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

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

VERSION 2.0

July 2022

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 carbon offset 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

Activity-Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner.
ATFS	American Tree Farm System
BIA	Bureau of Indian Affairs
Carrying Costs	Property taxes, mortgage interest, and insurance premiums.
CO_2	Carbon Dioxide. 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.
Crediting Period	The period of time in which the baseline is considered to be valid and project activities are eligible to generate ERTs.
DBH	Diameter at breast height
De minimis	Threshold of 3% of the final calculation of emission reductions and removals.
Emission Reduction	The measured decrease of GHG emissions over a specific period relative to an approved baseline. In the context of this methodology, emission reductions are carbon stock changes attributable to the baseline scenario.
ERT	Emission Reduction Ton
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. Land proposed for inclusion in this project area shall meet the cover requirement, in aggregate, over the entire area.
FSC	Forest Stewardship Council
GHG	Greenhouse gas
GIS	Geographic information system
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
Market Leakage	Increases in harvest levels on lands outside the project area due to shifts in the supply of and demand for wood products.
Minimum Project Term	The minimum period for which a Project Proponent commits to project monitoring and verification.
Native Species	Trees listed as native to a particular region by the Native Plant Society, SAF Forestry Handbook, or State-adopted list.
NGO	Non-governmental organization
NPV	Net present value. The difference between the present value of cash inflows and the present value of cash outflows over the life of the project.
PDA	Programmatic Development Approach
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. Otherwise, the individual must be certified by the Society of American Foresters or Association of Consulting Foresters.
Project Proponent	An individual or entity that undertakes, develops, and/or owns a project. This may include the project investor, developer, and/or owner of the lands/facilities on which project activities are conducted. The Project Proponent and land/or timber rights owner may be different entities.

QA/QC	Quality assurance/quality control
Removal	The mass of GHGs removed from the atmosphere over a specific period relative to an approved baseline. In the context of this methodology, removals are carbon stock changes resulting in sequestration attributable to the with-project scenario.
Reporting Period	The period of time covering a GHG assertion for a single verification and subsequent request for ERT issuance.
Reversal	An intentional or unintentional event that results in emission into the atmosphere of stored or sequestered CO_2e for which offset credits were issued, as further defined by the *ACR Standard.*
SFI	Sustainable Forestry Initiative
SOP	Standard operating procedures
Start Date	The point in time when project crediting begins, coinciding with the start of the first crediting period and as further defined by section 2.3 and the *ACR Standard.*
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).

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1 Methodology Description

1.1 Scope and Definitions

This methodology is designed to quantify GHG emission reductions and removals resulting from carbon projects that reduce emissions by exceeding baseline forest management practices. Removals are quantified for increased sequestration through retention of forest growth when project activities exceed the baseline.[1]

Baseline determination is project-specific and must describe the harvesting scenario that would maximize net present value (NPV) of wood products harvests per the assumptions in section 4.1, where various NPV discount rates for different timber ownership classes are used as proxies for their respective forest management objectives. The with-project scenario entails reduced harvest levels and increased retention of forest growth compared to the baseline scenario. The difference between baseline and with-project scenario carbon stocks forms the basis of ERT issuance.

Project Proponents must 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 Applicability Conditions

- This methodology is applicable only on non-federally owned or managed[2] 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.[3]
- The methodology applies to lands that can be legally harvested by entities owning or controlling timber rights on forestland.

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

[2] 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 NPV discount rate of the entity retaining full control of timber and carbon rights must be employed for baseline setting.

[3] See also ACR Guidance for Carbon Project Development on Tribal Lands available under the Guidance, Tools & Templates section of the ACR website.

- Participating entities (e.g., Project Proponent, landowner) must demonstrate ownership or control of timber rights for the entirety of the project area at the project start date and throughout the crediting period.
- The project must demonstrate an increase in onsite stocking levels above the baseline scenario by the end of the crediting period.
- Use of non-native species is specifically prohibited where adequately stocked native stands were converted for forestry or other land uses.
- Manipulation of water tables or filling of wetlands is prohibited.

1.3 Sustainable Management Requirements

All projects must adhere to the following sustainable management requirements over the crediting period:

- Project areas subject to commercial harvesting at the project start date in the with-project scenario must adhere to one or a combination of the following:
  - Be certified by FSC, SFI, or ATFS or become certified within one year of the project start date;
  - Be enrolled in a state sanctioned forestry program with monitoring and enforcement mechanisms in place;
  - For private landowners owning less than 2,500 forested acres, provide a documented long-term forest management plan, demonstrating sustainable forest management (per section 1.3.1), prepared and signed by a professional forester.
  - Federally recognized tribes[4] must demonstrate a current BIA approved forest management plan. Non-federally recognized tribal lands may utilize one or more of the sustainable management demonstrations above or, in the absence of such verifiable evidence, may 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.
- 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 life cycle, the project area must meet the requirements outlined above before commercial harvesting may occur.

