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

ACTIVE CONSERVATION AND SUSTAINABLE MANAGEMENT ON U.S. FORESTLANDS

VERSION 1.0

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ACR AT WINROCK INTERNATIONAL

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ABOUT ACR[SM]

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

Acknowledgements

This methodology is dedicated to the memory of D. Hunter Parks (1976 – 2022). Hunter's lifelong passion for conservation, his inspiration and insight, and years of experience in helping pioneer the forest carbon market enabled the creation of this methodology. May his legacy of conservation live on through the unique natural places that are conserved each time an active conservation and sustainable management project is developed.

Green Assets would like to acknowledge our families, friends, and colleagues whose love and support made this methodology possible. Additionally, the authors would like to thank the Natural Resources Conservation Service of the United States Department of Agriculture and the Division of Forestry & Natural Resources at West Virginia University for the technical expertise provided in support of this methodology.

This methodology was developed by:

GreenAssets®

In conjunction with:

ACR at Winrock International

Acronyms and Definitions

ATFS	American Tree Farm System
Activity-Shifting Leakage	Conversion of forestland outside of the project area to alternative land uses in response to the avoided conversion of the project area.
BIA	Bureau of Indian Affairs
cm	Centimeters
CO_2	Carbon dioxide. All pools and emissions in this methodology are represented by either CO_2 or CO_2 equivalent (CO_2e). 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).
CPD	Conversion Probability Discount
Commercial Harvesting	Any type of harvest producing merchantable material at least equal to the value of the direct costs of harvesting. Harvesting of dead, dying, or threatened trees (regardless of merchantability) is specifically excluded from this definition where a signed attestation from a Professional Forester is provided, confirming the harvests are in direct response to isolated forest health (insect/disease) or natural disaster event(s) not part of a long-term harvest regime.
DBH	Diameter at breast height
ERR	Emission reductions and/or removals
ERT	Emission Reduction Ton
Ex-ante	Prior to the occurrence and verification of a project activity.
Ex-post	After the event, a measure of past performance.
FIA	Forest Inventory and Analysis Program of the USDA Forest Service

FMV	Fair market value
FSC	Forest Stewardship Council
Forestland	Land with at least 10 percent cover (or equivalent stocking) by live trees of any size, or land formerly having such tree cover, and not currently developed for non-forest uses. Forestland must be at least one acre in size.[1] Land proposed for inclusion in the project area shall meet the cover requirement, in aggregate, over the entire area.
GHG	Greenhouse gas
GIS	Geographic Information System
GWP	Global Warming Potential
gSSURGO	Gridded Soil Survey Geographic
HBU	Highest and best use. The reasonably probable and legal use of vacant land or an improved property that is physically possible, appropriately supported, financially feasible and that results in the highest value.[2] For this methodology, HBU is identified in a qualified appraisal.
IPCC	Intergovernmental Panel on Climate Change
Long-term Forest Management Plan	A written document that guides current and future management practices to meet defined management objectives over ten years or longer.[3]

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

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

[2] Appraisal Institute. (2022). The Dictionary of Real Estate Appraisal. 7th Edition, 394 pp. https://www.appraisalinstitute.org/insights-and-resources/resources/books/the-dictionary-of-real-estate-appraisal-7th-edition

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

Market Leakage	Increases in harvest levels on lands outside the project area due to shifts in the supply of and demand for wood products.
Mineral Soil	A soil consisting predominantly of, and having its properties determined predominantly by, mineral matter. For this methodology, this includes all soils which do not meet the definition of organic soils.
NRCS	Natural Resource Conservation Service
Native Species	Trees listed as native to a particular region by the Native Plant Society, SAF Forestry Handbook, or State-adopted list, and as further defined by the *ACR Standard*.
Organic Soil	A soil in which the sum of the thickness of layers containing organic soil materials is generally greater than the sum of the thickness of mineral layers. For this methodology, in line with USDA soil taxonomy,[4] this includes, within the order of Histosols, all suborders other than Folists and, within the order of Gelisols, only the members of the suborder Histels other than the great group of Folistels.
PDA	Programmatic Development Approach
Professional Appraiser	An individual licensed to engage in the profession of real estate appraisals. The individual must be certified in at least one of the state jurisdictions in which the project is located and be a member of the Appraisal Institute (MAI designation).[5] Where federal charitable contributions are associated with a qualified appraisal, the Professional Appraiser must also meet the Internal Revenue Service's definition of a qualified appraiser.[6]
Professional Forester	An individual engaged in the profession of forestry. If a project is in a jurisdiction that has professional forester licensing laws, the individual must be credentialed in

[4] https://www.nrcs.usda.gov/sites/default/files/2022-06/Soil%20Taxonomy.pdf

[5] The Appraisal Institute's Find an Appraiser web page (https://ai.appraisalinstitute.org/eweb/DynamicPage.aspx?webcode=aifaasearch) can be utilized to locate Professional Appraisers.

[6] Section 170 (f)(11)(E)(ii) of the Internal Revenue Code.

	that jurisdiction.[7] Otherwise, the individual must be certified by the Society of American Foresters[8] or Association of Consulting Foresters.[9]
QA/QC	Quality assurance/quality control
SFI	Sustainable Forestry Initiative
SOC	Soil organic carbon
SOP	Standard operating procedures
Ton	A unit of mass equal to 1,000 kg.
USDA	United States Department of Agriculture
Tree	A perennial woody plant with a diameter at breast height (4.5') greater than or equal to 1" with the capacity to attain a minimum diameter at breast height of 5" and a minimum height of 15' (shrub species are not eligible).[10]

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

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

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

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

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

Contents

TABLES

EQUATIONS

1 Methodology Description

1.1 Methodology Summary

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

Converting forests to other land uses causes emissions of previously stored carbon to the atmosphere, which has negative implications for meeting the climate ambitions set out by the Paris Agreement. Forests also provide valuable ecosystem function and habitat for many living things. In the U.S., over 760,000 acres, 440,000 acres, and 1,750,000 acres of forestland are converted annually to settlements, cropland, and other uses, respectively.[11]

This project type requires a qualified appraisal to demonstrate the financial benefit of conversion to a non-forest land use. To establish additionality, the financial benefit of conversion for the land must meet or exceed the benchmark performance standard set in this methodology and the project must demonstrate that the projected conversion is not prohibited by any regulatory or legal requirements. If the benchmark and other requirements are met, projects can generate carbon credit revenue that helps to offset the opportunity costs of avoiding market- and revenue-driven conversion from forest to non-forest.

The baseline scenario is a project-specific projection of carbon stock changes resulting from conversion of the project area to non-forest. The baseline is developed by 1) determining the highest and best use (HBU) for the project area via an appraisal, 2) identifying the rate of conversion, and 3) modeling changes in carbon stocks over the Crediting Period based on the identified conversion schedule.

Emission Reduction Tons (ERTs) are based on GHG emission reductions associated with baseline land use conversion activities and GHG removals from retention of with-project forest growth.

[11] EPA (2022) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. U.S. Environmental Protection Agency, EPA 430-R-22-003. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020

Projects must adhere to sustainable forest management practices and commit to conservation of forestland through a legally binding mechanism.

1.2 Applicability Conditions

- This methodology is applicable only to non-federally owned forestland within the United States. Tribal lands in the United States not under Bureau of Indian Affairs (BIA) control or management that meet the applicability conditions of this methodology and the requirements of the relevant *ACR Standard* are eligible.[12]
- Project area lands must be legally convertible by entities owning or controlling carbon and surface rights to one of the following alternative land uses:
  - Agriculture;
  - Mining; or
  - Commercial, residential, or recreational development.
- Participating entities (e.g., Project Proponent, landowner) must demonstrate ownership and control of carbon, timber, and surface rights and land title for the entirety of the project area at the project Start Date and throughout the Crediting Period. Projects that avoid conversion to mining must also demonstrate ownership and control of mineral rights. The Project Proponent and the land, surface, and/or mineral rights owner may be different entities.
- A qualified appraisal (required per Section 2.4.2) must demonstrate that the project's GHG ERRs are additional under this methodology.
- Forestland that was converted from Native Species to Non-native Species within ten (10) years of the project Start Date is ineligible. The planting of or management for Non-native Species is prohibited.
- For all project areas, Project Proponent must either enact a conservation easement or transfer surface rights (mineral rights must also be transferred for projects that avoid conversion to mining) to a land trust or other conservation organization per Section 2.1.1.

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

1.3 Sustainable Management Requirements

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

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

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

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

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

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

If the project is not subject to Commercial Harvest within the project area as of the project Start Date, but harvests occur later in the project term, the project area must meet the requirements outlined above before Commercial Harvesting may occur.

Evidence demonstrating adherence to one of these options must be provided at validation as an appendix to the GHG Project Plan.

1.3.1 MONTRÉAL PROCESS COMPATIBILITY

Projects utilizing Options 2, 3, or 4 (Section 1.3) must demonstrate forest management compatibility with the Montréal Process Criteria.[13]

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

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

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

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

1.4 Pools And Sources

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

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

CARBON POOLS	INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Aboveground live biomass carbon	Included	Major carbon pool subject to the project activity.
Belowground live biomass carbon	Included	Major carbon pool subject to the project activity
Aboveground standing dead wood	Optional	Project Proponents may elect to include the pool. Where included, belowground standing dead wood must also be included, and the pool must be estimated in both the baseline and with-project scenarios.
Belowground standing dead wood	Optional	Project Proponents may elect to include the pool. Where included, aboveground standing dead wood must also be included, and the pool must be estimated in both the baseline and with-project scenarios.
Lying dead wood	Optional	Project Proponents may elect to include the pool. Where included, the pool must be estimated in both the baseline and with-project scenarios.
Harvested wood products	Included	Major carbon pool subject to the project activity.
Litter / Forest Floor	Excluded	Changes in the litter pool are considered *de minimis* as a result of project implementation.
Soil organic carbon (SOC)	Optional/ Excluded	Where the identified baseline land use is agriculture, Project Proponents may elect to include this pool in the baseline scenario. Where included, this pool is conservatively assumed to remain static in the with-project scenario. Soil organic carbon is conservatively excluded where the identified baseline land use is mining or development.

GAS	SOURCE	INCLUDED / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
CO_2	Burning of biomass	Excluded	Carbon emissions due to burning are accounted as a carbon stock change.
CH_4	Burning of biomass	Excluded	Potential emissions are *de minimis*.[14]
N_2O	Burning of biomass	Excluded	Potential emissions are *de minimis*.
N_2O	Fertilizer application	Excluded	Emissions are assumed to be unchanged or greater in the baseline scenario than in the with-project scenario and are conservatively excluded.
CH_4/N_2O	Livestock Production	Excluded	Emissions are assumed to be unchanged or greater in the baseline scenario than in the with-project scenario and are conservatively excluded.
CO_2/ CH_4/N_2O	Machinery Use	Excluded	Emissions from machinery are assumed to be greater in the baseline scenario than in the with-project scenario and are conservatively excluded.

[14] Regarding the *de minimis* determinations for CH_4 and N_2O from biomass burning, please see:

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

LEAKAGE SOURCE		INCLUDED / OPTIONAL / EXCLUDED	JUSTIFICATION / EXPLANATION OF CHOICE
Activity-Shifting	Displacement of alternative land use to other forestlands	Included	If conversion of forestland to alternate uses is avoided in the project area, the proposed development could result in forestland conversion on lands outside the project area.
Market Effects	Timber harvesting	Included	Reductions in product outputs due to project activity may result in shifts in supply and demand and be compensated for by other forestlands in the marketplace. Those emissions must be included in the quantification of project benefits.

2 Eligibility, Boundaries, Additionality, and Permanence

2.1 Project Eligibility

This methodology applies to non-federally owned U.S. forestlands that are able to document 1) clear land title, surface rights, and, for projects that avoid conversion to mining only, mineral rights and 2) carbon credit title. Projects must also meet all other requirements of Table 4 of the *ACR Standard* version effective at project listing or Crediting Period renewal.

