaluation of Baselines for ACR IFM Methodologies*;
- Calculations used to generate estimates of emissions, emission reductions, and removals;
- Assessment of growth model outputs and projections;
- Original underlying data and documentation as relevant and required to evaluate the GHG assertion;
- Ongoing adherence to activity-shifting leakage requirements;
- Implementation of procedures for measuring carbon stocks (full verifications only; Section 7.4.1);
- Implementation of data management systems and QA/QC procedures;
- Results from uncertainty assessments; and
- Updates to roles and responsibilities of participating entities (e.g., Project Proponent, landowner).

The Project Proponent must provide sufficient documentation and data to enable required verification activities.

7.4.1 RESAMPLING OF CARBON STOCK MEASUREMENTS

In addition to any other activities needed by the verifier to provide a reasonable level of assurance that the ERT assertion is without material discrepancy, full verification field visits must include a resampling of the carbon stock measurements, to be carried out according to the following specifications:

- The resampled carbon stock measurements must statistically agree with the project's carbon stock measurements using a two-tailed Student's t-test at the 90% confidence interval. If the project's forest inventory is comprised of permanent plots that may be efficiently relocated by the verifier, this test shall be paired. Otherwise, this test shall be unpaired, requiring installation of resampling plots at new locations;

- The minimum number of resampling plots shall be determined by calculating the square root of the most recent forest inventory's plot count:

Equation 22: Minimum Resampling Plot Count

$$n_{RESAMPLE} = \sqrt{n_{INVENTORY,t}}$$

WHERE

t	Time in years.
$n_{RESAMPLE}$	Minimum number of resampling plots.
$n_{INVENTORY,t}$	Total number of sampling plots in the most recent inventory used to estimate stocking at the end of year t.

- If the forest inventory has been stratified, resampling may include the lesser of either 1) five (5) strata selected by the verifier based on a strategic assessment of risk, or 2) fewer than five (5) strata comprising ≥90% of the proportional project carbon stocks. The Student's t-test(s) may be performed either independently by strata, or at a consolidated project level, so long as absence of bias and statistical agreement of the t-test(s) can be demonstrated; and
- Resampling plot allocation may be based on a strategic assessment of risk, proportional carbon stocking, proportional acreage, or another reasonable and demonstrably non-biased method. Plot selection and resampling sequence must be systematic and non-biased. This might be accomplished by assigning a plot sequence prior to the field visit and progressing through the sequence until both the minimum number of resampling plots and the required statistical agreement are reached.

In addition to the reporting requirements set forth in the *ACR Validation and Verification Standard*, verification reports pertaining to full verifications with field visits must include details about the resampling effort, including how it conformed to the aforementioned specifications.

7.5 Calculation of Total Uncertainty and Uncertainty Deduction

The following equation must be applied to calculate total uncertainty:

Equation 23: Total Uncertainty

$$\mathbf{UNC_t} = \sqrt{\frac{\left[\left(\left|\Delta C_{BSL,t}\right| + \bar{C}_{BSL,HWP}\right) \times UNC_{BSL}{}^2\right] + \left[\left(\left|\Delta C_{P,t}\right| + C_{P,HWP,t}\right) \times UNC_{P,t}{}^2\right]}{\left(\left|\Delta C_{BSL,t}\right| + \bar{C}_{BSL,HWP}\right) + \left(\left|\Delta C_{P,t}\right| + C_{P,HWP,t}\right)}}$$

WHERE

t	Time in years.
UNC_t	Total uncertainty for year **t**, in %.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t** (Section 4.3).
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e), prorated for Reporting Period duration.
UNC_{BSL}	Baseline uncertainty, in % (Section 4.5).
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t** (Section 5.2).
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.
$UNC_{P,t}$	With-project uncertainty for year **t**, in % (Section 5.5).

