American Carbon Registry
AT WINROCK INTERNATIONAL

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

September 2021

WINROCK
INTERNATIONAL

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
September 2021

American Carbon Registry®

WASHINGTON DC OFFICE
c/o Winrock International
2121 Crystal Drive, Suite 500
Arlington, Virginia 22202 USA
ph +1 703 302 6500

CALIFORNIA OFFICE
800 J Street, Suite 539
Sacramento, California 95814 USA

ACR@winrock.org
americancarbonregistry.org

ABOUT AMERICAN CARBON REGISTRY® (ACR)

A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance, and retirement reporting through its online registry system.

ACKNOWLEDGEMENTS

This methodology was modified by ACR based on a previous version authored by Matt Delaney and David Ford of L&C Carbon, based in Salem, Oregon, and Greg Latta of Oregon State University, based in Corvallis, Oregon, and originally developed by Finite Carbon. The methodology is being updated through ACR’s public consultation and scientific peer review processes.

ACRONYMS AND DEFINITIONS

ACR	American Carbon Registry
ATFS	American Tree Farm System
Activity-Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner.
Carrying Costs	Property taxes, mortgage interest, and insurance premiums.
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).
CO_2e	Carbon Dioxide equivalent. The amount of CO_2 that would have the same global warming potential (GWP) as other greenhouse gases over a 100-year lifetime using SAR-100 GWP values from the IPCC's fourth assessment report.
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 is specifically excluded 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.
De minimis	Threshold of 3% of the final calculation of emission reductions or removals.
ERT	Emission Reduction Ton
Ex ante	Prior to project certification.
Ex post	After the event, a measure of past performance.
FSC	Forest Stewardship Council

Forestland	Forest land is defined as land at least 10 percent stocked by trees of any size, or land formerly having such tree cover, and not currently developed for non-forest uses. Land proposed for inclusion in this project area shall meet the stocking requirement, in aggregate, over the entire area.
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.
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.
NGO	Non-governmental organization
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 licensed 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
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.*
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).
Ton	A unit of mass equal to 1000 kg.
Working Forest	A forest that is managed to generate timber revenue, amongst other possible ecosystem services and revenue streams.

CONTENTS

ACKNOWLEDGEMENTS 3
ACRONYMS AND DEFINITIONS 4
CONTENTS 7
1 METHODOLOGY DESCRIPTION 10
  1.1 SCOPE AND DEFINITIONS 10
  1.2 APPLICABILITY CONDITIONS 10
  1.3 POOLS AND SOURCES 11
  1.4 METHODOLOGY SUMMARY 13
2 ELIGIBILITY, BOUNDARIES, ADDITIONALITY, AND PERMANENCE 14
  2.1 PROJECT ELIGIBILITY 14
  2.2 PROJECT GEOGRAPHIC BOUNDARY 14
  2.3 PROJECT TEMPORAL BOUNDARY 15
  2.4 ADDITIONALITY 15
  2.5 PERMANENCE 16
3 STRATIFICATION 17
4 BASELINE 18
  4.1 IDENTIFICATION OF BASELINE 18
    4.1.1 CONFIDENTIALITY OF PROPRIETARY INFORMATION 22
  4.2 BASELINE NET REDUCTIONS AND REMOVALS 23
    4.2.1 STOCKING LEVEL PROJECTIONS IN THE BASELINE 29
    4.2.2 TREE CARBON STOCK CALCULATION 30
    4.2.3 DEAD WOOD CALCULATION 34
    4.2.4 HARVESTED WOOD PRODUCTS 38
  4.3 MONITORING REQUIREMENTS FOR BASELINE RENEWAL 42
  4.4 ESTIMATION OF BASELINE UNCERTAINTY 43
5 WITH-PROJECT SCENARIO 45
  5.1 MONITORING PROJECT IMPLEMENTATION 45
  5.2 MONITORING OF CARBON STOCKS IN SELECTED POOLS 45

5.3 MONITORING OF EMISSION SOURCES 46
5.4 ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS 46
5.4.1 TREE BIOMASS, DEAD WOOD CARBON CALCULATION, AND WOOD PRODUCTS 49
5.5 MONITORING OF ACTIVITY-SHIFTING LEAKAGE 49
5.6 ESTIMATION OF EMISSIONS DUE TO MARKET LEAKAGE 50
5.7 ESTIMATION OF WITH-PROJECT UNCERTAINTY 51
6 EX-ANTE ESTIMATION 53
6.1 EX-ANTE ESTIMATION METHODS 53
7 QA/QC, VALIDATION AND VERIFICATION, AND UNCERTAINTY 54
7.1 METHODS FOR QUALITY ASSURANCE 54
7.2 METHODS FOR QUALITY CONTROL 54
7.3 VALIDATION AND VERIFICATION 54
7.4 CALCULATION OF TOTAL UNCERTAINTY AND UNCERTAINTY DEDUCTION 55
8 CALCULATION OF ERTS 57

FIGURES

Figure 1: Sample Baseline Stocking Graph 27

TABLES

Table 1: Discount Rates for Net Present Value Determinations by U.S. Forestland Timber Ownership Class 20