[4] https://www.bia.gov/service/tribal-leaders-directory/federally-recognized-tribes

1.3.1 FOREST MANAGEMENT PLAN REQUIREMENTS

Private landowners owning less than 2,500 forested acres may fulfill the sustainable management requirement by providing a documented long-term forest management plan prepared and signed by a professional forester. Projects must identify how their plan is compatible with Criteria 1 through 6 of the Montréal Process Criteria and Indicators.[5] Criterion 5 (Maintenance of forest contribution to global carbon cycles) is satisfied by enrollment in the carbon 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.

Compatibility with the Montréal Process Criteria may be reported within the forest management plan or as an addendum using this methodology's reporting form.[6] References to specific Indicators from the Montréal Process may be provided but are not required.

1.4 Pools and Sources

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

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

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

		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* as a result of project implementation.
Soil organic carbon	Excluded	Changes in the soil carbon pool are considered *de minimis* as a result of project implementation.

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 negligible.
N_2O	Burning of biomass	Excluded	Potential emissions are negligible.

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 5.4).

	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.

2 Eligibility, Boundaries, Additionality, and Permanence

2.1 Project Eligibility

This methodology applies to non-federally owned or managed U.S. forestlands that are able to document 1) clear land title or timber rights and 2) offsets title. Projects must also meet all other requirements of the *ACR Standard* version effective at project listing or time of crediting period renewal and requirements set out therein.

This methodology applies to lands that could be legally harvested by entities owning or controlling timber rights.

Project Proponents must demonstrate that the project area, in aggregate, meets the methodology definition of forestland.

2.2 Project Geographic Boundary

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

- Project area map, delineated on a geographic information system;
- General location map; and
- Property parcel map or recognized equivalent.

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,[7] which provide guidelines for aggregating multiple landholdings into a single project to reduce per-acre transaction costs of monitoring, reporting, and verification.

2.3 Project Temporal Boundary

The project start date may be denoted by one of the following:

- Land acquisition or easement enrollment 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
- The date that the Project Proponent first demonstrated good faith effort to implement a carbon project. Such demonstrations must include documented evidence of:
  - The date the Project Proponent initiated a forest inventory for a carbon project;
  - The date that the Project Proponent entered into a contractual relationship or signed a corporate or board resolution to implement a carbon 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.

2.4 Additionality

Projects must apply a three-prong 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.

[7] Available under the Guidance, Tools & Templates section of the ACR website.

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 removals or emissions reductions associated with a project action or its baseline candidates, and which require technical, performance, or management actions. Where project lands were purchased with donor funds, this includes confirmation that funding stipulations do not prohibit baseline activities. All legally binding conditions of easements enacted either more than 1 year before or more than 3 years after the project start date must also be considered. Regulatory surplus must be confirmed at each verification. Voluntary guidelines are not considered in the regulatory surplus test.

The common practice test requires an evaluation of the predominant forest management practices of the 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 carbon offset 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. Projects initially deemed to go beyond common practice are considered to meet the requirement for the duration of their crediting period. If common practice adoption rates of a particular practice change during the crediting period, this may make the project ineligible for renewal but does not affect its additionality during the current crediting period.

The implementation barrier test examines any factor or consideration 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 revenues that is lower than the Project Proponents established minimum acceptable rate. Financial barriers can also include high risks such as unproven technologies or business models, poor credit rating of project partners, and project failure risk. When applying the financial implementation barrier test, Project Proponents should include quantitative evidence such as NPV and internal rate of return calculations. The results of the financial analysis (NPV) for the baseline and with-project scenarios must be provided with the GHG Project Plan, demonstrating that the baseline is more profitable. Since carbon revenue incentivizes the otherwise less profitable project activity, the with-project scenario's NPV does not need to account for the sale of carbon credits. The project must face capital constraints that carbon revenues can potentially address; or carbon funding must reasonably be expected to incentivize the project's implementation; or carbon 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.

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 loss of sequestered carbon, 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 contributions to the buffer pool, insurance, or other risk mitigation measures approved by ACR.

If using a buffer contribution to mitigate reversals, the Project Proponent must conduct a risk assessment addressing both general and project-specific risk factors. General risk factors include risks such as financial failure, technical failure, management failure, rising land opportunity costs, regulatory and social instability, and natural disturbances. Project-specific risk factors vary by project type 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. If they are using an alternate ACR-approved risk mitigation product, this risk assessment is not applicable.

Project Proponents must conduct their risk assessment using the *ACR Tool for Risk Analysis and Buffer Determination*.[8] The output of this tool is an overall risk category for the project, expressed as a percentage, translating into the buffer deduction that must be applied in the calculation of net ERTs (Equations 26 and 29). This deduction must be applied unless the Project Proponent uses another ACR-approved risk mitigation product.

[8] Available under the Guidance, Tools & Templates section of the ACR website.

