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

IMPROVED FOREST MANAGEMENT (IFM) ON SMALL NON-INDUSTRIAL PRIVATE FORESTLANDS

VERSION 1.0

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PUBLIC COMMENT

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American Carbon Registry®

WASHINGTON DC OFFICE
c/o Winrock International
2451 Crystal Drive, Suite 700
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 GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

ACKNOWLEDGEMENTS

This methodology was developed by Finite Carbon and ACR. The methodology is seeking approval through ACR's public comment and scientific peer-review processes.

ACRONYMS

ACR	American Carbon Registry
ATFS	American Tree Farm System
BMPs	Best Management Practices
CO_2	Carbon Dioxide. All pools and emissions in this methodology are represented by either CO_2 or CO_2 equivalents. Biomass is converted to carbon by multiplying by 0.5 and then to CO_2 by multiplying by the molecular weight ratio of CO_2 to Carbon (3.664)
CO_2e	Carbon Dioxide equivalent. The amount of CO_2 that would have the same global warming potential (GWP) as other greenhouse gases over a 100-year lifetime using SAR-100 GWP values from the IPCC's fifth assessment report.
CRM	Component Ratio Method
ERT	Emission Reduction Ton
FIA	USFS Forest Inventory and Analysis Program
FSC	Forest Stewardship Council
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
MRV	Monitoring, Reporting and Verification
NPV	Net Present Value
NIPF	Non-Industrial Private Forest
PDA	Programmatic Development Approach
SFI	Sustainable Forestry Initiative
SOP	Standard Operating Procedures
SSR	Sources, Sinks and Reservoirs
VVB	Validation/Verification Body

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1 METHODOLOGY DESCRIPTION

1.1 SCOPE

This methodology is designed to quantify GHG emission reductions and removals resulting from improved forest management (IFM) activities on aggregated ownerships of non-industrial private forest (NIPF) landowners that contain 40 – 5,000 forested acres. Emission reductions are achieved by managing forests such that they exceed baseline forest management practices. Removals are achieved from increased sequestration and retention of annual forest growth in excess of the baseline scenario. The primary carbon sequestration mechanism is harvest deferral over any Crediting Period.

This methodology is specific to aggregation or programmatic development approach (PDA) projects, as defined by the *ACR Standard*. All participating sites must demonstrate that the project activity exceeds regulatory requirements and an approved performance standard.

There are two acceptable sources for deriving project and baseline inventory data: 1) a statistically unbiased sample of inventory plots within the project boundary (project-level inventory), or 2) a statistically unbiased sample of inventory plot data sourced from the USFS Forest Inventory and Analysis (FIA) program[1] (regional inventory). If a regional inventory dataset is employed, stock estimates within the project boundary must be estimated through stratified stand typing.

Baseline determination is specific to a discrete project boundary and must represent a harvesting scenario that seeks to maximize net present value (NPV) of perpetual wood products harvests, per the assumptions described in section 4.1. The project scenario is the actual activity that increases carbon sequestration relative to the baseline through deferred harvesting and retention of forest growth (section 5.5). The difference between these two forest management forecasts is the basis for estimating the project's carbon impacts and the ERT's that will be generated throughout the crediting period.

This methodology limits applicability to NIPF's, comprising a diverse array of landowners, geographies, timber types, market conditions, and other factors. For this reason, this methodology equally distributes ERT issuances across each 20-year Crediting Period.

Project Proponents must demonstrate there is no activity-shifting leakage above ACR's de minimis threshold of 3%. Market leakage must be assessed and accounted for in the quantification of net project benefits. Carbon from wood products must be accounted for.

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[1] https://www.fia.fs.fed.us/tools-data/spatial/

ACR may require periodic methodology updates to reflect regulatory changes, emission factor revisions, expanded applicability criteria, or improvements in monitoring, reporting and verification (MRV) processes.

1.2 APPLICABILITY CONDITIONS

In addition to satisfying requirements of the relevant *ACR Standard*, project activities must satisfy the following applicability conditions:

- Participating sites must be located within the United States
- All landowners in the project area must meet the methodology definition of NIPF and demonstrate clear land title and ownership or control of timber and/or carbon rights prior to their site-specific start date
- The Project Proponent must be a landowner or an independent party with contractual agreement to enroll and implement a carbon project for each site
- The project geographic boundary must encompass one or more discrete sites, each between 40 – 5,000 forested acres
- Sites must be eligible for legal harvest at the time of their start date and must defer harvesting over any crediting period
- The Project Proponent must demonstrate that the project area, in aggregate, meets the methodology definition of forest
- 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

1.3 POOLS AND SOURCES

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Above-ground biomass carbon	Included	Major carbon pool subjected to the project activity
Below-ground biomass carbon	Included	Major carbon pool subjected to the project activity

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Standing dead wood	Included/ Optional	Major carbon pool subjected to the project activity. 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
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

LEAKAGE SOURCE		INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
	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 output due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.

2 BOUNDARIES, ADDITIONALITY AND PERMANENCE

2.1 PROJECT GEOGRAPHIC BOUNDARY

The Project Proponent must delineate the geographic boundary of each site at validation. Information to delineate the project boundary must include:

- Project area map, delineated on a geographic information system
- General location map
- Property parcel map

Geographic delineation of subsequently enrolling cohorts must be provided as an addendum to the initially validated GHG Project Plan in the associated Project Design Document.

Where projects utilize stratification to increase statistical precision, ACR requires geographical identification of strata boundaries and description of stratification criteria within the GHG Project Plan. Cohorts enrolling after the project start date must provide this information within the Project Design Document appendix to the GHG Project Plan.

2.2 PROJECT TEMPORAL BOUNDARY

The following project events must be defined in the GHG Project Plan or Project Design Document:

- Project, cohort, and site-specific start dates
- Crediting period duration for each site

The following project events must be defined in each Monitoring Report:

- Reporting period dates
- Implementation and start date for newly enrolled sites

2.2.1 Start Date

Projects must designate a single overarching project start date. For projects using project-level inventories, this corresponds to the earliest start date among the site(s) included in the initially validated cohort. Projects using regional inventories may submit a listing application to designate a project start date, and start dates for each site must qualify under one of the approved options below. For PDA projects, all subsequent enrolling sites must have an implementation date that is the same or after the established project start date and may be no later than 5 years after the project start date.

Start dates for each site must be denoted by one of the following:

1. The date that the Project Proponent initiated a forest carbon inventory (project-level inventory only)
2. The date that the Project Proponent or landowner entered into a contractual relationship to implement a carbon project
3. The date the project was submitted to ACR for listing review (only applicable for sites identified in the listing application)
4. Other dates may be approved by ACR case-by-case on the basis of verifiable evidence of reasonable intent to engage in a carbon project

2.2.2 Crediting Period

A crediting period is the finite length of time for which the baseline scenario is valid and which a cohort can generate offsets against its baseline. A crediting period consists of a 20-year duration. All sites sharing a crediting period within a PDA project must be on the same validation and verification schedule. All sites wishing to renew participation for a subsequent crediting period may be consolidated into a single cohort.

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

- Re-submitting the GHG Project Plan and Project Design Document in compliance with the then-current *ACR Standard* and methodology
- Re-evaluating the project baseline
- Demonstrating additionality against then-current regulations and performance standard
- Using ACR-approved baseline methods, emission factors, and tools in effect at the time of crediting period renewal, and
- Undergoing validation by an approved Validation/Verification Body (VVB)

ACR does not limit the number of crediting period renewals. Upon the first site request for a renewed crediting period, an updated GHG Project Plan and Project Design Document must be submitted and the project re-validated. At crediting period renewal, the Project Proponent may elect to combine all cohorts such that all renewing sites share the same subsequent crediting period and validation and verification schedule. If a site chooses not to renew its initial crediting period (transitions to a "non-crediting site"), it must still continue MRV activities for the duration of the minimum project term. All non-crediting sites may be reassigned into a single non-crediting cohort or retained under their previously designated cohorts. In either case, the Project Proponent must demonstrate carbon stocks across the aggregate of non-crediting sites remain above previously issued levels for the remainder of the minimum project term.

2.2.3 Project Term

The minimum project term is forty (40) years. The minimum project term begins on the project start date (not the first or last year of crediting).

2.3 ADDITIONALITY

Eligible offsets must be generated by projects that yield GHG reductions/removals that exceed any GHG reductions/removals otherwise required by law or regulation and an approved performance standard.

2.3.1 Regulatory Surplus Test

To pass the Regulatory Surplus Test, Project Proponents must demonstrate project activities are not mandated by existing laws, regulations, statutes, legal rulings, or any other regulatory frameworks that directly or indirectly affect the GHG emissions reductions or removals associated with a project.

Non-regulatory requirements such as voluntary forestry best management practices (BMPs) or current use/tax abatement programs are excluded from the Regulatory Surplus Test.

2.3.2 Performance Standard

This methodology utilizes a practice-based performance standard for demonstrating additionality of all sites that are eligible under this methodology. The *ACR Standard* defines practice-based as "developed by evaluating the adoption rates or penetration levels of a particular practice within a relevant industry, sector, or sub-sector. If these levels are sufficiently low that it is determined the project activity is not common practice, then the project activity is considered additional". The project action for this methodology is deferred harvest over any crediting period. The practice-based performance standard is provided in Appendix A.

