



The American Carbon Registry™

***Improved Forest Management Methodology for Quantifying
GHG Removals and Emission Reductions through Increased
Forest Carbon Sequestration on Non-Federal U.S. Forestlands***

Version 1.1

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Methodology developed by Columbia Carbon, LLC

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This methodology was drafted by Matt Delaney and David Ford of L&C Carbon, based in Salem, Oregon, and Greg Latta of Oregon State University, based in Corvallis, Oregon. The methodology was approved by ACR through the public consultation and scientific peer review process.

A. METHODOLOGY DESCRIPTION

A1. SCOPE AND DEFINITIONS

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

Baseline determination is project-specific and must describe the harvesting scenario that would maximize net present value (NPV) of perpetual wood products harvests per the assumptions as described in section C1, where various discount rates for different land ownership classes are used as proxies for the multiple forest management objectives typical of each owner class eligible under this methodology.

Project Proponents must demonstrate there is no activity-shifting leakage above the *de minimis* threshold. Market leakage must be assessed and accounted for in the quantification of net project benefits.

Definitions and Acronyms

ACR	American Carbon Registry
ATFS	American Tree Farm System
Activity Shifting Leakage	Increases in harvest levels on non-project lands owned or under management control of the project area timber rights owner
Baseline Management	Scenario in the absence of project activities
Carrying Costs	Property taxes, mortgage interest, and insurance premiums
Crediting Period	The period of time in which the baseline is considered to be valid and project activities are eligible to generate ERTs
<i>De minimis</i>	Threshold of 3% of the final calculation of emission reductions or removals
CO ₂	Carbon Dioxide. All pools and emissions in this methodology are represented by either CO ₂ or CO ₂ equivalents. Biomass is converted to carbon by multiplying by 0.5 and then to CO ₂ by multiplying by the molecular weight ratio of CO ₂ to Carbon (44/12)

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CO ₂ e	Carbon Dioxide equivalent. The amount of CO ₂ that would have the same global warming potential (GWP) as other greenhouse gases over a 100-year lifetime using SAR-100 GWP values from the IPCC's fourth assessment report.
ERT	Emission Reduction Ton
<i>Ex ante</i>	Prior to project certification
<i>Ex post</i>	After the event, a measure of past performance
FSC	Forest Stewardship Council
Forestland	Forest land is defined as land at least 10 percent stocked by trees of any size, and not currently developed for non-forest uses
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
Minimum Project Term	Time Period for which project activities must be maintained and monitored through third-party verification
Native Species	Trees listed as native to a particular region by the Native Plant Society, SAF Forestry Handbook, or State-adopted list
Net Present Value (NPV)	The difference between the present value of cash inflows and the present value of cash outflows over the life of the project
SFI	Sustainable Forestry Initiative
Timberlands	Forestlands managed for commercial timber production
Tree	A perennial woody plant with a diameter at breast height (1.37 m) >5 cm and a height of greater than 1.3 m
Ton	A unit of mass equal to 1000 kg
Unmanaged stands	Areas greater than 20 acres in size demonstrating mature stand characteristics that have not been subjected to timber harvesting activities within the last 50 years
VCS	Verified Carbon Standard

A2. APPLICABILITY CONDITIONS

- This methodology is applicable only on non-federally owned forestland within the United States
- The methodology applies to lands that are subject to commercial timber harvesting activities by entities owning or controlling timber rights on forestland under a forest management plan.
- Private or non-governmental organization ownerships must be certified by FSC, SFI, or ATFS or become certified within one year of the project Start Date.
- All Tribal lands in the United States, except those lands that are managed or administered by the Bureau of Indian Affairs, are eligible under this methodology
- Public non-federal ownerships must:
 - be certified by FSC, SFI, or ATFS or become certified within one year of the project Start Date; *or*
 - have its forest management plan sanctioned by a unit of elected government officials within a state, or a state agency, or a federal agency;
 - *and* have its forest management plan updated at minimum every 10 years.
- Use of non-native species is prohibited where adequately stocked native stands were converted for forestry or other land uses after 1997.
- Draining or flooding of wetlands is prohibited.
- Project proponent must demonstrate its ownership or control of timber rights for a period not less than 12 months prior to the project start date
- The project must demonstrate an increase in on-site stocking levels above the baseline condition by the end of the Crediting Period.

A3. POOLS AND SOURCES

Carbon pools	Included / Optional / Excluded	Justification / Explanation of choice
Above-ground biomass carbon	Included	Major carbon pool subjected to the project activity
Below-ground biomass carbon	Included	Major carbon pool subjected to the project activity
Standing dead wood	Included/Optional	Major carbon pool in unmanaged stands subjected to the project activity. Project Proponents may also elect to include the pool in managed stands. Where included, the pool must be estimated in both the baseline and with project cases.
Lying dead wood	Optional	Project Proponents may elect to include the pool. Where included, the pool must be estimated in both the baseline and with project cases.
Harvested wood products	Included	Major carbon pool subjected to the project activity

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Litter / Forest Floor	Excluded	Changes in the litter pool are considered <i>de minimis</i> as a result of project implementation
Soil organic carbon	Excluded	Changes in the soil carbon pool are considered <i>de minimis</i> as a result of project implementation

Gas	Source	Included/Excluded	Justification / Explanation of choice
CO ₂	Burning of biomass	Excluded	However, carbon stock decreases due to burning are accounted as a carbon stock change
CH ₄	Burning of biomass	Included	Non-CO ₂ gas emitted from biomass burning
N ₂ O	Burning of biomass	Excluded	Potential emissions are negligibly small

Leakage Source		Included / Optional / Excluded	Justification / Explanation of choice
Activity-Shifting	Timber Harvesting	Excluded	Project Proponent must demonstrate no activity-shifting leakage beyond the <i>de minimis</i> threshold will occur as a result of project implementation
	Crops	Excluded	Forestlands eligible for this methodology do not produce agricultural crops that could cause activity shifting
	Livestock	Excluded	Grazing activities, if occurring in the baseline scenario, are assumed to continue at the same levels under the project scenario and thus there are no leakage impacts.
Market Effects	Timber	Included	Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.