3 Stratification

If the project activity area is not homogeneous, 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 should contain information necessary such that the stratification can be examined and duplicated as necessary to provide reasonable assurance of the validity and non-bias of associated techniques. 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 management practices diverge. For estimation of initial carbon stocks, strata should be defined on the basis of parameters correlated to forest carbon stocking, for example:[9]

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

Stratification defined by parameters closely correlated to forest carbon stocks will decrease the likelihood of a required uncertainty deduction (section 7.5). If stratifying, Project Proponents must present in the GHG Project Plan an *ex ante* stratification of the project area. The number and boundaries of the strata defined *ex ante* may change during the crediting period (*ex post*).

The *ex post* stratification may be updated based on relevant changes to with-project scenario management, 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) may be implemented in a way that affects the existing stratification; or
- Established strata may be merged if reason for their establishment has disappeared.

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

4 Baseline Scenario

4.1 Identification of Baseline

The ACR IFM methodology[10] (originally approved by ACR in September 2010), takes a Faustmann approach to baseline determination. The literature supporting Faustmann's original 1849 work forms the basis for modern optimal rotation/investment decisions and forest economics (summarized in Newman 2002[11]), in addition to appearing in over 300 other book and journal articles.

Baseline determination is project-specific and represents a harvesting scenario that could be implemented to maximize NPV of wood products harvests over a 100-year modeling period, considering all legal and operational constraints to forest management. An NPV discount rate between 3 – 6% is assigned as a determinant for how a given landowner within a particular forestland timber ownership class would base their forest management decisions (Table 1).[12] This technique provides a transparent and systematic metric by which landowners, project developers, verifiers, and offset purchasers can base their assessment of an ACR IFM carbon project across all major non-federal U.S. timber ownership classes.

Project Proponents shall employ the baseline discount rate values in Table 1 corresponding to the current timber ownership class to model a project-specific NPV-maximizing baseline scenario, unless the ownership was recently acquired (less than 5 years of project start date) in which case the discount rate of the previous ownership class may be employed. NPV discount rates are assigned and weighted across the entirety of the project area based upon timber rights ownership. Project Proponents then design a with-project scenario for the purposes of increased carbon sequestration. The difference between baseline and with-project scenario carbon stocks is the basis for determining ERTs attributable to the project.

Table 1: Discount Rates for Net Present Value Determinations by U.S. Forestland Timber Ownership Class

[10] ACR Approved Methodology (2010), Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberlands. Finite Carbon Corporation. https://acrcarbon.org/methodology/improved-forest-management-ifm-on-non-federal-u-s-forestlands/ifm-methodology-for-non-federal-u-s-forestlands_v1-0_semptember-2011_final/

[11] Newman, D.H. 2002. Forestry's golden rule and the development of the optimal forest rotation literature. J. Econ. 8: 5–27

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

TIMBER OWNERSHIP CLASS	ANNUAL DISCOUNT RATE
Private Industrial	6%
Private Non-Industrial	5%
Tribal[13]	5%
Non-Federal Public	4%
Non-Governmental Organization	3%

Baseline silvicultural prescriptions must perpetuate existing onsite timber producing species while fully utilizing available growing space, and must be relevant to the forest type(s), ecological condition(s), and/or species/product mixture of the project area. Prescriptions must be substantiated according to the requirements of section 4.1.1.

All legally binding constraints to forest management (with the exception of easements enacted less than 1 year before or less than 3 years after the project start date) must be considered in baseline modeling. These include all existing laws, regulations, legal rulings, deed restrictions, and other relevant regulatory frameworks (such as legally binding terms and conditions associated with the land acquisition, or donor funding restrictions regulating the amount or type(s) of timber harvest that can occur on the property). Best management practices to protect water, soil stability, forest productivity, and wildlife, as published or prescribed by applicable federal, state, or local government agencies are also considered legally binding constraints to forest management. The resulting harvest schedule is used to establish baseline stocking levels throughout the crediting period. If new legal constraints are enacted during a crediting period that legally prohibit the modeled silvicultural practices or harvest removals, the baseline must be evaluated and re-modeled as necessary on a forward-moving basis, respecting these legally binding constraints for the remainder of the crediting period.

Required inputs for the project NPV calculation include the results of a recent forest inventory of the project lands, prices for wood products of grades that the project would produce, costs of logging, reforestation, and related costs, silvicultural treatment costs, and relevant carrying costs. Project Proponents shall include roading and harvesting costs as appropriate to the terrain and unit size, and

[13] Federally recognized tribes are classified under the "Tribal" ownership class. Non-federally recognized tribes are considered private ownerships and must be classified under either the "Private Industrial" or "Private Non-Industrial" ownership classes, depending on ownership characteristics.

timber included in baseline harvest must be demonstrably accessible and operable. Project Proponents must model growth of forest stands over 100 years. Project Proponents may use a constrained optimization program that calculates the maximum NPV for the harvesting schedule while meeting any forest practice legal requirements. The annual real (without inflation) discount rate for each non-federal timber ownership class given in Table 1 must be applied. Wood products must be accounted and included in the calculation of ERTs (Equation 24).

