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 ON CANADIAN FORESTLANDS

VERSION 1.0

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American Carbon Registry®

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

ACR@winrock.org
americancarbonregistry.org

ABOUT AMERICAN CARBON REGISTRY® (ACR)

A leading carbon offset program founded in 1996 as the first private voluntary greenhouse gas (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.

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This methodology was modified by John A. Kershaw and Yung-Han Hsu, based in Fredericton, NB, Canada, as well as Bluesource LLC., Finite Carbon and ACR, from an existing version of ACR's U.S.-based IFM methodology originally developed by Finite Carbon and updated by Matt Delaney and David Ford of L&C Carbon and Greg Latta of Oregon State University. The methodology has been approved by ACR through public consultation and scientific peer review processes.

ACRONYMS AND DEFINITIONS

ACR	American Carbon Registry
Activity Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner.
Baseline Management	Scenario in the absence of project activities.
BBAR	Biomass : tree basal area ratio
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 as other GHGs 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 registered professional forester is obtained, confirming the harvests are in direct response to isolated forest health (insect/disease) or natural disaster event(s) that are 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.
CSA	Canadian Standards Association
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.
FIA	Forest Inventory and Analysis
Forest Products Supply Area	An area of land producing forest products and fulfilling the needs of a given geographic market. Such areas must be defined by the Project Proponent and accompanied by verifiable evidence that any forest products produced on forested landholdings owned or managed by the Project Proponent and not enrolled in the carbon project fulfill separate and distinct market demands, such that leakage can be reasonably expected not to occur.
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.
FSC	Forest Stewardship Council, Canada
GHG	Greenhouse Gas
GWP	Global Warming Potential
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
Minimum Project Term	Time period for which project activities must be maintained and monitored through third-party verification.
Native Species	Trees listed as native to Canada in *Trees in Canada* by John Laird Farrar (Fitzhenry & Whiteside, 1995). Trees must be defined as regionally native according to range maps within the source above.
Net Present Value (NPV)	The difference between the present value of cash inflows and the present value of cash outflows over the life of the project.
NGO	Non-Governmental Organization
Project Proponent	An individual or entity that undertakes, develops, and/or owns a project. This may include the project investor, designer, and/or owner of the lands/facilities on which project activities are conducted. The Project Proponent and

	landowner/facility may be different entities. The Project Proponent is the ACR account holder.
Reporting Period	The period of time covering a GHG assertion for a single verification and subsequent request for ERT issuance.
SFI	Sustainable Forestry Initiative
Timberlands	Forestlands managed for commercial timber production.
Tree	A perennial woody plant with a diameter at breast height (1.3m) greater than or equal to 2cm and a height of greater than 1.3m, with the capacity to attain a minimum diameter at breast height of 9cm and a minimum height of 5m (shrub species are not eligible).
Tonne	A unit of mass equal to 1,000 kg.
USDA	United States Department of Agriculture
Working Forest	A forest that is managed to generate timber revenue, amongst other possible ecosystem services and revenue streams.

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1 METHODOLOGY DESCRIPTION

1.1 SCOPE

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

Baseline determination is project-specific and must describe the harvesting scenario that would maximize net present value (NPV) of perpetual wood products harvests per the assumptions as described in Section 3.1, where various discount rates for different land ownership classes are used as proxies for the multiple forest management objectives typical of each owner class eligible under this methodology.

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 net project benefits.

1.2 APPLICABILITY CONDITIONS

- This methodology is not applicable on provincial and federal crown land managed under license subject to provincial or federal forest management regulations. It is applicable on all other forestlands within Canada.
- All First Nations Reserves, Treaty Land Entitlements, and Metis Settlement lands are eligible under this methodology, provided that they meet ACR definitions.
- 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 or non-governmental organization (NGO) ownerships or other public non-federal or non-provincial ownerships, subject to commercial timber 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 CSA, SFI, or FSC or become certified within one year of the project start date; or
    - Adhere to a long-term forest management plan or program covering all their forested landholdings within the forest project's forest products supply area, prescribing the principals of sustained yield and natural forest management (plan and program criteria subject to ACR approval).

  - If the project is not subject to commercial harvest activities 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.
  - First Nations and Metis communities are not required to be certified by CSA, SFI, or FSC, but must adhere to sustainable forest management practices that are informed by traditional knowledge. Where possible, such practices will be evidenced by a document such as a traditional land use plan, but it is recognized that principles of traditional land use are often not documented and exist only in oral communication.
- Use of non-native species is prohibited where adequately stocked native stands were converted for forestry or other land uses.
- Draining or flooding of wetlands is prohibited.
- Participating entities (e.g., Project Proponent, landowner, project manager) must demonstrate its ownership or control of timber rights at the project start date.
- The project must demonstrate an increase in on-site stocking levels above the baseline condition by the end of the crediting period.

1.3 POOLS AND SOURCES

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Aboveground biomass carbon	Included	Major carbon pool subjected to the project activity.
Belowground live biomass carbon	Included	Major carbon pool subjected to the project activity.
Standing dead wood	Included/ Optional	Major carbon pool in unmanaged stands subjected to the project activity. Project Proponents may also elect to include the pool in managed stands. Where included, the pool must be estimated in both the baseline and with project cases.
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 cases.

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Harvested wood products	Included	Major carbon pool subjected 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 negligibly small.