The *ACR Standard* sets a statistical precision requirement of ±10% of the mean with 90% confidence. When total uncertainty is beyond this threshold, an uncertainty deduction affects the calculation of ERRs. The following equation must be applied to calculate an uncertainty deduction ($UNC_{DED,t}$):

Equation 24: Uncertainty Deduction

$$\textbf{if } [UNC_t \leq 10\%] \textbf{ then } UNC_{DED,t} = 0\%$$

or

$$\textbf{if } [UNC_t > 10\%] \textbf{ then } UNC_{DED,t} = UNC_t - 10\%$$

WHERE

t	Time in years.
UNC_t	Total uncertainty for year **t**, in %.
$UNC_{DED,t}$	Uncertainty deduction to be applied in calculation of ERRs for year **t**, in %.

8 Calculation of ERTs

This section describes the process of determining Total and Net GHG Emission Reductions and Removals for a Reporting Period for which a valid Verification Report has been accepted by ACR. Total GHG Emission Reductions and Removals ($ERR_{RP,t}$) are calculated using Equation 25 by adjusting the difference between the with-project and baseline carbon stock changes for leakage and uncertainty.

Equation 25: Total Emission Reductions and Removals

$$\mathbf{ERR_{RP,t} = [(\Delta C_{P,t} - \Delta C_{BSL,t}) + (C_{P,HWP,t} - \bar{C}_{BSL,HWP})] \times (1 - LK) \times (1 - UNC_{DED,t})}$$

WHERE

t	Time in years.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t** (Section 5.2).
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t** (Section 4.3).
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t** (Section 4.3.4).
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2e), prorated for Reporting Period duration (Equation 4 and Section 4.3.4).
LK	Market leakage discount (Section 5.4).
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t** (Section 7.5).

If the Project Proponent has chosen Buffer Pool Contributions as their risk mitigation mechanism, Total GHG Emission Reductions and Removals are then multiplied by a Buffer Pool Contribution Percentage (Equation 26) to calculate the Reporting Period's Buffer Pool Contribution. Subtracting this contribution calculates Net GHG Emission Reductions and Removals (i.e., the ERTs issued to the Project Proponent; Equation 27).

Equation 26: Buffer Pool Contribution

$$BUF_{RP,t} = ERR_{RP,t} \times BUF$$

WHERE

t	Time in years.
$BUF_{RP,t}$	Buffer Pool Contribution (in metric tons CO_2e) in Reporting Period **t**.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
BUF	Buffer Pool Contribution Percentage as calculated in Section 2.5. **BUF** may be set to zero if an ACR approved alternate risk mitigation mechanism is used.

Equation 27: Net Emission Reductions and Removals

$$ERR_{NETRP,t} = ERR_{RP,t} - BUF_{RP,t}$$

WHERE

t	Time in years.
$ERR_{NETRP,t}$	Net GHG Emission Reductions and Removals (in metric tons CO_2e) issued in Reporting Period **t**.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
$BUF_{RP,t}$	Buffer Pool Contribution (in metric tons CO_2e) in Reporting Period **t**.

Net GHG Emission Reductions and Removals by Vintage shall then be determined by prorating Reporting Period calendar days within Vintage year y (Equation 28), applying the Buffer Pool Contribution Percentage (Equation 29) and subtracting the Buffer Pool Contribution by Vintage year from the Total ERR by Vintage (Equation 30). Buffer Pool Contributions will be deposited by Vintage, if this is the risk mitigation mechanism the Project Proponent has chosen.

Equation 28: Total Emission Reductions and Removals by Vintage

$$\mathbf{ERR_{VIN,y} = ERR_{RP,t} \times (CAL_y / RP_{CAL,t})}$$

WHERE

t	Time in years.
y	Year of ERT Vintage.
$ERR_{VIN,y}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Vintage year **y**.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
CAL_y	Reporting Period calendar days within Vintage year **y**.
$RP_{CAL,t}$	Total calendar days within Reporting Period **t**.