2.4 PERMANENCE

Project Proponents must commit to a minimum project term of 40 years of MRV. 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. 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 using the ACR Tool for Risk Analysis and Buffer Determination[2], which addresses 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. The output of the tool is an overall risk category, expressed as a percentage, translating into a buffer deduction that must be applied in the calculation of net ERTs (section 8). This deduction must be applied unless the Project Proponent uses another ACR-approved risk mitigation product.

Examples of unintentional reversals include, but are not limited to, natural disasters (e.g., fire, pest/disease outbreaks, severe weather events), seizure of project lands through eminent domain or land use conversion caused by government agencies (e.g., transportation projects or mitigation projects).

Examples of intentional reversals include, but are not limited to, landowners or Project Proponents choosing to discontinue project activities and/or participate in an activity that results in emissions into the atmosphere of stored or sequestered CO_2e for which offset credits were previously issued, as further defined by the *ACR Standard*.

2.4.1 Assessment of Reversal Risk

To assess the risk of reversal or termination, the Project Proponents shall conduct a risk assessment addressing site-level internal, external and natural risks using the most recently approved ACR Tool for Risk Analysis and Buffer Determination. PDA projects must use a weighted risk assessment conducted across sites on a basis of contribution to total project acreage.

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[2] https://americancarbonregistry.org/carbon-accounting/guidance-tools-templates/acr-risk-tool-v1-0.pdf

2.4.2 Buffer Pool Contributions

The ACR Tool for Risk Analysis and Buffer Determination produces a total risk rating for the project which equals the percentage of offsets that must be deposited in the ACR buffer pool to compensate for reversal or termination (unless another ACR approved risk mitigation mechanism is used in lieu of buffer contribution). The risk assessment, overall risk rating, and proposed mitigation or buffer contribution shall be included in the GHG Project Plan and updated for PDA projects upon the start date of subsequent cohorts.

3 STRATIFICATION

This methodology specifies that inventory data for calculating the project and baseline scenario carbon stock may be derived from 1) a statistically unbiased sample of inventory plots within the project boundary (project-level inventory), or 2) a statistically unbiased sample of inventory plot data sourced from the USFS FIA program (regional inventory). Projects employing project-level inventories may utilize stratification if the project area is not homogeneous to inform modeling of management scenarios and improve precision of carbon stock estimates. Projects utilizing regional inventories are required to use stratification to estimate forest carbon stocks within the discrete project boundary. Regardless of inventory data source, carbon estimates must be representative of plot data within the discrete sampling frame of the project boundaries. Different stratifications may be used for the with-project and baseline scenarios.

If stratification is employed, a stratification standard operating procedures (SOP) document detailing relevant design, inputs, parameters, rules and techniques must be provided as an attachment to the initial GHG Project Plan for validation. The stratification SOP document should contain information necessary such that the stratification can be examined and duplicated as necessary to provide reasonable assurance of the validity and non-bias of associated techniques. The number and boundaries of strata may change during the crediting period (*ex post*). If so, updates and changes to stratification must be detailed and tracked in the stratification SOP, as well as the Monitoring Report. Updated geospatial identification must be provided as an addendum to the stratification SOP.

Strata may be defined using any number of parameters identified as useful for estimating forest carbon stocks and changes over time. The stratification approach must follow the validated and verifiable procedures detailed in the stratification SOP document. Examples of parameters that may be used for estimating changes in forest carbon stocks include, but are not limited to:

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

The *ex post* stratification may need to be updated due to, but not limited 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
- Land use change (i.e. forest to non-forest)

- Established strata may be merged if reason for their establishment is no longer relevant or to improve statistics

4 BASELINE

4.1 IDENTIFICATION OF BASELINE

This methodology quantifies GHG emission reductions and removals resulting from harvest deferral on NIPF lands. Emission Reduction Tons (ERTs) are quantified for carbon sequestered through deferred harvesting and retention of annual forest growth in excess of the baseline scenario.

Baseline determination is site-specific and must describe a legally and financially feasible harvesting scenario that seeks to maximize NPV of perpetual wood product harvests over a 100-year modeling period.

This methodology establishes an average baseline determination technique for NIPF's in the United States. Project Proponents shall use the baseline discount rate of 5% for NIPF landowners established in the ACR IFM methodology[3] to model a site-specific NPV-maximizing baseline scenario. Project Proponents then defer harvest activities for the purpose of increased carbon sequestration. The project scenario by definition will result in a lower NPV than the baseline scenario. The difference in carbon stocks between these two management scenarios is the basis for determining carbon sequestration and ERTs.

The baseline is a legally permissible harvest scenario that would maximize NPV of perpetual wood products harvests and shall be based on silvicultural prescriptions recommended by published state or federal agencies, or regionally appropriate silvicultural techniques endorsed by Qualified Forestry Professionals, to perpetuate existing onsite timber producing species while fully utilizing available growing space. 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 silvicultural prescriptions as noted above and must adhere to all applicable laws and regulations. The resulting harvest schedule is used to establish baseline stocking levels through the crediting period.

The modeled baseline scenario must utilize one of the two eligible sources of inventory data for this methodology: 1) a statistically unbiased sample of inventory plots within the project boundary (project-level inventory), or 2) a statistically unbiased sample of inventory plot data sourced from the USFS FIA program (regional inventory). Additional required inputs for the NPV calculation include prices for wood products of grades that the project would produce, associated costs of logging and reforestation, silvicultural treatment costs, and carrying costs, as applicable. Project Proponents shall include road building, infrastructure and harvesting costs as appropriate to

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[3] https://americancarbonregistry.org/carbon-accounting/standards-methodologies/improved-forest-management-ifm-methodology-for-non-federal-u-s-forestlands

the terrain and unit size. Acceptable sources of economic information for the NPV calculation include price and cost data or studies published by governmental agencies, scientific literature, university cooperative extension services, or Qualified Forestry Professionals with demonstrable forest management knowledge and experience. Project Proponents must model growth of forest stands over a 100-year modeling period and may use a constrained optimization program to calculate the maximum NPV for the baseline harvesting schedule while meeting any forest practice legal requirements. Wood products must be accounted for in the NPV calculus.

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

Sites and associated cohorts are considered enrolled in the PDA project upon successful validation by an approved VVB. However, each site may have its own implementation date for which ERT generation begins. Change in baseline compared to project scenario stocks is used to calculate ERTs.

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.

4.2 BASELINE NET REDUCTIONS AND REMOVALS

Baseline carbon stock change must be quantified for the duration of each sites crediting period. The baseline stocking level used for the stock change calculation is derived from the baseline management scenario developed in Section 4.1. This methodology requires 1) annual baseline stocking levels to be modeled 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 4.2.1 and wood products calculations described in Section 4.2.1:

Equation 1

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

WHERE

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

Equation 2

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

WHERE

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

Equation 3

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

WHERE

t	Time in years
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2)
$C_{BSL,HWP,t}$	Baseline value of carbon remaining in wood products 100 years after being harvested in the year t (in metric tons CO_2)

NOTE: Please see section 4.2.1 for detailed instructions on baseline wood products calculations.

Equation 4

$$\overline{\mathrm{GHG}_{\mathrm{BSL}}} = \frac{\sum_{t=1}^{20}\left(\mathrm{BS}_{\mathrm{BSL},t} \times \mathrm{ER}_{\mathrm{CH_4}} \times \frac{16}{44} \times \mathrm{GWP}_{\mathrm{CH_4}}\right)}{20}$$

WHERE

t	Time in years
$\overline{\mathrm{GHG}_{\mathrm{BSL}}}$	Twenty-year average value of greenhouse gas emissions (in metric tons CO_2e) resulting from the implementation of the baseline
$\mathrm{BS}_{\mathrm{BSL},t}$	Carbon stock (in metric tons CO_2) in logging slash burned in the baseline for year t
$\mathrm{ER}_{\mathrm{CH_4}}$	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[4] of 0.012.
$\frac{16}{44}$	Molar mass ratio of CH_4 to CO_2
$\mathrm{GWP}_{\mathrm{CH_4}}$	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 ($\mathrm{BS}_{\mathrm{BSL},t}$) shall use the method described in section 4.2.2 for bark, tops and branches, and section 4.2.3 if dead wood is selected. The reduction in carbon stocks due to slash burning in the baseline must be properly accounted in Equations 1 and 2.

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

Equation 5

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

WHERE

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

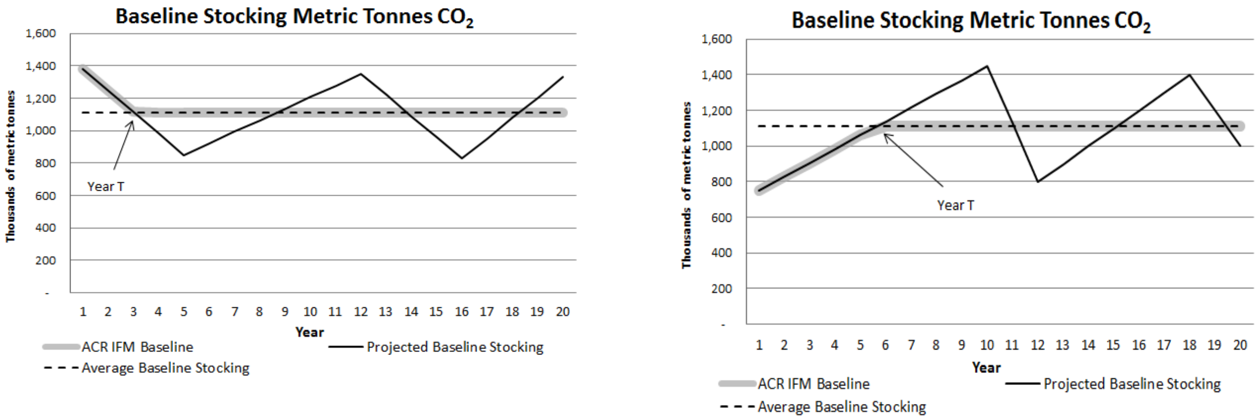
t	Time in years
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO_2)
$C_{BSL,TREE,t}$	Baseline value of carbon stored in above and below ground live trees (in metric tons CO_2) at year t
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in standing and lying dead trees at year t (in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

Change in baseline carbon stock is computed over time. The Project Proponent shall provide a graph of the projected baseline stocking levels and the long-term average baseline stocking level for the entire crediting period (see Figure 1). The year that the projected stocking levels reach the long-term average (time $t = T$) is determined by either Equation 6 or 7, depending on initial stocking levels. Prior to time T, the projected stocking levels are used for the baseline stock change calculation, as determined by Equation 8. In the year that the projected stocking levels reach the long-term average (time $t = T$), the baseline stock change calculation is determined by Equation 9. Thereafter, the long-term average stocking level is used in the baseline stock change calculation, as determined by Equation 10, and only project-scenario growth is credited for the remaining years in the crediting period.