The baseline scenario's harvested timber output must not exceed regional mill capacity for the species and size forest products produced throughout the crediting period. Mills must be within hauling distances that allow the baseline's forest management activities to be economical. The feasibility of the baseline harvest regime must be demonstrated with mill reports, testimony from a professional forester, published literature from a state or federal agency, or other verifiable evidence.

Exceptions to the requirement that the baseline management scenario shall perpetuate existing onsite timber producing species may be made where it can be demonstrated that a baseline management scenario involving replacement of existing onsite timber producing species (e.g., where forest is converted to plantations, replacing existing onsite timber producing species) is feasible and has been implemented in the region within 10 years of the project start date. This shall be substantiated either by (1) demonstrating with management records that the baseline management scenario involving replacement of existing onsite timber producing species has been implemented within 10 years of the project start date on other lands in the project area region owned or managed by the timber rights owner (or by the previous timber rights owner) or by (2) providing dated (from previous 10 years) aerial imagery or other remote sensing that identifies at least two properties (of similar forest type, ecological condition, or species/product mixture) in the project area region showing, first, the initial or existing onsite timber, and second, the replacement use (e.g., commercial plantation). The areas of forest conversion identified must have combined acreage equal to or greater than the annual acreage converted in the project baseline scenario.

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

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

[14] ISO 14064-2:2006(E)

4.1.1 BASELINE REPORTING

The GHG Project Plan must include the following baseline metrics:

- A general description of the baseline management scenario over the crediting period, including how the baseline scenario compares to regional common practice.
- Descriptions of baseline silvicultural prescriptions, including trees retained (e.g., residual volumes, species), harvest frequency, and regeneration assumptions. One or more of the following sources must substantiate the choice of baseline silvicultural prescriptions and their relevance to the ecological conditions of the project area:
  - Publications, statements, or attestations from state or federal agencies;
  - Written statements or attestations from a regional professional forester(s);
  - Peer-reviewed or academic publications;
  - Management records of the silvicultural prescriptions applied in similar forest conditions within the last 10 years; or
  - Other verifiable evidence that the baseline silvicultural prescriptions have been employed in similar forests of the region.
- A list of any and all legal constraints affecting baseline forest management, including:
  - A description of each constraint and its effect upon baseline forest management;
  - The geographic extent of each constraint;
  - The governing agency or body associated with each constraint; and
  - A description of how each constraint is considered in the baseline scenario.
- If the baseline employs the discount rate of the previous ownership class, evidence of the recent acquisition (less than 5 years from the project start date) must be provided.

4.1.2 CONFIDENTIALITY OF PROPRIETARY INFORMATION

While it remains in the interest of the general public for Project Proponents to be as transparent as possible regarding carbon projects, the Project Proponent may choose at their own option to designate proprietary financial information as confidential. If the Project Proponent chooses to identify information related to financial performance as confidential, the Project Proponent must submit the confidential baseline and with-project documentation in a separate file marked “Confidential” to ACR and this information shall not be made available to the public. ACR and the validation/verification

body shall utilize this information only to the extent required to register the project and issue ERTs. If the Project Proponent chooses to keep financial information confidential, a publicly available GHG Project Plan must still be provided to ACR.

4.2 Estimation of Baseline Emission Reductions

Baseline carbon stock change must be calculated for the entire crediting period. The baseline stocking level used for the stock change calculation is derived from the baseline management scenario developed in section 4.1. 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 carbon stocks to be computed for each time period, t; and
- The long-term average value of baseline carbon stored in wood products 100 years after harvest to be calculated following section 4.2.4 and Equation 3 for the calculation of ERTs (Equation 24).

The following equations are used to construct the baseline stocking levels using the models described in section 4.2.1 and wood products calculations described in section 4.2.4:

Equation 1

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

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_2) during year **t**.
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Equation 2

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

WHERE

t	Time in years.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock in dead wood (in metric tons CO_2) during year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Equation 3

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

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_2).
$C_{BSL,HWP,t}$	Baseline carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2) during year **t**.

NOTE: Please see section 4.2.4 for detailed instructions on baseline wood products calculations.

Any projected reductions in carbon stocks due to harvests, disturbances, or slash burning in the baseline must be properly accounted in Equations 1 and 2.