A4. METHODOLOGY SUMMARY

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

The IFM baseline is the legally permissible harvest scenario that would maximize net present value (NPV) of perpetual wood products harvests, used as a proxy for the multiple forest management objectives typical of each owner class eligible under this methodology. The baseline management scenario shall be based on silvicultural prescriptions recommended by published state or federal agencies to perpetuate existing onsite timber-producing species while fully utilizing available growing space.

In developing the baseline scenario, exceptions to the requirement that the baseline management scenario shall perpetuate existing onsite timber-producing species may be made where it can be demonstrated that a baseline management scenario involving replacement of existing onsite timber producing species (e.g. where forest is converted to plantations, replacing existing onsite timber-producing species) is feasible and has been implemented in the region within 10 years of the project start date. This shall be substantiated either by (1) demonstrating with management records that the baseline management scenario involving replacement of existing onsite timber producing species has been implemented within 10 years of the project start date on lands in the state containing the project area owned or managed by the project proponent (or by the previous project area owner/manager) or by (2) providing dated (from previous 10 years) aerial imagery that identifies at least two properties (of similar site conditions and forest type) in the state showing, first, the initial or existing onsite timber, and second, the replacement use (e.g. commercial plantation). The areas of forest conversion identified must have combined acreage equal to or greater than the annual acreage converted in the project baseline scenario. Published or written evidence that the baseline scenario (e.g., conversion of existing onsite timber) is common practice in the region (this can be a state or local forester, a consulting forester, an owner of a mill, etc) must also be provided.

The resulting harvest schedule is used to establish baseline stocking levels through the Crediting Period.

This methodology is similar to a previously approved ACR IFM methodology developed by Finite Carbon Corporation¹ in that it quantifies GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline management practice levels.

The discount rate assumptions for calculating NPV vary by ownership class (see Table 1, Section C1) and include the 6% rate for private industrial timberlands from the earlier IFM methodology. Actual

¹ American Carbon Registry *Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberlands*. September 2010.

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landowner discount rate assumptions are typically not publicized in the scientific literature and companies, individuals, and organizations by and large do not share the values they use. However, approximate discount rates can be indirectly estimated by using forest economic theory and the age-class structure distribution of different U.S. forest ownership classes.

This methodology establishes an average baseline determination technique for all major forest ownership classes in the United States with the exception of federal lands. The appropriate ownership class is used to identify a project-specific NPV-maximizing baseline scenario as described in section C1. Project Proponents then design a project scenario for the purposes of increased carbon sequestration. The project scenario by definition will result in a lower NPV than the baseline scenario. Project Proponents use the baseline discount rate values for NPV maximization for the appropriate ownership class and run a project scenario for purposes of increased carbon sequestration. The difference between these two harvest forecasts are the basis for determining carbon impacts and ERTs attributable to the project.

B. ELIGIBILITY, BOUNDARIES, ADDITIONALITY, AND PERMANENCE

B1. PROJECT ELIGIBILITY

This methodology applies to non-federal U.S. forestlands that are able to document 1) clear land title or timber rights and 2) offsets title. Projects must also meet all other requirements of the *ACR Standard* and *ACR Forest Carbon Project Standard*.

The methodology applies to lands subject to timber harvesting activities held by entities owning or controlling timber rights on forestland under an existing forest management plan. All ownerships must provide evidence of existing and on-going forest management. For Private Industrial and Tribal ownerships, management plans must have the primary objective of engaging in timber harvest activities. For Private Industrial and Tribal ownerships, evidence must include records from recent timber sales conducted by the entity within the previous 10-year period, or long-term management plans prepared by forestry professionals, or other work plans for forest management activities conducted with the primary objective to engage in timber sales activities. All other ownerships in Table 1 must have a forest management plan that includes legally permissible options for timber harvesting.

Proponents must use the U.S. Forest Service Forest Inventory & Analysis Program definition to demonstrate the project area meets the definition of Forestland conditions. Forestland is defined as land at least 10 percent stocked by forest trees of any size, and not currently developed for non-forest uses.

B2. PROJECT GEOGRAPHIC BOUNDARY

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

- Project area delineated on USGS topographic map
- General location map
- Property parcel map

Aggregation of forest properties with multiple landowners is permitted under the methodology consistent with Chapter 7 of the *ACR Forest Carbon Project Standard* which provides guidelines for aggregating multiple landholdings into a single forest carbon project, as a means to reduce per-acre transaction costs of inventory and verification.

B3. PROJECT TEMPORAL BOUNDARY

Projects with a Start Date of November 1, 1997 or later are eligible². The Start Date is when the Project Proponent began to apply the land management regime to increase carbon stocks and/or reduce emissions.

In accordance with the American Carbon Registry's *Forest Carbon Project Standard v2.1*, all projects will have a Crediting Period of twenty (20) years. The minimum Project Term is forty (40) years. The minimum Project Term begins on the Start Date (not the first or last year of crediting).

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

B4. ADDITIONALITY

Projects must apply a three-prong additionality test³ to demonstrate that they exceed currently effective and enforced laws and regulations; exceed common practice in the forestry sector and geographic region; and face a financial implementation barrier.

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

The common practice test requires Project Proponents to evaluate the predominant forest industry technologies and practices in the project's geographic region. The Project Proponent shall demonstrate that the proposed project activity exceeds the common practice of similar landowners managing similar forests in the region. Projects initially deemed to go beyond common practice are considered to meet the requirement for the duration of their Crediting Period. If common practice adoption rates of a particular practice change during the Crediting Period, this may make the project non-additional and thus ineligible for renewal, but does not affect its additionality during the current Crediting Period.