Figure 1: Sample Baseline Stocking Graph

FOR PROJECT BEGINNING:

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



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

Equation 6

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

WHERE

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

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

Equation 7

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

WHERE

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

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

Equation 8

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

WHERE

t	Time in years
$\Delta\mathrm{C}_{\mathrm{BSL,t}}$	Change in the baseline carbon stock (in metric tons CO_2) for year t
$\Delta\mathrm{C}_{\mathrm{BSL,TREE,t}}$	Change in the baseline carbon stock stored in above and below ground live trees (in metric tons CO_2) for year t
$\Delta\mathrm{C}_{\mathrm{BSL,DEAD,t}}$	Change in the baseline carbon stock stored in dead wood pools live trees (in metric tons CO_2) for year t
$\bar{\mathrm{C}}_{\mathrm{BSL,HWP}}$	Twenty-year average value of annual carbon remaining in wood products 100 years after harvest (in metric tons CO_2)
$\overline{\mathrm{GHG}}_{\mathrm{BSL}}$	Twenty-year average value of annual greenhouse gas emissions (in metric tons 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 $\Delta\mathrm{C}_{\mathrm{BSL,t}}$ will most likely be negative for projects with initial stocking levels higher than $\mathrm{C}_{\mathrm{BSL,AVE}}$ or positive for projects with initial stocking levels lower than $\mathrm{C}_{\mathrm{BSL,AVE}}$. If years elapsed since the start of the IFM project activity (t) equals T, use the following equation to compute baseline stock change:

Equation 9

$$\Delta \mathbf{C}_{\mathbf{BSL,t}} = \mathbf{C}_{\mathbf{BSL,AVE}} - (\mathbf{C}_{\mathbf{BSL,TREE,t-1}} + \mathbf{C}_{\mathbf{BSL,DEAD,t-1}} + \sum_{\mathbf{t=1}}^{\mathbf{t-1}} \bar{\mathbf{C}}_{\mathbf{BSL,HWP}} - \sum_{\mathbf{t=1}}^{\mathbf{t-1}} \overline{\mathbf{GHG}}_{\mathbf{BSL}})$$

WHERE

t	Time in years
$\Delta\mathrm{C}_{\mathrm{BSL,t}}$	Change in the baseline carbon stock (in metric tons CO_2) for year t

$\mathrm{C_{BSL,AVE}}$	20-year average baseline carbon stock (in metric tons CO_2).
$\mathbf{C_{BSL,TREE,t-1}}$	Baseline carbon stock stored in above and below ground live trees (in metric tons CO_2) in the year prior to year t.
$\mathbf{C_{BSL,DEAD,t-1}}$	Baseline carbon stock stored in dead wood pools (in metric tons CO_2) in the year prior to year t.
$\mathbf{\bar{C}_{BSL,HWP}}$	Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2).
$\mathbf{\overline{GHG}_{BSL}}$	Twenty-year average value of greenhouse gas emissions (in metric tons CO_2e) resulting from the implementation of the baseline.

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

Equation 10

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

WHERE

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

4.2.1 Stocking Level Projections in the Baseline

Whether a project implements the project-level or regional inventory data approaches, plot-level data and models must be used to estimate and update baseline and project scenario forest carbon stocks over each crediting period. In the baseline scenario, stocks are modeled according to a plausible, legally permissible harvesting scenario that seeks to maximize NPV of harvested wood products over 100-years. Models are used to “grow” project and baseline scenario initial carbon stocks to discrete points in time for MRV and ERT calculation purposes in both the project-level and regional inventory methods.

Modeling must be completed with a peer reviewed forestry model that has been calibrated for use in the project’s specific geographical region(s) and approved by ACR. The GHG Project Plan must detail which model is being used and variants selected. All model inputs and outputs must be available for review by the verifier, and the VVB shall document the methods used in validating the growth and yield model outputs in the Validation Report.

Examples of approved models include:

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

Models must be:

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

Model outputs must include either projected total aboveground and belowground carbon per acre, volume in live aboveground tree biomass, or another appropriate unit by strata in the baseline. All model output must be converted to biomass and finally CO_2e per acre. If model output for the tree is volume, use the steps in Section 4.2.2[5] to convert volume to biomass, carbon and CO_2 equivalent. Where model projections are output in multiple year increments, the outputs shall be annualized to give a stock change number for each year.

If processing of alternative data on dead wood is necessary, equations in section 4.2.3 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.

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

4.2.2 Tree Carbon Stock Calculation

Under the component ratio method (CRM), biomass for each tree is calculated from its merchantable volume. The Project Proponent must use the same set of equations, diameter at

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[5] The steps prescribed in Section 4.2.2 are not relevant where models output projected total aboveground and belowground biomass or carbon.

breast height thresholds, and selected biomass components for *ex ante* and *ex post* baseline and project estimates.

To ensure accuracy and conservative estimation of the mean aboveground live biomass per unit area within the project area, projects must account for missing cull in both the *ex ante* and ex post baseline and project scenarios. Determine missing cull deductions with cull attribute data collected during field measurement of sample plots.

The following steps are used to calculate tree biomass using the CRM:

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

Step 2 Determine aboveground biomass by choosing a combination of the following components: stump, bark, tops and branches, and/or foliage, in addition to below-ground biomass, by applying component ratios from Jenkins et al (2003) Table 6[6], where biomass of each component is calculated as its component ratio × merchantable stem biomass from Step 1 × (1 / stem wood component ratio). If stump, top, and branch components are included, please use the quantification methodology found in Woodall et al. 2011[7]. Note that the same components must be calculated for *ex ante* and *ex post* baseline and project estimates.

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

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

Step 5 Determine total project carbon (in metric tons CO_2) by summing the biomass of each stratum for the project area and converting biomass to carbon by multiplying by 0.5, kilograms to metric tons by dividing by 1,000, and finally carbon to CO_2 by multiplying by 3.664.

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

[7] Woodall, Christopher W.; Heath, Linda S.; Domke, Grant M.; Nichols, Michael C. 2011. Methods and equations for estimating aboveground volume, biomass, and carbon for trees in the U.S. forest inventory, 2010. Gen. Tech. Rep. NRS-88. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

NOTE: The FVS Fire and Fuels Extension volume-based default estimates[8] of live carbon are compliant with the above, but do not include bark and stump components.

4.2.3 Dead Wood Calculation

Dead wood included in the methodology comprises two components— standing dead wood and lying dead wood. Below-ground dead wood is considered optional and shall be quantified using the same procedures as below-ground live tree biomass. Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components.

4.2.3.1 STANDING DEAD WOOD (IF INCLUDED)

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

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

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

Step 3 Biomass must be estimated using the CRM as used for live trees 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.

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[8] Hoover, C.M. and Rebain, S.A., 2011. Forest carbon estimation using the Forest Vegetation Simulator: Seven things you need to know. http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs77.pdf

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[9].

Step 5 Determine total project standing dead carbon (in metric tons CO_2) by summing the biomass of each stratum for the project area and converting biomass to carbon by multiplying by 0.5, kilograms to metric tons by dividing by 1,000, and finally carbon to CO_2 by multiplying by 3.664.

NOTE: The FVS Fire and Fuels Extension estimates of Standing Dead Carbon are compliant with this methodology, but do not include bark and stump components.

4.2.3.2 LYING DEAD WOOD (IF INCLUDED)

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.[10, 11] 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), section 4.3.3.5.3. 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.[12]

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

[10] 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.

[11] 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

[12] USFS FIA Phase 3 proportions

Step 3 The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[13] as modified by Van Wagner (1968)[14] 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

$V_{LDW,DC}$	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

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

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

WD_{DC}	Basic wood density (in kilograms per cubic meter) of dead wood in the density class — sound (1), intermediate (2), and rotten (3)

Step 5 Determine total project lying dead carbon by summing the biomass of each stratum for the project area and converting biomass to dry metric tons of carbon by multiplying by 0.5, kilograms to metric tons by dividing by 1,000, and finally carbon to CO_2 by multiplying by 3.664.

4.2.4 Wood Products Calculations

Harvest removals are not permitted in the project scenario and are therefore excluded from project scenario accounting. However, a defined subset of management activities is permitted (see section 5.5.1), in which case, any removals must be reported and accounted for.