This methodology applies to lands that 1) could be legally converted to non-forest uses by entities owning or controlling surface, timber, and, if project avoids conversion to mining, mineral rights and 2) are additional per the benchmark performance standard and regulatory surplus test.

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

2.1.1 CONSERVATION COMMITMENT

To be eligible under this methodology, Project Proponents must demonstrate a legally documented commitment to conservation that is minimally in effect through the end of the Minimum Project Term, through one of the following options:

- Establishing a conservation easement that refers to the requirements of this methodology, applies to current and all subsequent landowners, and prevents the conversion of the project area to the HBU specified by the qualified appraisal (Section 2.4.2). To qualify under this methodology, the conservation easement must:
    - Be legally granted by the individual or entity with the project area's land title and surface rights, and, if project avoids conversion to mining, mineral rights to an eligible easement holder. An eligible easement holder is a non-profit organization legally established under 501(c)(3) of the Internal Revenue Code whose mission includes land conservation; and
    - Minimally geographically encompass the boundary of the project area.

- Transfering the surface rights and, if project avoids conversion to mining, mineral rights ownership to a land trust or other conservation organization who directly commits to a restriction on conversion of the project area to the HBU specified by the qualified appraisal (Section 2.4.2) via either an accepted deed restriction or a legally binding contract. Carbon credit title must be retained by the Project Proponent. To qualify under this methodology, the deed restriction or contract must:
  - Be legally executed between the individual or entity with clear land title and surface rights and, if project avoids conversion to mining, mineral rigths and a non-profit organization legally established under 501(c)(3) of the Internal Revenue Code whose mission includes land conservation; and
  - Minimally geographically encompass the boundary of the project area.
- For projects located on tribal lands, enacting a legal commitment that prevents conversion of the project area to the HBU specified by the qualified appraisal (Section 2.4.2) and minimally geographically encompasses the project area. Given the varied nature of tribal legal structures and associated barriers, projects located on these lands may demonstrate a legal conservation commitment through other means, subject to verification and ACR review.

The conservation commitment must be enacted and finalized prior to validation and ERT issuance and no more than one year before or three years after project Start Date.

2.2 Project Geographic Boundary

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

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

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

Aggregation of forest properties with multiple landowners, including Programmatic Development Approach (PDA), is permitted under this methodology consistent with the *ACR Standard* as a means to reduce per-acre transaction costs of inventory and verification.

2.3 Project Temporal Boundary

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

- The date of the conservation commitment as indicated by:
  - The date of signing or enactment of a conservation easement with terms outlined in Section 2.1.1;
  - The date of signing of a corporate or board resolution, or entering a contractual agreement, to establish a conservation easement with terms outlined in Section 2.1.1; or
  - The date of entering a contractual agreement for, or date of, transfer of ownership of surface rights and, if project avoids conversion to mining, mineral rights to a land trust or other conservation organization per Section 2.1.1; or
- The date that the Project Proponent first demonstrated good faith effort to implement the GHG Project. Such demonstrations must include documented evidence of:
  - The date that a qualified appraisal (per the requirements in Section 2.4.2) was completed;
  - The date the Project Proponent initiated a forest inventory for the GHG Project;
  - The date that the Project Proponent entered into a contractual relationship or signed a corporate or board resolution to implement the GHG Project; or
  - The date the project was submitted to ACR for listing review.

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

In accordance with the *ACR Standard*, projects will have a Crediting Period of forty (40) years. The Minimum Project Term is forty (40) years. The Minimum Project Term begins on the project Start Date (not the first or last year of crediting). Projects may renew for subsequent Crediting Periods per the *ACR Standard* and Section 4.5. Projects must be validated within 3 years of the project Start Date.

2.4 Additionality

To qualify as additional, every GHG Project must exceed an approved performance standard, as defined in this methodology, and a regulatory surplus test.

2.4.1 REGULATORY SURPLUS TEST

As required by the *ACR Standard*, projects must establish regulatory additionality, demonstrating that existing laws, regulations, statutes, legal rulings, deed restrictions, or other regulatory frameworks relevant to the project area do not restrict the conversion of the project area to alternative non-forest land uses. Unless established in support of project activities (Section 2.1.1), all legally binding conditions of easements in place for more than one year prior to Start Date must also be considered. Voluntary agreements without an enforcement mechanism, proposed laws or regulations, optional guidelines, or general government policies are not considered in the regulatory surplus test.

Regulatory surplus must be assessed at each verification. Newly enacted legal requirements that prohibit land conversion in the project area may make the project non-additional from the time of enforceability going forward, but previously issued ERTs and prior eligibility are not affected. Baseline conversion activities are assumed to be completed according to their temporal land conversion rate (Section 4.1), and once conversion is complete, demonstration of regulatory surplus is unnecessary.

2.4.2 PERFORMANCE STANDARD

A qualified appraisal is required to demonstrate the threat of conversion and that a project surpasses the performance standard. For an appraisal to be qualified, it must be completed in accordance with the Uniform Standards of Professional Appraisal Practice,[15] be prepared and signed by a Professional Appraiser, be geographically representative of the project area, and contain the following components:

- Determination of the project area's Fair Market Value (FMV) under its current forested, or As Is, use;
- Identification of the project area's HBU and determination of FMV under its HBU;[16]
- Description of how the project area is physically suitable for conversion to its identified HBU, including:
    - Topographical considerations, including identification of specific areas that are unsuitable for the identified HBU due to topography;
    - Suitability of soils for agricultural use purposes, if applicable;
    - Availability of water for agricultural use purposes, if applicable; and
    - Availability and extractability of mineral resources, if applicable.

[15] https://www.appraisalfoundation.org/imis/TAF/Standards/Appraisal_Standards/Uniform_Standards_of_Professional_Appraisal_Practice/TAF/USPAP.aspx?hkey=62c73d17-9bcf-42b3-a6e4-d4b4b72c098f

[16] The appraised HBU value must consider the costs and revenues associated with land use conversion.

- Description of how the existing infrastructure (transportation and utilities) is suitable for the alternative land use. Where existing infrastructure is insufficient, describe how existing infrastructure can feasibly and realistically be modified to meet the alternative land use needs;
- Description of anticipated market demand for the identified HBU, confirming that the associated industry will support the conversion. The description must include proximity to populations where commercial, residential, or recreational development is the identified HBU.
- Identification of specific areas within the project area that are unsuitable for conversion to the identified HBU, such that the spatial extent (acres) of these unsuitable areas may be determined.

Where the project area's appraised FMV under the HBU is at least 50% higher[17] than the appraised FMV of its As Is use, the benchmark performance standard has been met and the project activity is considered additional. Once validated, exceeding the performance standard need not be reassessed during the Crediting Period. Refer to Section 4.2 for consideration of a conversion probability discount (CPD).

In addition to surpassing the benchmark performance standard, all eligible projects must enact a legally binding conservation commitment (Section 2.1.1), which is itself above and beyond what would have occurred without the project. That is, it is not common practice for landowners to encumber their property with a conservation easement, transfer ownership to other entities, or otherwise legally commit to forest conservation (for tribal projects) for the project duration and forego the opportunity to fully capitalize on their investment.[18] Carbon credit revenue helps offset this opportunity cost.

[17] The performance standard is informed by the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects (adopted June 25, 2015), which uses a 40% threshold, and Wear and Newman (2004)'s study of forest conversion risk, which suggests forestland conversion would begin at a land value of $600 per acre, which is 36% higher than the study's area-weighted average forestland value of $440 per acre. This methodology's performance standard of 50% is a considerably higher and therefore more conservative threshold.

[18] In the USA, land uses eligible for conservation easements (including grassland pasture, range, and forest-use land, but conservatively excluding cropland) occupy 1.28 billion acres: https://www.ers.usda.gov/webdocs/publications/84880/eib-178.pdf?v=8829

Lands with conservation easements occupy 38 million acres, or about 3% of eligible land: https://www.conservationeasement.us/

2.5 Permanence

Project Proponents commit to a Minimum Project Term of 40 years. Per Section 2.1.1, projects must make a legally documented commitment to conservation that is minimally in effect through the end of the Minimum Project Term to be eligible for this methodology. Additionally, projects must have effective risk mitigation measures in place to compensate fully for any Reversal, whether this occurs through an unforeseen natural disturbance or through a Project Proponent or landowners' choice to discontinue project activities. Such mitigation measures can include Buffer Pool Contributions or an alternate risk mitigation measure approved by ACR.

If using Buffer Pool Contributions to mitigate Reversals, the Project Proponent must conduct a Reversal Risk Analysis addressing both general and project-specific risk factors. General risk factors include risks such as financial failure, technical failure, management failure, rising land opportunity costs, regulatory and social instability, and natural disturbances. Project-specific risk factors vary by project type but can include land tenure, technical capability and experience of the project developer, fire potential, risks of insect/disease, flooding and extreme weather events, illegal logging potential, and others.

Project Proponents must conduct their Reversal Risk Analysis using the *ACR Tool for Reversal Risk Analysis and Buffer Pool Contribution Determination*.[19] The output of this tool is a Buffer Pool Contribution Percentage for the project, an overall risk rating expressed as a percentage, which is applied at each issuance to determine the Buffer Pool Contribution that must be applied in the calculation of Net Emission Reductions and Removals (Equations 21 and 22). This deduction must be applied at each issuance (exceptions may apply if the Project Proponent uses an ACR-approved alternate risk mitigation mechanism).

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

3 Stratification

If the project activity area is not homogeneous, stratification may be used to improve the modeling of management scenarios and precision of carbon stock estimates. If stratification is used, a stratification standard operating procedures (SOP) document detailing relevant design, inputs, parameters, rules, and techniques must be provided as an attachment to the initial GHG Project Plan for validation. The stratification SOP document should contain sufficient information such that the stratification can be examined and duplicated as necessary to provide reasonable assurance of the validity of associated techniques and the absence of bias. The stratification must be the same for the baseline and with-project scenarios for the estimates of initial stocking levels. However, the number and boundaries of strata may change during the Crediting Period (*ex-post*) as baseline and with-project scenario management practices diverge. For estimation of initial carbon stocks, strata should be defined on the basis of parameters correlated to forest carbon stocking in an effort to reduce within-strata variability and improve sampling efficiency, for example:[20]

- Size and density class
- Age class
- Management regime
- Forest cover types
- Site class
- Soil type or related characteristics

Stratification defined by parameters closely correlated to forest carbon stocks will decrease the likelihood of a required uncertainty deduction (Section 7.5).

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

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

[20] This list is not exhaustive and only includes examples of common stratification procedures.

4 Baseline

4.1 Identification of Baseline

Baseline determination is project-specific and represents a legally permissible and operationally feasible scenario converting the project area to the non-forest land use identified as its HBU, following either a schedule set forth in planning documentation or a conservative default schedule.

All legally binding constraints to land conversion (with the exception of easements, deed restrictions, contracts, or other legal mechanisms enacted at project onset for the purpose of the project per Section 2.1.1) must be considered in baseline modeling. These include all existing laws, regulations, legal rulings, deed restrictions, and other relevant regulatory frameworks (such as legally binding terms and conditions associated with the land acquisition, or donor funding restrictions regulating the types of land uses that can occur on the property). Best management practices to protect water, soil stability, and wildlife which apply to land conversion and are published or prescribed by applicable federal, state, or local government agencies are also considered legally binding constraints. If new legal constraints that prohibit land conversion are enacted during a Crediting Period and prior to the completion of modeled forest conversion activities, the baseline must be evaluated and re-modeled as necessary on a forward-moving basis, respecting these legally binding constraints for the remainder of the Crediting Period from the time of enforceability.