An implementation barrier represents any factor or consideration that would prevent the adoption of the practice/activity proposed by the Project Proponent. Financial barriers can include high costs, limited access to capital, or an internal rate of return in the absence of carbon revenues that is lower than the Proponent's established minimum acceptable rate. Financial barriers can also include high risks such as unproven technologies or business models, poor credit rating of project partners, and project

² American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.1*. Winrock International, Little Rock, Arkansas.

³ Ibid.

failure risk. When applying the financial implementation barrier test, Project Proponents should include solid quantitative evidence such as NPV and Internal Rate of Return (IRR) calculations. The project must face capital constraints that carbon revenues can potentially address; or carbon funding is reasonably expected to incentivize the project's implementation; or carbon revenues must be a key element to maintaining the project action's ongoing economic viability after its implementation.⁴

B5. PERMANENCE

Project Proponents commit to a minimum Project Term of 40 years. Projects must have effective risk mitigation measures in place to compensate fully for any loss of sequestered carbon whether this occurs through an unforeseen natural disturbance or through a Project Proponent or landowners' choice to discontinue forest carbon project activities. Such mitigation measures can include contributions to the buffer pool, insurance, or other risk mitigation measures approved by ACR.

If using a buffer contribution to mitigate reversals, the Project Proponent must conduct a risk assessment addressing both general and project-specific risk factors. General risk factors include risks such as financial failure, technical failure, management failure, rising land opportunity costs, regulatory and social instability, and natural disturbances. Project-specific risk factors vary by project type but can include land tenure, technical capability and experience of the project developer, fire potential, risks of insect/disease, flooding and extreme weather events, illegal logging potential, and others. If they are using an alternate ACR-approved risk mitigation product, they will not do this risk assessment.

Project Proponents must conduct their risk assessment using the *ACR Tool for Risk Analysis and Buffer Determination* or, until release of this tool, the *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*. The output of either tool is an overall risk category, expressed as a fraction, for the project translating into the buffer deduction that must be applied in the calculation of net ERTs (section G1). This deduction must be applied unless the Project Proponent uses another ACR-approved risk mitigation product.

⁴ American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.1*. Winrock International, Little Rock, Arkansas.

C. BASELINE

C1. IDENTIFICATION OF BASELINE

The Finite Carbon Corporation IFM methodology⁵ (approved by ACR in September 2010), takes a Faustmann approach to baseline determination using NPV maximization with a 6% discount rate on future cash flows. The literature supporting Faustmann's original 1849 work forms the basis for modern optimal rotation/investment decisions and forest economics (summarized in Newman 2002⁶) in addition to appearing in over 300 other book and journal articles. One of the reasons there is such an extensive literature base for NPV maximization is that the Faustmann approach to forest investment and optimal rotation is not perfect. Like the basic economic model of supply and demand, these underlying theorems go far to predict how agents will act, however they do not correctly account for all situations.

In the Finite IFM methodology, the 6% discount is an assumption for how a common industrial forest landowner would make their forest management decisions. This 6% NPV maximization determination of the baseline level of emission and sequestration is appropriate in that it gives a common transparent and conservative metric by which landowners, project developers, verifiers, and offset purchasers can base their assessment of an ACR IFM carbon project. However, less than 40% of aggregate U.S. timber supply comes from Private Industrial (PI) timberland⁷ necessitating an adaption of the methodology to allow consideration of other landowner classes who are actively managing their forests.

This methodology is the same as the Finite Carbon methodology in that it quantifies GHG emission reductions resulting from forest carbon projects that reduce emissions by exceeding baseline management practice levels. Emission Reduction Tons (ERTs) are quantified for increased sequestration through retention of annual forest growth when project activities exceed the baseline.

The baseline determination is project-specific and must describe the harvesting scenario that would maximize NPV of perpetual wood products harvests over a 100 year modeling period. The discount rate assumptions for calculating NPV⁸ vary by ownership class (Table 1) and include the 6% rate for PI

⁵ ACR Approved Methodology (2010), *Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberlands*. Finite Carbon Corporation. <http://www.americancarbonregistry.org/carbon-accounting/improved-forest-management-methodology-for-increased-forest-carbon-sequestration-on-u.s.-timberlands>

⁶ Newman, D.H. 2002. Forestry's golden rule and the development of the optimal forest rotation literature. *J. Econ.* 8: 5–27

⁷ See Tables 7-10 in Adams, D.M.; Haynes, R.W. and A. Daigneault. 2006. Estimated timber harvest by U.S. region and ownership, 1950-2002. PNW-GTR-659. Portland, OR: USDA, Forest Service, Pacific Northwest Research Station. 64 p

⁸ Sewall, Sizemore & Sizemore, Mason, Bruce & Girard, Inc and Brookfield internal research. 2010. Global Timberlands Research Report. <http://www.industryintel.com/Corporate/downloads/4QBrookfield2010.pdf>

timberlands from the Finite methodology. Actual landowner discount rate assumptions are typically not publicized in the scientific literature and companies, individuals, and organizations by and large do not share the values they use. However, approximate discount rates can be indirectly estimated by using forest economic theory and the age-class structure distribution of different U.S. forest ownership classes.

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

The United States Department of Agriculture (USDA) Forest Inventory and Analysis (FIA) group provides inventory data on forests in their periodic assessment of forest resources (Smith et al. 2009¹⁴). This data allows for the analysis of total U.S. forest acres by age class for three broad ownership classes: Private, State, and National Forest. While the publicly available FIA data does not include any further breakdown of the private ownership group, we were provided with the twenty-year age class data from USDA FIA research foresters, including private corporate and private non-corporate classes. Bringing this economic theoretical framework together with this data aided in the derivation of discount rate value estimates for other forestland ownership classes (Table 1).