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[15]:

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
5. Summing the carbon remaining in wood products 100 years after harvest

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

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

I. Determine the amount of wood harvested in the baseline that would be delivered to mills, by volume (cubic feet) or by green weight (lbs.), and by species for the current year (y). In all cases, harvested wood volumes and/or weights must exclude bark.
   A. Baseline harvested wood quantities and species are derived from modeling a baseline harvesting scenario using an approved growth model.

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

i. If baseline harvested wood volumes are reported in units besides cubic feet or green weight, convert to cubic feet using the following conversion factors:

VOLUME MULTIPLIERS FOR CONVERTING TIMBER AND CHIP UNITS TO CUBIC FEET OR CUBIC METERS

UNIT	FT^3 FACTOR	M^3 FACTOR
Bone Dry Tons	71.3	2.0
Bone Dry Units	82.5	2.3
Cords	75	2.1
Cubic Meters	35.3	1.0
Cunits-Chips (CCF)	100	2.8
Cunits-Roundwood	100	2.8
Cunits-Whole tree chip	126	3.6
Green tons	31.5	0.9
MBF-Doyle	222	6.3
MBF-International 1/4"	146	4.1
MBF-Scribner ("C" or "Small")	165	4.7
MBF-Scribner ("Large" or "Long")	145	4.1
MCF-Thousand Cubic Feet	1,000	28.3
Oven Dried Tonnes	75.8	2.1

II. If a volume measurement is used, multiply the cubic foot volume by the appropriate green specific gravity by species from table 5-3a of the USFS Wood Handbook[16]. This results in pounds of biomass with zero moisture content. If a

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[16] 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.

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 calculations.

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

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

V. Divide the carbon weight by 2,204.6 pounds/metric ton and multiply by 3.664 to convert to metric tons of CO_2. Sum the CO_2 for each species into saw log and 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 tons of carbon) for each group derived in Step 1 by the mill efficiency identified for the cohort's mill location(s) in the Regional Mill Efficiency Database, found on the reference documents section of this methodology's website. This output represents the total carbon transferred into wood products. The remainder (sawdust and other byproducts) of the harvested carbon is considered to be immediately emitted to the atmosphere for accounting purposes in this methodology.

Step 3 ESTIMATE THE CARBON 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 decay. Decay rates depend on the type of wood product that is produced. Thus, in order to account for the decomposition of harvested wood over time, a decay rate is applied to wood products according to their product class. To approximate the climate benefits of carbon storage, this methodology accounts for the amount of carbon stored 100 years after harvest. Thus, decay rates for each wood product class have been converted into "storage factors" in the table below.

WOOD PRODUCT CLASS	IN-USE
Softwood Lumber	0.234
Hardwood Lumber	0.064

Softwood Plywood	0.245
Oriented Strandboard	0.349
Non-Structural Panels	0.138
Miscellaneous Products	0.003
Paper	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 the baseline harvest that 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 verifiable mill report from the mill(s) where the project area's logs are sold indicating the product categories the mill(s) sold for the time duration in question **OR**
- If a verifiable mill report cannot be obtained, assigning weighted default wood product classes for the project's assessment area(s), as provided in the Assessment Area Data File found on the reference documents section of this methodology's website

If breakdowns for wood product classes are not available from either of these sources, classify all wood products as "miscellaneous." Mill efficiencies and wood product class percentages shall be calculated on an area weighted basis for regional, stratified inventories to arrive at strata-level estimates of carbon stored in wood products for the baseline scenario.

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

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

4. Sum all of the resulting values to calculate the carbon stored in in-use wood products after 100 years (in units of CO_2-equivalent metric tons)
5. This value is used for input into the ERT calculation worksheet. The baseline value is the 100-year average, and does not change from year to year

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 values for each product class by the storage factor for landfill carbon
4. Sum all of the resulting values to calculate the carbon stored in landfills after 100 years (in units of CO_2-equivalent metric tons)

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

The total carbon storage in wood products after 100 years for a given harvest volume is the sum of the carbon stored in landfills after 100 years and the carbon stored in in-use wood products after 100 years. This value is used for input into the ERT calculation worksheet. The value for the actual harvested wood products will vary every year depending on the total amount of harvesting that has taken place. The baseline value is the 100-year average value, and does not change from year to year.

4.3 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. If estimating uncertainty associated with a statistical sampling design (whether a project-level or regional inventory approach), 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 project scenario uncertainty.

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

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

Therefore,

Equation 13

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

WHERE

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

$e_{BSL,DEAD}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in dead wood (in metric tons CO_2) for the initial inventory in year t

5 WITH-PROJECT SCENARIO

5.1 MONITORING AND DATA COLLECTION

Initial mean carbon stock in aboveground biomass per unit area within the project boundary is estimated based on field measurements, derived from either 1) a statistically unbiased sample of inventory plots within the project area (project-level inventory), or 2) a statistically unbiased sample of inventory plot data sourced from the USFS FIA program (regional inventory). When the project-level inventory approach is used, an inventory SOP must be developed that describes the inventory process including sample size, sample inventory design, plot locations, and data collected. When using the regional inventory approach, it is assumed that measurement procedures adhered to the then current FIA Core Field Guide[17], in which case, the FIA Core Field Guide can be referenced in lieu of an inventory SOP. All plot inventory data used in biomass calculations and growth and yield projections may not be older than 10 years. Growth and yield projections may not be older than one crediting period. Plots in project-level inventories may be permanent or temporary and may have a defined boundary or use variable radius sampling methods.

Each project shall include a GHG Project Plan sufficiently meeting the requirements of the *ACR Standard*. The plan shall describe the collection of all data required to be monitored in a manner which meets the requirements for accuracy and precision of this methodology. Project Proponents shall use the template for GHG Project Plans available at www.americancarbonregistry.org. Additionally, projects are required to submit a GHG Monitoring Report for each reporting period. Project Proponents shall use the template for GHG Monitoring Reports available at http://americancarbonregistry.org/carbon-accounting/tools-templates. PDA projects are required to submit cohort-specific appendices to the Project Design Document detailing eligibility criteria and geographical identification for each new cohort submitted for validation.

5.2 MONITORING PROJECT IMPLEMENTATION

Information shall be provided, and recorded in the GHG Project Plan (and subsequent cohort appendices for PDA projects) to establish:

- The geographical boundaries of the project region (regional inventories only)
- 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

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[17] https://www.fia.fs.fed.us/library/field-guides-methods-proc/

(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
- If project-level inventory plots are established, SOPs and quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection, stratification 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.
- If a regional inventory approach employing FIA plots is used, SOPs and QA/QC procedures are not required, however, detailed stratification and data management procedures are required
- Where permitted management activities (as defined in section 8.2.1) occur in the project boundaries in the with-project scenario, documentation should be provided to detail the nature and type, geographical scope, amounts and compensation mechanisms of harvest removals
- Participating sites must maintain regulatory compliance over the minimum project term and are not eligible to earn ERTs during any period of non-compliance

5.3 MONITORING OF CARBON STOCKS IN SELECTED POOLS

The 90% statistical confidence interval (CI) of sampling can be no more than ±10% of the mean estimated amount of the combined carbon stock at the project level[18]. If the Project Proponent cannot meet the targeted ±10% of the mean at 90% confidence, projects must use Equation 20 to determine an appropriate confidence deduction. If calculated uncertainty in Equation 20 exceeds 10%, then the estimated amount of the combined carbon stock at the project level cannot be verified without additional sampling or stratification to improve statistical confidence.

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

- Project area
- Sample plot area
- Tree species
- Tree biomass
- Dead wood pool, if selected

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

5.4 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.

5.5 ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS

This section describes the steps required to calculate $\Delta C_{P,t}$ (carbon stock change under the project scenario; tons CO_2e). This methodology requires: 1) carbon stock levels to be determined at the end of the reporting period, t, and 2) the change in project carbon stock to be computed from the end of the prior reporting period, $t\text{-}1$.

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

Equation 14

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

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 tons CO_2) for year t
$C_{P,TREE,t}$	Project value of carbon stored in above and below ground live trees at year t (in metric tons CO_2) and $t\text{-}1$ signifies the value at the prior year.

Equation 15

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

WHERE

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

Equation 16

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

WHERE

t	Time in years
$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO_2e) resulting from the implementation of the project for year t
$BS_{P,t}$	Carbon stock (in metric tons CO_2) in logging slash burned in the project for year t
ER_{CH_4}	Methane (CH_4) emission ratio (ratio of CO_2 as CH_4 to CO_2 burned). If local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value of 0.012[19].
$\frac{16}{44}$	Molar mass ratio of CH_4 to CO_2
GWP_{CH_4}	100-year global warming potential (in CO_2e per CH_4) for CH_4 (IPCC SAR-100 value in the Assessment Report specified in the applicable *ACR Standard* version)

Carbon stock calculation for logging slash burned shall use the method described in section 4.2.2 for bark, tops and branches, and section 4.2.3 if dead wood is selected. The reduction in

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

carbon stocks due to slash burning due to project activities must be properly accounted in Equations 14 and 15.

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

Equation 17

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

WHERE

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

5.5.1 Allowable Management Activities

While harvesting is not a permissible project activity, there is a subset of permitted management activities that must be monitored and accounted for in the project scenario. These include firewood harvesting for personal use, the installation of small clearings, and salvage cutting and preventative silvicultural treatments to manage pest and disease outbreaks. Other permitted management activities may be considered by the VVB and ACR on a case-by-case basis and must be explicitly defined and approved in the GHG Project Plan.