Equation 29: Buffer Pool Contribution by Vintage

$$\mathbf{BUF_{VIN,y} = ERR_{VIN,y} \times BUF}$$

WHERE

y	Year of ERT Vintage.
$BUF_{VIN,y}$	Buffer Pool Contribution (in metric tons CO_2e) in Vintage year **y**.
$ERR_{VIN,y}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Vintage year **y**.
BUF	The Buffer Pool Contribution Percentage as calculated in Section 2.5. **BUF** may be set to zero if an ACR approved alternate risk mitigation mechanism is used.

Equation 30: Net Emission Reductions and Removals by Vintage

$$\mathbf{ERR_{NETVIN,y} = ERR_{VIN,y} - BUF_{VIN,y}}$$

WHERE

y	Year of ERT Vintage.
$ERR_{NETVIN,y}$	Net GHG Emission Reductions and Removals (in metric tons CO_2e) in Vintage year **y**.
$ERR_{VIN,y}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Vintage year **y**.
$BUF_{VIN,y}$	Buffer Pool Contribution (in metric tons CO_2e) in Vintage year **y**.

The Project Proponent may elect to distinguish between Removals ($REM_{RP,t}$) and Emission Reductions ($ER_{RP,t}$) for a given Reporting Period with a positive Total GHG Emission Reductions and Removals. In the context of this methodology, Removals are carbon stock changes resulting in sequestration attributable to the with-project scenario and are calculated by adjusting the with-project carbon stock change for leakage and uncertainty. Emission Reductions are carbon stock changes attributable to the baseline scenario and are calculated as the Total GHG Emission Reductions and Removals minus Removals (Equation 33). If distinguishing, Removals and Emission Reductions must be allocated to Vintage years following the procedure outlined in Equations 32 and 34, respectively.

Equation 31: Removals

$$\mathbf{if\ \left[\left(\Delta C_{P,t} + C_{P,HWP,t}\right) \times (1 - LK) \times \left(1 - UNC_{DED,t}\right) \geq ERR_{RP,t}\right]\ then\ REM_{RP,t} = ERR_{RP,t}}$$

or

$$\mathbf{if\ \left[\left(\Delta C_{P,t} + C_{P,HWP,t}\right) \times (1 - LK) \times \left(1 - UNC_{DED,t}\right) < ERR_{RP,t}\right]\ then\ REM_{RP,t} = \left(\Delta C_{P,t} + C_{P,HWP,t}\right) \times (1 - LK) \times \left(1 - UNC_{DED,t}\right)}$$

WHERE

t	Time in years.
$REM_{RP,t}$	Total Removals (in metric tons CO_2e) in Reporting Period **t**.

$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t**.
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) for the project for during year **t**.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
LK	Market leakage discount.
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t**.

Equation 32: Removals by Vintage

$$\mathbf{REM_{VIN,y} = REM_{RP,t} \times (CAL_y / RP_{CAL,t})}$$

WHERE

t	Time in years.
y	Year of ERT Vintage.
$REM_{VIN,y}$	Total Removals (in metric tons CO_2e) in Vintage year **y**.
$REM_{RP,t}$	Total Removals (in metric tons CO_2e) in Reporting Period **t**.
CAL_y	Reporting Period calendar days within Vintage year **y**.
$RP_{CAL,t}$	Total calendar days within Reporting Period **t**.

Equation 33: Emission Reductions

$$\mathbf{ER_{RP,t} = ERR_{RP,t} - REM_{RP,t}}$$

WHERE

t	Time in years.

$ER_{RP,t}$	Total Emission Reductions (in metric tons CO_2e) in Reporting Period **t**.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
$REM_{RP,t}$	Total Removals (in metric tons CO_2e) in Reporting Period **t**.

Equation 34: Emission Reductions by Vintage

$$ER_{VIN,y} = ER_{RP,t} \times (CAL_y / RP_{CAL,t})$$

WHERE

t	Time in years.
y	Year of ERT Vintage.
$ER_{VIN,y}$	Total Emission Reductions (in metric tons CO_2e) in Vintage year **y**.
$ER_{RP,t}$	Total Emission Reductions (in metric tons CO_2e) in Reporting Period **t**.
CAL_y	Reporting Period calendar days within Vintage year **y**.
$RP_{CAL,t}$	Total calendar days within Reporting Period **t**.