This methodology establishes an average baseline determination technique for all major non-federal forest ownership classes in the United States. Project Proponents shall use the baseline discount rate values in Table 1 for the appropriate ownership class to identify a project-specific NPV-maximizing baseline scenario. Project Proponents then design a project scenario for the purposes of increased carbon sequestration. The project scenario by definition will result in a lower NPV than the baseline

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

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

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

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

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

¹⁴ Smith, W. Brad, tech. coord.; Miles, Patrick D., data coord.; Perry, Charles H., map coord.; Pugh, Scott A., Data CD coord. 2009. *Forest Resources of the United States, 2007*. GTR WO-78. Washington, DC: USDA, Forest Service, Washington Office. 336 p

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

Table 1. Discount rates for Net Present Value determinations by U.S. Forestland Ownership Class.

Ownership	Annual Discount Rate
Private Industrial	6%
Private Non-Industrial	5%
Tribal	5%
Non-governmental organization	4%
Non-federal public lands	4%

The IFM baseline is the legally permissible harvest scenario that would maximize NPV of perpetual wood products harvests. The baseline management scenario shall be based on silvicultural prescriptions recommended by published state or federal agencies to perpetuate existing onsite timber producing species while fully utilizing available growing space. Where the baseline management scenario involves replacement of existing onsite timber producing species (e.g. where forest is converted to plantations, replacing existing onsite timber-producing species), the management regime should similarly be based on silvicultural prescriptions recommended by published state or federal agencies, and must adhere to all applicable laws and regulations. The resulting harvest schedule is used to establish baseline stocking levels through the Crediting Period.

Required inputs for the project NPV calculation include the results of a recent timber inventory of the project lands, prices for wood products of grades that the project would produce, costs of logging, reforestation and related costs, silvicultural treatment costs, and carrying costs. Project Proponents shall include roading and harvesting costs as appropriate to the terrain and unit size. Project Proponents must model growth of forest stands through the Crediting Period. Project Proponents should use a constrained optimization program that calculates the maximum NPV for the harvesting schedule while meeting any forest practice legal requirements. The annual real (without inflation) discount rate for each non-federal owner class is given in Table 1. Wood products must be accounted.

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

The ISO 14064-2 principle of conservativeness must be applied for the determination of the baseline scenario. In particular, the conservativeness of the baseline is established with reference to the choice of assumptions, parameters, data sources and key factors so that project emission reductions and removals are more likely to be under-estimated rather than over-estimated, and that reliable results are maintained over a range of probable assumptions. However, using the conservativeness principle does not always imply the use of the “most” conservative choice of assumptions or methodologies¹⁵.

¹⁵ ISO 14064-2:2006(E)

C 1.1 Confidentiality of Proprietary Information

While it remains in the interest of the general public for Project Proponents to be as transparent as possible regarding GHG reduction projects, the Project Proponent may choose at their own option to designate any information regarded as confidential due to proprietary considerations. If the Project Proponent chooses to identify information related to financial performance as confidential, the Project Proponent must submit the confidential baseline and project documentation in a separate file marked “Confidential” to ACR and this information shall not be made available to the public. ACR and the validation/verification body shall utilize this information only to the extent required to register the project and issue ERTs. If the Project Proponent chooses to keep financial information confidential, a publically available GHG Project Plan must still be provided to ACR.

C2. BASELINE STRATIFICATION

If the project activity area is not homogeneous, stratification must be carried out to improve the precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy and precision of the estimates of net GHG emissions reductions or GHG removal by sinks. For estimation of baseline carbon stocks, strata must be defined on the basis of parameters that are key variables for estimating changes in managed forest carbon stocks, for example:

- a. Management regime
- b. Species or cover types
- c. Size and density class
- d. Site class

C3. BASELINE NET REDUCTIONS AND REMOVALS

Baseline carbon stock change must be calculated for the entire Crediting Period. The baseline stocking level used for the stock change calculation is derived from the baseline management scenario developed in section C1. This methodology requires 1) annual baseline stocking levels to be determined for the entire Crediting Period, 2) a long-term average baseline stocking level be calculated for the Crediting Period, and 3) the change in baseline carbon stocks be computed for each time period, t .

The following equations are used to construct the baseline stocking levels using models described in section 3.1 and wood products calculations described in section 3.2:

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

where:

t Time in years

$\Delta C_{BSL, TREE, t}$ Change in the baseline carbon stock stored in above and below ground live trees (in metric tons CO₂) for year t .

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$C_{BSL, TREE, t}$ Change in the baseline value of carbon stored in above and below ground live trees at the beginning of the year t (in metric tons CO₂) and $t-1$ signifies the value in the prior year.

$$\Delta C_{BSL, DEAD, t} = (C_{BSL, DEAD, t} - C_{BSL, DEAD, t-1}) \quad (2)$$

where:

t Time in years

$\Delta C_{BSL, DEAD, t}$ Change in the baseline carbon stock stored in dead wood (in metric tons CO₂) for year t .