- The cutting of standing dead or dying trees for firewood for personal or familial use is permitted under this methodology. The Project Proponent must attest that no firewood was sold and was for personal use only.

  The landowner may elect to harvest standing dead or dying trees for firewood on an annual basis. The carbon stocks associated with 5 cords will be deducted from the site's reported project carbon stocks for each year this option is elected. The total deduction representing stocks in above and below ground live and dead trees will be no less than 25 tCO_2e per year (as estimated from the total tree biomass/carbon stocks associated with 5 cords and illustrated below).

375.00	cubic feet
11.90	green tons
2,568.49	board feet (Int ¼")
5.00	cords
9.74	merchantable bole tCO_2e
24.35	above and below ground tCO_2e
25.00	**TOTAL DEDUCTION FOR FUELWOOD (tCO_2e)**

- The clearing of trees in small areas for use as food plots and hunt stands, borrow pits, turn arounds, short spur roads, small pasture areas or small cabin sites is permitted under this methodology. The Project Proponent must attest that no timber cut in the establishment of the clearing was sold.
  - Limit of no more than 2% of any site enrolled with an overall cap of 5 acres per site of alternative uses over the 40-year project life. Example, a 40-acre project site could clear a 0.8-acre (2%) food plot or cabin site. A 250-acre or greater project site could clear up to and no more than 5 acres total during the project life.
  - The landowner may elect to clear a portion of the project area limited by the requirements described above. The area cleared must be mapped and re-classified as a zero-stocked stratum, with 100% of the area's project stocks cancelled from the inventory for the remainder of the project life.
- The cutting of trees to mitigate pest and disease outbreaks is permitted, including salvage cutting and preventative silvicultural treatments. To conduct these types of activities, the Project Proponent must provide a management plan prepared by a Qualified Forestry Professional describing the nature of the disturbance and the silvicultural methods employed to mitigate the impact. Carbon stock removals resulting from these harvests must be monitored, reported, verified and deducted from project scenario carbon stocks and included in HWP calculations.

Regardless of the management implemented, electing to cut trees under these permissible activities must still consider the requirements to maintain and/or increase project stocks over the project life and does not change any obligations or requirements with respect to reversals, as described in the methodology. Any site(s) that violate the deferred harvest commitment (i.e., they conduct harvesting activities beyond those explicitly specified here or in the GHG Project Plan during a crediting period and are not designated as a non-crediting site) will be considered terminated and all stocks attributed to the given site(s) deducted from the project inventory and reflected in crediting at next ERT issuance.

5.6 LEAKAGE

Leakage is an increase in GHG emissions outside the project area that occurs as a result of the project activity. ACR requires Project Proponents to assess, account for, and mitigate leakage above de minimis levels. There are two categories of leakage that must be addressed under this methodology: activity-shifting leakage and market leakage.

5.6.1 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(s).

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 activity-shifting leakage within their operations on comparable lands — i.e., on other lands that are managed/operated by the landowner and outside the boundaries of the ACR carbon project (that total 40 acres or more of eligible forest land in a single or a group of adjacent parcels). This demonstration is not required if the Project Proponent and associated landowner(s) enroll all of their eligible 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 for tracts or groupings of small adjacent tracts that total 40 acres or more of forest, requiring sustainable practices (programs can include FSC, SFI, or ATFS). Management certification must cover all entity owned lands with active timber management programs **OR**
- Adherence to a long-term forest management plan or program incorporating all their forested landholdings, prescribing principals of sustained yield and natural forest management (plan and program criteria subject to ACR approval) **OR**
- Annual disclosure and review of harvests occurring outside of enrolled project lands owned by the participant. For the purposes of this demonstration, leakage is assumed when any harvest of 40 contiguous acres or greater occurs that is deemed to diverge from silvicultural or sustainable norms for the region and forest types. Confirmation of divergence/non-divergence of relevant harvests by a Qualified Forestry Professional is required. Upon inspection (empirical), the Qualified Forestry Professional must provide a signed letter to the VVB and ACR that includes the date of inspection, location, owner name, pre-harvest

condition, product types removed, treatment applied, and post-harvest condition. Notes on other related issues such as BMP performance, wildlife habitat retention, use of riparian buffers, and other sustainable practices, can also be provided as appropriate.

5.7 MARKET LEAKAGE

Market leakage is a principal consideration for carbon accounting amongst all offset types and is complex in nature. Still, carbon programs must determine applicable market leakage deduction rates to protect the integrity of the offsets entering the marketplace. Murray et al. (2004) explains market leakage dynamics, including:

- Leakage impacts are related to the elasticity of demand/supply
- Leakage in forestry projects cannot be assumed to be zero
- Leakage increases as a proportion or percent of output in smaller vs larger projects

Galik (2018) expanded on these principles and noted that "some projects ameliorate their real risk of market leakage through project design characteristics". Project size, geographic spread, diversity of wood products, ownership diversity, and other variables can have both direct and indirect effects on project level market leakage risk (Galik 2018). Murray et al. (2004) and Galik (2018) also note that, for some projects, proportional leakage may be high when compared to project output but the resulting number of credits deducted at that rate can be de minimis in significance to the marketplace.

The literature supports a lower market leakage deduction for the unique project design and landowner characteristics of this methodology compared to large, single ownership IFM projects for two main reasons:

- **PDA PROJECTS ARE MORE DIVERSE BY DESIGN.** PDA projects are assemblages of private landowners across a large geography with variable forest products, management objectives, and size, and thus, can directly and indirectly reduce the risk of leakage when compared to a single owner project of equal size (Galik 2018; Murray 2008).
- **IN COMPARISON TO LARGER LANDOWNERS, SMALLER FOREST OWNERS ARE NOT AS DIRECTLY OR SPECIFICALLY DRIVEN BY DEMAND-INDUCED MARKET PRICE RESPONSES DUE TO REDUCED SUPPLY.** Amacher et al. (2004) further explains this dynamic; "The behavior of private landowners is far less predictable than industry behavior, because of the multi-objective nature of their ownership and the difference in time horizons for management decisions. NIPF landowners may not always respond to prices in the same way that forest industry does; this makes predicting timber supply from NIPF land quite difficult, as noted first by Dennis (1989) and Newman and Wear (1993)". Further, while most private landowners do cut trees at some point in their land tenure, income need for personal situations, historical use, recreation, wildlife management, family legacy, and aesthetics also impact small private landowner choices (Amacher et al. 2004; Butler and Ma 2011; Butler et

al. 2020). As a result, supply from this landowner type is more inelastic in nature and therefore less prone to market leakage.

5.7.1 Market Leakage Deduction

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

Equation 18

$$\mathrm{LK} = 0$$

  - Where project activities decrease total wood products produced by the project relative to the baseline by more than 5% over the crediting period, the market leakage deduction is 20%.

Equation 19

$$\mathrm{LK} = 0.2$$

- 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(s) 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 VVB and ACR's discretion to determine whether the method for quantifying market leakage is appropriate for the project.

5.8 ESTIMATION OF WITH-PROJECT UNCERTAINTY

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 20

$$\mathrm{UNC}_{P,t} = \sqrt{\frac{\left(C_{P,TREE,t} \times e_{P,TREE,t}{}^{2}\right) + \left(C_{P,DEAD,t} \times e_{P,DEAD,t}{}^{2}\right) + \left(C_{P,HWP,t} \times e_{P,TREE,t}{}^{2}\right) + \left(\mathrm{GHG}_{P,t} \times e_{P,TREE,t}{}^{2}\right)}{C_{P,TREE,t} + C_{P,DEAD,t} + C_{P,HWP,t} + \mathrm{GHG}_{P,t}}}$$

WHERE

t	Time in years
$\mathrm{UNC}_{P,t}$	Percentage uncertainty in the combined carbon stocks in the project at year t
$C_{P,TREE,t}$	Carbon stock in the project stored in above and below ground live trees (in metric tons CO_2) at year t
$C_{P,DEAD,t}$	Carbon stock in the project stored in dead wood (in metric tons CO_2) at year t
$C_{P,HWP,t}$	Carbon (in metric tons CO_2) remaining stored in wood products in the project 100 years after harvest for year t
$\mathrm{GHG}_{P,t}$	Greenhouse gas emission (in metric tons CO_2e) resulting from the implementation of the project for year t
$e_{P,TREE,t}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the carbon stock in above and below ground live trees (in metric tons CO_2) for the last remeasurement of the inventory prior to year t

$e_{P,DEAD,t}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the carbon stock in dead wood (in metric tons CO_2) for the last remeasurement of the inventory prior to year t

6 QA/QC, VALIDATION AND VERIFICATION, AND UNCERTAINTY

6.1 METHODS FOR QUALITY ASSURANCE

Standard operating procedures and QA/QC procedures for forest inventory and modeling, including field data collection and data management, shall be documented. Use or adaptation of SOPs already applied in national forest monitoring (USFS FIA), 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 emission reductions/removals, including estimating and accounting for any decreases in carbon pools and/or increases in GHG emission sources. This methodology sets a *de minimis* threshold of 3% of the final calculation of emission reductions/removals. For the purpose of completeness any decreases in carbon pools and/or increases in GHG emission sources must be included if they exceed the *de minimis* threshold. Any exclusion using the *de minimis* principle shall be justified using fully documented *ex ante* calculations.