LEAKAGE SOURCE		INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Activity-Shifting	Timber Harvesting	Excluded	Project Proponent must demonstrate no activity-shifting leakage beyond the *de 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 project scenario and thus there are no leakage impacts.
Market .	Timber	Included	Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.

1.4 METHODOLOGY SUMMARY

This methodology is adapted from a previously approved ACR IFM methodology for U.S. forestlands[1]. It is designed to quantify GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline forest management practices. Removals are quantified for increased sequestration through retention of annual forest growth when project activities exceed the baseline.

The IFM baseline is the legally permissible harvest scenario that would maximize NPV of perpetual wood products harvests, used as a proxy for the multiple forest management objectives typical of each owner class eligible under this methodology. It is not implied that any landowner would be required manage according to the baseline, but rather the baseline sets a proxy standard across all landowner types. The baseline management scenario shall be based on silvicultural prescriptions commonly employed within the relevant ownership class and geography to perpetuate existing onsite timber-producing species while fully utilizing available growing space. The resulting harvest schedule is used to establish baseline stocking levels through the crediting period.

In developing the baseline scenario, 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

[1] American Carbon Registry (2018) Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands Version 1.3.

on lands in the province 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 LIDAR that identifies at least two properties (of similar site conditions and forest type) in the province 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 area equal to or greater than the annual area 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 a provincial or local forester, a consulting forester, an owner of a mill, etc.) must also be provided.

The discount rate assumptions for calculating NPV vary by ownership class (Table 1) and includes the 6% rate for private industrial timberlands from the earlier IFM methodology. 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, approximate discount rates can be indirectly estimated by using forest economic theory and the age-class structure distribution of different Canadian forest ownership classes.

Project Proponents then design a project scenario for the purposes of increased carbon sequestration. The project scenario, by definition, will result in a lower NPV than the baseline scenario. Project Proponents use the baseline discount rate values for NPV maximization for the appropriate ownership class and implement a project scenario for purposes of increased carbon sequestration. The difference between these two harvest forecasts is the basis for determining carbon impacts and Emissions Reduction Tons (ERTs) attributable to the project.

2 ELIGIBILITY, BOUNDARIES, ADDITIONALITY, AND PERMANENCE

2.1 PROJECT ELIGIBILITY

This methodology applies to Canadian forestlands that are able to document 1) freehold title, Indigenous 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.

Proponents must demonstrate that the project area, in aggregate, meets the 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:

- Project area delineated on a Natural Resources Canada topographic map;
- General location map; and
- Property parcel map.

Aggregation of forest properties with multiple landowners is permitted under the methodology consistent with the *ACR Standard*, which provides guidelines for aggregating multiple landholdings into a single forest carbon project as a means to reduce per-hectare transaction costs of inventory and verification.

2.3 PROJECT TEMPORAL BOUNDARY

The project start date may be denoted by one of the following: 1) 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, 2) the date that the Project Proponent initiated a forest carbon inventory, 3) the date that the Project Proponent entered into a contractual relationship to implement a carbon project, or 4) the date the project was submitted to ACR for listing review. Other dates may be approved 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 start date (not the first or last year of crediting).

If the project start date is more than one year before submission of the GHG Project Plan, the Project Proponent shall provide evidence that GHG mitigation was seriously considered in the decision to proceed with the project activity. Evidence shall be based on official and/or legal documentation. Early actors undertaking voluntary activities to increase forest carbon sequestration prior to the release of this requirement may submit as evidence recorded conservation easements or other deed restrictions that affect onsite carbon stocks.

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 examines 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. If similar landowner types are unavailable within the project area region, common practices of all landowner types in the region may be considered. Lacking any relevant local common practices, comparisons to common practices from elsewhere in Canada with similar forest conditions may be considered (subject to validation/verification body and ACR approval). Projects initially deemed to go beyond common practice are considered to meet the requirement for the duration of their crediting period. If common practice adoption rates of a particular practice change during the crediting period, this may make the project non-additional and thus ineligible for renewal, but does not affect its additionality during the current crediting period.

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 Proponent's established minimum acceptable rate. Financial barriers can also include high risks such as unproven technologies or business models, poor credit rating of project partners, and project failure risk. When applying the financial implementation barrier test, Project Proponents should include quantitative evidence such as NPV and internal rate of return calculations. The project must face capital constraints that carbon revenues can potentially address; or 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 current *ACR Tool for Risk Analysis and Buffer Determination*[2]. The output of the tool is an overall risk category, expressed

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

as a fraction, for the project translating into the buffer deduction that must be applied in the calculation of net ERTs (Section 7). This deduction must be applied unless the Project Proponent uses another ACR-approved risk mitigation product.

3 BASELINE

3.1 IDENTIFICATION OF BASELINE

The ACR IFM methodology[3] (initially approved by ACR in September 2010), takes a Faustmann approach to baseline determination using NPV maximization with a 6% discount rate on future cash flows. As discussed in Section 1.4, the baseline sets a proxy standard across all landowner types and does not imply that any landowner would be required to manage in such a way. The literature supporting Faustmann's original 1849 work forms the basis for modern optimal rotation/investment decisions and forest economics (summarized in Newman 2002)[4] in addition to appearing in over 300 other books 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 ownership class would make their forest management decisions. This technique is appropriate in that it provides a common transparent and conservative metric by which landowners, project developers, verifiers, and offset purchasers can base their assessment of an ACR IFM carbon project.