EQUATIONS

Equation 1 23
Equation 2 23
Equation 3 24
Equation 4 24

Equation 5..25
Equation 6..27
Equation 7..28
Equation 8..28
Equation 9..29
Equation 10..29
Equation 11..37
Equation 12..37
Equation 13..43
Equation 14..47
Equation 15..47
Equation 16..47
Equation 17..48
Equation 18..50
Equation 19..50
Equation 20..50
Equation 21..51
Equation 22..55
Equation 23..56
Equation 24..57
Equation 25..58
Equation 26..58
Equation 27..59
Equation 28..59
Equation 29..60

1 METHODOLOGY DESCRIPTION

1.1 SCOPE AND DEFINITIONS

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

Baseline determination is project-specific and must describe the harvesting scenario that would maximize net present value (NPV) of perpetual wood products harvests per the assumptions in section 4.1, where various discount rates for different timber ownership classes are used as proxies for their respective forest management objectives.

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[1] forestland within the United States.
- The methodology applies to lands that can be legally harvested by entities owning or controlling timber rights on forestland.
- All projects must adhere to the following sustainable management requirements:
  - Private, non-governmental organization (NGO)and public non-federal 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 requirements:
    - Be certified by FSC, SFI, or ATFS or become certified within one year of the project start date; or
    - Adhere to a long-term forest management plan or program incorporating all their forested landholdings subject to commercial harvesting, prescribing the principals of sustained yield and natural forest management (plan and program criteria subject to ACR approval).

---

[1] 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.

  - 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.
- Tribal lands in the United States meeting applicability conditions of this methodology and requirements of the relevant *ACR Standard* are eligible[2].
- 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.
- 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.
- The project must demonstrate an increase in onsite stocking levels above the baseline scenario by the end of the crediting period.

1.3 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 included, and the pool must be estimated in both the baseline and with-project scenarios.

---

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

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	However, carbon stock decreases due to burning are accounted as a carbon stock change.
CH_4	Burning of biomass	Included	Non-CO_2 gas emitted from biomass burning.
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.
	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 emissions must be included in the quantification of project benefits.

1.4 METHODOLOGY SUMMARY

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

The baseline scenario is the legally permissible harvest scenario that would maximize net present value (NPV) of perpetual wood products harvests, used as a proxy for the multiple forest management objectives typical of each ownership class eligible under this methodology. The baseline management scenario shall be based on silvicultural prescriptions in published recommendations from state or federal agencies to perpetuate existing onsite timber-producing species while fully utilizing available growing space. At project initiation, the appropriate ownership classes are used to identify a project-specific NPV-maximizing baseline scenario (as described in section 4.1).

The with-project scenario is the actual activity that increases carbon sequestration relative to the baseline scenario through retention of forest growth and reduced harvest levels. At project initiation, Project Proponents design a with-project scenario for the purposes of increased carbon sequestration. The with-project scenario by definition will result in a lower NPV than the baseline scenario.

The difference between these two forest management forecasts is the basis for estimating the project's carbon impacts and the Emission Reduction Tons (ERTs) that will be generated throughout the crediting period.

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.

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*[3], which provide guidelines for aggregating multiple landholdings into a single forest carbon project as a means to reduce per-acre transaction costs of inventory and verification.

---

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

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.

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

The common practice test requires Project Proponents to evaluate the predominant forest industry technologies and practices in the project's geographic region. The Project Proponent shall demonstrate that the proposed project activity exceeds the common practice of similar landowners managing similar forests in the region. Projects initially deemed to go beyond common practice are considered to meet the requirement for the duration of their crediting period. If common practice adoption rates of a particular practice change during the crediting period, this may make the project 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 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 project must face capital constraints that carbon revenues can potentially address; or that carbon funding is reasonably 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.

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 forest carbon 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, they will not do this risk assessment.

Project Proponents must conduct their risk assessment using the *ACR Tool for Risk Analysis and Buffer Determination*[4]*.* The output of this tool is an overall risk category, expressed as a percentage, for the project translating into the buffer deduction that must be applied in the calculation of net ERTs (Equations 25 and 28). This deduction must be applied unless the Project Proponent uses another ACR-approved risk mitigation product.

---

[4] 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 may be defined on the basis of parameters that are key variables for estimating changes in managed forest carbon stocks, for example[5]:

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

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. due to fire, pests or disease outbreaks), affecting differently various parts of an originally homogeneous stratum;
- Forest management activities (e.g. cleaning, planting, thinning, harvesting, coppicing, 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.

---

[5] Please note this list is not exhaustive and only includes examples of common stratification parameters.

4 BASELINE

4.1 IDENTIFICATION OF BASELINE

The ACR IFM methodology[6] (approved by ACR in September 2010), takes a Faustmann approach to baseline determination using NPV maximization. The literature supporting Faustmann's original 1849 work forms the basis for modern optimal rotation/investment decisions and forest economics (summarized in Newman 2002[7]) in addition to appearing in over 300 other book and journal articles.