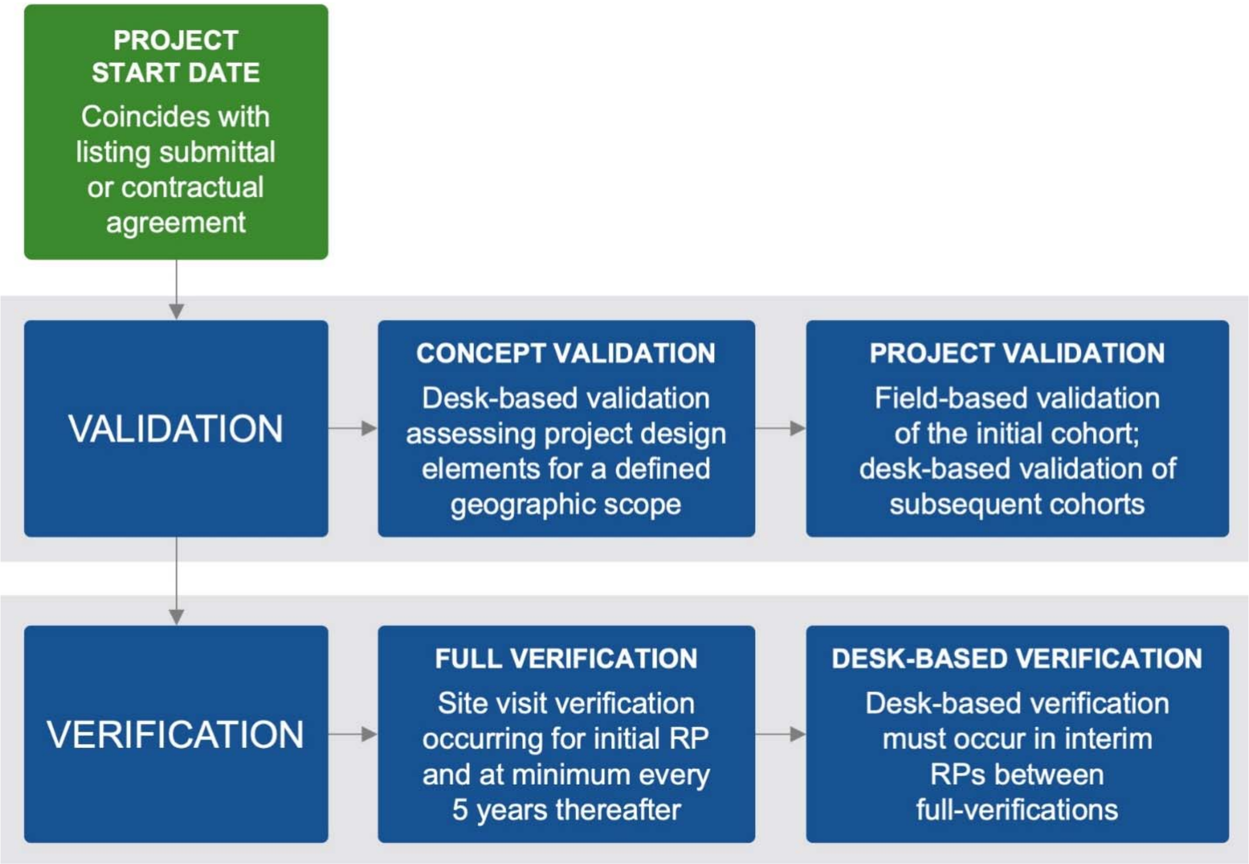
6.3 VALIDATION AND VERIFICATION

Certain validation and verification procedures for this methodology supersede requirements within the ACR Verification and Validation Standard. Specific exceptions and clarifications relevant to this methodology are described below. Unless otherwise stated, the requirements in the most recent version of the ACR Validation and Verification Standard apply to all projects.

The process for validation and verification of projects implementing this methodology is illustrated in Figure 2.

Figure 2: Process for Project Validation and Verification

Projects may conduct validation and verification concurrently or as separate events.



Projects utilizing regional inventories may (if desired) list a project prior to contractual enrollment of sites/landowners in the carbon project by submitting an ACR Offset Project Listing Form. This may be desirable when the Project Proponent would like to validate project design elements prior to enrolling landowners. In this instance the date of listing submittal is deemed an eligible project start date, but site-specific start dates for crediting must be based on the date a landowner enrolls in a contractual relationship to implement a carbon project. All sites must be enrolled by the Project Proponent within 5 years after the project start date.

6.3.1 Validation

Validation may be conducted as a two-step process or consolidated as a single event. The first step, concept validation, provides the opportunity for Project Proponents to desk validate project design elements prior to enrolling landowners. The second step, project validation, includes field-based and desk-based assessments of project and site-level elements not assessed in concept validation. When the concept validation and project validation steps are conducted as a single event, the full scope of both validation steps must still be addressed.

6.3.1.1 CONCEPT VALIDATION

PDA or aggregated projects utilizing regional inventories must undergo a concept validation. The concept validation is specific to a defined geographic scope and entails a desk-based assessment of inventory/quantification methods, baseline and project modeling, baseline and project uncertainty calculations, aggregation/cohort design and monitoring and QA/QC systems as defined in the GHG Project Plan and associated Project Design Document. The concept validation is conducted after PDA Project Listing and may occur before the first site enrolls.

Concept validation is required within 3 years of the project Start Date, and occurs only once per crediting period, unless significant changes have occurred to the project design. Significant changes may include changes to the regional or project-level inventory method or geographic scope or changes to underlying quantification methods. Significant changes do not include enrollment of additional Sites within a previously validated geographic scope.

Scope of concept validation:

- Project conformance with eligibility/applicability criteria
- Project geographic scope/boundaries and procedures for establishing existing and future project region(s)
- Physical infrastructure, activities, technologies, and processes of the project
- GHGs, sources, and sinks within the project boundary or project region
- Project temporal boundary
- Description of and justification for the baseline scenario
- Methodologies, algorithms, and calculations that will be used to generate estimates of baseline and project scenario stocks and emission reductions/removal enhancements (this includes an evaluation of growth and yield model selection and parameterization)
- Project procedures for collecting process information, source identification/counts, and operational attributes
- Project implementation of data management systems and QA/QC procedures
- Processes for estimating, calculating and accounting for project-level uncertainty, and
- Roles and responsibilities of Project Proponent staff and landowners

6.3.1.2 PROJECT VALIDATION

All new sites must undergo a project validation, which includes a site visit assessment of the initial cohort and desk-based assessments for subsequent cohorts. Project validation examines cohort/site-level aspects of the GHG Project Plan that could not be validated in concept validation. Project validation must occur prior to or concurrent with verification of a given site.

Scope of project validation (limited to aspects of the project requiring site visit evaluation) includes:

- Site conformance with eligibility/applicability criteria
- Site geographic scope/boundaries and ownership criteria
- Physical infrastructure, activities, technologies, and processes of the project
- GHGs, sources, and sinks within the project boundary or project region
- Site temporal boundaries
- Site-specific attributes of methodolodies, algorithms, and calculations that will be used to generate estimates of baseline and project scenario stocks and emission reductions/removal enhancements (this includes an evaluation of growth and yield model selection and parameterization)
- Site-level procedures for collecting process information, source identification/counts, and operational attributes
- Site-level implementation of data management systems and QA/QC procedures
- Processes for estimating, calculating and accounting for site-level uncertainty, and
- Roles and responsibilities of Project Proponent staff and landowners

6.3.2 Verification

At initial verification, and at least once every 5 years thereafter, projects must conduct a full verification. In interim years, desk-based verification(s) may occur. Verification (whether full or desk-based) is required prior to ERT issuance for a given reporting period, consistent with the *ACR Standard*.

6.3.2.1 FULL VERIFICATION

A full verification includes a site visit to a subset of participating landowners and must occur for the initial reporting period and at least once every 5 years thereafter, but allows for new sites to enroll and undergo desk-based verifications before the next required full verification if employing a regional inventory. Newly enrolling sites utilizing a project-level inventory must undergo full verification (including a site visit) prior to issuance of ERTs. Non-crediting sites are exempt from the site visit requirement. However, these sites must still demonstrate that their carbon stocking levels remain above previously credited stocking levels for the minimum project term, according to the monitoring and reporting systems as described and validated and verified in the GHG Project Plan.

Scope of full verification:

- Physical infrastructure, activities, technologies, and processes of the project
- GHG SSRs within the project boundary
- Temporal boundary
- Baseline scenarios

- Calculations used to generate estimates of emissions and emission reductions/removal enhancements
- Assessment of the project's growth and yield model outputs and projections to ensure accurate representation of biological conditions and prediction consistency with existing forest growth research
- Original underlying data and documentation as relevant and required to evaluate the GHG assertion
- Process information, source identification/counts, and operational details
- Updates to roles and responsibilities of project participants or Project Proponent staff
- Implementation of data management systems and QA/QC procedures
- Results from uncertainty assessments, and
- Project-specific conformance to ACR eligibility criteria

6.3.2.2 DESK-BASED VERIFICATION

A desk-based verification is required prior to the issuance of ERTs for reporting periods not subject to ACR's 5-year full verification schedule. This includes projects employing a regional inventory that have conducted an initial full verification and are between 5-year full verifications. Desk-based verification is relevant to both the regional and project-level inventory approaches, so long as no new sites/cohorts have enrolled in those projects utilizing a project-level inventory.