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

Equation 4

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

WHERE

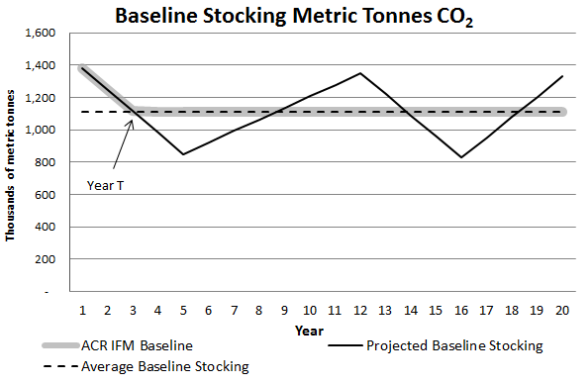
t	Time in years.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2) including the initial value (i.e., t =0).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2) at the end of year t.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2) 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 1). The year that the projected stocking levels reach the long-term average (time $t = T$) is determined by either Equation 5 or 6, 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 7. 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 8. Thereafter, the long-term average stocking level is used in the baseline stock change calculation, as determined by Equation 9, and only with-project removals are credited for the remaining years in the crediting period.

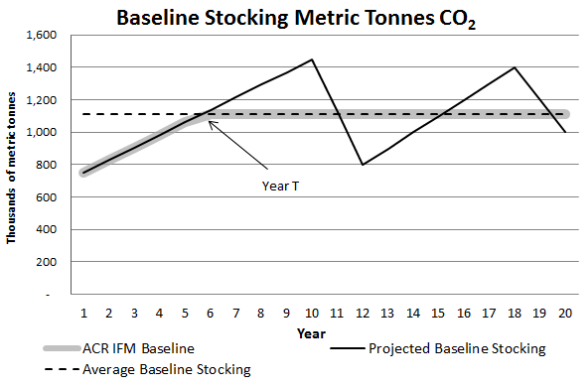
Figure 1: Sample Baseline Stocking Graph

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 5

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

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_2).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2) at the end of year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2) 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 6

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

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_2).
$C_{BSL,TREE,t}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2) at the end of year **t**.
$C_{BSL,DEAD,t}$	Baseline carbon stock in dead wood (in metric tons CO_2) 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 7

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) during year **t**.
$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock in above and belowground live trees (in metric tons CO_2) during year **t**.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock in dead wood (in metric tons CO_2) 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 8

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) during year **t**.
$C_{BSL,AVE}$	Twenty-year average baseline carbon stock (in metric tons CO_2).
$C_{BSL,TREE,t-1}$	Baseline carbon stock in above and belowground live trees (in metric tons CO_2) 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_2) 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 9

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) during year **t**.

4.2.1 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 and yield 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 aboveground tree biomass, or another appropriate unit by strata in the baseline. Where model projections are output in multi-year increments, the numbers shall be annualized to give a stock change number for each year. The same model must be used in baseline and with-project scenario stocking projections.

If the model output is volume, then this must be converted to biomass and carbon using the steps in section 4.2.2. If processing of alternative data on dead wood is necessary, the steps in section 4.2.3 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 4.2.2.1) as live trees.

4.2.2 TREE CARBON STOCK CALCULATION

The mean carbon stock in aboveground biomass per unit area is estimated based on field measurements in sample plots.[15] 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 applicable;
- Process for recording missing volume, or tree class code as applicable, and how corresponding deductions for unsound wood were applied;
- Biomass estimation technique (section 4.2.2.1);
- Data management systems and processes, including QA/QC procedures; and
- Procedures for updating the forest inventory, including following harvests or disturbances.

Use or adaptation of inventory SOPs already applied in national forest monitoring systems such as the USDA FIA program,[16] available from published handbooks, or from the *IPCC GPG LULUCF 2003* 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 or use variable radius sampling methods.

Biomass for each tree is calculated using one of three estimation techniques (section 4.2.2.1). 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 missing portions of the tree in both the *ex ante* and *ex post* baseline and with-project scenarios. Determine missing volume deductions with cull attribute

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

[16] USDA FIA program: 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.

data (noting defects affecting carbon, not just merchantability) collected during field measurement of sample plots.

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 4.2.2.1).

Step 2 Adjust the calculation of biomass in standing live trees to account for missing portions of the tree (i.e., cavities, broken tops, or other missing wood).

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.

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_2) 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_2 by multiplying by 3.664.

4.2.2.1 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).[17] 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,[18] as employed by default in the FVS Fire and

[17] 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

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

Fuels Extension (Rebain et al. 2010).[19] 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:[20]

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.[21] The methods described in Woodall et al. (2011)[22] are used to calculate gross and sound volumes by region and species.[23] 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.[24] 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).[25] Biomass is then estimated using the equations within

[19] Rebain, Stephanie A. comp. 2010 (revised June 28, 2021). 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. 407 p.

[20] Adapted from the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects, June 25, 2015.

[21] 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.

[22] 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.

[23] See the REF_SPECIES table, prepared by the Forest Inventory and Analysis Database, to determine correct coefficients: https://apps.fs.usda.gov/fia/datamart/CSV/REF_SPECIES.zip

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

[25] Volume Estimation for the PNW-FIA Integrated Database; 2014. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

"Biomass Equations for California, Oregon, and Washington" (2014).[26] 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)[27] at the plot level to estimate belowground biomass density based on aboveground biomass density in tons per hectare. The live 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.[28] 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.