$C_{BSL, DEAD, t}$ Change in the baseline value of carbon stored in dead wood at the beginning of the year t (in metric tons CO₂) and $t-1$ signifies the value in the prior year.

$$\bar{C}_{BSL, HWP} = \frac{\sum_{t=1}^{20} C_{BSL, HWP, t}}{20} \quad (3)$$

where:

t Time in years

$\bar{C}_{BSL, HWP}$ Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons of CO₂)

$C_{BSL, HWP, t}$ Baseline value of carbon remaining in wood products 100 years after being harvested in the year t (in metric tons CO₂).

$$\overline{GHG}_{BSL} = \frac{\sum_{t=1}^{20} \left(BS_{BSL, t} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \right)}{20} \quad (4)$$

where:

t Time in years

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\overline{GHG}_{BSL}	Twenty-year average value of greenhouse gas emissions (in metric tons CO ₂ e) resulting from the implementation of the baseline.
$BS_{BSL,t}$	Carbon stock (in metric tons CO ₂) in logging slash burned in the baseline in year <i>t</i> .
ER_{CH_4}	Methane (CH ₄) emission ratio (ratio of CO ₂ as CH ₄ to CO ₂ burned). If local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value ¹⁶ of 0.012
16/44	Molar mass ratio of CH ₄ to CO ₂
GWP_{CH_4}	100-year global warming potential (in CO ₂ per CH ₄) for CH ₄ (IPCC SAR-100 value of 21 per the Fourth Assessment Report) ¹⁷

Carbon stock calculation for logging slash burned ($BS_{BSL,t}$) shall use the method described in Section 3.1.1 for bark, tops and branches, and section 3.1.2 if dead wood is selected. The reduction in carbon stocks due to slash burning in the baseline must be properly accounted in equations 1 and 2.

To calculate long-term average baseline stocking level for the Crediting Period use:

$$C_{BSL,AVE} = \frac{\sum_{t=1}^{20} (C_{BSL,TREE,t} + C_{BSL,DEAD,t} + C_{BSL,HWP,t})}{20} \quad (5)$$

where:

<i>t</i>	Time period (in years)
$C_{BSL,AVE}$	20-year average baseline carbon stock (in metric tons CO ₂)
$C_{BSL,TREE,t}$	Baseline value of carbon stored in above and below ground live trees (in metric tons CO ₂) at the beginning of the year <i>t</i>
$C_{BSL,DEAD,t}$	Baseline value of carbon stored in standing and lying dead trees at the beginning of the year <i>t</i> (in metric tons CO ₂)

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

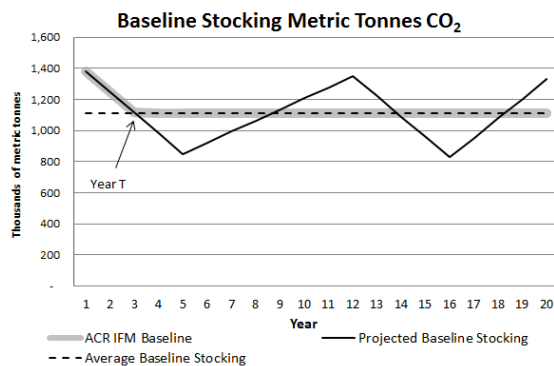
¹⁷ Table 2.14, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://ipccwg1.ucar.edu/wg1/Report/AR4WG1_Print_Ch02.pdf.

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$C_{BSL,HWP,t}$ Baseline value of carbon remaining in wood products 100 years after being harvested in the year t (in metric tons CO₂)

Change in baseline carbon stock is computed for each time period. The Project Proponent shall provide a graph of the projected baseline stocking levels and the long-term average baseline stocking level for the entire Crediting Period (see Figure1). Annual projected stocking levels are used for the baseline stock change calculation until the projected stocking level reaches the long term average (time $t = T$). Thereafter, the long-term average stocking level is used in the baseline stock change calculation for the entire Project Period.

a) Above average stocking



b) Below average stocking

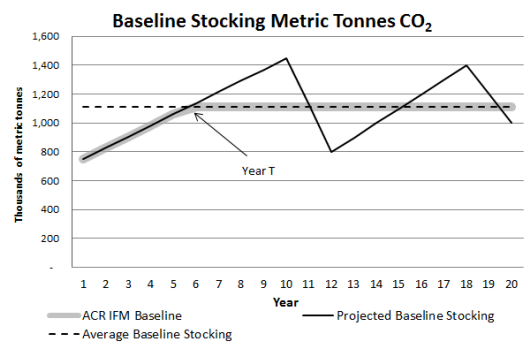


Figure 1. Sample Baseline Stocking Graph for project beginning: a) above 20-year average baseline stocking, and b) below 20-year baseline stocking.

The following equations must be applied until year t equals T :

$$\Delta C_{BSL,t} = \Delta C_{BSL,TREE,t} + \Delta C_{BSL,DEAD,t} + \bar{C}_{BSL,HWP} - \overline{GHG}_{BSL} \quad (6)$$

where:

t Time in years

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$\Delta C_{BSL,t}$	Change in the baseline carbon stock (in metric tons CO ₂) for year <i>t</i> .
$\Delta C_{BSL,TREE,t}$	Change in the baseline carbon stock stored in above and below ground live trees (in metric tons CO ₂) for year <i>t</i> .
$\Delta C_{BSL,DEAD,t}$	Change in the baseline carbon stock stored in dead wood pools live trees (in metric tons CO ₂) for year <i>t</i> .
$\bar{C}_{BSL,HWP}$	Twenty-year average value of annual carbon remaining stored in wood products 100 years after harvest (in metric tons CO ₂).
\overline{GHG}_{BSL}	Twenty-year average value of annual greenhouse gas emissions (in metric tons CO ₂) resulting from the implementation of the baseline.

Prior to year T (T = year projected stocking reaches the long-term baseline average) the value of $\Delta C_{BSL,t}$ will most likely be negative for projects with initial stocking levels higher than $C_{BSL,AVE}$ or positive for projects with initial stocking levels lower than $C_{BSL,AVE}$. If years elapsed since the start of the IFM project activity (*t*) is $\geq T$ to compute long-term average stock change use:

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

(2)
(7)

3.1 Stocking Level Projections in the Baseline

$C_{BSL,TREE,t}$ and $C_{BSL,DEAD,t}$ must be estimated using models of forest management across the baseline period. Modeling must be completed with a peer reviewed forestry model that has been calibrated for use in the project region. The GHG Plan must detail what model is being used and what variants have been selected. All model inputs and outputs must be available for inspection by the verifier. The baseline must be modeled over a 20-year period.