Scope of desk-based verification:

- Physical infrastructure, activities, technologies, and processes of the project
- GHG SSRs within the project boundary
- Temporal boundary
- Baseline scenarios
- Calculations used to generate estimates of emissions and emission reductions/removal enhancements
- Assessment of the project's growth and yield model outputs and projections to ensure accurate representation of biological conditions and prediction consistency with existing forest growth research
- Original underlying data and documentation as relevant and required to evaluate the GHG assertion
- Process information, source identification/counts, and operational details
- Updates to roles and responsibilities of landowners or Project Proponent staff
- Implementation of data management systems and QA/QC procedures
- Results from uncertainty assessments, and
- Project-specific conformance to ACR eligibility criteria

6.3.3 Site Visits

In accordance with the *ACR Standard* and the ACR Validation and Verification Standard, projects developed with this methodology must undergo a full verification, including a site visit, no less frequently than every 5 years.

PDA projects may often encompass many sites spread across large geographies such as States or groups of States. In these instances, verification activities should combine a risk-based approach and the principles of systematic or random sampling to the selection of participant sites to be visited. Verifiers may use geo-political boundaries or equivalent spatial determinations to select geographies to visit within the project boundaries. Once a geography is selected, physical sites can be selected within that geography based on risk characteristics, or systematic or random selection. This approach is intended to guide the verification process in a manner that ensures the rigor needed to reach a reasonable level of assurance of conformance of the project while providing efficiencies and a reasonable means to conduct the site visit portion of verification activities.

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

6.3.3.1 SITE VISITS FOR REGIONAL INVENTORIES

For projects developed under this methodology that use a regional inventory, the USDA FIA field plots are considered verified and are exempt from the scope of the site visit. However, other critical aspects of the project must be part of the site visit. The full scope of site visit verification for regional inventories is defined in the *PDA Verification of Small Non-Industrial Private Forestlands Site Visit Tool* available on the ACR Registry website.

6.3.3.2 SITE VISITS FOR PROJECT-LEVEL INVENTORIES

In addition to any other activities needed by the verifier to provide a reasonable level of assurance that the GHG assertion is without material discrepancy, projects developed under this methodology that use a project-level inventory must include a resampling of the initial carbon stock measurements at the initial verification, to be carried out according to the following specifications:

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

- For paired tests, a minimum of 5% of the original forest inventory must be resampled. For unpaired tests, the number of resampling plots to be installed shall be no less than 5% of the original forest inventory's plot count.
- If the carbon stock inventory has been stratified, all strata must be included in resampling. The Student's t-test may be carried out either at the project level or strata level, so long as an absence of bias can be demonstrated.

Resampling plot allocation must be based on a strategic assessment of risk, proportional carbon stocking, proportional acreage, or another reasonable and demonstrably non-biased method. The sequence of resampling plot selection must be systematic and non-biased. This might be accomplished by assigning a plot sequence prior to the field visit and progressing through the sequence until both the minimum number of resampling plots and the required statistical agreement are reached.

Subsequent field verifications for project-level inventories must employ sampling procedures as outlined in the *PDA Verification of Small Non-Industrial Private Forestlands Site Visit Tool* available on the ACR Registry website.

6.4 TOTAL PROJECT UNCERTAINTY AND UNCERTAINTY DEDUCTION

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

Equation 21

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

WHERE

t	Time in years
$\mathrm{UNC_t}$	Total project uncertainty in year t, in %
$\Delta \mathrm{C_{BSL,t}}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 5.8)
$\mathrm{UNC_{BSL}}$	Baseline uncertainty, in % (section 4.3)

$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 5.5)
$UNC_{P,t}$	With-project uncertainty at year t, in % (section 5.8)

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 ($UNC_{DED,t}$):

Equation 22

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

or

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

WHERE

t	Time in years
UNC_t	Total project uncertainty at year t, in %
$UNC_{DED,t}$	Uncertainty deduction to be applied in calculation of ERTs at year t, in %

If calculated UNC_t in equation (22) exceeds 10%, then the estimated amount of the combined carbon stock at the project area level cannot be verified without additional sampling or stratification to improve statistical confidence.

7 CALCULATION OF ERTS

This section describes the process of determining total and net greenhouse gas emission reductions and ERTs issued for a reporting period for which a valid verification report has been submitted to ACR.

First, total ERTs are summed over each year of a 20-year crediting period (Equation 23) by adjusting the difference between the project and baseline carbon stock changes for leakage and uncertainty.

Equation 23

$$\mathbf{ERT_{CP,t} = \Sigma_{t=1}^{20}\left(\left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) \times (1 - LK) \times \left(1 - UNC_{DED,t}\right)\right)}$$

WHERE

t	Time in years
$ERT_{CP,t}$	Total Emission Reduction Tons in crediting period t
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 5.5)
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) for year t (section 4.2)
LK	Leakage discount (section 5.7.1)
$UNC_{DED,t}$	Total project uncertainty deduction, (in %) for year t (section 6.4).

Then, ERT issuance volumes are determined based on number of calendar days within the given reporting period (Equation 24).

Equation 24

$$\mathbf{ERT_{RP,t} = ERT_{CP,t} \times \left(\frac{CAL_{RP,t}}{CAL_{CP,t}}\right)}$$

WHERE

t	Time in years

$ERT_{RP,t}$	Total emission reduction tons in reporting period t
$CAL_{RP,t}$	Total calendar days within reporting period t
$CAL_{CP,t}$	Total calendar days within crediting period t

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

Equation 25

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

WHERE

t	Time in years
$BUF_{RP,t}$	Buffer tons deducted in reporting period t
$ERT_{RP,t}$	Total emission reduction tons in reporting period t
BUF	The non-permanence buffer deduction as calculated in section 2.4. BUF will be set to zero if an ACR approved insurance product is used

Equation 26

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

WHERE

t	Time in years
$ERT_{NETRP,t}$	Net emission reduction tons issued in reporting period year t
$ERT_{RP,t}$	Total emission reduction tons in reporting period t
$BUF_{RP,t}$	Buffer tons deducted in reporting period t

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

Equation 27

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

WHERE

t	Time in years
$ERT_{VIN,t}$	Total Emission Reduction Tons in vintage year t
$ERT_{RP,t}$	Total Emission Reduction Tons in Reporting Period t
CAL_t	Reporting Period calendar days within vintage year t.
$RP_{CAL,t}$	Total calendar days within Reporting Period t.

Equation 28

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

WHERE

t	Time in years
$BUF_{VIN,t}$	Buffer tons deducted in vintage year t
$ERT_{VIN,t}$	Total Emission Reduction Tons issued in vintage year t
BUF	The non-permanence buffer deduction percentage as calculated in section 2.5. BUF will be set to zero if an ACR approved insurance product is used.

Equation 29

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

WHERE

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

Negative project stock change ($ERT_{,RP,t}$) before the first offset credit issuance is a negative balance of greenhouse gas emissions, to be compensated by the project prior to any future issuance. After the first offset issuance, negative project stock change is a reversal. AFOLU reversals must be reported and compensated following requirements detailed in the Reversal Risk Mitigation Agreement and the Buffer Pool Terms and Conditions. As outlined in the Buffer Pool Terms and Conditions, sequestration projects will terminate automatically if a reversal causes project stocks to decrease below the long-term average baseline stocking level ($C_{BSL,AVE}$) at any point prior to the end of the minimum project term. Projects with initial stocking levels lower than long-term average baseline stocking are subject to this requirement only after project stocks exceed the long-term average baseline stocking level.

DEFINITIONS

If not otherwise defined here, the current definitions in the latest version of the ACR Standard apply.

Activity Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner.
Additionality	ACR's additionality requirements are intended to ensure that project offsets are in addition to reductions and/or removals that would have occurred in the absence of the project activity and without carbon market incentives. A Project Proponent must demonstrate that the GHG emission reductions and removals associated with an offset project are above and beyond the "business as usual" scenario. This methodology requires that every project pass an approved performance standard and a regulatory additionality test.
Aggregate	The grouping of multiple sites into a single project registered on ACR. An aggregate project must be coordinated by a Project Proponent (public or private entity) serving as the aggregator. The GHG Project Plan will define the overall project boundary and baseline conditions encompassing all project instances, fields, producers, or facilities. An aggregate project will have a single start date and crediting period and cannot add additional sites after validation.
Agriculture, Forestry, and Other Land Use (AFOLU)	A broad category of ACR-eligible project activities that reduce GHG emissions and/or enhance GHG removals through changes in agriculture, forestry, and land-use practices.
Baseline Management Scenario	Scenario in the absence of project activities.
Buffer Contribution	The number of offsets contributed to the buffer pool for AFOLU projects with a risk of reversal.
Buffer Pool	An account managed by ACR as a risk mitigation mechanism for AFOLU projects into which Project Proponents contribute a determined quantify of ERTs to replace unforeseen losses in carbon stocks. The buffer contribution is a percentage of the project's reported offsets and is determined through a project-specific assessment of reversal risk.