The qualified appraisal (required per Section 2.4.2) identifies the HBU for the project area and thus the baseline alternative land use. The following are applicable baseline non-forest land uses under this methodology:

- Agriculture;
- Mining; or
- Commercial, residential, or recreational development.

The temporal land conversion rate for the identified baseline land use must be based on either:

- Land conversion planning documentation, subject to validation, containing at minimum the following information:
    - Geographic boundaries of the area planned for conversion. The planning documentation must be relevant to the project area and exclude areas identified by the the qualified appraisal as unsuitable for conversion to the HBU (Section 2.4.2);

- Timeframe for completion of conversion activities. Conversion is considered complete when the aboveground live biomass and dead wood have been removed to sufficiently allow the alternative land use;
- The areas affected by conversion activities and the residual forested areas unaffected by conversion actitivities, expressed in acres (or another unit of area or proportion of area);
- Expected cost of land use conversion; and
- Qualifications of the company providing the planning documentation, demonstrating relevant experience with similar projects.

The project must demonstrate that the land conversion plan does not conflict with any legal constraints.The total conversion impact (percentage of project area converted to non-forest) must be calculated and annualized based on the provided timeframe for completion of conversion activities.

- Where planning documenation is unavailable, the default land conversion rates, based on project area size as defined in Table 1, may be used.[21] The project must demonstrate that the default rates do not conflict with any legal constraints. If the qualified appraisal identifies areas unsuitable for conversion to the HBU that cumulatively exceed 10% of the project area, unsuitable areas must be excluded from the project area until no more than 10% of the project area is identified as unsuitable. Recreational development is not eligible for the default conversion rates and must use planning documentation.

[21] Default temporal land conversion rates are derived from an analysis of quotations for forest conversion services. They were then confirmed to be conservative (i.e., longer than expected to meet both typical landowner income goals and land conversion productivity goals) for all project area sizes by several independent land conversion specialists.

Table 1: Default Temporal Land Conversion Rates by Project Area Size

PROJECT AREA SIZE (ACRES)	DURATION OF CONVERSION (YEARS)	ANNUAL CONVERSION RATE (CARBON)
<2,500	1	90%
2,500 to <5,000	2	45%
5,000 to <7,500	3	30%
7,500 to <10,000	4	22.5%
≥ 10,000	5	18%

PDA projects, which include multiple properties or landowners, must determine the conversion rates for each group of properties or landowners enrolling simultaneously (i.e., Cohort). If applying the default rates, previously enrolled Cohorts are not considered in project area size.

The resulting conversion schedule is used to establish baseline carbon stocking levels throughout the Crediting Period beginning with the initial inventoried tree stocks. The application of annual conversion rates is aspatial; conversion rates are applied directly to the total carbon stored in each relevant and included pool within the project area (above- and belowground live biomass, and, if included, standing and lying dead wood).[22] Where annual conversion rates do not align with Reporting Period length, each pool's projected reduction must be prorated accordingly.

During baseline conversion activities, carbon stocks associated with residual live trees are conservatively held static, and growth of residual trees is not required to be projected using an approved growth and yield model. This methodology assumes that, following conversion, residual live trees are sparsely distributed along the fringe of development, exhibit stagnant growth due to crown exposure and depleted site resources, may not survive depending on the amount of compaction and disturbance (especially in the case of residential construction), and are not characteristic of a managed or productive forest. As such, once conversion activities are completed, $\Delta C_{BSL,TREE,t} = 0$ and $\Delta C_{BSL,DEAD,t} = 0$, including cases where land conversion results in an incomplete removal of live and dead trees.

[22] When SOC is an included pool, it must not be modeled using the temporal land conversion rates applied to other pools and must instead use the projection methods detailed in Appendix A (Section A.2).

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

The ISO 14064-2 principle of conservativeness must be applied for the determination of the baseline scenario.[23] In particular, the conservativeness of the baseline is established with reference to the choice of approaches, assumptions, methods, parameters, data sources, and key factors so that GHG baseline emissions are more likely to be under-estimated rather than over-estimated, and that reliable results are maintained over a range of probable assumptions. However, using the conservativeness principle does not always imply the use of the "most" conservative choice of assumptions or methods.

4.2 Conversion Probability Discount

The probability of baseline land conversion activities occurring is assumed to be 100%, resulting in no CPD applied to the calculation of ERRs ($CPD = 0$), where one of the following conditions are met:

- The temporal land conversion rate for the identified baseline land use is based on verifiable conversion planning documentation (Section 4.1); or
- The project area's appraised FMV under the HBU is at least 80% higher than the appraised FMV of its As Is use (Section 2.4.2).[24]

Where the temporal land conversion rate for the identified baseline land use is based on the default rates defined in Table 1, and where the project area's appraised FMV under the HBU is less than 80% higher than the appraised FMV of its As Is use, the CPD is computed by the following equation:[25]

[23] ISO 14064-2:2019. https://www.iso.org/standard/66454.html.

[24] The conversion probability discount threshold is informed by the California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects (adopted June 25, 2015), which also uses 80%, and Wear and Newman (2004)'s study, which suggests $800 per acre is a plausible "switching" value, beyond which forestland conversion always occurs. $800 is approximately 80% higher than the study's area-weighted average forestland value of $440 per acre.

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

Equation 1: Conversion Probability Discount

$$\text{if } \left[(\Delta C_{P,t} - \Delta C_{BSL,t} - LK_t) \times (1 - UNC_{DED,t})\right] \leq 0 \text{ then } CPD = 0$$

or

$$\text{if } \left[(\Delta C_{P,t} - \Delta C_{BSL,t} - LK_t) \times (1 - UNC_{DED,t})\right] > 0 \text{ then } CPD = 1.8 - \left(\frac{FMV_{HBU}}{FMV_{AS\ IS}}\right)$$

WHERE

CPD	Conversion probability discount factor (in %) to be applied in calculation of ERRs for year t.
$\Delta C_{P,t}$	Change in the with-project carbon stock and GHG emissions (in metric tons CO_2e) during year t.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) during year t.
LK_t	Total leakage deduction (in metric tons CO_2e) for year t.
$UNC_{DED,t}$	Uncertainty deduction (in %) for year t.
FMV_{HBU}	Fair market value (in U.S. dollars) for highest and best use of property as determined by a qualified appraisal.
$FMV_{AS\ IS}$	Fair market value (in U.S. dollars) for current forested, or As Is, condition of property as determined by a qualified appraisal.

4.3 Baseline Reporting

The GHG Project Plan must include the following baseline metrics:

- A general description of the baseline scenario over the Crediting Period, including:
  - The HBU (the baseline alternative land use) identified by the qualified appraisal;
  - A description of the conversion schedule and how it was derived;
  - The FMV for the HBU as determined by the qualified appraisal;
  - The FMV of the current forested, or As Is, condition as determined by the qualified appraisal;
  - The calculation of the CPD, if applicable;

- A list of any and all legal constraints restricting land use conversion, including:
  - A description of each constraint and its effect upon land use conversion;
  - The geographic extent of each constraint;
  - The governing agency or body associated with each constraint; and
  - A description of how each constraint is considered in the baseline scenario.
- A graph depicting the projected baseline and with-project stocking levels, with time (40 years) in the x-axis and metric tons CO_2e in the y-axis, for the following pools:
  - Standing live trees;
  - Standing dead trees, if included;
  - Lying dead wood, if included;
  - Harvested wood products; and
  - SOC, if included.

4.4 Estimation of Baseline Emission Reductions

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

- Baseline stocking levels to be determined for the entire Crediting Period;
- The change in baseline live tree, dead wood (if included), and SOC carbon stocks (if included) to be computed for each time period, t;[26] and
- Baseline carbon stored in wood products 100 years after harvest for each time period, t, to be calculated following Section 4.4.4.

The following equations are used to construct the baseline stocking levels using the temporal land conversion rate identified per Section 4.1, wood products calculations described in Section 4.4.4, and SOC calculations described in Appendix A.

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

Equation 2: Change in Baseline Live Tree Stocks

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

WHERE

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

Equation 3: Change in Baseline Dead Wood Stocks

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

WHERE

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

Any projected reductions in live tree and dead wood carbon stocks due to baseline conversion activities, including harvests and slash burning, must be properly accounted for in Equations 2 and 3. Once conversion activities are completed, $\Delta C_{BSL,TREE,t} = 0$ and $\Delta C_{BSL,DEAD,t} = 0$.

Equation 4: Change in Baseline SOC Stocks

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

WHERE

$\Delta C_{BSL,SOC,t}$	Change in the baseline SOC stock (in metric tons CO_2e) during year **t**
$C_{BSL,SOC,t}$	Baseline SOC stock (in metric tons CO_2e) at the end of year **t** and **t-1** signifies the value at the end of the prior year (Equation 44). The first Reporting Period must use the initial SOC stock ($C_{BSL,SOC,0}$; Equation 40) for the value at the end of the prior year (**t-1**).

NOTE: Please see Section 4.4.5 and Appendix A for detailed instructions on SOC calculations.

Use the following equation to compute the baseline stock change:

Equation 5: Change in Baseline Total Stocks

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

WHERE

t	Time in years.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t**.
$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock stored in above and below ground live trees (in metric tons CO_2e) during year **t**.
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock in dead wood (in metric tons CO_2e) during year **t**.
$\Delta C_{BSL,SOC,t}$	Change in the baseline SOC stock (in metric tons CO_2e) during year **t**.
$C_{BSL,HWP,t}$	Baseline carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**. See Section 4.4.4 for detailed instructions on baseline wood products calculations.

4.4.1 TREE STOCKING LEVEL PROJECTIONS

Baseline tree stocking levels ($C_{BSL,TREE,t}$ and $C_{BSL,DEAD,t}$) must be estimated using the temporal land conversion rate identified per Section 4.1, beginning with the initial inventoried tree stocks. With-project tree stocking levels ($C_{P,TREE,t}$ and $C_{P,DEAD,t}$) must be estimated using approved forest growth and yield models. Modeling must be completed with a peer reviewed forestry model that has been calibrated for use in the project region and approved by ACR. The GHG Project Plan must detail what model is being used and what variants and calibration processes have been selected. All model inputs and outputs (e.g., plot data, model selection, geographic variant, calibration for site-specific conditions, tree list outputs) must be available for inspection by the verifier, and the verifier shall document the methods used in validating the growth and yield model in the validation report.

The following are approved growth and yield models:

- Forest Vegetation Simulator (FVS)

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

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

The output of the models must include either projected total aboveground and belowground carbon per acre, volume in live tree biomass, or another appropriate unit by strata in the baseline. If the model output is volume, then this must be converted to biomass and carbon using equations in Section 4.4.2. Where model projections are output in multi-year increments, the numbers shall be annualized to give stocking values for each year. The same model and calibration must be used in the baseline and with-project scenario stocking projections.

If including dead wood and processing of alternative data on dead wood is necessary, the steps in Section 4.4.3 must be used. Estimations of dead wood in the with-project scenario may remain static between measurement events or may be estimated using an approved growth model that predicts dead wood dynamics. Dead wood in the baseline scenario is conservatively held static (not subject to mortality modeling) as the temporal land conversion schedule is applied. If included, standing dead wood must use the same biomass estimation technique (Section 4.4.2.1) as live trees.

4.4.2 TREE CARBON STOCK CALCULATION

The mean carbon stock in live tree biomass per unit area is estimated based on field measurements in sample plots.[27] Professionally accepted principles of forest inventory must be applied. An inventory SOP document must be developed and attached to the GHG Project Plan for validation that describes the inventory process, including the following:

- Sample size;
- Determination of plot locations and numbers;
- Plot size and design, in-field location procedures, and monumentation;
- Whether plots are permanent or temporary;
- Data collected and measurement tools used;
- Detailed measurement procedures such that measurements are repeatable;
- Decay classification of standing dead wood, if an included pool;
- Process for recording missing volume, or tree class code as applicable, and how corresponding deductions for unsound wood were applied;
- Biomass estimation technique (Section 4.4.2.1);
- Components of the tree selected for biomass quantification;
- Data management systems and processes, including Quality assurance / quality control (QA/QC) procedures;
- Procedures for updating the inventory, including following harvests or disturbances; and
- Equations and steps used to calculate uncertainty in each included carbon pool and emission source.