In the ACR IFM methodology, a discount rate between 4 – 6% is assigned as a determinant for how a given landowner within a particular forestland timber ownership class would base their forest management decisions. This technique is appropriate in that it 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.

This methodology quantifies GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline management practice levels. Emission Reduction Tons are quantified for increased sequestration through retention of forest growth when project activities exceed the baseline.

The baseline determination is project-specific and must describe the harvesting scenario that seeks to maximize NPV of perpetual wood products harvests over a 100-year modeling period. The discount rate assumptions for calculating NPV[8] vary by timber ownership class (Table 1). Actual landowner discount rate assumptions are typically not publicized in the scientific literature and companies, individuals, and organizations by and large do not share the values they use. However, discount rates can be indirectly estimated by using forest economic theory and the age-class structure distribution of different U.S. forest timber ownership classes.

---

[6] 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://americancarbonregistry.org/carbon-accounting/standards-methodologies/improved-forest-management-ifm-methodology-for-non-federal-u-s-forestlands/ifm-methodology-for-non-federal-u-s-forestlands_v1-0_semptember-2011_final.pdf

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

[8] Sewall, Sizemore & Sizemore, Mason, Bruce & Girard, Inc and Brookfield internal research 2010 Global Timberlands Research Report.https://www.industryintel.com/_resources/pdf/brookfield/4QBrookfield2010.pdf

Amacher et al. (2003)[9] and Beach et al. (2005)[10] provide literature reviews and a basis of economic analysis of private non-industrial harvesting decisions. Newman and Wear (1993)[11] show that private industrial and private non-industrial timber owners both demonstrate behavior consistent with profit maximization, yet the determinants of profit differ with the private non-industrial owners deriving significant non-market benefits associated with standing timber. Pattanayak et al. (2002)[12] revisited the problem as they studied private non-industrial timber supply and found joint optimization of timber and non-timber values, while Gan et al. (2001)[13] showed that the impact of a reduced discount rate actually had the same impact as the addition of an amenity value.

The United States Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) group provides inventory data on forests in their periodic assessment of forest resources (Oswalt et al. 2009[14]). This data allows for the analysis of total U.S. forest acres by age class for three broad ownership classes: private, state, and national forest. While the publicly available FIA data does not include any further breakdown of the private ownership group, we were provided with the twenty-year age class data from USDA FIA research foresters, including private corporate and private non-corporate classes. Bringing this economic theoretical framework together with this data aided in the derivation of discount rate value estimates for other forestland timber ownership classes (Table 1).

This methodology establishes an average baseline determination technique for all major non-federal timber ownership classes in the United States. Project Proponents shall use the baseline discount rate values in Table 1 for the appropriate timber ownership class to identify a project-specific NPV-maximizing baseline scenario. Appropriate 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 with-project scenario by definition will result in a lower NPV than the baseline scenario.

---

[9] Amacher, G.S., Conway, M.C., and J. Sullivan. 2003. Econometric analyses of nonindustrial forest landowners: is there anything left to study? Journal of Forest Economics 9, 137–164

[10] Beach, R.H., Pattanayak, S.K., Yang, J.C., Murray, B.C., and R.C. Abt. 2005. Econometric studies of non-industrial private forest management a review and synthesis. Forest Policy and Economics, 7(3), 261-281

[11] Newman, D.H. and D.N. Wear. 1993. Production economics of private forestry: a comparison of industrial and nonindustrial forest owners. American Journal of Agricultural Economics 75:674-684

[12] Pattanayak, S., Murray, B., Abt, R., 2002. How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. Forest Science 47 (3), 479– 491

[13] Gan, J., Kolison Jr., S.H. and J.P. Colletti. 2001. Optimal forest stock and harvest with valuing non-timber benefits: a case of U.S. coniferous forests. Forest Policy and Economics 2(2001), 167-178

[14] Oswalt, Sonja N.; Smith, W. Brad; Miles, Patrick D.; Pugh, Scott A., coords. 2019. Forest Resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 223 p. https://doi.org/10.2737/WO-GTR-97.

The difference between these two harvest forecasts is the basis for determining carbon impacts and ERTs attributable to the project.

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

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

The IFM baseline is the legally permissible harvest scenario that seeks to maximize NPV of perpetual wood products harvests. NPV baseline modeling must use the annual discount rate based on the current ownership class (Table 1), except for those projects in which land acquisition date occurred within 1 year of the project start date. In this case, NPV discount rate of the prior ownership class may be employed.

The baseline management scenario shall be based on silvicultural prescriptions in published recommendations from state or federal agencies to perpetuate existing onsite timber producing species while fully utilizing available growing space. All legally binding constraints to forest management (in place more than 1 year prior to project start date) must be considered in baseline modeling. Voluntary best management practices to protect water, soil stability, forest productivity, and wildlife, as prescribed by applicable federal, state, or local government agencies are considered legally binding constraints to forest management. The resulting harvest schedule is used to establish baseline stocking levels through the crediting period.