This methodology is the same as the ACR IFM methodology in that it quantifies GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline management practice levels. ERTs are quantified for increased sequestration through retention of annual 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 vary by ownership class (Table 1) and include the 6% rate for private industrial timberlands[5] from the ACR IFM methodology. Actual landowner discount rate assumptions are typically not publicized in the scientific literature and

[3] 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

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

[5] 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

companies, individuals, and organizations by and large do not share the values they use. However, approximate discount rates can be indirectly estimated by using forest economic theory and the age-class structure distribution of different forest ownership classes.

Amacher et al. (2003)[6] and Beach et al. (2005)[7] provide literature reviews and a basis of economic analysis of private non-industrial harvesting decisions. Newman and Wear (1993)[8] show that industrial and non-industrial 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)[9] 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)[10] 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 (Smith et al. 2009)[11]. 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 ownership classes (Table 1). Rates of return on southern US forestlands largely drive expected rates of return on forestlands world-wide. While Canada has a less liquid market, international investors would perceive a risk premium associated with the fluctuating currency.

This methodology establishes an average baseline determination technique for all major non-Crown (federal and provincial) forest ownership classes in Canada. Project Proponents shall use the baseline discount rate values in Table 1 for the appropriate ownership class to identify a

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[6] 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.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] Smith, W. Brad, tech. coord.; Miles, Patrick D., data coord.; Perry, Charles H., map coord.; Pugh, Scott A., Data CD coord. 2009. Forest Resources of the United States, 2007. GTR WO-78. Washington, DC: USDA, Forest Service, Washington Office. 336 p.

project-specific NPV-maximizing baseline scenario. Appropriate ownership classes are assigned and weighted across the entirety of the project area based upon timber rights ownership. Project Proponents then design a project scenario for the purposes of increased carbon sequestration. The project scenario, by definition, will result in a lower NPV than the baseline scenario. 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 Canadian Forestland Ownership Class

PRIVATE INDUSTRIAL	6%
PRIVATE NON-INDUSTRIAL	5%
INDIGENOUS	5%
NON-GOVERNMENTAL CONSERVATION OR NATURAL RESOURCES ORGANIZATION	4%
NON-FEDERAL AND NON-PROVINCIAL 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 treatment levels and harvest levels that seek to perpetuate existing onsite timber producing species while fully utilizing available growing space. All legally binding constraints to forest management (in place >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, provincial, or local government agencies, are considered legally binding constraints to forest management. The resulting harvest schedule is used to establish baseline stocking levels throughout the crediting period.

Where the baseline management scenario involves replacement of existing onsite timber producing species (e.g., where forest is converted to plantations, replacing existing onsite timber-producing species), the management regime should similarly be based on treatment levels and harvest levels that seek to perpetuate forest growth potential, and must adhere to all applicable laws and regulations.

In cases where the mission, objective or goal 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[12] 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 NGO's. 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 on-the-ground timber inventory of the project lands, prices for wood products of grades that the project would produce, costs of logging, reforestation and related costs, silvicultural treatment costs, and carrying costs. Project Proponents shall include roading and harvesting costs as appropriate to the terrain and unit size. Project Proponents must model growth of forest stands through the crediting period. Project Proponents should use 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 owner class is given in Table 1. Wood products must be accounted.

The baseline scenario's harvested output volume must not exceed the 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 be economical. The feasibility of the baseline harvest regime must be demonstrated with mill reports, testimony from a professional forester, published literature from a provincial or federal agency, or other verifiable evidence.

Baseline scenario forest management must also be plausible given fundamental institutional barriers[13] 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 barri-

[12] 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.

[13] "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.

ers 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[14].

3.1.1 Confidentiality of Proprietary Information

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

3.2 BASELINE 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. Different stratifications may be used for the baseline and project scenarios. For estimation of baseline 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:[15]

- Management regime;
- Species or cover types;
- Size and density class;

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

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

- Site class; or
- Age Class

3.3 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 3.1. This methodology requires 1) annual baseline stocking levels to be determined for the entire crediting period, 2) a long-term average baseline stocking level be calculated for the crediting period, and 3) the change in baseline carbon stocks be computed for each time period, t.

The following equations are used to construct the baseline stocking levels using models described in section 3.3.1 and wood products calculations described in Section 3.3.2:

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 tonnes CO_2) for year t.
$C_{BSL,TREE,t}$	Baseline value of carbon stored in above and below ground live trees at the beginning of the year t (in metric tonnes CO_2) and t-1 signifies the value in 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 tonnes CO_2) for year t.
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in dead wood at the beginning of the year t (in metric tonnes CO_2) and t-1 signifies the value in 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 tonnes of CO_2).
$C_{BSL,HWP,t}$	Baseline value of carbon remaining in wood products 100 years after being harvested in the year t (in metric tonnes CO_2).

Please see Section 3.3.2 for detailed instructions on baseline wood products calculations.

Equation 4

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

WHERE

t	Time in years.
$\overline{GHG}_{BSL}$	Twenty-year average value of greenhouse gas emissions (in metric tonnes CO_2e) resulting from the implementation of the baseline.
$BS_{BSL,t}$	Carbon stock (in metric tonnes CO_2) in logging slash burned in the baseline in 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[16] 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 3.3.1.1 for bark, tops and branches, and section 3.3.1.2 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 use:

Equation 5

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

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tonnes 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 tonnes CO_2) at the beginning of the year t.
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in dead wood at the beginning of the year t (in metric tonnes CO_2).
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tonnes of CO_2).