4.2.3 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.

4.2.3.1 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

[26] Regional Biomass Equations Used by FIA to Estimate Bole, Bark, and Branches; 2014. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

[27] Cairns, Michael A.; Brown, Sandra; Helmer, Eileen H.; Baumgardner, Greg A. 1997. Root biomass allocation in the world's upland forest. Oecologia. 111: 1-11

[28] Alaska Biomass Equations; 2002. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

trees. The decomposed portion that corresponds to the original biomass is discounted in Step 2.

Step 2 Adjust the calculation of carbon to account for missing portions of the tree (i.e., cavities, broken tops, or other missing wood).

Standing dead tree biomass must be adjusted for density reductions and structural loss. Decay classes must be collected during field measurements according to the classification system of the USDA FIA program.[29]

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.[30] Density reduction factors shall be based on either the hardwood/softwood default values found in Table 6 of Harmon et al. (2011)[31] 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. If aboveground biomass is estimated without separating into the components specified in Table 2, the structural loss adjustment factor for roots may be used alone.

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

[29] 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.

[30] 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. 6:14.

[31] 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. Res. Pap. NRS-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 40 p.

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 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.

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_2) 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_2 by multiplying by 3.664.

4.2.3.2 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).[32, 33] At least two 50-meter lines (164 ft) are established bisecting each plot and the diameters of the lying dead wood (≥ 10 cm diameter [≥ 3.9 inches]) intersecting the lines are measured.

Step 2 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 Good Practice

[32] 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.

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

Guidance for LULUCF.[34] 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.[35]

Step 3 The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[36] as modified by Van Wagner (1968)[37] separately for each density class.

Equation 10

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

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:

Equation 11

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

WHERE

B_{LDW}	Biomass (in kilograms per hectare) of lying dead wood per unit area.

[34] 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

[35] USDA FIA Phase 3 proportions

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

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

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_2 by multiplying by 3.664.

4.2.4 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:[38]

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.

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.

[38] Adapted from Appendix C of the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects, June 25, 2015.

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:

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.[39] 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 CO2. Sum the CO2 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.[40] This output represents the total carbon transferred into wood products. The 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

[39] Forest Products Laboratory. Wood handbook - Wood as an engineering material. General Technical Report FPL-GTR-190. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory: 508 p. 2010.

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

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.

100-YEAR STORAGE FACTORS[41]

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 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

[41] Smith J.E, Heath L.S., Skog K.E., Birdsey R.A. (2006) Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. In: General Technical Report NE-343 (eds Usdafs), PP. 218. USDA Forest service, Washington, DC, USA.

Supersection is determined using the GIS shapefiles,[42] 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 units of CO_2-equivalent metric tons).

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.
4. Sum all the resulting values to calculate the carbon stored in landfills after 100 years (in units of CO_2-equivalent metric tons).

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

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

products after 100 years. This value is used for the calculation of ERTs (Equation 24). 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 3 and does not change from year to year.

4.3 Monitoring Requirements for Baseline Renewal

A project's crediting period is the finite period of time for which the baseline scenario is valid and during which a project can generate offsets against its baseline. Once validated for a crediting period, a project's baseline scenario is fixed, unless legal constraints change such that the baseline scenario is no longer legally permissible (per section 4.1).

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 standards and criteria;
- Re-evaluating the project baseline;
- Demonstrating additionality against then-current regulations, common practice, and implementation barriers. Stipulations of easements put in place less than one year before or less than three years after the project start date are not considered legally binding for baseline constraint modeling or baseline 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.

4.4 Estimation of Baseline Uncertainty

It is assumed that uncertainties associated with the estimates of the various carbon pools are available, either as estimates based on sound statistical sampling, or as default values given in IPCC Guidelines (2006) or IPCC GPG-LULUCF (2003). 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 expressed as the weighted average uncertainty of each of the included pools. For measured or modeled carbon stock estimates and wood products use the confidence interval of the input 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.

Model uncertainty is not included in the assessment of baseline or project uncertainty. Standardization of models for baseline and with-project projections should minimize the impacts of model uncertainties on differences between with-project and baseline values.

Therefore,

Equation 12

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

WHERE

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_2) for the initial inventory at year 0.
$C_{BSL,DEAD,0}$	Baseline carbon stock in dead wood (in metric tons CO_2) 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_2).
$e_{BSL,TREE,0}$	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_2) 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_2) for the initial inventory at year 0.

5 With-Project Scenario

5.1 Monitoring Project Implementation

Information shall be provided, and recorded in the GHG Project Plan, to establish:

- The geographic position of the project boundary is recorded for all areas of land;
- The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded, and archived. This may be achieved 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);
- Professionally accepted principles of forest inventory and management are implemented;
- Stratification procedures are applied and described in a stratification SOP document (section 3); and
- SOPs and QA/QC procedures for forest inventory, including field data collection and data management, are applied and described in an inventory SOP document (section 4.2.2).