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 lands in the state containing the project area owned or managed by the project proponent (or by the previous project area owner/manager) or by (2) providing dated (from previous 10 years) aerial imagery or other remote sensing that identifies at least two properties (of similar site conditions and forest type) in the state 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. Published or written evidence that the baseline scenario (e.g., conversion of existing onsite timber) is common practice in the region (this can be from a state or local forester, a professional forester, an owner of a mill, etc.) must also be provided.

In cases where the mission of an NGO includes land conservation and stewardship, the Project Proponent (NGO or associated private entity claiming carbon credit ownership) must justify the baseline scenario by demonstrating[15] they manage their lands consistent with the definition of a working forest. If sufficient justification can be provided and verified, baseline harvest levels may be determined using an NPV analysis at the 4% harvest discount rate for NGOs. In the baseline, harvests and silviculture must also be constrained such that documented long-term management objectives of the NGO, specific to the project area if available, can reasonably and verifiably be expected to be accomplished.

Required inputs for the project NPV calculation include the results of a recent timber inventory of the project lands, prices for wood products of grades that the project would produce, costs of logging, reforestation and related costs, silvicultural treatment costs, and relevant carrying costs. Project Proponents shall include roading and harvesting costs as appropriate to the terrain and unit size. Project Proponents must model growth of forest stands through the crediting period. Project Proponents 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 is given in Table 1. 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. If baseline harvested forest product output assumes increased regional mill capacity over time, the Project Proponent must provide an analysis demonstrating the feasibility of future mills that could be opened within the bounds of historical (<40 years) market conditions or credible forecasts of future viability, and the baseline harvest schedule must temporally account for mill construction or expansion. Mills must be within hauling distances that allow the baseline's forest management activities to

---

[15] This demonstration not relevant for NGO projects with project start dates within one year of land acquisition and using NPV discount rate of the prior ownership class. For this demonstration, evidence may include terms of legal ownership, a conservation easement, a forest management plan, forest certification documentation, or other verifiable evidence meeting the intent of this methodology.

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.

Baseline scenario forest management must be plausible given fundamental institutional barriers[16] not captured as legal constraints or in the NPV calculation. Projects in which land acquisition date occurred within 1 year of the project start date may consider the institutional barriers of the prior ownership. Consideration shall be given to a reasonable range of feasible baseline assumptions and the selected assumptions should be 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[17].

4.1.1 Confidentiality of Proprietary Information

While it remains in the interest of the general public for Project Proponents to be as transparent as possible regarding GHG reduction/removal projects, the Project Proponent may choose at their own option to designate any information regarded as confidential due to proprietary considerations. If the Project Proponent chooses to identify information related to financial performance as confidential, the Project Proponent must submit the confidential baseline and project documentation in a separate file marked “Confidential” to 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.

---

[16] “Fundamental institutional barriers” are political, social, or operational barriers to the baseline harvest regime engrained in the management of a specific property and unlikely to change over time.

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

4.2 BASELINE NET REDUCTIONS AND REMOVALS

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 be calculated for the crediting period;
- The change in baseline carbon stocks be computed for each time period, t;
- 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); and
- The long-term average value of baseline greenhouse gas emissions to be calculated following Equation 4 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 stored in above and below ground live trees (in metric tons CO_2) for year t.
$C_{BSL,TREE,t}$	Baseline value of carbon stored in above and below ground live trees at year t (in metric tons CO_2) and t-1 signifies the value at 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 stored in dead wood (in metric tons CO_2) for year t.
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in dead wood at year t (in metric tons CO_2) and $t-1$ signifies the value at 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 average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2).
$C_{BSL,HWP,t}$	Baseline value of carbon remaining in in-use and landfill wood products 100 years after being harvested in the year t (in metric tons CO_2).

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

Equation 4

$$\overline{GHG}_{BSL} = \frac{\sum_{t=1}^{20}\left(BS_{BSL,t} \times ER_{CH_4} \times \frac{16}{44} \times GWP_{CH_4}\right)}{20}$$

WHERE

t	Time in years.
$\overline{GHG}_{BSL}$	Twenty-year average value of greenhouse gas emissions (in metric tons CO_2e) resulting from the implementation of the baseline.
$BS_{BSL,t}$	Carbon stock (in metric tons CO_2) in logging slash burned in the baseline for year t.

ER_{CH_4}	Methane (CH_4) emission ratio (ratio of CO_2 as CH_4 to CO_2 burned). If local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value[18] of 0.012.
$\frac{16}{44}$	Molar mass ratio of CH_4 to CO_2.
GWP_{CH_4}	100-year global warming potential (in CO_2 per CH_4) for CH_4 (IPCC SAR-100 value in the assessment report specified in the applicable *ACR Standard* version).

Carbon stock calculation for logging slash burned ($BS_{BSL,t}$) shall use the method described in section 4.2.2 for bark, tops and branches, and section 4.2.3 if dead wood is selected. The reduction in carbon stocks due to 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 5

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

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO_2) including the initial value (i.e., t =0).
$C_{BSL,TREE,t}$	Baseline value of carbon stored in above and below ground live trees (in metric tons CO_2) at year t.
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in standing and lying dead trees at year t (in metric tons CO_2).