Use or adaptation of inventory SOPs already applied in national forest monitoring systems such as the United State Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) program,[28] available from published handbooks, or from the Intergovernmental Panel on Climate Change (IPCC)

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

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

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

GPG LULUCF[29] is recommended. Plot data used for biomass calculations may not be older than 10 years. Plots may be permanent or temporary and they may have a defined boundary or use variable radius sampling methods.

Biomass for each tree is calculated using one of three estimation techniques (Section 4.4.2.1). The Project Proponent must use the same set of equations, diameter at breast height thresholds, and selected biomass components for *ex-ante* and *ex-post* baseline and with-project estimates.

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

The following steps are used to calculate tree biomass:

Step 1 Determine the biomass of each tree based on appropriate volume and/or biomass equations (see Section 4.4.2.1).

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

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

Step 4 Determine the tree biomass estimate for each stratum by calculating a mean biomass per acre estimate from plot level biomass derived in Step 3 multiplied by the number acres in the stratum. If not stratified, determine the total tree biomass by calculating the mean biomass per acre from plot level biomass derived in Step 3 and multiplying by the total area in the project.

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

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

4.4.2.1 Biomass Estimation

One of the following biomass estimation techniques must be used:

Option 1 Generalized allometric regression equations for estimating biomass from 10 species groups (Jenkins et al. 2003; Table 4).[30] Appendix A assigns species to species groups. Biomass of above and belowground components must be estimated according to their component ratios (ibid., Table 6);

Option 2 Biomass algorithms based on the regional volume equations from the USDA Forest Service National Volume Estimator Library,[31] as employed by default in the FVS Fire and Fuels Extension (Rebain et al. 2010).[32] The belowground biomass must be estimated using the Jenkins method (option 1 above). The correct variant for the project area must be selected; or

Option 3 Species specific volume and biomass estimators according to geographic region:[33]

PROJECTS OUTSIDE CA, OR, WA AND AK must use the component ratio method described in Appendix K of the FIA Database Description and User Guide.[34] The methods described in Woodall et al. (2011)[35] are used to calculate gross and sound volumes by

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

[31] U.S. Department of Agriculture, Forest Service, National Volume Estimator Library. https://www.fs.usda.gov/forestmanagement/products/measurement/volume/nvel/index.php

[32] Rebain, Stephanie A. comp. (2010, revised June 28, 2021). The Fire and Fuels Extension to the Forest Vegetation Simulator: Updated Model Documentation. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 407 p.

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

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

[35] 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.

region and species.[36] Projects located in IA, IL, IN, KS, MI, MO, MN, ND, NE, SD, and WI must calculate sound volume using the equations specified in Table 5 of Appendix A.[37] For other states, gross volume must be converted to sound volume by subtracting rotten and missing volume. Other components, including belowground live and dead biomass, are estimated and adjusted according to Appendix K (Burrill et al. 2021). Aboveground components are summed for total aboveground biomass.

PROJECTS IN CA, OR OR WA must use regional volume and biomass equations provided by the USDA FIA program. The Project Proponent must first estimate volume using the models and associated coefficients within “Volumetric Equations for California, Oregon, and Washington” (2014).[38] Biomass is then estimated using the equations within “Biomass Equations for California, Oregon, and Washington” (2014).[39] The CA, OR and WA volume models from Woodall et al. (2011) must not be used. Sum the aboveground standing live and aboveground standing dead tree carbon stocks and apply the methods described in Cairns et al. (1997; Table 3, Equation 3).[40] at the plot level to estimate belowground biomass density based on aboveground biomass density in tons per acre. The live and standing dead aboveground biomass must be combined prior to the calculation of belowground biomass. The live and dead belowground pools may then be separated by multiplying the belowground biomass density by each pool’s respective proportion of total aboveground biomass at the plot level. Calculation of belowground biomass must be consistent for both baseline and with-project scenarios.

PROJECTS IN AK must use regional biomass equations provided by the USDA FIA program.[41] The AK volume models found in Woodall et al. (2011) must not be used. Sum

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

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

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

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

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

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

the aboveground standing live and aboveground standing dead tree carbon stocks and apply the methods described in Cairns et al. (1997, Table 3, Equation 3) at the plot level to estimate belowground biomass density based on aboveground biomass density in tons per acre. The live and standing dead aboveground biomass must be combined prior to the calculation of belowground biomass. The live and dead belowground pools may then be separated by multiplying the belowground biomass density by each pool's respective proportion of total aboveground biomass at the plot level. Calculation of belowground biomass must be consistent for both baseline and with-project scenarios.

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

4.4.3 DEAD WOOD CALCULATION

Dead wood included in the methodology comprises two pools – standing dead wood (above and belowground) and lying dead wood. Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components.

4.4.3.1 Standing Dead Wood (if included)

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

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

Standing dead tree biomass must be adjusted for density reductions and structural loss. Decay classes must be collected during field measurements according to the classification system of the USDA FIA program.[42]

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

FOR PROJECTS USING OPTIONS 1 OR 2 OF 4.2.2.1

Standing dead tree biomass must be adjusted for density reduction and structural loss using the Domke (2011) method.[43] Density reduction factors shall be based on either the hardwood/softwood default values found in Table 6 of Harmon et al. (2011)[44] or the species-specific values found in Appendix B. This choice must be applied consistently across the with-project and baseline scenarios. When applying density reduction factors from Appendix B and species are not available, Project Proponents must identify an appropriate decay class from the same genus (Appendix D). With either choice, class 5 standing dead wood must receive the density reduction factor for class 4. Structural loss factors for all species are found in Table 2 of Domke et al. (2011) for decay classes 1-5 for top, bark, bole, stump, and roots. If aboveground biomass is estimated without separating into the components specified in Table 2, the structural loss adjustment factor for roots may be used alone.

FOR PROJECTS USING OPTION 3 OF 4.2.2.1

Projects outside AK, CA, OR, and WA: Standing dead tree biomass must be adjusted for density reduction and structural loss using the Domke (2011) method. Species-specific decay class and density reduction factors are found in Appendix B of Harmon et al. (2011). Where species are not found in Appendix B, Project Proponents must identify an appropriate decay class from the same genus (Appendix D). If not possible, use the hardwood/softwood default values found in Table 6 of Harmon et al. (2011). Class 5 standing dead wood must receive the density reduction factor for class 4. Structural loss factors for all species are found in Table 2 of Domke et al. (2011) for decay classes 1-5 for top, bark, bole, stump, and roots.

Projects in AK, CA, OR, and WA: Apply density reduction factors based on decay classes from Harmon et al. (2011). Density reductions shall be assessed prior to plot-level calculations of belowground biomass.

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

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

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

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

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

4.4.3.2 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 on previous and projected forest management). Uncertainty within this pool must be quantified per Section 4.6. Where included, the following steps are required:

Step 1 Lying dead wood must be sampled using the line intercept method (Harmon and Sexton 1996).[45, 46] At least two 50-meter lines (164 ft) are established bisecting each plot and the diameters of the lying dead wood (≥ 10 centimeters, or cm, diameter [≥ 3.9 inches]) intersecting the lines are measured.

Step 2 The dead wood is assigned to one of the three density states (sound, intermediate and rotten) by species using the 'machete test', as recommended by IPCC GPG LULUCF.[47] 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.[48]

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

[46] A variant on the line intercept method is described by Waddell, K. L. (2002). Sampling coarse woody debris for multiple attributes in extensive resource inventories. *Ecological indicators, 1*(3), 139-153. https://www.sciencedirect.com/science/article/abs/pii/S1470160X01000127

This method may be used in place of Steps 1 to 3.

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

[48] 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)[49] as modified by Van Wagner (1968)[50] separately for each density class.

Equation 6: Volume of Lying Dead Wood

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

WHERE

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

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

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

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

Equation 7: Biomass of Lying Dead Wood

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

WHERE

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

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

4.4.4 HARVESTED WOOD PRODUCTS CALCULATION

There are five steps required to account for the harvesting of trees and to determine carbon stored in wood products in the baseline and with-project scenarios:[51]

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 in-use and landfill wood products 100 years after harvest.

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

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

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

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

Table 2: Volume Multipliers for Converting Timber and Chip Units to Cubic Feet or Cubic Meters

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

Green tons	31.5	0.9
MBF-Doyle	222.0	6.3
MBF-International 1/4"	146.0	4.1
MBF-Scribner ("C" or "Small")	165.0	4.7
MBF-Scribner ("Large" or "Long")	145.0	4.1
MCF-Thousand Cubic Feet	1000.0	28.3
Oven Dried Tons	75.8	2.1

II. If a volume measurement is used, multiply the cubic foot volume by the appropriate green specific gravity by species from table 5-3a of the USFS Wood Handbook.[52] This results in pounds of biomass with zero moisture content. If a particular species is not listed in the Wood Handbook, the project should request ACR to approve a substitute species. Any substitute species must be consistently applied across the baseline and with-project calculations.

III. If a weight measurement is used, subtract the water weight based on the moisture content of the wood. This results in 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_2e. Sum the CO_2e for each species into saw log and pulp volumes (if applicable), and then again into softwood species and hardwood species. These values are used in the next step, accounting for mill efficiencies. Please note that the categorization criteria (upper and lower diameter at breast height, or DBH, limits) for hardwood/softwood saw log and pulp volumes are to remain the same between the baseline and with-project scenario.

Step 2 ACCOUNT FOR MILL EFFICIENCIES

Multiply the total carbon weight (metric tons of carbon) for each group derived in Step 1 by the mill efficiency identified for the project's mill location(s) in the Wood Product

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

Reference File.[53] This output represents the total carbon transferred into wood products. The remainder (sawdust and other byproducts) of the harvested carbon is considered to be immediately emitted to the atmosphere for accounting purposes in this methodology.

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

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

Table 3: 100-Year Storage Factors[54]

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

[53] Found on the Reference documents section of this methodology’s website.

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

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

To determine the carbon storage in in-use wood products after 100 years, the first step is to determine what percentage of a project area's harvest will end up in each wood product class for each species (where applicable), separated into hardwoods and softwoods. This must be done by either:

- Obtaining verifiable supporting documentation indicating the product categories the mill(s) sold for the year in question; or
- If verifiable supporting documentation cannot be obtained, looking up default wood product classes for the project's Supersection, as given in the Wood Product Reference File. A project's Supersection is determined using the GIS shapefiles,[55] for either the lower 48 states or Alaska respectively. Projects spanning multiple Supersections should use a weighted average wood product class distribution.

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

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

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

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

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

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

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 metric tons CO_2e).

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

The total carbon storage in wood products after 100 years ($C_{BSL,HWP,t}$ or $C_{P,HWP,t}$) 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. These values are used for the calculation of baseline and with-project carbon stock changes in Equations 5 and 11, respectively. The value for the with-project harvested wood products will vary every time period depending on the total amount of harvesting that has taken place. The baseline value will vary every time period until the point in time when conversion activities are complete, after which the baseline value will be 0.

4.4.5 SOIL ORGANIC CARBON (SOC) CALCULATION

Where the identified baseline land use is agriculture, SOC emissions associated with baseline conversion activities may be optionally included in the determination of ERRs and may be estimated via Natural Resource Conservation Service (NRCS) Gridded Soil Survey Geographic (gSSURGO) data, direct sampling, or a combination thereof.

See Appendix A for detailed instructions and requirements on SOC computations.