8.1 Negative Project Stock Change, Reversals, and Termination

Negative project stock change ($ERR_{RP,t}$) before the first carbon credit issuance is a negative balance of greenhouse gas emissions, to be compensated by the project prior to any future issuance. After the first carbon credit issuance, negative project stock change ($ERR_{RP,t}$) is a Reversal. Reversals must be reported and compensated following requirements detailed in the *ACR AFOLU Carbon Project Reversal Risk Mitigation Agreement* and the *ACR Buffer Pool Terms and Conditions*.[62]

As outlined in the *ACR Buffer Pool Terms and Conditions*, sequestration projects will terminate automatically if a Reversal causes the with-project live biomass carbon and dead wood pools, in sum, to decrease below the long-term average baseline stocking level ($C_{BSL,AVE}$) at any point prior to the end of the Minimum Project Term. Projects with initial stocking levels lower than long-term average baseline stocking are subject to this requirement only after with-project stocks first exceed the long-term average baseline stocking level.

[62] Available under the Program Resources section of the ACR website.

Definitions

Activity-Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner.
Carrying Costs	Property taxes, mortgage interest, and insurance premiums.
Carbon dioxide (CO_2)	All pools and emissions in this methodology are represented by either CO_2 or CO_2 equivalents. Biomass is converted to carbon by multiplying by 0.5 and then to CO_2 by multiplying by the molecular weight ratio of CO_2 to Carbon (3.664).
Commercial Harvesting	Any type of harvest producing merchantable material at least equal to the value of the direct costs of harvesting. Harvesting of dead, dying, or threatened trees (regardless of merchantability) is specifically excluded from this definition where a signed attestation from a Professional Forester is provided, confirming the harvests are in direct response to isolated forest health (insect/disease) or natural disaster event(s) not part of a long-term harvest regime.
Common Practice Silviculture	Baseline silvicultural prescriptions and Harvest Intensities which have been substantiated according to Section 4.1.2.5.
Ex-ante	Prior to the occurrence and verification of a project emission mitigation activity.
Ex-post	After the event, a measure of past performance.
Forestland	Land with at least 10 percent cover (or equivalent stocking) by live trees of any size, or land formerly having such tree cover, and not currently developed for non-forest uses. Forestland must be at least 1 acre in size.[63]
Harvest Intensity	Percent biomass removed per acre per year, relative to a property's relevant stratum size, as further defined by Section 4.1.2.5.1.

[63] Based on U.S. Forest Service Forest Inventory and Analysis program definition:

U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2021) The Forest Inventory and Analysis Database: Database Description and User Guide for Phase 2, version 9.1. page 2-38. https://www.fia.fs.usda.gov/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2_9-0-1_final.pdf

Long-term Forest Management Plan	A written document that guides current and future management practices to meet defined management objectives over ten years or longer.[64]
Market Leakage	Increases in harvest levels on lands outside the project area due to shifts in the supply of and demand for wood products.
Native Species	Trees listed as native to a particular region by the Native Plant Society, SAF Forestry Handbook, or State-adopted list, and as further defined by the *ACR Standard*.
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.
Professional Forester	An individual engaged in the profession of forestry. If a project is in a jurisdiction that has professional forester licensing laws, the individual must be credentialed in that jurisdiction.[65] Otherwise, the individual must be certified by the Society of American Foresters[66] or Association of Consulting Foresters.[67]
Ton	A unit of mass equal to 1000 kg.
Tree	A perennial woody plant with a diameter at breast height (4.5') greater than or equal to 1" with the capacity to attain a minimum diameter at breast height of 5" and a minimum height of 15' (shrub species are not eligible).[68]

[64] Based on Food and Agriculture Organization of the United Nations' Global Forest Resources Assessment 2020: https://www.fao.org/3/I8661EN/i8661en.pdf

[65] For projects located in multiple jurisdictions with professional forester licensing laws, the individual must be credentialed in at least one of the jurisdictions.