---

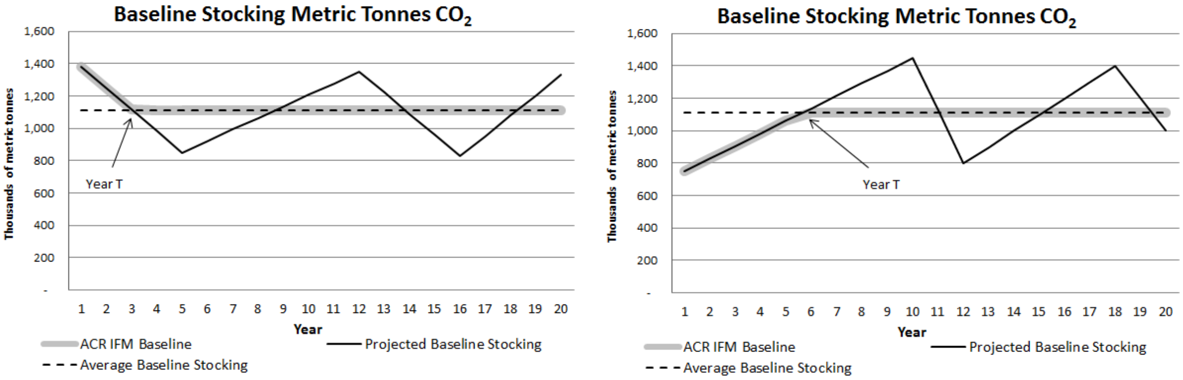
[18] Table 3A.1.15, Annex 3A.1, GPG-LULUCF (IPCC 2003)

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 6 or 7, depending on initial stocking levels. Prior to time T, the projected stocking levels are used for the baseline stock change calculation, as determined by Equation 8. In the year that the projected stocking levels reach the long-term average (time $t = T$), the baseline stock change calculation is determined by Equation 9. Thereafter, the long-term average stocking level is used in the baseline stock change calculation, as determined by Equation 10, and only project-scenario growth is 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 baseline stocking



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

Equation 6

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

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO_2).
$C_{BSL,TREE,t}$	Baseline carbon stored in above and below ground live trees (in metric tons CO_2) at year t.
$C_{BSL,DEAD,t}$	Baseline carbon stock stored in dead wood pools (in metric tons CO_2) at year t.

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

Equation 7

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

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO_2).
$C_{BSL,TREE,t}$	Baseline carbon stock stored in above and below ground live trees (in metric tons CO_2) at year t.
$C_{BSL,DEAD,t}$	Baseline carbon stock stored in dead wood pools (in metric tons CO_2) at year t.

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

Equation 8

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

WHERE

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

Prior to year T (T = year projected stocking reaches the long-term baseline average) 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 years elapsed since the start of the IFM project activity (t) equals T, use the following equation to compute baseline stock change:

Equation 9

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) for year t.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO_2).
$C_{BSL,TREE,t-1}$	Baseline carbon stock stored in above and below ground live trees (in metric tons CO_2) in the year prior to year t.
$C_{BSL,DEAD,t-1}$	Baseline carbon stock stored in dead wood pools (in metric tons CO_2) in the year prior to year t.

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

Equation 10

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2) for 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, variant and calibrations, 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. The baseline must be modeled over a 100-year period.

Examples of appropriate models include:

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

Models must be:

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

The output of the models must include either projected total aboveground and below ground carbon per acre, volume in live aboveground tree biomass, or another appropriate unit by strata in the baseline. Where model projections are output in five- or ten-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 project scenario stocking projections.

If the output for the tree is the 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. Where models do 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. 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 classication 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 inventory, including following harvests or disturbances.

Use or adaptation of inventory SOPs already applied in national forest monitoring[19], or 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. 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 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 data (noting defects which affect 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.

---

[19] e.g., 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.

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 tonnes 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 tonnes 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)[20]. 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 National Volume Estimator Library[21], as employed by default in the FVS Fire and Fuels Extension (Rebain et al. 2010)[22]. 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[23]:

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[24]. The

---

[20] 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

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

[22] 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.

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

[24] 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.

methods described in Woodall et al. (2011)[25] are used to calculate gross and sound volumes by region and species[26]. 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[27]. 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. The Project Proponent must first estimate volume using the models and associated coefficients within “Volumetric Equations for California, Oregon, and Washington” (2014)[28]. Biomass is then estimated using the equations within “Biomass Equations for California, Oregon, and Washington” (2014)[29]. 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)[30] at the plot level to estimate belowground biomass density based on aboveground biomass density in tonnes 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.

---

[25] 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.

[26] 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

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

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

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

[30] 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

Projects in AK must use regional biomass equations provided by the USDA FIA[31]. 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 tonnes 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 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 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 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[32].

For projects using Options 1 or 2 of 4.2.2.1:

---

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

[32] 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.

Standing dead tree biomass must be adjusted for density reduction and structural loss using the Domke (2011) method[33]. Density reduction factors shall be based on the hardwood/softwood default values found in Table 6 of Harmon et al. (2011)[34]. 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 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 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.

---

[33] Domke, Grant M.; Woodall, Christopher W.; Smith, James 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.