Examples of appropriate models include:

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

Models must be:

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

The output of the models must include projected volume in live aboveground tree biomass, or appropriate unit, by strata in the baseline scenario. Where model projections produce changes in volume over five year periods, the numbers shall be annualized to give a stock change number for each year.

If the output for the tree is the volume then this must be converted to biomass and carbon using equations in Section 3.1.1. If processing of alternative data on dead wood is necessary, equations in section 3.1.2 may be used. Where models do not predict dead wood dynamics, the baseline harvesting scenario may not decrease dead wood more than 50% through the Crediting Period.

3.1.1 Tree Carbon Stock Calculation

The mean carbon stock in aboveground biomass per unit area is estimated based on field measurements in sample plots. A sampling plan must be developed that describes the inventory process including sample size, determination of plot numbers, plot layout and locations, and data collected. Plot data used for biomass calculations may not be older than 10 years. Plots may be permanent or temporary and they may have a defined boundary or use variable radius sampling methods. Biomass for each tree is calculated from its merchantable volume using a component ratio method. The Project Proponent must use the same set of equations for *ex ante* and *ex post* baseline and project projections.

The following steps are used to calculate tree biomass:

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

Step 2: Determine the biomass of bark, tops and branches, and below-ground biomass as a proportion of the bole biomass based on component proportions from Jenkins *et al* (2003).¹⁸

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

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

Step 5: Determine total project carbon (in metric tons CO₂) 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 CO₂ by multiplying by 44/12.

¹⁸ Jenkins, J.; Chojnacky, D.C.; Heath, L.S.; Birdsey, R.A. 2003. National Scale Biomass Estimators for United States Tree Species. *Forest Science*. 49(1): 12-35

3.1.2 Dead Wood Calculation

Dead wood included in the methodology comprises two components only – standing dead wood and lying dead wood. Below-ground dead wood is conservatively neglected. Considering the differences in the two components, different sampling and estimation procedures shall be used to calculate the changes in dead wood biomass of the two components.

3.1.2.1 Standing Dead Wood (if included)

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

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

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

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

Step 4: The biomass of dead wood is determined by using the following dead wood density classes deductions: Class 1 – 97% of live tree biomass; Class 2 – 95% of live tree biomass; Class 3 – 90% of live tree biomass; Class 4 – 80% of live tree biomass¹⁹.

Step 5: Determine total project standing dead carbon (in metric tons CO₂) 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 CO₂ by multiplying by 44/12.

3.1.2.2 Lying Dead Wood (if selected)

¹⁹ IPCC Good Practice Guidelines 2006. http://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf_files/Chp4/Chp4_3_Projects.pdf

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The lying dead wood pool is highly variable, and stocks may or may not increase as the stands age depending if the forest was previously unmanaged (mature or unlogged) where it would likely increase or logged with logging slash left behind where it may decrease through time.

Step 1: Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996).^{20,21} At least two 50-meter lines (164 ft) are established bisecting each plot and the diameters of the lying dead wood (≥ 10 cm diameter [≥ 3.9 inches]) intersecting the lines are measured.

Step 2: The dead wood is assigned to one of the three density states (sound, intermediate and rotten) by species using the ‘machete test’, as recommended by IPCC Good Practice Guidance for LULUCF (2003), Section 4.3.3.5.3. The following dead wood density class deductions must be applied to the three decay classes: For Hardwoods, sound – no deduction, intermediate - 0.45, rotten - 0.42; for Softwoods, sound – no deduction, intermediate - 0.71, rotten - 0.45.²²

Step 3: The volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)²³ as modified by Van Wagner (1968)²⁴ separately for each density class

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

where:

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

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

$$B_{LDW} = A \sum_{DC=1}^3 V_{LDW,DC} \cdot WD_{DC} \quad (9)$$

²⁰ 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.

²¹ A variant on the line intersect method is described by Waddell, K.L. 2002. Sampling coarse wood debris for multiple attributes in extensive resource inventories. *Ecological Indicators* 1: 139-153. This method may be used in place of Steps 1 to 3

²² USFS FIA Phase 3 proportions

²³ Warren, W.G. and Olsen, P.F. (1964) A line intersect technique for assessing logging waste. *Forest Science* 10:267-276

²⁴ Van Wagner, C.E. (1968). The line intersect method in forest fuel sampling. *Forest Science* 14: 20-26

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 CO₂ by multiplying by 44/12.

3.2 Wood Products Calculation

Wood products shall be calculated using the U.S. DOE 1605(b) method. The following steps must be followed to determine the amount of carbon in harvested wood:

Step 1: Calculate the annual biomass of the total volume extracted from within the project boundary, with extracted timber volume differentiated into hardwood sawtimber, hardwood pulpwood, softwood sawtimber, or softwood pulpwood and converted to carbon using specific gravity for each species.

Step 2: Calculate the proportion of extracted timber that remains sequestered after 100 years. Instead of tracking annual emissions through retirement, burning and decomposition, the methodology calculates the proportion of wood products that have not been emitted to the atmosphere 100 years after harvest and assumes that this proportion is permanently sequestered. The method uses Table 1.6 from the Forestry Appendix of the Technical Guidelines of the U.S. Department of Energy’s Voluntary Reporting of Greenhouse Gases Program (known as Section 1605b)²⁵. Users must determine the region the project is located in (using Figure 1.1 of the same document) and whether the timber is softwood or hardwood. The proportions defined as “In Use” and “Landfill” 100 years after production shall be used.

C4. MONITORING REQUIREMENTS FOR BASELINE RENEWAL

A project’s Crediting Period is the finite length of time for which the baseline scenario is valid and during which a project can generate offsets against its baseline.