4.5 Monitoring Requirements for Baseline Renewal

A project's Crediting Period is the finite length of time for which the baseline scenario is valid and during which a project can generate carbon credits against its baseline. Once validated for a Crediting Period, a project's baseline scenario is fixed, unless legal constraints change such that the baseline conversion activities are legally prohibited (per Section 4.1). The baseline modeled conversion of forest to non-forest must fully occur within the initial Crediting Period. Renewed baselines for subsequent Crediting Periods will be a steady state and result in no emission reductions, and thus only with-project scenario growth will be credited (as removals).

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

- Re-submitting the GHG Project Plan in compliance with then-current *ACR Standard* and program rules and criteria;
- Demonstrating a continued conservation comittment per Section 2.1.1. Easements, deed restrictions, and legally binding contracts which limit conversion must be in place until the end of the renewed Crediting Period;
- Using ACR-approved baseline methods, emission factors, and tools in effect at the time of Crediting Period renewal; and
- Undergoing validation and verification by an approved validation/verification body.

4.6 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,[56] IPCC GPG LULUCF,[57] or estimates based on sound statistical sampling. Uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools must be quantified. Indisputably conservative estimates of uncertainty may also be employed, provided they are justified with relevant verifiable literature and approved by ACR.

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

Uncertainty in the baseline scenario should be defined as the weighted average uncertainty of each of the included pools. For measured or modeled live tree and dead wood (both standing and lying)

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

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

carbon stock estimates, use the confidence interval of the input inventory data. Wood products also use the live tree inventory data. For SOC use the confidence interval of directly sampled data or 0% for gSSURGO-derived estimates. Since gSSURGO SOC data is provided without statistical uncertainty, this methodology requires that indisputably conservative estimates be utilized (Section A.1.2). The uncertainty in each pool shall be weighted by the size of the pool so that projects may target a lower precision level in pools that only form a small proportion of the total stock.

Therefore,

Equation 8: Baseline Uncertainty

$$UNC_{BSL,t} = \sqrt{\frac{\left(\begin{array}{c}\left(C_{BSL,TREE,0} \times e_{BSL,TREE,0}{}^{2}\right) + \left(C_{BSL,DEAD,0} \times e_{BSL,DEAD,0}{}^{2}\right) \\ +\left(C_{BSL,SOC,0} \times e_{BSL,SOC,0}{}^{2}\right) + \left(C_{BSL,HWP,t} \times e_{BSL,TREE,0}{}^{2}\right)\end{array}\right)}{\left(C_{BSL,TREE,0} + C_{BSL,DEAD,0} + C_{BSL,SOC,0} + C_{BSL,HWP,t}\right)}}$$

WHERE

t	Time in years.
$UNC_{BSL,t}$	Percentage uncertainty in the combined carbon stocks in the baseline for year **t**.
$C_{BSL,TREE,0}$	Baseline carbon stock in above and below ground live trees (in metric tons CO_2e) for the initial inventory at year 0.
$C_{BSL,DEAD,0}$	Baseline carbon stock in dead wood (in metric tons CO_2e) for the initial inventory at year 0.
$C_{BSL,SOC,0}$	Baseline SOC stock (in metric tons CO_2e) for the initial inventory at year 0.
$C_{BSL,HWP,t}$	Baseline carbon remaining stored in wood products 100 years after harvest (in metric tons of CO_2e) during year **t**.
$e_{BSL,TREE,0}$	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_2e) for the initial inventory at year 0.
$e_{BSL,DEAD,0}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the carbon stock in dead wood (in metric tons CO_2e) for the initial inventory at year 0.

$e_{BSL,SOC,0}$	Percentage uncertainty expressed as 90% confidence interval of the mean of the directly sampled carbon stock in SOC (in metric tons CO_2e) for the initial inventory at year 0. SOC carbon stocks completely derived from gSSURGO data shall use 0%. SOC carbon stocks derived from a combination of direct sampling and gSSURGO data must calculate percentage uncertainty, expressed as 90% confidence interval of the mean, by weighting uncertainty by area, assuming 0% uncertainty for areas using gSSURGO data.

5 With-Project Scenario

5.1 Monitoring of Carbon Stocks in Selected Pools and Emissions Sources

With-project scenario stocks are determined by periodically remeasuring plots (data cannot be older than 10 years) according to the inventory SOP document and modeling carbon stocks to a discrete point in time. For sampling, information shall be provided and recorded in the GHG Project Plan to establish that professionally accepted principles of forest inventory and management are implemented. SOPs and QA/QC procedures for forest inventory, including field data collection and data management, shall be applied. Use or adaptation of inventory SOPs already applied in national forest monitoring systems such as the USDA FIA program,[58] available from published handbooks, or from the IPCC GPG LULUCF[59] is recommended. The inventory SOP document must describe how the project will update the forest inventory data following harvests or disturbances. Any changes to inventory practices from the originally validated inventory SOP document are subject to verification, must maintain or increase accuracy (in terms of the amount of relevant data collected, not necessarily the confidence interval of the mean), and shall be described in an updated inventory SOP document to be submitted to ACR.

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

The 90% statistical confidence interval (CI) of sampling can be no more than ±10% of the mean estimated amount of the combined carbon stock at the project area level.[60] If the Project Proponent

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

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

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

cannot meet the targeted ±10% of the mean at 90% confidence, then an uncertainty deduction is applied as determined by Section 7.5.

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

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

5.2 Estimation of With-Project Removals

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

- Carbon stock levels to be determined at the end of each Reporting Period, t;
- The change in with-project live tree and dead wood, if included, to be computed from the end of the prior Reporting Period, t-1; and
- The Reporting Period value of with-project carbon stored in wood products 100 years after harvest to be calculated following Section 4.4.4.

The following equations are used to construct the with-project stocking levels using models and forest inventory measurements described in Sections 4.4.1 and 4.4.2, respectively:

Equation 9: Change in With-Project Live Tree Stocks

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

WHERE

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

Equation 10: Change in With-Project Dead Wood Stocks

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

WHERE

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

Any reductions in carbon stocks due to harvests, disturbances, or slash burning that occurred during the Reporting Period must be accounted for in Equations 9 and 10.

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

Equation 11: Change in With-Project Total Stocks

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

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t**.
$\Delta C_{P,TREE,t}$	Change in the with-project carbon stock in above and below ground live trees (in metric tons CO_2e) during year **t**.
$\Delta C_{P,DEAD,t}$	Change in the with-project carbon stock in dead wood (in metric tons CO_2e) during year **t**.
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.

5.2.1 TREE BIOMASS, DEAD WOOD, AND WOOD PRODUCTS CALCULATIONS

The Project Proponent must use the same set of equations used in Section 4.4.2, 4.4.3, and 4.4.4 to calculate carbon stocks in the with-project scenario.

5.3 Estimation of Emissions Due to Activity-Shifting Leakage

The avoided conversion to the alternative land use within the project area may increase pressures to convert forestland outside the project area. The emissions resulting from this activity-shifting leakage must be included in the quantification of project benefits. Intensity of land use demand is highly regional, and GHG projects located within certain regions are expected to induce higher rates of activity-shifting leakage than projects located elsewhere. Activity-shifting leakage shall be quantified by applying a discount factor (Equation 12), which conservatively assumes all projects are located within regions of high land use demand.[61]

Equation 12: Activity-Shifting Leakage

$$\mathbf{LK_{A-S} = 0.0431}$$

This deduction is applied to the total project stock change in the calculation of total leakage emissions (Equation 15).

5.4 Estimation of Emissions Due to Market Leakage

While land use supply and demand are the primary economic drivers displaced by the GHG project, reductions in wood product outputs may also 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 applying the appropriate default market leakage discount factor (Equation 13 or 14):

- Where the project consists of multiple small private landowners (each owning less than 5,000 forested acres), the market leakage deduction is 20%.[62]

Equation 13: Small Landowner Market Leakage

$$\mathbf{LK_{MARKET} = 0.20}$$

[61] 158 randomly selected counties located in the conterminous United States (approximately 5% of CONUS counties) were evaluated over an 11-year period (2008-2019) using the National Land Cover Database (NLCD) to determine their rates of conversion of forestland to alternative land uses. Of all the counties evaluated, the highest rate of conversion was approximately 2.6%. This result is then adjusted for eligibility for conversion based on land ownership, where conservatively only Private Corporate and Private Non-Corporate ownership classes (accounting for 60.31% of CONUS forestland) are considered.

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

- Where the project consists of one or more large private landowners (owning more than 5,000 forested acres) or any non-private landowners, the market leakage deduction is 30%.[63]

Equation 14: General Market Leakage

$$\mathbf{LK_{MARKET} = 0.30}$$

This discount factor is applied to the wood products that would have been produced in the baseline scenario, net of the wood products produced by the with-project scenario, in the calculation of total leakage emissions (Equation 15).

5.5 Estimation of Total Leakage Emissions

Estimations of activity-shifting and market leakage shall be combined into a total leakage deduction (Equation 15) to be applied within the calculation of ERRs (Equation 20). Leakage is conservatively excluded from quantification if it is negative.

Equation 15: Total Leakage Deduction

$$\textbf{if } \left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) \leq 0, \quad \textbf{then } LK_t = 0$$

or

$$\textbf{if } \left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) > 0 \textbf{ and } \left(C_{P,HWP,t} - C_{BSL,HWP,t}\right) > 0,$$
$$\textbf{then } LK_t = \left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) \times LK_{A-S} + \left(C_{P,HWP,t} - C_{BSL,HWP,t}\right) \times LK_{MARKET}$$

or

$$\textbf{if } \left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) > 0 \textbf{ and } \left(C_{P,HWP,t} - C_{BSL,HWP,t}\right) \leq 0,$$
$$\textbf{then } LK_t = \left(\Delta C_{P,t} - \Delta C_{BSL,t}\right) \times LK_{A-S}$$

[63] Based on ACR's *Methodology for the Quantification, Monitoring, Reporting, and Verification of Greenhouse Gas Emission Reductions and Removals for Improved Forest Management on Non-Federal U.S. Forestlands*.

WHERE

t	Time in years.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t**.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO_2e) during year **t**.
LK_t	Total leakage deduction (in metric tons CO_2e) for year **t**.
$C_{P,HWP,t}$	With-project carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.
$C_{BSL,HWP,t}$	Baseline carbon remaining stored in wood products 100 years after harvest (in metric tons CO_2e) during year **t**.
LK_{A-S}	Activity-shifting leakage discount factor, in % (Section 5.3).
LK_{MARKET}	Market leakage discount factor, in % (Section 5.4).

5.6 Estimation of With-Project Uncertainty

Uncertainty in the with-project scenario should be defined as the weighted average error of each of the measurement pools, including live trees and, if included, standing dead wood and lying dead wood. If the with-project carbon stocks in live trees and dead wood are derived from modeling (Section 4.4.1), use the confidence interval ($e_{P,TREE/DEAD,t}$) of the input inventory data. For wood products with measured and documented harvest volume removals use zero as the confidence interval (instead of $e_{P,TREE,t}$; Equation 16). For estimated wood product removal use the confidence interval of the live tree inventory data ($e_{P,TREE,t}$). The errors in each pool shall be weighted by the size of the pool so that projects may target a lower precision level in pools that only form a small proportion of the total stock.

Therefore,

Equation 16: With-Project Uncertainty

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

WHERE

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

6 Ex-Ante Estimation

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

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

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

- Data from well-referenced peer-reviewed literature or other well-established published sources;
- National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; or
- In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value must be noted in the GHG Project Plan. For any data provided by experts, the GHG Project Plan shall also record the expert's name, affiliation, and principal qualification as an expert.

When selecting values based on data that is not specific to the project circumstances, such as default data, Project Proponents must select values that will lead to an accurate estimation of net GHG ERRs, taking into account uncertainties. If uncertainty is significant, Project Proponents must choose data such that it tends to underestimate, rather than overestimate, net GHG ERRs. Include data sources in the description of methods and assumptions within the GHG Project Plan.