[66] https://www.eforester.org/Main/Certification_Education/Certified_Forester/Main/Certification/Certification_Home.aspx?hkey=53f11286-5500-4c13-a371-251dd0df0d7a

[67] https://www.acf-foresters.org/

[68] Based on U.S. Forest Service Forest Inventory and Analysis program definition:

U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2022) Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.2. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf

Appendix A: Confidentiality of Proprietary Information

While it remains in the interest of the general public for Project Proponents to be as transparent as possible regarding projects, some may choose to designate certain parts of the GHG Project Plan or other project documentation as Commercially Sensitive Information (see definition in the *ACR Standard)*. If the Project Proponent chooses to identify information as Commercially Sensitive, they must upload the confidential documentation in separate files marked "Confidential" to the Registry and, if the information meets the ACR definition of Commercially Sensitive Information, this information shall not be made available to the public. ACR and the VVB shall utilize this information only to the extent required to validate/verify, register the project, and issue ERTs. If parts of a GHG Project Plan, Monitoring Report, or required appendices/addendums/attachments of either contain Commercially Sensitive Information, the Project Proponent must also upload versions to be made publicly available.

Appendix B: References

Burrill, Elizabeth A.; DiTommaso, Andrea M.; Turner, Jeffery A.; Pugh, Scott A.; Menlove, James; Christiansen, Glenn; Perry, Carol J.; Conkling, Barbara L. (2021). The Forest Inventory and Analysis Database: database description and user guide version 9.0.1 for Phase 2. U.S. Department of Agriculture, Forest Service. Appendix K: Biomass Estimation in the FIADB, K-1–K-8 p. https://www.fia.fs.usda.gov/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2_9-0-1_final.pdf

Cairns, M. A., Brown, S., Helmer, E. H., & Baumgardner, G. A. (1997). Root biomass allocation in the world's upland forests. *Oecologia, 111*, 1-11. https://www.jstor.org/stable/4221653

California Air Resources Board. (2015) Compliance Offset Protocol - U.S. Forest Projects (adopted June 25, 2015). https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/forestprotocol2015.pdf

Domke, G. M., Woodall, C. W., & Smith, J. E. (2011). Accounting for density reduction and structural loss in standing dead trees: Implications for forest biomass and carbon stock estimates in the United States. *Carbon Balance and Management, 6*, 1-11. https://link.springer.com/article/10.1186/1750-0680-6-14

Eggleston, H. S., Buendia, L., Miwa, K., Ngara, T., & Tanabe, K. (2006). 2006 IPCC guidelines for national greenhouse gas inventories. https://www.osti.gov/etdeweb/biblio/20880391

Fargione, J. E., Bassett, S., Boucher, T., Bridgham, S. D., Conant, R. T., Cook-Patton, S. C., ... & Griscom, B. W. (2018). Natural climate solutions for the United States. *Science Advances*, *4*(11), eaat1869. https://doi.org/10.1126/sciadv.aat1869

Food and Agriculture Organization of the United Nations. (2020). Global Forest Resources Assessment. https://www.fao.org/3/I8661EN/i8661en.pdf

Franzluebbers, A. J. (2021). Soil organic carbon sequestration calculated from depth distribution. *Soil Science Society of America Journal, 85*(1), 158-171. https://doi.org/10.1002/saj2.20176

Harmon, M.E. and J. Sexton. (1996) Guidelines for measurements of wood detritus in forest ecosystems. U.S. LTER Publication No. 20. U.S. LTER Network Office, University of Washington, Seattle, WA, USA. https://andrewsforest.oregonstate.edu/sites/default/files/lter/pubs/webdocs/reports/detritus/publications/Guidelines%20for%20Measurements%20of%20Woody%20Detritus%20in%20Forest%20Ecosystems.pdf