A Project Proponent may apply to renew the Crediting Period by²⁶:

²⁵ <http://www.pi.energy.gov/enhancingGHGregistry/documents/PartIForestryAppendix.pdf>

²⁶ American Carbon Registry (2010), *American Carbon Registry Forest Carbon Project Standard, version 2.1*. Winrock International, Little Rock, Arkansas.

- Re-submitting the GHG Project Plan in compliance with then-current ACR standards and criteria
- Re-evaluating the project baseline
- Demonstrating additionality against then-current regulations, common practice and implementation barriers
- Using ACR-approved baseline methods, emission factors, and tools in effect at the time of Crediting Period renewal
- Undergoing validation and verification by an approved validation/verifier body

C5. ESTIMATION OF BASELINE UNCERTAINTY

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

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

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

The uncertainty in the baseline scenario should be defined as the square root of the summed errors in each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products and logging slash burning emissions use the confidence interval of the inventory data. The errors in each pool shall be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

Therefore,

$$UNC_{BSL} = \frac{\sqrt{(C_{BSL,TREE,1} \cdot e_{BSL,TREE})^2 + (C_{BSL,DEAD,1} \cdot e_{BSL,DEAD})^2 + (\bar{C}_{BSL,HWP} \cdot e_{BSL,TREE})^2 + (\overline{GHG}_{BSL} \cdot e_{BSL,TREE})^2}}{C_{BSL,TREE,1} + C_{BSL,DEAD,1} + C_{BSL,HWP} + \overline{GHG}_{BSL}} \quad (10)$$

where:

UNC_{BSL} Percentage uncertainty in the combined carbon stocks in the baseline.

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$C_{BSL,TREE,1}$	Carbon stock in the baseline stored in above and below ground live trees (in metric tons CO ₂) for the initial inventory in year 1.
$C_{BSL,DEAD,1}$	Carbon stock in the baseline stored in dead wood (in metric tons CO ₂) for the initial inventory in year 1.
$\bar{C}_{BSL,HWP}$	Twenty-year baseline average value of annual carbon (in metric tons CO ₂) remaining stored in wood products 100 years after harvest.
\overline{GHG}_{BSL}	Twenty-year average value of annual greenhouse gas emissions (in metric tons CO ₂ e) resulting from the implementation of the baseline.
$e_{BSL,TREE}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in above and below ground live trees (in metric tons CO ₂) for the initial inventory in year 1.
$e_{BSL,DEAD}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in dead wood (in metric tons CO ₂) for the initial inventory in year 1.

D. WITH-PROJECT SCENARIO

D1. WITH-PROJECT STRATIFICATION

If the project activity area is not homogeneous, stratification must be carried out to improve the precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy and precision of the estimates of net GHG emissions reductions or GHG removal by sinks. For estimation of baseline carbon stocks strata must be defined on the basis of parameters that are key variables in any method used to estimate changes in managed forest carbon stocks, for example:

- a. Management regime
- b. Species or cover types
- c. Size and density class
- d. Site class

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

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

- Unexpected disturbances occurring during the Crediting Period (e.g. due to fire, pests or disease outbreaks), affecting differently various parts of an originally homogeneous stratum
- Forest management activities (e.g. cleaning, planting, thinning, harvesting, coppicing, replanting) may be implemented in a way that affects the existing stratification
- Established strata may be merged if reason for their establishment has disappeared

D2. MONITORING PROJECT IMPLEMENTATION

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

- The geographic position of the project boundary is recorded for all areas of land
- The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This can be achieved by field mapping (e.g. using GPS), or by using georeferenced spatial data (e.g. maps, GIS datasets, orthorectified aerial photography or georeferenced remote sensing images)
- Professionally accepted principles of forest inventory and management are implemented
- Standard operating procedures (SOPs) and quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of SOPs already applied in national forest monitoring, or available from published handbooks, or from the IPCC GPG LULUCF 2003, is recommended

- The forest management plan, together with a record of the plan as actually implemented during the project shall be available for validation and verification, as appropriate

D3. MONITORING OF CARBON STOCKS IN SELECTED POOLS

Information shall be provided, and recorded in the GHG Plan, to establish that professionally accepted principles of forest inventory and management are implemented. Standard operating procedures (SOPs) and quality control / quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of SOPs already applied in national forest monitoring, or available from published handbooks, or from the *IPCC GPG LULUCF 2003*, is recommended. The forest management plan, together with a record of the plan as actually implemented during the project shall be available for validation and verification, as appropriate.

The 90% statistical confidence interval (CI) of sampling can be no more than $\pm 10\%$ of the mean estimated amount of the combined carbon stock across all strata²⁷. If the Project Proponent cannot meet the targeted $\pm 10\%$ of the mean at 90% confidence, then the reportable amount shall be the lower bound of the 90% confidence interval.

At a minimum the following data parameters must be monitored:

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

D4. MONITORING OF EMISSION SOURCES

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

D5. ESTIMATION OF PROJECT EMISSION REDUCTIONS OR ENHANCED REMOVALS

This section describes the steps required to calculate $\Delta C_{p,t}$ (net annual carbon stock change under the project scenario; tons CO_{2e}). This methodology requires: 1) carbon stock levels to be determined in each

²⁷ For calculating pooled CI of carbon pools across strata, see equations in Barry D. Shiver, *Sampling Techniques for Forest Resource Inventory* (John Wiley & Sons, Inc, 1996)

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time period, t , for which a valid verification report is submitted, and 2) the change in project carbon stock be computed from the prior verification time period, $t-1$.