7 QA/QC, Validation and Verification, and Uncertainty

7.1 Methods for Quality Assurance

An inventory SOP document, including data management systems and processes and QA/QC procedures, must be developed according to the requirements of this methodology (Section 4.4.2). These systems, processes, and procedures are subject to validation and subsequent verifications. Use or adaptation of inventory SOPs already applied in national forest monitoring systems such as the USDA FIA program,[64] available from published handbooks, or from the IPCC GPG LULUCF[65] is recommended. A stratification SOP document must also be developed (Section 3). Where SOC is an included pool, sampling and stratification SOP documents must be provided (Appendix A).

7.2 Methods for Quality Control

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

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

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

7.3 Validation

In accordance with the *ACR Standard* and the *ACR Validation and Verification Standard*, projects must be validated by an ACR-approved Validation/Verification Body (VVB) prior to its first ERT issuance. Validation may be conducted in conjunction with the project's initial full verification or as a stand-alone validation activity. Projects must be validated within three years of the project Start Date.

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

- Conformance with eligibility, applicability, and sustainable forest management requirements;
- Compatibility of forest management with the Montréal Process (if applicable; Section 1.3.1);
- Project geographic boundaries;
- Physical infrastructure, activities, technologies, and processes;
- GHGs, sources, and sinks within the project boundary;
- Project temporal boundary, including the event denoting the project Start Date;
- Stratification procedures and implementation, if applicable;
- Additionality, including regulatory surplus, the qualified appraisal, and calculation of the CPD;
- Description of and justification for the baseline scenario, including land conversion planning documentation (if provided), application of the land conversion schedule, and required reporting (Section 4.3);
- Methodologies and calculations used to generate estimates of baseline and with-project scenario carbon stocks, emissions, emission reductions, and removals (including growth and yield model selection and parameterization);
- Procedures for measuring carbon stocks (inventory SOPs);
- Methods for measuring, estimating, and projecting the baseline SOC pool (if applicable, Appendix A); if SOC is directly sampled, the inventory SOP document's methodology and implementation is subject to validation, as well as the chain of custody of soil samples and laboratory results of combustion analysis;
- Data management systems and QA/QC procedures;
- Processes for estimating, calculating, and accounting for project-level uncertainty and leakage;
- Reversal risk analysis and buffer contribution percentage; and
- Roles and responsibilities of participating entities (e.g., Project Proponent, landowner).

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

7.4 Verification

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

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

- Continued regulatory surplus and conformance with eligibility, applicability, and sustainable forest management requirements;
- Project geographic boundary updates;
- Temporal boundary of the Reporting Period;
- Stratification updates;
- Calculations used to generate estimates of emissions, emission reductions, and removals;
- Assessment of growth and yield model outputs and projections;
- Original underlying data and documentation as relevant and required to evaluate the GHG assertion;
- Any changes to inventory practices from the originally validated inventory SOP document, and whether they maintain or increase accuracy (in terms of the amount of relevant data collected, not necessarily the confidence interval of the mean);
- Implementation of procedures for measuring carbon stocks (full verifications only; Section 7.4.1);
- Implementation of data management systems and QA/QC procedures;
- Results from uncertainty assessments and leakage calculations;
- Reversal risk analysis, buffer contribution percentage, and buffer contribution; and
- Updates to roles and responsibilities of participating entities (e.g., Project Proponent, landowner).

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

7.4.1 RESAMPLING OF CARBON STOCK MEASUREMENTS

In addition to any other activities needed by the verifier to provide a reasonable level of assurance that the GHG assertion is without material discrepancy, full verification field visits must assess carbon stock measurements and estimates, to be conducted according to the following specifications:

- The VVB resampled carbon stock (live tree and, if included, standing dead wood and lying dead wood) measurements must statistically agree with the project's carbon stock measurements using a two-tailed Student's *t*-test at the 90% confidence interval. If the project's forest inventory is comprised of permanent plots that may be efficiently relocated by the verifier, this test shall be paired. Otherwise, this test shall be unpaired, requiring installation of resampling plots at new locations. The minimum number of resampling plots, for the aboveground biomass pools, shall be determined by calculating the square root of each respective pool's most recent inventory's plot count:

Equation 17: Minimum Resampling Plot Count

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

WHERE

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

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

sequence until both the minimum number of resampling plots and the required statistical agreement are reached.

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

7.5 Calculation of Total Uncertainty and Uncertainty Deduction

The following equation must be applied to calculate total uncertainty:

Equation 18: Total Uncertainty

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

WHERE

t	Time in years.
UNC_t	Total uncertainty for year **t**, in %.
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t** (Section 4.4).
UNC_{BSL}	Baseline uncertainty, in % (Section 4.6).
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t** (Section 5.2).
$UNC_{P,t}$	With-project uncertainty for year **t**, in % (Section 5.6).

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

Equation 19: Uncertainty Deduction

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

$$\text{or}$$

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

WHERE

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

8 Calculation of ERTs

This section describes the process of determining Total and Net GHG Emission Reductions and Removals for a Reporting Period for which a valid Verification Report has been accepted by ACR. Total GHG Emission Reductions and Removals ($ERR_{RP,t}$) are calculated using Equation 20 by adjusting the difference between the with-project carbon stock change, baseline carbon stock change, and leakage deduction for conversion probability and uncertainty.

Equation 20: Total Emission Reductions and Removals

$$ERR_{RP,t} = (\Delta C_{P,t} - \Delta C_{BSL,t} - LK_t) \times (1 - CPD) \times (1 - UNC_{DED,t})$$

WHERE

t	Time in years.
$ERR_{RP,t}$	Total GHG Emission Reductions and Removals (in metric tons CO_2e) in Reporting Period **t**.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t** (Section 5.2).
$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO_2e) during year **t** (Section 4.4).
LK_t	Total leakage deduction (in metric tons CO_2e) for year **t** (Section 5.5).
CPD	Conversion probability discount (in %; Section 4.2).
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t** (Section 7.5).

If the Project Proponent has chosen Buffer Pool Contributions as their risk mitigation mechanism, Total GHG Emission Reductions and Removals are then multiplied by a Buffer Pool Contribution Percentage (Equation 21) to calculate the Reporting Period's Buffer Pool Contribution. Subtracting this calculates Net GHG Emission Reductions and Removals (i.e., the ERTs issued to the Project Proponent) (Equation 22).

Equation 21: Buffer Pool Contribution

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

WHERE

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

Equation 22: Net Emission Reductions and Removals

$$\mathbf{ERR_{NET,RP,t} = ERR_{RP,t} - BUF_{RP,t}}$$

WHERE

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

Net Emission Reductions and Removals by Vintage shall then be determined by prorating Reporting Period calendar days within Vintage year y (Equation 23), applying the Buffer Pool Contribution Percentage (Equation 24) and subtracting the Buffer Pool Contribution by Vintage from the Total ERR by Vintage (Equation 25). Buffer Pool Contributions will be deposited by Vintage, if this is the risk mitigation mechanism the Project Proponent has chosen.

Equation 23: Total Emission Reductions and Removals by Vintage

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

WHERE

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

Equation 24: Buffer Pool Contribution by Vintage

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

WHERE

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

Equation 25: Net Emission Reductions and Removals by Vintage

$$ERR_{NET,VIN,y} = ERR_{VIN,y} - BUF_{VIN,y}$$

WHERE

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

The Project Proponent may elect to distinguish between Removals ($REM_{RP,t}$) and Emission Reductions ($ER_{RP,t}$) for a given Reporting Period with positive Total GHG Emission Reductions and Removals. In the context of this methodology, Removals are carbon stock changes resulting in sequestration attributable to the with-project scenario and are calculated by adjusting the with-project carbon stock change for leakage and uncertainty (Equation 26). Emission Reductions are carbon stock changes attributable to the baseline scenario and are calculated as the Total GHG Emission Reductions and Removals minus Removals (Equation 28). If distinguishing, Removals and Emission Reductions must be allocated to Vintage years following the procedure outlined in Equations 27 and 29, respectively.

Equation 26: Removals

$$\mathbf{REM_{RP,t} = (\Delta C_{P,t} - LK_t) \times (1 - CPD) \times (1 - UNC_{DED,t})}$$

WHERE

t	Time in years.
$REM_{RP,t}$	Total Removals (in metric tons CO_2e) in Reporting Period **t**.
$\Delta C_{P,t}$	Change in the with-project carbon stock (in metric tons CO_2e) during year **t**.
LK_t	Total leakage deduction (in metric tons CO_2e) for year **t**.
CPD	Conversion probability discount (in %).
$UNC_{DED,t}$	Uncertainty deduction (in %) for year **t**.

Equation 27: Removals by Vintage

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

WHERE

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

Equation 28: Emission Reductions

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

WHERE

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

Equation 29: Emission Reductions by Vintage

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

WHERE

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

8.1 Reversals and Termination

Negative project stock change ($ERR_{RP,t}$) is a Reversal. Reversals must be reported and compensated following requirements detailed in the *ACR AFOLU Carbon Project Reversal Risk Mitigation Agreement* and the *ACR Buffer Pool Terms and Conditions*.[66]

The *ACR Buffer Pool Terms and Conditions* establishes a threshold for when a Reversal results in Early Project Termination and lays out associated requirements for reporting and compensation. Notwithstanding this threshold, due to the inherent nature and intent of this methodology's project activity, projects registered under this methodology are subject to Early Project Termination and the associated requirements if a Reversal causes the with-project live biomass carbon and dead wood pools, in sum, to decrease below 80% of the initial stocking levels of their respective pools, in sum, at any point prior to the end of the Minimum Project Term.

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

Appendix A: Determining and Projecting SOC Stocks

The Soil Organic Carbon (SOC) pool may be optionally included in project accounting where the identified baseline land use is agriculture. This methodology conservatively assumes that the baseline land uses of mining and development have a negligible impact on the SOC pool, which is therefore excluded from such projects. Where included, SOC stocks are conservatively assumed to be in a steady state in the with-project scenario, such that they are fixed over the project term. As a result, there is no change in the with-project SOC stock during each Reporting Period and this term is not included in with-project stock change (Equation 11). Credit generation from the SOC pool is due solely to emission reductions associated with the baseline scenario. The SOC pool is limited to the first thirty centimeters (30 cm) of soil depth, beyond which management activities rarely affect SOC concentration.[67]

Accounting for baseline SOC stock change is comprised of two steps:

- Determining the SOC stocks at the project Start Date; and
- Projecting the change in baseline SOC stocks due to land conversion activities.

These steps result in estimates of the baseline SOC stock ($C_{BSL,SOC,t}$) for the entire Crediting Period, to be included in annualized *ex-ante* projections, prorated for Reporting Period length (if applicable), and used in Equation 4.

A.1 Determining Initial SOC Stocks

This methodology distinguishes SOC stocks into organic soils and mineral soils. For the purposes of this methodology, organic soils include, within the order of Histosols, all suborders other than Folists and, within the order of Gelisols, only the members of the suborder Histels other than the great group of Folistels. All other soils are considered mineral soils under this methodology. The project area shall be stratified into areas consisting of mineral soils and areas consisting of organic soils. No single area can be classified as (and thus contribute to SOC stock estimates of) both mineral and organic soils (i.e., areas of mineral soils and organic soils must each be stratified in a manner as to be spatially

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

independent). The initial SOC stocks in mineral ($SOC_{MINL,0}$) and organic soils ($SOC_{ORG,0}$) shall be distinctly determined by one of the following methods:

Option 1 **Direct sampling**, as further described in Section A.1.1. Stratification by mineral and organic soils is required. Projects may choose to further stratify the project area to reduce variability in the sampled SOC estimates. Strata may be defined on the basis of parameters that are key variables for estimating SOC stocks, such as soil taxonomy. However strata are defined, an absence of bias must be demonstrated in application of the stratification procedures and each stratum must be classified as either mineral or organic. The SOC stratification design may be entirely different than the design employed for live and dead biomass (Section 3);

Option 2 **NRCS gSSURGO data**, as further described in Section A.1.2. Projects must stratify the project area according to gSSURGO map units. Map units may not be further divided and must be classified as either mineral or organic based on its soil order or hydric criterion code; or

Option 3 **A combination thereof**, as further described in Section A.1.3. Projects must stratify by gSSURGO map units where they are utilized. Directly sampled areas must be stratified by soil type (mineral or organic) and may be further stratified based on guidelines provided for Option 1.