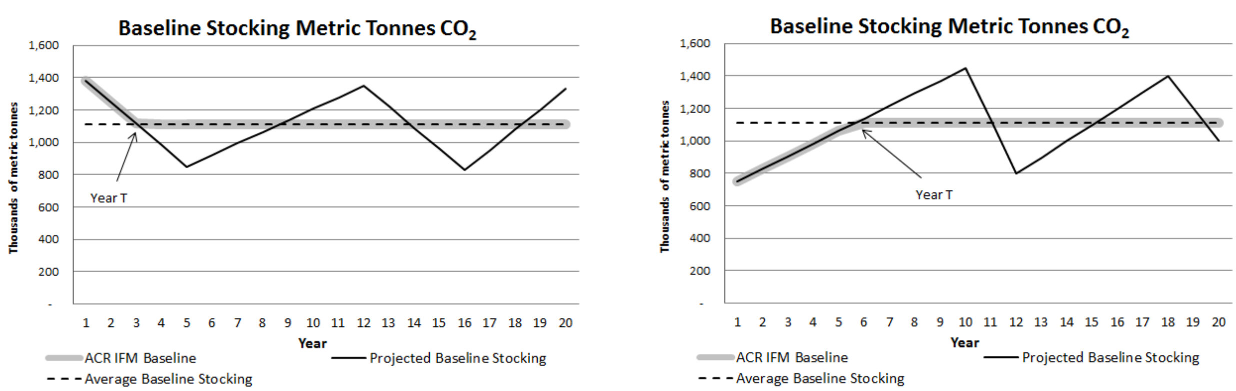
[16] Table 3A.1.15, Annex 3A.1, GPG-LULUCF (IPCC 2003).

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 (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 this year, annual projected stocking levels are used for the baseline stock change calculation, as determined by equation 8. Thereafter, the long-term average stocking level is used in the baseline stock change calculation, as determined by equation 10, and only removals from growth are credited for the remaining years in the crediting period.

Figure 1: Sample Baseline Stocking Graph

FOR PROJECT BEGINNING:

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



When initial baseline stocking levels 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

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

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tonnes CO_2).
$C_{BSL,TREE,t}$	Baseline carbon stock stored in above and belowground live trees (in metric tonnes CO_2) for year t.

$C_{BSL,DEAD,t}$	Change in the baseline carbon stock stored in dead wood (in metric tonnes CO_2) for year t.
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining in wood products 100 years after harvest (in metric tonnes CO_2).

When initial baseline stocking levels 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

$$if\ [(C_{BSL,TREE,t} + C_{BSL,DEAD,t}) + \bar{C}_{BSL,HWP} \geq C_{BSL,AVE}]\ then\ t = T$$

WHERE

t	Time in years.
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tonnes CO_2).
$C_{BSL,TREE,t}$	Baseline carbon stock stored in above and belowground live trees (in metric tonnes CO_2) for year t.
$C_{BSL,DEAD,t}$	Change in the baseline carbon stock stored in dead wood (in metric tonnes CO_2) for year t.
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining in wood products 100 years after harvest (in metric tonnes CO_2).

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

Equation 8

$$\Delta C_{BSL,t} = \Delta C_{BSL,TREE,t} + \Delta C_{BSL,DEAD,t} + \bar{C}_{BSL,HWP} - \overline{GHG}_{BSL}$$

WHERE

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

$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock stored in above and belowground live trees (in metric tonnes CO_2) for year t.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock stored in dead wood (in metric tonnes CO_2) for year t.
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining in wood products 100 years after harvest (in metric tonnes CO_2).
$\overline{GHG}_{BSL}$	Twenty-year average value of annual greenhouse gas emissions (in metric tonnes CO_2) resulting from the implementation of the baseline.

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, to compute baseline stock change use:

Equation 9

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

WHERE

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

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

Equation 10

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

3.3.1 Stocking Level Projections in the Baseline

$C_{BSL,TREE,t}$ and $C_{BSL,DEAD,t}$ must be estimated using models of forest management across the baseline period. Modeling must be completed with a 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 calibration processes have been used. All model inputs and outputs must be available for inspection by the verifier. The baseline must be modeled over a 100-year period.

Approved models include:

- Forest Vegetation Simulator equivilents
  - PrognosisBC (BC)
  - $FVS_{ONTARIO}$ (ON)
  - FVS-ACD (NB, NS, PEI, NL)
- Open Stand Model, OSM-ACD (NB, NS, PEI, NL)
- TASS (BC)
  - SYLVER
  - TIPSY
- GYPSY (AL)
- NATURE2014 (QC, stand-level model)
- ARTEMIS2014 (QC, tree-level model)

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 hectare, 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 equations in section 3.3.1.1. If processing of alternative data on dead wood is necessary, equations in section 3.3.1.2.1 may 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.

3.3.1.1 TREE CARBON STOCK CALCULATION

The mean carbon stock at project start date in aboveground biomass per hectare is estimated based on field measurements in sample plots. These initial stock measurements are subsequently used in modeling project and baseline stocks over the crediting period and are used for the basis of establishing project uncertainty.

A sampling plan must be developed that describes the inventory process including sample size, determination of plot numbers, plot layout and locations, and data collected. Plot data used for biomass calculations may not be older than 10 years. Plots may be permanent or temporary and they may have a defined boundary or use variable radius sampling methods.