Harmon, M. E., Woodall, C. W., Fasth, B., Sexton, J., & Yatkov, M. (2011). Differences between standing and downed dead tree wood density reduction factors: a comparison across decay classes and tree species. *USDA For. Serv. Res. Pap. NRS-15*, 40. https://www.fs.usda.gov/research/treesearch/38699

Jenkins, J. C., 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. https://www.fs.usda.gov/ne/newtown_square/publications/other_publishers/OCR/ne_2003jenkins01.pdf

Kaarakka, L., Cornett, M., Domke, G., Ontl, T., & Dee, L. E. (2021). Improved forest management as a natural climate solution: A review. Ecological Solutions and Evidence, 2(3), e12090. https://doi.org/10.1002/2688-8319.12090

Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Wagner, F. (2003) Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

Pokharel, R., & Latta, G. S. (2020). A network analysis to identify forest merchantability limitations across the United States. Forest policy and economics, 116, 102181. https://www.sciencedirect.com/science/article/abs/pii/S1389934119301765.

Rebain, Stephanie A. comp. (2010, revised February 2022). The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. https://www.fs.usda.gov/fmsc/ftp/fvs/docs/gtr/FFEguide.pdf

Shiver, B. D., & Borders, B. E. (1996). *Sampling techniques for forest resource inventory*. John Wiley and Sons. https://www.cabdirect.org/cabdirect/abstract/19970604413

Smith, J. E. (2006). *Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States* (No. 343). United States Department of Agriculture, Forest Service, Northeastern Research Station. https://www.fs.usda.gov/research/treesearch/22954

U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2022) Forest Inventory and Analysis national core field guide, volume I: Field data collection procedures for phase 2 plots, version 9.2. https://www.fia.fs.usda.gov/library/field-guides-methods-proc/docs/2022/core_ver9-2_9_2022_SW_HW%20table_rev_12_13_2022.pdf

U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis National Program. (2021) The Forest Inventory and Analysis Database: Database Description and User Guide for Phase 2, version 9.1. https://www.fia.fs.usda.gov/library/database-documentation/current/ver90/FIADB%20User%20Guide%20P2_9-0-1_final.pdf

U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. (2021). *Wood handbook - Wood as an engineering material*. General Technical Report FPL-GTR-282. https://www.fs.usda.gov/research/treesearch/62200

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2002) Alaska Biomass Equations. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2015/alaskabiomassequations.pdf

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2014) Regional Biomass Equations Used by FIA to Estimate Bole, Bark, and Branches. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2014/biomass_equations.pdf

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. (2014) Volume Estimation for the PNW-FIA Integrated Database. https://ww2.arb.ca.gov/sites/default/files/cap-and-trade/protocols/usforest/2014/volume_equations.pdf

U.S. Environmental Protection Agency. (2022) AP-42, Air Pollutant Emission Factors, section 1.6.3.2. https://www.epa.gov/system/files/documents/2022-03/c1s6_final_0.pdf

U.S. Environmental Protection Agency. (2023). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. U.S. Environmental Protection Agency, EPA 430-R-23-002. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021

Van Wagner, C. E. (1968). The line intersect method in forest fuel sampling. *Forest science, 14*(1), 20-26. https://academic.oup.com/forestscience/article-abstract/14/1/20/4709615

Waddell, K. L. (2002). Sampling coarse woody debris for multiple attributes in extensive resource inventories. *Ecological indicators, 1*(3), 139-153. https://www.sciencedirect.com/science/article/abs/pii/S1470160X01000127

Warren, W., & Olsen, P. F. (1964). A line intersect technique for assessing logging waste. *Forest science, 10*(3), 267-276. https://academic.oup.com/forestscience/article-abstract/10/3/267/4746187

Woodall, C. W., Heath, L. S., Domke, G. M., & Nichols, M. C. (2011). Methods and equations for estimating aboveground volume, biomass, and carbon for trees in the US forest inventory, 2010.

Gen. Tech. Rep. NRS-88. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station, 30. https://www.nrs.fs.usda.gov/pubs/gtr/gtr_nrs88.pdf