5.2 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,[43] available from published handbooks, or the *IPCC GPG LULUCF 2003* is recommended. The inventory SOP document must describe how the project will update the

[43] USDA FIA program: 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.

forest inventory data following harvests or disturbances. 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.[44] If the Project Proponent cannot 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.

5.3 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; tons CO_2). This methodology requires:

- Carbon stock levels to be determined at the end of each reporting period, t;
- The change in with-project 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 4.2.4 for the calculation of ERTs (Equation 24).

The following equations are used to construct the with-project stocking levels using models and forest inventory measurements described in sections 4.2.1 and 4.2.2, respectively:

[44] For calculating pooled confidence interval of carbon pools across strata, see equations in Barry D. Shiver, Sampling Techniques for Forest Resource Inventory (John Wiley & Sons, Inc, 1996).

Equation 13

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

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_2) during year **t**.
$C_{P,TREE,t}$	With-project carbon stock in above and belowground live trees (in metric tons CO_2) at the end of year **t**, and **t-1** signifies the value at the end of the prior year.

Equation 14

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

WHERE

t	Time in years.
$\Delta C_{P,DEAD,t}$	Change in the with-project carbon stock in dead wood (in metric tons CO_2) during year **t**.
$C_{P,DEAD,t}$	With-project carbon stock in dead wood (in metric tons CO_2) 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 13 and 14.

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

Equation 15

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

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2) 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_2) during year **t**.
$\Delta C_{P,DEAD,t}$	Change in the with-project carbon stock in dead wood (in metric tons CO_2) during year **t**.

5.3.1 TREE BIOMASS, DEAD WOOD, AND WOOD PRODUCTS

The Project Proponent must use the same set of equations used in sections 4.2.2, 4.2.3, and 4.2.4 to calculate carbon stocks in the with-project scenario.

5.4 Monitoring of Activity-Shifting Leakage

If the project decreases wood product production by greater than 5% relative to the baseline then the Project Proponent 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 carbon 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 carbon project.

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

- Entity-wide adherance to the sustainable management requirements 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;

- For private landowners owning less than 2,500 forested acres, provision of a documented long-term forest management plan, demonstrating sustainable forest management (per section 1.3.1), prepared and signed by a professional forester; or
- For federally recognized tribal lands, demontration of a current BIA approved forest management plan. For non-federally recognized tribal lands, adherance to one or more of the sustainable management demonstrations above or adherance to sustainable forest management practices informed by traditional knowledge (as specified in section 1.3).

- 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 carbon project.

5.5 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 (16, 17, or 18):
  - If the project demonstrates that any decrease in total wood products produced by the project relative to the baseline is less than 5% over the crediting period then:

Equation 16

$$LK = 0$$

  - 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%.[45]

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

Equation 17

$$LK = 0.1$$

- Where the project is aggregated or employing a PDA consisting of 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 25% or more over the crediting period, the market leakage deduction is 20%.

Equation 18

$$LK = 0.2$$

- Where project activities decrease total wood products produced by the project relative to the baseline by 25% or more over the crediting period, the market leakage deduction is 30%.

Equation 19

$$LK = 0.3$$

- 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.

5.6 Estimation of With-Project Uncertainty

Uncertainty in the with-project scenario should be defined as the weighted average error of each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products with measured and documented harvest volume removals use zero as the confidence interval. For estimated wood product removal use the confidence interval of the inventory data. 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 20

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

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_2) at the end of year **t**.
$C_{P,DEAD,t}$	With-project carbon stock in dead wood (in metric tons CO_2) 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_2) 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_2) 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_2) 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 removals and emissions 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 removals and emissions, taking into account uncertainties. If uncertainty is significant, Project Proponents must choose data such that it tends to underestimate, rather than overestimate, net GHG emission reductions/removals.

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 4.2.2). 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,[46] 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 emission reductions/removals, 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 emission reductions and removals. 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 validation activity. Projects must be validated within 3 years of the project start date.

[46] USDA FIA program: 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.

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;
- Methodologies and calculation procedures used to generate estimates of baseline and with-project scenario stocks, emission reductions, and removals (including growth and yield 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 a verification by an ACR-approved validation/verification body at each request for issuance of ERTs. For the initial reporting period, and no less frequently than every 5 years of reporting thereafter, projects must conduct a full verification including a field 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;
- Calculations used to generate estimates of emissions, emission reductions, and removals;
- Assessment of growth and yield 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 21

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

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 22

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

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_2) during year **t** (section 4.2).
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2), prorated for reporting period duration.
UNC_{BSL}	Baseline uncertainty, in % (section 4.4).
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2) during year **t** (section 5.3).
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2) during year **t**.
$UNC_{P,t}$	With-project uncertainty for year **t**, in % (section 5.6).