[34] Harmon, Mark E.; Woodall, Christopher W.; Fasth, Becky; Sexton, Jay; Yatkov, Misha. 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.

Step 5 Determine total project standing dead carbon (in metric tonnes 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 tonnes by dividing by 1000, and finally carbon to CO_2 by multiplying by 3.664.

4.2.3.2 LYING DEAD WOOD (IF SELECTED)

The lying dead wood pool is highly variable 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).[35, 36] 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 Guidance for LULUCF[37]. 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[38].

Step 3 The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[39] as modified by Van Wagner (1968)[40] separately for each density class.

---

[35] 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.

[36] 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

[37] 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

[38] USDA FIA Phase 3 proportions

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

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

Equation 11

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

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 12

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

WHERE

B_{LDW}	Biomass (in kilograms per hectare) of lying dead wood per unit area.
A	Area (in hectares).
$V_{LDW,DC}$	Volume (in cubic meters per hectare) of lying dead wood in density class DC per unit area.
WD_{DC}	Basic wood density (in kilograms per cubic meter) of dead wood in the density class — sound (1), intermediate (2), and rotten (3).

Step 5 Determine total project lying dead carbon by summing the biomass of each stratum for the project area and converting biomass to dry metric tonnes of carbon by multiplying by 0.5, kilograms to metric tonnes 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[41]:

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 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.
    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

---

[41] Adapted from Appendix C of the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects, November 14, 2014.

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 Tonnes	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[42]. This results in pounds of biomass with zero moisture content. If a particular species is not listed in the USFS Wood Handbook, it shall be at the verifier's discretion to approve a substitute species. Any substitute species must be consistently applied across the baseline and with-project calculations.

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

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

V. Divide the carbon weight by 2,204.6 pounds/metric ton and multiply by 3.664 to convert to metric tons of CO_2. Sum the CO_2 for each species into saw log and

---

[42] 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.

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 scenario.

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 Regional Mill Efficiency Database, found on the reference documents section of this methodology's website. 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 in this methodology.

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 either decay or are sent to landfills. Decay rates depend on the type of wood product that is produced. Thus, in order to account for the decomposition of harvested wood over time, a decay rate is applied to wood products according to their product class. 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[43]

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

---

[43] Smith JE, Heath LS, Skog KE, Birdsey RA (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.

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 done 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 Assessment Area, as given in the most current Assessment Area Data File found on the reference documents section of this methodology's website.

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 of 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 products after 100 years. This value is used for input into the ERT calculation worksheet. The value for the actual harvested wood products will vary every year depending on the total amount of harvesting that has taken place. The baseline value is the 20-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, regardless of any changes to legal constraints that may occur within the crediting period.

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 within one year of the project start date are not considered legally binding for baseline constraint modeling;

- 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 the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), or estimates based on sound statistical sampling. Uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools shall always be quantified.

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

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

The uncertainty in the baseline scenario should be defined as the weighted average uncertainty of each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products and logging slash burning emissions, use the confidence interval of the 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 project projections should minimize the impacts of model uncertainties on differences between project and baseline values.

Therefore,

Equation 13

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

WHERE

t	Time in years.
UNC_{BSL}	Percentage uncertainty in the combined carbon stocks in the baseline.
$C_{BSL,TREE,t}$	Carbon stock in the baseline stored in above and below ground live trees (in metric tons CO_2) for the initial inventory at year t.
$C_{BSL,DEAD,t}$	Carbon stock in the baseline stored in dead wood (in metric tons CO_2) for the initial inventory at year t.
$\overline{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon (in metric tons CO_2) remaining stored in wood products 100 years after harvest.
$\overline{GHG}_{BSL}$	Twenty-year average value of annual greenhouse gas emissions (in metric tons CO_2e) resulting from the implementation of the baseline.
$e_{BSL,TREE,t}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in above and below ground live trees (in metric tons CO_2) for the initial inventory at year t.
$e_{BSL,DEAD,t}$	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 t.

5 WITH-PROJECT SCENARIO

5.1 MONITORING PROJECT IMPLEMENTATION

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

- The geographic position of the project boundary is recorded for all areas of land;
- The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded, and archived. This may be achieved by field mapping (e.g. using GPS), or by using georeferenced spatial data (e.g. maps, GIS datasets, orthorectified aerial photography, or georeferenced remote sensing images);
- Professionally accepted principles of forest inventory and management are implemented;
- SOP's 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); and
- Where commercial harvesting occurs in the project area in the with-project scenario, mill receipts or other harvest records for harvests occurring within the reporting period are provided for verification purposes.

5.2 MONITORING OF CARBON STOCKS IN SELECTED POOLS

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, or available from published handbooks or the *IPCC GPG LULUCF 2003*, is recommended. The inventory SOP document must describe how the project will update the forest inventory data following harvests or disturbances. Mill receipts or other harvest records for 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

---

[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)

cannot meet the targeted ±10% of the mean at 90% confidence, then an uncertainty deduction is applied as determined by section 7.4.