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	A metric to compare GHGs based on their global warming potential (GWP) relative to CO_2 over the same timeframe. The Intergovernmental Panel on Climate Change publishes GWP values for converting all GHGs to a CO_2e basis.
Cohort	A new group of sites, meeting all eligibility, project boundary, baseline, and additionality criteria of an already established PDA project.
Crediting Period	The finite length of time for which a GHG Project Plan is valid, and during which a project can generate offsets against its baseline scenario. The baseline must be re-evaluated to renew the crediting period. ACR sector standards and methodologies specify the crediting period for particular project types.
De Minimis	So minor as to merit disregard. ACR sets a de minimis threshold of 3% of the final calculation of emission reductions or removals. For the purpose of completeness, any decreases in carbon pools and/or increases in GHG emission sources that exceed the de minimis threshold must be included. Any exclusions using the de minimis principle shall be justified using fully documented *ex ante* calculations, within the specifications of the chosen methodology.
Emission Reduction Ton (ERT)	The ACR unit of exchange for tradable, project-based carbon offsets. ERTs refer to both emission reductions and enhancements in sequestration. ACR issues one ERT for each metric ton of CO_2e emission reductions or removals verified against an ACR Standard and methodology.
Ex ante	Prior to project certification.
Ex post	After the event, a measure of past performance.
Forest	Defined as land with at least 10% cover (or equivalent stocking) by live trees of any size, including land that formerly had such tree cover and that will be naturally or artificially regenerated. To qualify, the area must be at least 1 acre in size. Forest land includes transition zones, such as areas between forest

	and non-forest lands that have at least 10% cover (or equivalent stocking) with live trees and forest areas adjacent to urban and built-up lands.
Greenhouse Gas (GHG)	Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds, causing the greenhouse effect. The primary GHGs regulated under the Kyoto Protocol are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), HFCs, perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The IPCC lists and periodically updates GHGs in its assessment reports.
GHG Project Plan	A document that describes the project activity, satisfies eligibility requirements, identifies sources and sinks of GHG emissions, establishes project boundaries, describes the baseline scenario, defines how GHG quantification will be done and what methodologies, assumptions, and data will be used, and provides details on the project's MRV procedures. ACR requires every project to submit GHG Project Plan using an ACR-approved methodology.
Implementation Date	The date corresponding to the start of project activities on a given site. Eligible implementation dates for AFOLU-based carbon projects are defined in the relevant ACR Standard and methodology.
Intentional Reversal	The decrease of average carbon stocks within a project area below levels associated with previously issued ERTs as a result of intentional, willful activity (e.g., harvesting, forest conversion) on the part of the Project Proponent or landowner(s). When carbon stocks decline in this way (i.e., negative stocks, relative to previous reporting), it is assumed that the carbon is released back into the atmosphere and must be compensated per the provisions in the Project Proponent's Risk Mitigation Agreement with ACR.
Minimum Project Term	The minimum period for which a Project Proponent commits to project MRV.
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.
Non-Crediting Site	A site which has elected not to renew its crediting period after the first 20-year crediting period. Non-crediting sites must demonstrate permanence over the minimum project term, regardless of crediting period renewal.

Non-Industrial Private Forest (NIPF)	An individual, family, trust, estate, association, or other legal private or Tribal entity owning ≤ 5,000 acres of forest land or who receives concurrence from the landowner for making the claim in lieu of the owner. Owners or lessees engaged in the primary processing of raw wood products are explicitly excluded from this definition.
Programmatic Development Approach (PDA)	A project in which successive cohorts of sites are added incrementally to a project over time. A PDA must be coordinated by a Project Proponent (public or private entity) that must use an approved baseline and monitoring methodology that defines the appropriate boundary, avoids double counting, accounts for leakage, and ensures that the emission reductions are real, measurable, verifiable, and additional to any that would occur in the absence of the project.
Project Design Document	A document summarizing eligibility criteria, geographic boundaries, land ownership and baseline and project activities for each site enrolled within an aggregate or PDA project. This document is provided as an addendum to the GHG Project Plan for aggregate or PDA projects. The Project Design Document is updated upon the entrance of each new cohort for PDA projects.
Project-level Inventories	Project-level inventories are inventories based on ground plots located within participant site boundaries only.
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 owner may be different entities. The Project Proponent is the ACR account holder.
Project Region	The defined geographical extent within which qualifying sites may enroll. A project region is subject to validation and is only applicable to projects utilizing the regional inventory method.
Qualified Forestry Professional	Public foresters operating in the vicinity of the project location, SAF certified foresters, state licensed foresters where appropriate, or members of the Association of Consulting Foresters.
Regional Inventories	Regional inventories are based on plot data collected as part of the USDA USFS FIA continuous forest inventory program. FIA plot data may or may not be derived from within participant site boundaries.

Reporting Period	The period of time covering a GHG assertion that is submitted for a single verification and subsequent request for ERT issuance.
Reversal	An intentional or unintentional event that results in the emissions into the atmosphere of stored or sequestered CO_2e for which ERTs were issued.
Site	A discrete physical location (i.e., forestland) at which GHG emissions are generated and/or GHG emissions reductions are achieved within the project boundary. Sites must be between 40 – 5,000 acres to be eligible. A site will be considered “participating” in the PDA project upon its successful validation by an ACR-approved VVB.
Start Date	The point in time when crediting begins, coinciding with the start of the first crediting period and as further defined by section 3.2.1 and the ACR Standard.
Ton	A unit of mass equal to 1,000 kg.
Unintentional Reversal	The decrease of average carbon stocks within a project area below levels associated with previously issued ERTs as a result of natural disturbances. Examples include fire, severe weather events, disease, and insect infestations.
Validation	The systematic, independent, and documented process for the evaluation of a GHG Project Plan against applicable requirements of the ACR Standard, sector standard, and approved methodology.
Validation/Verification Body (VVB)	A competent and independent person, persons, or firm responsible for performing the validation and/or verification process. A VVB must be ACR-approved to conduct verification.
Verification	The systematic, independent, and documented assessment by a qualified and impartial third party of the GHG assertion for a specific reporting period. The verification process is intended to assess the degree to which a project complies with ACR-approved methodologies, tools, eligibility criteria, requirements, and specifications, and has correctly quantified net GHG reductions or removals. Verification must be conducted by an independent, third-party VVB.

PERFORMANCE STANDARD

The application of a performance standard under ACR must include a demonstration that all activities that are eligible under a given methodology are consistently and broadly additional. To establish the performance standard for this methodology, project activities under this methodology were evaluated in relation to common practice and ACR implementation barriers. Baseline management levels were derived from the USFS National Woodland Owners Survey (NWOS) and USFS Timber Products Output study (TPO) data, as well as peer-reviewed literature. The NWOS has been conducted on a nation-wide basis for over six decades and is widely used to design and implement policies, programs and services aimed at NIPF's (Dickinson and Butler 2013). The NWOS is considered the official census of family forest owners in the U.S. The TPO program has been a fundamental component of the USDA FIA program since 1948 to estimate amount and flow of roundwood removed from U.S. forestlands by product, species group and source.

This methodology limits participant eligibility to a specific population demographic: non-industrial private forest landowners with forested acres between 40 – 5,000 acres. Analyses indicate that this demographic of landowner who opts to enter the carbon market and forgo harvest during any crediting period is additional to common practice for the reasons described below.

A.1 COMMON PRACTICE ANALYSIS

Despite owning over a third of U.S. forestlands, NIPF enrollment in carbon markets is estimated to be less than 1%. Meanwhile, NIPF's generate significant volumes of raw wood mill materials to U.S. timber markets and greater than 70% of NIPF forest owners have cut or removed trees in their ownership tenure. While research shows that NIPF's tend to manage for multiple objectives, it also shows that they are responsive to timber price and profit maximization (Zhang and Schelhas 2005; Newman and Wear 1993; Galik et al. 2012). Further, many NIPF's may manage their forestlands in association with amenity values but also view forestlands as an asset available for harvest in times of financial need or as market conditions improve (Agular et al. 2014, Beach et al. 2015). Clear opportunities to manage for NPV maximization, in combination with reduced harvest levels on public lands, underscore demand and market pressures for this landowner demographic to continue to supply an equal or even greater contribution of timber in future markets (Agular et al. 2014, Beech et al. 2005, Harrell 1989). The additionality of the project action of deferred harvest is further bolstered by a 40-year minimum project term. According to the NWOS, the vast majority (> 85% of NIPF lands) are expected to be sold or transferred within the next 40 years, frequently resulting in harvest and/or a change in land use. When land transfer occurs, only 6% of those lands have a conservation easement. Similarly, NIPF enrollment in forest certification programs is minimal (~4%) and nearly 80% of NIPF's do not have long-term forest management plans. Commitment to defer harvest activity and abide by the long-term management objectives and encumbrances required by this methodology, especially those which persist as land transfers ownership, represents a significant divergence from business-as-usual, and thus exceeds common practice for this ownership demographic and is considered additional.

A.2 FINANCIAL AND INSTITUTIONAL BARRIERS

This methodology limits enrollment to a landowner demographic and size class which faces financial and institutional barriers that have hindered their ability to participate in traditional carbon markets to date. Experts attribute the financial barrier to high project development and MRV costs which require a relatively large minimum project acreage to implement and generate capital (Kelly et al. 2016, Lindsay et al. 2011, Miller et al. 2012). Project start-up, inventory, and initial validation and verification costs often exceed $100,000, regardless of project size (Kelly et al. 2016). Meanwhile, rate of return on carbon revenue is currently not sufficient to close the financial gap associated with forgone timber revenues over the project term (Diaz et al. 2018; Thompson and Hansen 2012). These same landowners are also subject to institutional barriers, including lack of familiarity with carbon markets and aversion to long-term commitment periods (Khanal et al. 2017, Miller et al. 2012, NWOS 2018). This methodology applies the ACR aggregation/PDA approach, in conjunction with streamlined administrative and MRV procedures, to overcome these barriers for small forest owners.

APPENDIX B: REFERENCES

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