SOC stratification procedures must be described in an addendum to the stratification SOP document (Section 3), to be attached to the GHG Project Plan for validation. This addendum must include the relevant design, inputs, parameters, rules, and techniques used, such that soil stratification is replicable, and it must describe the criteria and processes for classifying mineral and organic soils.

The distinct estimates of SOC stock in mineral ($SOC_{MNL,0}$) and organic soils ($SOC_{ORG,0}$) are summed to calculate total initial SOC stock (i.e., content; $C_{BSL,SOC,0}$) in Equation 40 and are then projected according to their respective loss rates (Section A.2).

A.1.1 DIRECT SAMPLING

Initial SOC stocks may be determined through direct sampling. Soil plots are installed across the project area, and soil cores are collected at each plot to determine both carbon content and bulk density. Measurements must be collected within 3 years of the project Start Date and are subject to validation.

A.1.1.1 Sampling Procedures

SOC sampling procedures must be described in an addendum to the inventory SOP document (Section 4.4.2), to be attached to the GHG Project Plan for validation. This addendum must describe the following sampling parameters:

- Sample size;
- Determination of plot locations and numbers;
- Whether SOC plot locations are spatially related to aboveground biomass inventory plot locations;
- In-field location procedures and monumentation;
- Data collected and measurement tools used;
- Detailed measurement procedures such that measurements are repeatable;
- Process for collecting and aggregating multiple cores per plot;
- Georeferenced, photographic evidence of each soil sample collected;
- Names and locations of laborities utilized; and
- Data management systems and processes, including QA/QC procedures.

The sample design must be statistically unbiased and should achieve a desired precision level to reduce deductions for uncertainty. Plot locations may be determined via systematic and/or random allocation. SOC measurements may be collected at the same plots used for aboveground biomass, or via a separate allocation. SOC plots must be permanently monumented to allow relocation for validation purposes. The sampling error(s) and 90% confidence interval resulting from SOC inventory must be computed for use in Equation 8.

SOC must be estimated by collecting soil cores to a depth of 30 centimeters and subsequently analyzing for soil carbon content with standard dry combustion at a commercial, university affiliated, or state affiliated laboratory. SOC sampling procedures must include unbiased methods for addressing soil core sample relocation when the sampling probe will not penetrate to the required 30-centimeter depth (due to a restrictive layer).

SOC plots must have a radius of 20 feet. The collection and aggregation of at least six SOC cores per plot is required to reduce variability. Within-plot SOC core locations must be determined systematically and represent each sextant of the plot. At least two bulk density cores per plot must also be collected and aggregated. Each aggregate sample must be processed through a 2-millimeter sieve prior to laboratory analysis. Visible root biomass and any surface material must be separated and excluded from all collected samples. The volume of large coarse fragments (>10 mm diameter) which are too large to be included in the bulk density cores (but small enough to be moved to the laboratory) must be estimated using water displacement or using other relevant techniques which are widely accepted as valid, documented, and subject to validation.

The sample design, inventory methods and their implementation, chain of custody of soil samples, and laboratory results of combustion analyses are subject to validation. However, the results of SOC direct sampling are not subject to a statistical validation procedure.

A.1.1.2 Calculation of SOC Stocks from Direct Sampling

To calculate the estimates of initial SOC content for mineral ($SOC_{MNL,0}$) and organic ($SOC_{ORG,0}$) soils from direct sampling, the average stock per unit area (in metric tons carbon per acre) must first be calculated. The following equation multiplies percent carbon, bulk density, and volume per hectare at 30 centimeters sampling depth (3000), and lastly converts from per hectare to per acre (0.404686). To estimate the SOC stock per acre for a given set of sample plots within each stratum, use:

Equation 30: Plot-Level SOC Stocks from Direct Sampling

$$SOC_{sp,i} = OM_{sample,sp,i} \times BD_{sample,sp,i} \times [(1 - CF_{sample,sp,i})] \times 3000 \times 0.404686$$

WHERE

$SOC_{sp,i}$	SOC stock (in metric tons carbon per acre) for sample plot **sp** within soil stratum **i**.
$OM_{sample,sp,i}$	Organic matter (in % by weight carbon) of the sample at sample plot **sp** within soil stratum **i** as determined in laboratory (fine fraction <2 mm diameter).
$BD_{sample,sp,i}$	Bulk density of fine (<2 mm diameter) fraction of soil (in grams per cubic centimeter) in sample plot **sp** within soil stratum **i** as determined in the laboratory.
$CF_{sample,sp,i}$	Coarse (>= 2 mm diameter) rock fragment volume (in %) in sample plot **sp** within soil stratum **i** as determined in the laboratory. Mass may be converted to volume assuming a density value of 2.6 g/cm^3.

Next, the mean SOC stock per acre for each stratum must be calculated and converted to tons carbon dioxide per acre.

Equation 31: Stratum-Level SOC Stocks from Direct Sampling

$$\mathbf{SOC_i = \frac{\sum_{sp=1}^{P_i} SOC_{sp,i}}{P_i} \times 3.664}$$

WHERE

SOC_i	Mean SOC content (in metric tons CO_2e per acre) for soil stratum **i**.
$SOC_{sp,i}$	SOC stock (in metric tons carbon per acre) for sample plot **sp** within soil stratum **i**.
P_i	Total number of sample plots (**sp**) within soil stratum **i**.

If the project area is comprised of both mineral and organic soils, then Equations 30 and 31 must be performed at least twice. They may be performed further depending on the number of defined soil strata. Stratum estimates must be multiplied by their respective areas and combined according to their soil type (mineral or organic) to calculate the initial SOC stocks for mineral ($SOC_{MNL,0}$) and organic ($SOC_{ORG,0}$) soils.

Equation 32: Initial SOC Mineral Stocks from Direct Sampling

$$\mathbf{SOC_{MNL,0} = \sum_{i=1}^{x_{MNL}} (SOC_{i,MNL} \times acres_{i,MNL})}$$

WHERE

$SOC_{MNL,0}$	Initial SOC stock in mineral soils (in metric tons CO_2).
$SOC_{i,MNL}$	Mean SOC stock (in metric tons CO_2e per acre) in mineral soil stratum **i** as derived from direct sampling.
$acres_{i,MNL}$	Acres in mineral soil stratum **i**.
x_{MNL}	Total number of mineral soil strata.

Equation 33: Initial SOC Organic Stocks from Direct Sampling

$$SOC_{ORG,0} = \sum_{i=1}^{x_{ORG}} (SOC_{i,ORG} \times acres_{i,ORG})$$

WHERE

$SOC_{ORG,0}$	Initial SOC stock in organic soils (in metric tons CO_2).
$SOC_{i,ORG}$	Mean SOC stock (in metric tons CO_2e per acre) in organic soil stratum **i** as derived from direct sampling.
$acres_{i,ORG}$	Acres in organic soil stratum **i**.
x_{ORG}	Total number of organic soil strata.

A.1.2 NRCS gSSURGO DATA

Initial SOC stocks may be determined using the Gridded Soil Survey Geographic (gSSURGO) database, maintained by the Natural Resources Conservation Service (NRCS).[68] The project area is mapped in GIS with the geographically appropriate gSSURGO dataset, allowing retrieval of soil carbon content and soil type (mineral or organic) for each map unit that comprises the project area. Detailed instructions for data retrieval are available in the gSSURGO SOC Instructions document.[69]

The most recently published gSSURGO data as of the project Start Date must be used. Data is available for each state or for the whole contiguous United States (CONUS), and either may be used. Null values are presented where data is incomplete or unavailable; these map units and their associated acres must be removed from the gSSURGO-derived stratification and subsequent project SOC accounting. However, these areas are eligible for direct sampling (Section A.1.3).

Taxonomic order or hydric criterion codes ("Hydric Criterion" field) are used to classify map units as either mineral or organic soils. A hydric criterion code of 1 denotes a map unit is comprised of organic soils. Map units shall be classified as organic if they include soils belonging to, within the order of

[68] U.S. Department of Agriculture, Natural Resources Conservation Service, Soil Survey Staff. (2020). Gridded Soil Survey Geographic (gSSURGO) Database for the United States of America and the Territories, Commonwealths, and Island Nations served by the USDA-NRCS. https://www.nrcs.usda.gov/resources/data-and-reports/gridded-soil-survey-geographic-gssurgo-database/

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

Histosols, any suborder other than Folists and, within the order of Gelisols, the suborder of Histels other than the great group of Folistels. All other map units shall be classified as mineral soils.

A.1.2.1 Calculation of SOC Stocks from gSSURGO Data

To calculate the initial SOC stock estimates for mineral ($SOC_{MNL,0}$) and organic ($SOC_{ORG,0}$) soils from gSSURGO data, each map unit's SOC stock estimate must first be calculated per the following methods (Equations 34-37).[70] SOC estimates must be calculated for each horizon up to 30 centimeters depth for each component within a map unit. Since gSSURGO data does not include variance of its SOC estimates, uncertainty is accounted for with a conservative static deduction applied to the organic matter derived from gSSURGO data. This methodology prescribes the third quartile (0.75) between the map unit's representative value and its low value, which is the estimated minimum value. For each horizon (up to 30 centimeters depth) within a given map unit's component, use the following equation to calculate a deducted estimate of organic matter:

Equation 34: Uncertainty Deduction for Organic Matter from gSSURGO

$$OM_{DED} = [(om\_r - om\_l) \times 0.75] + om\_l$$

WHERE

OM_{DED}	Organic matter (in % carbon by weight) deducted for uncertainty.
om_r	Organic matter (in % carbon by weight), representative value, as found in the gSSURGO 'chorizon' table.
om_l	Organic matter (in % by weight carbon), low value, as found in the gSSURGO 'chorizon' table.

The SOC estimate for each horizon within 30 centimeters depth is then calculated, assuming soil organic matter is approximately 58% carbon by weight, by multiplying by the oven dry weight and the soil horizon depth, accounting for volume occupied by fragments, and converting to kilograms per

[70] Personal communications with Steve Campbell, Soil Scientist, USDA Natural Resources Conservation Service, September 21, 2022.

square meter (10).[71] Total volume composed of fragments is accounted for by summing all fragment volume percentages within the horizon:

Equation 35: Horizon-Level SOC Stocks from gSSURGO

$$\mathbf{SOC_{h,cp,i}} = [(\mathbf{OM_{DED}} \times \mathbf{0.58})/\mathbf{100}] \times \mathbf{dbthirdbar\_r} \times \left[\left(\mathbf{100} - \sum \mathbf{fragvol\_r}\right)/\mathbf{100}\right] \times (\mathbf{hzdepb\_r} - \mathbf{hzdept\_r}) \times \mathbf{10}$$

WHERE

$SOC_{h,cp,i}$	SOC estimate (in kilograms carbon per square meter) for horizon **h** within component **cp** within map unit **i**.
OM_{DED}	Organic matter (in % by weight carbon) after deduction.
dbthirdbar_r	Oven dry weight of soil material (<2 mm diameter) per unit volume of soil (in grams per cubic centimeter) at a water tension of 1/3 bar, representative value, as found in the gSSURGO ‘chorizon’ table.
fragvol_r	Percentage volume of the horizon occupied by the 2 mm diameter or larger fraction, on a whole soil base, representative value, as found in the gSSURGO ‘chfrags’ table.
hzdepb_r	Distance (in cm) from the top of the soil to the base of the soil horizon, representative value, as found in the gSSURGO ‘chorizon’ table. If the base of the soil horizon exceeds 30 cm, use 30 cm.
hzdept_r	Distance (in cm) from the top of the soil to the upper boundary of the soil horizon, representative value, as found in the gSSURGO ‘chorizon’ table.