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 MONITORING OF EMISSION SOURCES

Emissions from biomass burning must be monitored during project activities. When applying all relevant equations provided in this methodology for the *ex ante* calculation of net anthropogenic GHG reductions/removals by sinks, Project Proponents shall provide transparent estimations for the parameters that are monitored during the crediting period. These estimates shall be based on measured or existing published data where possible. In addition, Project Proponents must apply the principle of conservativeness. If different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

5.4 ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS

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

- Carbon stock levels to be determined at the end of each reporting period, t;
- The change in project carbon stock to be computed from the end of the prior reporting period, t-1;
- 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); and
- The reporting period value of with-project greenhouse gas emissions to be calculated following Equation 16 for the calculation of ERTs (Equation 24).

The following equations are used to construct the project stocking levels using models described in section 4.2.1:

Equation 14

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

WHERE

t	Time in years.
$\Delta C_{P,TREE,t}$	Change in the project carbon stock stored in above and belowground live trees (in metric tons CO_2) for year t.
$C_{P,TREE,t}$	Project value of carbon stored in above and belowground live trees at year t (in metric tons CO_2) and t-1 signifies the value at the prior year.

Equation 15

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

WHERE

t	Time in years.
$\Delta C_{P,DEAD,t}$	Change in the project carbon stock stored in dead wood (in metric tons CO_2) for year t.
$C_{P,DEAD,t}$	Project value of carbon stored in dead wood at year t (in metric tons CO_2) and t-1 signifies the value at the prior year.

The reduction in carbon stocks due to harvests or disturbances that occurred during the reporting period must be accounted in Equations 14 and 15.

Equation 16

$$GHG_{P,t} = BS_{P,t} \times ER_{CH_4} \times \frac{16}{44} \times GWP_{CH_4}$$

WHERE

t	Time in years.

$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO_2e) resulting from the implementation of the project for year t.
$BS_{P,t}$	Carbon stock (in metric tons CO_2) in logging slash burned in the project for year t.
ER_{CH_4}	Methane (CH_4) emission ratio (ratio of CO_2 as CH_4 to CO_2 burned). If local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value of 0.012[45].
$\frac{16}{44}$	Molar mass ratio of CH_4 to CO_2.
GWP_{CH_4}	100-year global warming potential (in CO_2e per CH_4) for CH_4 (IPCC SAR-100 value in the Assessment Report specified in the applicable *ACR Standard* version).

Carbon stock calculation for logging slash burned shall use the method described in section 4.2.2 for bark, tops and branches, and section 4.2.3 if dead wood is selected. The reduction in carbon stocks due to slash burning due to project activities must be properly accounted in Equations 14 and 15.

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

Equation 17

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

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the project carbon stock (in metric tons CO_2) for year t.
$\Delta C_{P,TREE,t}$	Change in the project carbon stock stored in above and belowground live trees (in metric tons CO_2) for year t.
$\Delta C_{P,DEAD,t}$	Change in the project carbon stock stored in dead wood (in metric tons CO_2) for year t.

---

[45] Table 3A.1.15, Annex 3A.1, GPG-LULUCF (IPCC 2003)

5.4.1 Tree Biomass, Dead Wood Carbon Calculation, 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.

5.5 MONITORING OF ACTIVITY-SHIFTING LEAKAGE

There may be no leakage beyond *de minimis* levels through activity shifting to other lands owned, or under management control, by the timber rights owner.

If the project decreases wood product production by >5% relative to the baseline then the Project Proponent and all associated landowners must demonstrate that there is no leakage within their operations – i.e., on other lands they manage/operate outside the bounds of the ACR carbon project. 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 ACR carbon project.

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

- Entity-wide management certification that requires sustainable practices (programs can include FSC, SFI, or ATFS). Management certification must cover all entity owned lands with active timber management programs;
- Adherence to an ACR-approved long-term forest management plan or program as specified in section 1.2;
- 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 deviation from management plans;
- Historical records covering all Project Proponent 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.

5.6 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 (18, 19, or 20):
  - If the project is able to demonstrate that any decrease in total wood products produced by the project relative to the baseline is less than 5% over the crediting period then:

Equation 18

$$\mathrm{LK} = 0$$

  - Where project activities decrease total wood products produced by the project relative to the baseline by more than 5% but less than 25% over the crediting period, the market leakage deduction is 10%.

Equation 19

$$\mathrm{LK} = 0.1$$

  - 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%[46].

Equation 20

$$\mathrm{LK} = 0.3$$

- 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 shall be based on verifiable methods for quantifying leakage. It is at the verifier and ACR's discretion to determine whether the method for quantifying market leakage is appropriate for the project.

---

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

5.7 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 21

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

WHERE

t	Time in years.
$UNC_{P,t}$	Percentage uncertainty in the combined carbon stocks in the project at year t.
$C_{P,TREE,t}$	Carbon stock in the project stored in above and below ground live trees (in metric tons CO_2) at year t.
$C_{P,DEAD,t}$	Carbon stock in the baseline stored in dead wood (in metric tons CO_2) at year t.
$C_{P,HWP,t}$	Carbon (in metric tons CO_2) remaining stored in wood products in the project 100 years after harvest for year t.
$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO_2e) resulting from the implementation of the project for year t.
$e_{P,TREE,t}$	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 last remeasurement of the inventory prior to year t.