The Canadian National Biomass equations[17,18], are the preferred equations for estimating per tree biomass components. Locally calibrated equations may be used when available and have undergone proper independent peer review. The Project Proponent must use the same set of equations, diameter at breast height (DBH) 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 cull in both the ex ante and ex post baseline and project scenarios. Determine missing cull deductions using cull attribute data collected during field measurement of sample plots.

Plot-level biomass per unit area can be estimated by summation of biomass expansion factors[19] or bigBAF subsampling methods. Alternatively, carbon may be estimated using the Carbon

[17] Ung, C.-H., P. Y. Bernier, and X. Guo. 2008. Canadian national biomass equations: new parameter estimates that include British Columbia data. Can. J. For. Res. 38:1123–1132.

[18] Lambert, M.-C., C.-H. Ung, and F. Raulier. 2005. Canadian national tree aboveground biomass equations. Can. J. For. Res. 35(8):1996–2018.

[19] Kershaw, J. A., Jr., M. J. Ducey, T. W. Beers, and B. Husch. 2016. Forest Mensuration. 5th ed. Wiley/Blackwell, Hobokin, NJ. 640 p.

Budget Model of the Canadian Forest Sector (CBM-CFS3)[20,21] based on merchantable yield tables developed from field data (see (**b**) below). CBM-CFS3 and the same merchantable yield tables must be used for ex ante and ex post baseline and project estimates.

(**a**) To determine biomass directly from field data, the following steps are used to calculate biomass:

Step 1 Determine which aboveground biomass components are going to be included from among the following: wood, bark, branches, and foliage. Estimate each biomass component using the appropropriate species-specific equations from Ung et al. (2008)[22] or Lambert et al. (2005)[23]. Equations from Ung et al. (2008) should be used if the species is available, otherwise, equations from Lambert et al. (2005) should be used. Equations found in the Tables 4 in both publications should be used when both DBH and total height data are available, otherwise equations found in the Tables 3 should be used. Use of “All Hardwoods”, “All Softwoods” or “All Species” equations should be avoided except in the cases where no species-specific equations exist. BigBAF subsampling methods should not be used when height data are not collected.

Step 2 If summation methods are used, biomass expansion factors are calculated by multiplying individiual tree total biomass obtained in step 1 by the appropriate tree factor. Plot-level total aboveground biomass per hectare is obtained by summing the biomass expansion factors across all trees on each plot. Note that the same components must be calculated for ex ante and ex post baseline and project estimates.

If bigBAF subsampling methods are used, the biomass : tree basal area ratio (BBAR) is calculated for each measure tree and the average BBAR across all plots in the sample, or all plots within each strata, is calculated, Plot-level biomass is obtained by multiplying plot-level basal area by average BBAR[23].

[20] Kull, S.J.; Rampley, G.J.; Morken, S.; Metsaranta, J.; Neilson, E.T.; Kurz, W.A. 2019. Operational-scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) version 1.2: user’s guide. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre. Edmonton, AB. 348 p.

[21] Li, Z.; Kurz, W.A.; Apps, M.J.; Beukema, S.J. 2003. Belowground biomass dynamics in the Carbon Budget Model of the Canadian Forest Sector: Recent improvements and implications for the estimation of NPP and NEP. Can. J. For. Res. 33(1):126-136.

[22] Ung, C.-H., P. Y. Bernier, and X. Guo. 2008. Canadian national biomass equations: new parameter estimates that include British Columbia data. Can. J. For. Res. 38:1123–1132.

[23] Lambert, M.-C., C.-H. Ung, and F. Raulier. 2005. Canadian national tree aboveground biomass equations. Can. J. For. Res. 35(8):1996–2018.

Step 3 Determine the biomass estimates for each stratum by calculating a mean biomass per unit area estimate from plot level biomass estimates derived in step 2 multiplied by the number of hectares in the stratum.

Step 4 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 1,000, and finally carbon to CO_2 by multiplying by 3.664.

(**b**) To determine biomass using the CBM-CFS3 model, the following steps must be followed:

Step 1 Determine which aboveground components are going to be included (merchantable, other, foliage, as defined in CBM-CFS3). Using an acceptable, peer-reviewed total volume equation, determine indivudal tree volumes. Estimate merchantable volumes by multipling total volume by merchantable volume ratios. Merchantable volume expansion factors are calculated by multiplying individual tree merchantable volume by the appropriate tree factor. Plot-level merchantable volumes are obtained by summing merchantable volume expansion factors by species.

Step 2 Stratum-level average merchantable yield curves are obtained by arranging plots into predefined age classes and averaging plot level estimates within each age class by species.

Step 3 Obtain carbon estimates from CBM-CFS3 by inputing merchantable yield tables, the appropriate volume-to-biomass and biomass-to-carbon conversion factors, and letting the software perform the conversions.

Step 4 Determine total project carbon (in metric tonnes CO_2) by summing the carbon estimates from CBM-CFS3 of each stratum for the project area by multiplying per unit area carbon estimates by the number of hectares in the stratum and converting carbon to CO_2 by multiplying by 3.664.

3.3.1.2 DEAD WOOD CALCULATION

Dead wood included in the methodology comprises two components only — standing dead wood and lying dead wood. Belowground dead wood is conservatively neglected. Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components. Estimates for deadwood may be obtained using CBM-CFS3 but projects must include a model calibration and verification procedure that utilizes field data following the sampling procedures described in the following sections.