Equation 35 must be performed for each horizon within 30 centimeters depth. The SOC estimates for each horizon within a given component and up to 30 centimeters depth must then be summed to calculate total SOC for the component:

[71] U.S. Department of Agriculture, Natural Resources Conservation Service, Soil Survey Staff. (2011). Soil Survey Laboratory Information Manual. Soil Survey Investigations Report No. 45, Version 2.0. R. Burt (ed.). page 247. https://www.nrcs.usda.gov/sites/default/files/2022-10/SSIR45.pdf

Equation 36: Component-Level SOC Stocks from gSSURGO

$$\mathbf{SOC_{cp,i}} = \sum_{\mathbf{h=1}}^{\mathbf{z}} \mathbf{SOC_{h,cp,i}}$$

WHERE

$SOC_{cp,i}$	SOC estimate (in kilograms carbon per square meter; 30 cm depth) for component $\mathbf{cp}$ within map unit $\mathbf{i}$.
$SOC_{h,cp,i}$	SOC estimate (in kilograms carbon per square meter) for horizon $\mathbf{h}$ within component $\mathbf{cp}$ within map unit $\mathbf{i}$.
$\mathbf{z}$	Total number of horizons within component $\mathbf{cp}$ within map unit $\mathbf{i}$.

Each map unit's SOC estimate is then calculated through a weighted average of its various components, which is converted to metric tons carbon per hectare (10), then to metric tons carbon per acre (0.404686), and finally to metric tons carbon dioxide per acre:

Equation 37: Map Unit-Level SOC Stocks from gSSURGO

$$\mathbf{SOC_i} = \frac{\sum_{\mathbf{cp=1}}^{\mathbf{p}} (\mathbf{SOC_{cp,i}} \times \mathbf{comppct\_r})}{\sum \mathbf{comppct\_r}} \times \mathbf{10} \times \mathbf{0.404686} \times \mathbf{3.664}$$

WHERE

SOC_i	SOC estimate (in metric tons CO_2e per acre; 30 cm depth) for map unit $\mathbf{i}$.
$SOC_{cp,i}$	SOC estimate (in kilograms per square meter; 30 cm depth) for component $\mathbf{cp}$ within map unit $\mathbf{i}$.
$comppct\_r$	Percentage area of component $\mathbf{cp}$ within map unit $\mathbf{i}$, representative value, as found in the gSSURGO 'component' table.
$\mathbf{p}$	Total number of components within map unit $\mathbf{i}$.

Lastly, map unit estimates must be multiplied by their respective areas and combined according to their soil type (mineral or organic).

Equation 38: Initial SOC Mineral Stocks from gSSURGO

$$SOC_{MNL,0} = \sum_{i=1}^{x_{MNL}} (SOC_{i,MNL} \times acres_{i,MNL})$$

WHERE

$SOC_{MNL,0}$	Initial SOC stock in mineral soils (in metric tons CO_2).
$SOC_{i,MNL}$	SOC estimate (in metric tons CO_2e per acre; 30 cm depth) in mineral soil map unit i as derived from gSSURGO data.
$acres_{i,MNL}$	Acres in mineral soil map unit i.
x_{MNL}	Total number of mineral soil map units.

Equation 39: Initial SOC Organic Stocks from gSSURGO

$$SOC_{ORG,0} = \sum_{i=1}^{x_{ORG}} (SOC_{i,ORG} \times acres_{i,ORG})$$

WHERE

$SOC_{ORG,0}$	Initial SOC stock in organic soils (in metric tons CO_2).
$SOC_{i,ORG}$	SOC estimate (in metric tons CO_2e per acre; 30 cm depth) in organic soil map unit i as derived from gSSURGO data.
$acres_{i,ORG}$	Acres in organic soil map unit i.
x_{ORG}	Total number of organic soil map units.

A.1.3 COMBINING DIRECT SAMPLING AND NRCS gSSURGO METHODS

The direct sampling and NRCS gSSURGO SOC estimation methods may be combined in a single project. If so, the soil stratification SOP addendum and geospatial data submissions must clearly distinguish and delineate the stratified geographic extent of each approach. Only one approach (direct sampling or NRCS gSSURGO) may be used per stratum. Following the initial validation, the SOC estimation approach is set for the duration of the Crediting Period.

All requirements from Sections A.1.1 and A.1.2 must be applied to their respective approaches.

A.1.4 ESTIMATION OF TOTAL INITIAL SOC STOCK

Regardless of the option chosen (Section A.1), the following equation must be applied to calculate the total initial SOC stock:

Equation 40: Initial Total SOC Stocks

$$C_{BSL,SOC,0} = SOC_{MNL,0} + SOC_{ORG,0}$$

WHERE

$C_{BSL,SOC,0}$	Baseline SOC stock (in metric tons CO_2) at project Start Date (t=0).
$SOC_{MNL,0}$	Initial SOC stock in mineral soils (in metric tons CO_2).
$SOC_{ORG,0}$	Initial SOC stock in organic soils (in metric tons CO_2).

A.2 Projecting Baseline SOC Stocks

The impacts of forestland conversion to agriculture on mineral and organic soils are vastly different.[72] Therefore, projections of baseline SOC stocks in each soil type shall be treated distinctly by applying unique loss rates to the initial SOC stocks in mineral soils ($SOC_{MNL,0}$) and organic soils ($SOC_{ORG,0}$). Total baseline SOC stock ($C_{BSL,SOC,t}$) is then determined by summing the SOC stocks in each soil type in Equation 44.

To align SOC loss with Crediting Period length and loss models outlined below, SOC loss of the entire project area is assumed to begin at year 0, regardless of the temporal land conversion rate (Section 4.1). Where the total conversion impact (percentage of project area converted to non-forest) is less than 100%, the unconverted proportion must be equivalently withheld from the projected reductions in both organic and mineral SOC stocks.

[72] Description of soil organic carbon loss rates for ACR's Active Conservation methodology v1.0 (2023). Found on the Reference documents section of this methodology's website.

A.2.1 MINERAL SOILS

A regression was performed using data from the meta-analysis conducted by Wei et. al. (2014),[73] and a linear model was fitted for SOC loss in temperate forest environments. This empirical model demonstrates that time is a significant ($R2 = 0.41$; $p < 0.001$) predictor of SOC loss, with SOC on average decreasing by 1.06% per year for a 40-year timeframe. For conservatism, the lower bound of the 90% confidence threshold is used, with a cumulative loss of 60% of SOC stocks in mineral soils being realized over the 40-year Crediting Period.[74]

To compute the baseline SOC stock in mineral soils, as affected by forestland conversion to agriculture, over the 40-year Crediting Period, use the following equation:

Equation 41: Baseline SOC Mineral Stocks

$$C_{BSL,SOC,MNL,t} = SOC_{MNL,0} \times (1 - [17.68\% + (t \times 1.06\%)])$$

WHERE

t	Time in years (since project Start Date).
$C_{BSL,SOC,MNL,t}$	Baseline SOC stock in mineral soils (in metric tons CO_2) at the end of year t.
$SOC_{MNL,0}$	Initial SOC stock in mineral soils (in metric tons CO_2) (t=0).

A.2.2 ORGANIC SOILS

The unique and rapid weathering processes of organic soils yields a markedly higher loss of SOC than mineral soils when converted to agricultural use. Based on available literature and the mineral SOC stock loss following conversion to agriculture (approximately 60% over 40 years), this methodology assumes 90% loss of the initial SOC stock in organic soils over 40 years due to forestland conversion to agriculture.[75]

[73] Wei, X., Shao, M., Gale, W., & Li, L. (2014). Global pattern of soil carbon losses due to the conversion of forests to agricultural land. *Scientific reports*, *4*(1), 4062. https://doi.org/10.1038/srep04062.

[74] Description of soil organic carbon loss rates for ACR's Active Conservation methodology v1.0 (2023). Found on the Reference documents section of this methodology's website.

[75] Description of soil organic carbon loss rates for ACR's Active Conservation methodology v1.0 (2023). Found on the Reference documents section of this methodology's website.

Project Proponents may use the following table[76] to estimate the loss of baseline SOC stock in organic soils over the 40-year Crediting Period:

Table 4: Organic Soil Loss Schedule

YEARS POST-CONVERSION	ANNUAL LOSS RATE
1-5	9.0%
6-10	5.4%
11-40	0.6%

When using Table 4 to determine the loss rate of organic soils, the cumulative lost amount ($SOC_{LOSS,ORG,t}$) must be calculated by applying the loss rate for the given number of years since the project Start Date and prorating for Reporting Period length, if applicable. The baseline SOC stock in organic soils is then computed for each Reporting Period using the following equation:

Equation 42: Baseline SOC Organic Stocks using Table 4

$$C_{BSL,SOC,ORG,t} = SOC_{ORG,0} \times (1 - SOC_{LOSS,ORG,t})$$

WHERE

t	Time in years (since project Start Date).
$C_{BSL,SOC,ORG,t}$	Baseline SOC stock in organic soils (in metric tons CO_2) at the end of year t.
$SOC_{ORG,0}$	Initial SOC stock in organic soils (in metric tons CO_2) at project Start Date (t=0).
$SOC_{LOSS,ORG,t}$	Cumulative lost SOC stock in organic soils (%) at the end of year t, as derived from the Table 4.

Alternatively, Project Proponents may choose to estimate the baseline SOC stock in organic soils using a loss rate of 2.25% each year of the 40-year Crediting Period. This schedule conservatively

[76] The organic soil loss schedule of Table 4 aligns with the temporal effects observed in the literature, where most carbon loss is realized within the first ten years post-conversion.

depletes the organic SOC stock at a slower rate than those observed in the literature.[77] If employing the annual loss rate of 2.25%, use the following equation to compute the baseline SOC stock in organic soils over the 40-year Crediting Period:

Equation 43: Baseline SOC Organic Stocks using Steady Decline

$$C_{BSL,SOC,ORG,t} = SOC_{ORG,0} \times [1 - (t \times 2.25\%)]$$

WHERE

t	Time in years (since project Start Date).
$C_{BSL,SOC,ORG,t}$	Baseline SOC stock in organic soils (in metric tons CO_2) at the end of year **t**.
$SOC_{ORG,0}$	Initial SOC stock in organic soils (in metric tons CO_2) (**t**=0).

A.2.3 ESTIMATION OF TOTAL BASELINE SOC STOCK

The following equation must be applied to calculate total baseline SOC stock throughout the Crediting Period:

Equation 44: Baseline Total SOC Stocks

$$C_{BSL,SOC,t} = C_{BSL,SOC,MNL,t} + C_{BSL,SOC,ORG,t}$$

WHERE

t	Time in years.
$C_{BSL,SOC,t}$	Total baseline SOC stock (in metric tons CO_2) at the end of year **t**.
$C_{BSL,SOC,MNL,t}$	Baseline SOC stock in mineral soils (in metric tons CO_2) at the end of year **t**.
$C_{BSL,SOC,ORG,t}$	Baseline SOC stock in organic soils (in metric tons CO_2) at the end of year **t**.

The resulting value is used to calculate the change in baseline SOC stock in Equation 4.

[77] Description of soil organic carbon loss rates for ACR's Active Conservation methodology v1.0 (2023). Found on the Reference documents section of this methodology's website.

Appendix B: Confidentiality of Proprietary Information

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

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