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 ERTs. The following equation must be applied to calculate an uncertainty deduction ($UNC_{DED,t}$):

Equation 23

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

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 ERTs for year **t**, in %.

8 Calculation of ERTs

This section describes the process of determining total and net greenhouse gas emission reductions, removals, and ERTs issued for a reporting period for which a valid verification report has been submitted to ACR. Total greenhouse gas emission reductions and removals ($C_{ACR,t}$) and ERTs are calculated using Equation 24 by adjusting the difference between the with-project and baseline carbon stock changes for leakage and uncertainty.

Equation 24

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

WHERE

t	Time in years.
$ERT_{RP,t}$	Total ERTs in reporting period **t**.
$C_{ACR,t}$	Total greenhouse gas emission reductions/removals (in metric tons CO_2) in reporting period **t**.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2) during year **t** (section 5.3).
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) during year **t** (section 4.2).
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2) during year **t** (section 4.2.4).
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2), prorated for reporting period duration (Equation 3 and section 4.2.4).
LK	Market leakage discount (section 5.5).
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t** (section 7.5).

If the Project Proponent has chosen the ACR buffer pool as their risk management option, total ERTs are then multiplied by a non-permanence buffer deduction (Equation 25) to calculate the reporting period buffer contribution. Subtracting this contribution calculates net ERTs (Equation 26).

Equation 25

$$\mathbf{BUF_{RP,t} = ERT_{RP,t} \times BUF}$$

WHERE

t	Time in years.
$BUF_{RP,t}$	Buffer tons deducted in reporting period **t**.
$ERT_{RP,t}$	Total ERTs in reporting period **t**.
BUF	The non-permanence buffer deduction percentage as calculated in section 2.5. **BUF** will be set to zero if an ACR approved insurance product is used.

Equation 26

$$\mathbf{ERT_{NETRP,t} = ERT_{RP,t} - BUF_{RP,t}}$$

WHERE

t	Time in years.
$ERT_{NETRP,t}$	Net ERTs issued in reporting period **t**.
$ERT_{RP,t}$	Total ERTs in reporting period **t**.
$BUF_{RP,t}$	Buffer tons deducted in reporting period **t**.

ERTs by vintage shall then be determined by prorating reporting period calendar days within vintage year y (Equation 27), applying the non-permanence buffer deduction (Equation 28) and subtracting ERTs by vintage year from the non-permanence buffer deduction (Equation 29). Buffer pool ERTs will be deposited by vintage, if this is the risk management option the Project Proponent has chosen.

Equation 27

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

WHERE

t	Time in years.
y	Year of ERT vintage.
$ERT_{VIN,y}$	Total ERTs in vintage year **y**.
$ERT_{RP,t}$	Total ERTs 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 28

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

WHERE

y	Year of ERT vintage.
$BUF_{VIN,y}$	Buffer tons deducted in vintage year **y**.
$ERT_{VIN,y}$	Total ERTs issued in vintage year **y**.
BUF	The non-permanence buffer deduction percentage as calculated in section 2.5. **BUF** will be set to zero if an ACR approved insurance product is used.

Equation 29

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

WHERE

y	Year of ERT vintage.
$ERT_{NETVIN,y}$	Net ERTs issued in vintage year **y**.
$ERT_{VIN,y}$	Total ERTs issued in vintage year **y**.
$BUF_{VIN,y}$	Buffer tons deducted 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 ERT issuance. Removals are calculated by adjusting the with-project carbon stock change for leakage and uncertainty. Emission reductions are calculated as the remaining ERTs, which are the ERTs attributable to the baseline scenario stock change. Since removals may never exceed ERTs, the twenty-year baseline average value of wood products is conservatively deducted. If distinguishing, removals and emission reductions must be allocated to vintage years following the procedure outlined in Equation 27.

Equation 30

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

WHERE

t	Time in years.
$REM_{RP,t}$	Total removals in reporting period **t**.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2) during year **t**.
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2) for the project for during year **t**.
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2), prorated for reporting period duration.
LK	Market leakage discount.
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t**.

Equation 31

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

WHERE

t	Time in years.
$ER_{RP,t}$	Total emission reductions in reporting period **t**.
$ERT_{RP,t}$	Total ERTs in reporting period **t**.
$REM_{RP,t}$	Total removals in reporting period **t**.

8.1 Negative Project Stock Change, Reversals, and Termination

Negative project stock change ($C_{ACR,t}$) before the first offset credit issuance is a negative balance of greenhouse gas emissions, to be compensated by the project prior to any future issuance. After the first offset issuance, negative project stock change ($C_{ACR,t}$) 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*.[47]

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 after with-project stocks exceed the long-term average baseline stocking level.

[47] Available under the Guidance, Tools & Templates section of the ACR website.