3.3.1.2.1 Standing Dead Wood (If Included)

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

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

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

Step 3 Biomass must be estimated using the same methods used for live trees (as described section 3.3.1.1) for decomposition classes 1, 2, and 3 with deductions as stated in step 4 (below). When the standing dead tree is in decomposition class 4, the biomass estimate must be limited to the main stem of the tree. If the top of the standing dead tree is missing, then top and branch biomass may be assumed to be zero. Identifiable tops on the ground meeting category 1 criteria may be directly measured. For trees broken below minimum merchantability specifications used in the tree biomass equation, existing standing dead tree height shall be used to determine tree bole biomass.

Step 4 The biomass of dead wood is determined by using the following dead wood density classes deductions: class 1 — 97% of live tree biomass; class 2 — 95% of live tree biomass; class 3 — 90% of live tree biomass; class 4 — 80% of live tree biomass[24].

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 1,000, and finally carbon to CO_2 by multiplying by 3.664.

[24] IPCC Good Practice Guidelines 2006. http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp4/Chp4_3_Projects.pdf.

3.3.1.2.2 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 if the forest was previously unmanaged (mature or unlogged) where it would likely increase or logged with logging slash left behind where it may decrease through time.

Step 1 Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996) [25, 26]. 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 (2003)[27], section 3.3.1.2.2. 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.[28]

Step 3 The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[29] as modified by Van Wagner (1968)[30] separately for each density class

Equation 11

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

WHERE

[25] 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.

[26] 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.

[27] Penman, J., Gytarsky, M., Hiraishi, T., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner, F. 2003. Good practice guidelines for land use, land-use change and forestry. ISBN 4-88788-003-0.

[28] USFS FIA Phase 3 proportions.

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

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

$V_{LDW,DC}$	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 1,000, and finally carbon to CO_2 by multiplying by 3.664.

3.3.2 Wood Products Calculations

There are five steps required to account for the harvesting of trees and to determine carbon stored in wood products in the baseline and project scenarios[31]:

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 tonnes 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 meters) or by green weight (tonnes), 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 meters or green weight, convert to cubic meters 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 Tonnes	71.3	2.0
Bone Dry Units	82.5	2.3

[31] 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 tonnes	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 meter volume by the appropriate green specific gravity by species from Table 5-3a of the USFS Wood Handbook[32] (specific gravity is in g/cm^3 = tonnes/m^3). This results in tonnes of biomass with zero moisture content. If a particular species is not listed in the 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 in the same units as the weight measurement.

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

V. If weight is in kilograms, divide the carbon weight by 1000 kilograms/metric tonne. Finally, multiply carbon weight by 3.664 to convert to metric tonnes of

[32] 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.

CO_2. Sum the CO_2 for each species into saw log and pulp volumes (if applicable), and then again into softwood species and hardwood species. These values are used in the next step, accounting for mill efficiencies. Please note that the categorization criteria (upper and lower DBH limits) for hardwood/softwood saw log and pulp volumes are to remain the same between the baseline and project scenario.

Step 2 **ACCOUNT FOR MILL EFFICIENCIES**

Multiply the total carbon weight (metric tonnes of carbon) for each group derived in step 1 by the mill efficiency for the project's mill location(s). Mill efficiencies may either be derived directly using monitored data or estimated using a default production loss factor of 25%[33]. This output represents the total carbon (75%) 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 REMAINING IN IN-USE WOOD PRODUCTS 100 YEARS AFTER HARVEST**

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 methodology 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[34]

WOOD PRODUCT CLASS	IN-USE	LANDFILLS
Softwood Lumber	0.234	0.405
Hardwood Lumber	0.064	0.490
Softwood Plywood	0.245	0.400

[33] Protocol for the Creation of Forest Carbon Offsets in British Columbia.

[34] 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 USDA FS), PP. 218. USDA Forest service, Washington, DC, USA.

Oriented Strandboard	0.349	0.347
Non Structural Panels	0.138	0.454
Miscellaneous Products	0.003	0.518
Paper	0	0.151
Fuel[35]	0	0
Landfill	0	0
Effluent	0	0

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, wood product classes must be derived according to the following:
  - All provinces except B.C. shall use the PR Calc software[36]. In PR Calc, product classes must be assigned using verifiable project or regionally specific data. Where data are unavailable, product classes may be assigned according to the table below[37]:

	HARVEST VOLUME (%)
Softwood Lumber	56.6%
Hardwood Lumber	16.6%

[35] Fuel, landfill and effluent product classes considered immediate emissions.

[36] Kershaw JA, Richards E, Larusic J. 2007. A product ratio calculator for northeastern tree species. North. J. Appl. For. 24(4):307-311. http://ifmlab.for.unb.ca/people/kershaw/index.php/pr-calculator/

[37] Chen J, Colombo SJ, Ter-Mikaelian MT, Heath LS. 2008. Future carbon storage in harvested wood products from Ontario's Crown forests. Can J For Res 38:1947-1958.

Paper	26.1%
Fuelwood	0.67%

- Within B.C., assign default timber harvest wood product class proportions by region[38, 39] using the table below:

	COAST	NORTHERN INTERIOR	SOUTHERN INTERIOR
Softwood Lumber	39.1%	36.3%	39.3%
Hardwood Lumber	0.4%	3.2%	0.2%
Softwood Plywood	4.1%	3.8%	4.1%
Oriented Strandboard	3.8%	3.8%	3.8%
Paper	18.3%	18.3%	18.3%
Fuel	33.7%	33.7%	33.7%
Landfill	0.2%	0.2%	0.2%
Effluent	0.4%	0.4%	0.4%

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;

[38] Dymond CD. 2012. Forest carbon in North America: Annual storage and emissions from British Columbia's harvest, 1965-2065. Carbon Balance and Management 7(1):8.