$e_{P,DEAD,t}$	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 last remeasurement of the inventory prior to year t.

6 EX-ANTE ESTIMATION

6.1 EX-ANTE ESTIMATION METHODS

The Project Proponent must make an *ex ante* calculation of all net anthropogenic GHG removals and emissions for all included sinks and sources for the entire crediting period. 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.

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

- Data from well-referenced peer-reviewed literature or other well-established published sources;
- 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– plus inclusion of a 1-page summary CV for each expert consulted, included in an annex.

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

7 QA/QC, VALIDATION AND VERIFICATION, AND UNCERTAINTY

7.1 METHODS FOR QUALITY ASSURANCE

SOPs and QA/QC procedures for forest inventory including field data collection and data management shall be documented. Use or adaptation of SOPs already applied in national forest monitoring, or available from published handbooks or the IPCC GPG LULUCF 2003, is recommended.

7.2 METHODS FOR QUALITY CONTROL

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

7.3 VALIDATION AND VERIFICATION

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.

Projects developed with this methodology must undergo a full verification, including a field visit to the project site, no less frequently than every 5 years of reporting. 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, the 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 carbon stock 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;
- For paired tests, a minimum of 5% of the original forest inventory must be resampled. For unpaired tests, the number of resampling plots to be installed shall be no less than 5% of the original forest inventory plot count;
- If the carbon stock 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 must be based on a strategic assessment of risk, proportional carbon stocking, proportional acreage, or another reasonable and demonstrably non-biased method. The plot selection and sequence for resampling 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.

7.4 CALCULATION OF TOTAL UNCERTAINTY AND UNCERTAINTY DEDUCTION

The following equation must be applied to calculate total uncertainty:

Equation 22

$$\mathrm{UNC_t} = \sqrt{\frac{|\Delta \mathrm{C_{BSL,t}}| \times \mathrm{UNC_{BSL,t}}^2 + |\Delta \mathrm{C_{P,t}}| \times \mathrm{UNC_{P,t}}^2}{|\Delta \mathrm{C_{BSL,t}}| + |\Delta \mathrm{C_{P,t}}|}}$$

WHERE

t	Time in years.
$\mathrm{UNC_t}$	Total uncertainty in year t, in %.

$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 4.2).
UNC_{BSL}	Baseline uncertainty, in % (section 4.4).
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 5.4).
$UNC_{P,t}$	With-project uncertainty at year t, in % (section 5.7).

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 at year t, in %.
$UNC_{DED,t}$	Uncertainty deduction to be applied in calculation of ERTs at 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 ($C_{ACR,t}$) and ERTs are calculated using Equation 24 by adjusting the difference between the project and baseline carbon stock changes for leakage and uncertainty.

Equation 24[47]

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

WHERE

t	Time in years.
$ERT_{RP,t}$	Total ERTs in reporting period t.
$C_{ACR,t}$	Total greenhouse gas emission reductions (in metric tons CO_2e) in reporting period t.
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 5.4).
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 4.2).
$C_{P,HWP,t}$	Carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2) for the project for year t.
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2; section 4.2).
$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO_2e) resulting from the implementation of the project for year t.

---

[47] If either the baseline or with-project scenarios account for greenhouse gas emissions during the reporting period, ERTs must be calculated using:

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

$\overline{GHG}_{BSL}$	Twenty-year average value of greenhouse gas emissions (in metric tons CO₂e) resulting from the implementation of the baseline.
LK	Market leakage discount (section 5.6).
$UNC_{DED,t}$	Total uncertainty with deduction, (in %) for year t (section 7.4).

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 year 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 t (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

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

WHERE

t	Time in years.
$ERT_{VIN,t}$	Total ERTs in vintage year t.
$ERT_{RP,t}$	Total ERTs in reporting period t.
CAL_t	Reporting period calendar days within vintage year t.
$RP_{CAL,t}$	Total calendar days within reporting period t.

Equation 28

$$BUF_{VIN,t} = ERT_{VIN,t} \times BUF$$

WHERE

t	Time in years.
$BUF_{VIN,t}$	Buffer tons deducted in vintage year t.
$ERT_{VIN,t}$	Total ERTs issued in vintage year 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 29

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

WHERE

t	Time in years.
$ERT_{NETVIN,t}$	Net ERTs issued in vintage year t.
$ERT_{VIN,t}$	Total ERTs issued in vintage year t.
$BUF_{VIN,t}$	Buffer tons deducted in vintage year t.

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 is a reversal. AFOLU 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*[48]. As outlined in the *ACR Buffer Pool Terms and Conditions*, sequestration projects will terminate automatically if a reversal causes project stocks to decrease below the long-term average baseline stocking level ($C_{BSL,AVE}$) at any point prior to the end of the minimum project term. Projects with initial stocking levels lower than long-term average baseline stocking are subject to this requirement only after project stocks exceed the long-term average baseline stocking level.

---

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