[39] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/ministry-of-forests-lands-and-natural-resource-operations-region-district-contacts

3. Multiply the values for each product class by the storage factor for in-use wood products; and
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 tonnes).

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

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 100-year average value, and does not change from year to year.

3.4 MONITORING REQUIREMENTS FOR BASELINE RENEWAL

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

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

- Re-submitting the GHG Project Plan in compliance with then-current *ACR standard* and criteria;
- Re-evaluating the project baseline;

- Demonstrating additionality against then-current regulations, common practice and implementation barriers. Stipulations of easements put into place within one year prior to 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/verifier body.

3.5 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 baseline and project values.

Therefore,

Equation 13

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

WHERE

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 tonnes CO_2) for the initial inventory in year t.
$C_{BSL,DEAD,t}$	Carbon stock in the baseline stored in dead wood (in metric tonnes CO_2) for the initial inventory in year t.
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon (in metric tonnes 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 tonnes 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 belowground live trees (in metric tonnes CO_2) for the initial inventory in 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 tonnes CO_2) for the initial inventory in year t.

4 WITH-PROJECT SCENARIO

4.1 WITH-PROJECT STRATIFICATION

If the project activity area is not homogeneous, stratification may be carried out to improve the precision of carbon stock estimates. Different stratifications may be used for the baseline and project scenarios. For estimation of with-project scenario carbon stocks, strata may be defined on the basis of parameters that are key variables determining forest carbon stocks, for example:

- Management regime;
- Species or cover types;
- Size and density class;
- Site class; or
- Age class.

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

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

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

4.2 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 can be achieved by field mapping (e.g., using GPS), or by using georeferenced spatial data (e.g., maps, GIS datasets, orthorectified aerial photography or georeferenced remote sensing images);
- Professionally accepted principles of forest inventory and management are implemented;

- Standard operating procedures (SOPs) and quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of field-based SOPs already applied in national forest monitoring, or available from published handbooks, or from the IPCC GPG LULUCF 2003, is recommended; and
- Where commercial timber harvesting occurs in the project area in the with-project scenario, the forest management plan, together with a record of the plan as actually implemented during the project shall be available for validation and verification, as appropriate.

4.3 MONITORING OF CARBON STOCKS IN SELECTED POOLS

Project scenario stocks are determined by periodically remeasuring plots (data cannot be older than 10 years) 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 from the IPCC GPG LULUCF 2003, is recommended. The forest management plan, together with a record of the plan as actually implemented during the project shall be available for validation and verification, as appropriate.

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[40]. If the Project Proponent cannot meet the targeted ±10% of the mean at 90% confidence, then the reportable amount shall be the lower bound of the 90% confidence interval.

At a minimum the following data parameters must be monitored:

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

[40] 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).

4.4 MONITORING OF EMISSION SOURCES

Emissions from biomass burning must be monitored during project activities. When applying all relevant equations provided in this methodology for the ex ante calculation of net anthropogenic GHG removals by sinks, Project 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.

4.5 ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS

This section describes the steps required to calculate $\Delta C_{P,t}$ (net annual carbon stock change under the project scenario; tonnes CO_2e). This methodology requires: 1) carbon stock levels to be determined in each time period, t, for which a valid verification report is submitted, and 2) the change in project carbon stock be computed from the prior verification time period, t-1.

The following equations are used to construct the project stocking levels using models described in Section 3.3.1 and wood products calculations described in Section 3.3.2:

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 below ground live trees (in metric tonnes CO_2) for year **t**.
$C_{P,TREE,t}$	Project value of carbon stored in above and belowground live trees at the beginning of the year **t** (in metric tonnes CO_2) and **t-1** signifies the value in 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 tonnes CO_2) for year **t**.
$C_{P,DEAD,t}$	Project value of carbon stored in dead wood at the beginning of the year **t** (in metric tonnes CO_2) and **t-1** signifies the value in the prior year.

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 tonnes CO_2e) resulting from the implementation of the project in year **t**.
$BS_{P,t}$	Carbon stock (in metric tonnes CO_2) in logging slash burned in the project in 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[41].
$\frac{16}{44}$	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).

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

Carbon stock calculation for logging slash burned shall use the method described in section 3.3.1.1 for bark, tops and branches, and section 3.3.1.2 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.

To compute change in project carbon stock for each time period use:

Equation 17

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

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the project carbon stock (in metric tonnes CO_2) for year t.
$\Delta C_{P,TREE,t}$	Change in the project carbon stock stored in above and below ground live trees (in metric tonnes CO_2) for year t.
$\Delta C_{P,DEAD,t}$	Change in the project carbon stock stored in dead wood (in metric tonnes CO_2) for year t.
$C_{P,HWP,t}$	Carbon remaining stored in wood products 100 years after harvest (in metric tonnes CO_2) for the project in year t.
$GHG_{P,t}$	Greenhouse gas emission (in metric tonnes CO_2e) resulting from the implementation of the project in year t.

4.5.1 Tree Biomass, Dead Wood Carbon Calculation, Wood Products

The Project Proponent must use the same set of equations used in Section 3.3 to calculate carbon stocks in the project scenario.

4.6 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 of 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 CSA, SFI or FSC). 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;
- Historical records covering all Project Proponent ownership trends in harvest volumes paired with records from the with-project time period showing no deviation from historical trends over most recent 10-year average; and/or
- 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.

4.7 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 either of the following:

- Applying the appropriate default market leakage discount factor (equation 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

$$\mathbf{LK = 0}$$

- 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

$$\mathbf{LK = 0.1}$$

- 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 40%[42].

Equation 20

$$\mathbf{LK = 0.4}$$

- 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.

4.8 ESTIMATION OF WITH-PROJECT UNCERTAINTY

It is assumed that the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), or estimates based 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

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

zero. However, this section provides a procedure to combine uncertainty information and conservative estimates resulting in an overall project scenario uncertainty.

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

The uncertainty in the project scenario should be defined as the 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 can be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

Therefore,

Equation 21

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

WHERE

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

5 EX-ANTE ESTIMATION

5.1 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 removals by sinks and the actual net GHG removals by sinks, especially when global default values are used. Project Proponents shall identify key parameters that would significantly influence the accuracy of estimates. Local values that are specific to the project circumstances must then be obtained for these key parameters, whenever possible. These values must be based on:

- Data from well-referenced peer-reviewed literature or other well-established published sources;
- 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 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 removals by sinks[43].

[43] CDM Approved Consolidated Methodology AR-ACM0001, "Afforestation and Reforestation of Degraded Land".

6 QA/QC AND UNCERTAINTY

6.1 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 field-based SOPs already applied in national forest monitoring, or available from published handbooks, or from the IPCC GPG LULUCF 2003, is recommended.

6.2 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.

6.3 CALCULATION OF TOTAL PROJECT UNCERTAINTY

The following equation must be applied to calculate total project uncertainty:

Equation 22

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

WHERE

UNC_t	Total project uncertainty in year t, in %.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tonnes CO_2e) for year t (section 3.3).
$UNC_{BSL,t}$	Baseline uncertainty in year t, in % (section 3.5).

$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tonnes CO_2e) for year t (section 4.5).
$UNC_{P,t}$	With-project uncertainty in year t, in % (section 4.8).

The ACR Standard sets a statistical precision requirement of ±10% of the mean with 90% confidence. When total project uncertainty is beyond this threshold, an uncertainty deduction affects the calculation of ERTs. The following equation must be applied to calculate an uncertainty deduction:

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

$UNC_{tDED,t}$	Uncertainty deduction to be applied in calculation of ERTs, in %.
UNC_t	Total project uncertainty in year t, in %.

7 CALCULATION OF ERTS

This section describes the process of determining net GHG emission reductions and ERTs issued for a reporting period for which a valid verification report has been filed with ACR. Total GHG emission reductions ($C_{ACR,t}$) are calculated using equation 24 by adjusting the difference between the project and baseline carbon stock changes for leakage and uncertainty then multiplying by a non-permanence buffer deduction.

Equation 24

$$\mathbf{ERT_{RP,t} = C_{ACR,t} = (\Delta C_{P,t} - \Delta C_{BSL,t}) \times (1 - LK) \times (1 - UNC_{DED,t}) \times (1 - BUF)}$$

WHERE

$ERT_{RP,t}$	Emission Reduction Tons (in metric tonnes CO_2e) in reporting period $\mathbf{t}$.
$C_{ACR,t}$	Total greenhouse gas emission reductions (in metric tonnes CO_2e) at time $\mathbf{t}$.
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tonnes CO_2e) for year $\mathbf{t}$ (Section 4.5).
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tonnes CO_2e) for year $\mathbf{t}$ (Section 3.3).
LK	Leakage discount (Section 4.7).
$UNC_{DED,t}$	Total project uncertainty with deduction, (in %) for year $\mathbf{t}$ (section 6.3).
BUF	The non-permanence buffer deduction as calculated in section 2.5. **BUF** will be set to zero if an ACR approved insurance product is used.

ERTs by vintage shall then be determined by prorating reporting period calendar days within vintage year t (Equation 25), applying the non-permanence buffer deduction (Equation 26) and subtracting ERT's by vintage year from the non-permanence buffer deduction (Equation 27). Buffer pool ERTs will be deposited by vintage, if this is the risk management option the Project Proponent has chosen.

Equation 25

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

WHERE

$ERT_{VIN,t}$	Total Emission Reduction Tons (in metric tonnes CO_2e) in vintage year **t**.
$ERT_{RP,t}$	Total emission reductions (in metric tonnes CO_2e) issued 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 26

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

WHERE

$BUF_{VIN,t}$	Buffer tons (in metric tonnes CO_2e) deducted in vintage year **t**.
$ERT_{VIN,t}$	Emission reductions (in metric tonnes CO_2e) issued 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 27

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

WHERE

$ERT_{NETVIN,t}$	Net Emission Reduction tons (in metric tonnes CO_2e) issued in vintage year **t**.
$ERT_{VIN,t}$	Emission reductions (in metric tonnes CO_2e) issued in reporting period **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 GHG emissions. 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 Reversal Risk Mitigation Agreement* and the *Buffer Pool Terms and Conditions*, Exhibit 1 of the *ACR Standard*. As outlined in Exhibit 1, sequestration projects will terminate automatically if a reversal causes project stocks to decrease below baseline levels prior to the end of the minimum project term.