The following equations are used to construct the project stocking levels using models described in section 3.1 and wood products calculations described in section 3.2:

$$\Delta C_{P,TREE,t} = (C_{P,TREE,t} - C_{P,TREE,t-1}) \quad (11)$$

where:

t	Time in years
$\Delta C_{P,TREE,t}$	Change in the project carbon stock stored in above and below ground live trees (in metric tons CO ₂) for year t .
$C_{P,TREE,t}$	Change in the project value of carbon stored in above and below ground live trees at the beginning of the year t (in metric tons CO ₂) and $t-1$ signifies the value in the prior year.

$$\Delta C_{P,DEAD,t} = (C_{P,DEAD,t} - C_{P,DEAD,t-1}) \quad (12)$$

where:

t	Time in years
$\Delta C_{P,DEAD,t}$	Change in the project carbon stock (in metric tons CO ₂) for year t .
$C_{P,DEAD,t}$	Change in the project value of carbon stored in dead wood at the beginning of the year t (in metric tons CO ₂) and $t-1$ signifies the value in the prior year.

$$GHG_{P,t} = BS_{P,t} \cdot ER_{CH_4} \cdot \frac{16}{44} \cdot GWP_{CH_4} \quad (13)$$

where:

t	Time in years
$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO ₂ e) resulting from the implementation of the project in year (t).
$BS_{P,t}$	Carbon stock (in metric tons CO ₂) in logging slash burned in the project in year t .

ER_{CH_4}	Methane (CH ₄) emission ratio (ratio of CO ₂ as CH ₄ to CO ₂ burned). If local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value of 0.012 ²⁸
$16/44$	Molar mass ratio of CH ₄ to CO ₂
GWP_{CH_4}	100-year global warming potential (in CO ₂ e per CH ₄) for CH ₄ (IPCC SAR-100 value of 21 per the Fourth Assessment Report) ²⁹

Carbon stock calculation for logging slash burned shall use the method described in Section 3.1.1 for bark, tops and branches, and Section 3.1.2 if dead wood is selected. The reduction in carbon stocks due to slash burning due to project activities must be properly accounted in equations 11 and 12.

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

$$\Delta C_{P,t} = \Delta C_{P,TREE,t} + \Delta C_{P,DEAD,t} + C_{P,HWP,t} - GHG_{P,t} \quad (14)$$

where:

t	Time in years
$\Delta C_{P,t}$	Change in the project carbon stock (in metric tons CO ₂) for year t .
$\Delta C_{P,TREE,t}$	Change in the project carbon stock stored in above and below ground live trees (in metric tons CO ₂) for year t .
$\Delta C_{P,DEAD,t}$	Change in the project carbon stock stored in dead wood pools live trees (in metric tons CO ₂) for year t .
$C_{P,HWP,t}$	Carbon remaining stored in wood products 100 years after harvest (in metric tons CO ₂) for the project in year t .
$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO ₂ e) resulting from the implementation of the project in year (t).

5.1 Tree Biomass, Dead Wood Carbon Calculation, Wood Products

The Project Proponent must use the same set of equations used in Section C3.1.1, C3.1.2, and C3.2 to calculate carbon stocks in the project scenario.

²⁸ Table 3A.1.15, Annex 3A.1, GPG-LULUCF (IPCC 2003)

²⁹ Table 2.14, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

D6. MONITORING OF ACTIVITY-SHIFTING LEAKAGE

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

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

Such a demonstration must include one of the following:

- Historical records covering all Project Proponent ownership trends in harvest volumes paired with records from the with-project time period showing no deviation from historical trends over most recent 10-year average; *or*
- Forest management plans prepared ≥24 months prior to the start of the project showing harvest plans on all owned/managed lands paired with records from the with-project time period showing no deviation from management plans; *or*
- Entity-wide management certification that requires sustainable practices (programs can include FSC, SFI, or ATFS). Management certification must cover *all* entity owned lands with active timber management programs.

D7. ESTIMATION OF EMISSIONS DUE TO MARKET LEAKAGE

Reductions in product outputs due to project activity may be compensated by other entities in the marketplace. Those emissions must be included in the quantification of project benefits.

If the project is able to demonstrate that any decrease in total wood products produced by the project relative to the baseline is less than 5% over the Crediting Period then:

$$LK = 0 \tag{15}$$

Where project activities decrease total wood products produced by the project relative to the baseline by more than 5% but less than 25% over the Crediting Period, the market leakage deduction is 10% (according to VCS AFOLU Guidance Document³⁰).

$$LK = 0.1 \tag{16}$$

Where project activities decrease total wood products produced by the project relative to the baseline by 25% or more over the Crediting Period, the market leakage deduction is 40%³¹.

$$LK = 0.4 \tag{17}$$

³⁰ [http://www.v-c-s.org/sites/v-c-s.org/files/Guidance for AFOLU Projects.pdf](http://www.v-c-s.org/sites/v-c-s.org/files/Guidance%20for%20AFOLU%20Projects.pdf)

³¹ We assume that any decrease in production would be transferred to forests of a similar type.

D8. ESTIMATION OF WITH-PROJECT UNCERTAINTY

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

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

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

The uncertainty in the project scenario should be defined as the square root of the summed errors in each of the measurement pools. For modeled results use the confidence interval of the input inventory data. For wood products with measured and documented harvest volume removals use zero as the confidence interval. For estimated wood product removal use the confidence interval of the inventory data. The errors in each pool can be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

Therefore,

$$UNC_{P,t} = \frac{\sqrt{(C_{P,TREE,t} \cdot e_{P,TREE})^2 + (C_{P,DEAD,t} \cdot e_{P,DEAD})^2 + (C_{P,HWP,t} \cdot e_{P,TREE})^2 + (GHG_{P,t} \cdot e_{P,TREE})^2}}{C_{P,TREE,t} + C_{P,DEAD,t} + C_{P,HWP,t} + GHG_{P,t}} \quad (18)$$

where:

$UNC_{P,t}$	Percentage uncertainty in the combined carbon stocks in the project in year t .
$C_{P,TREE,t}$	Carbon stock in the project stored in above and below ground live trees (in metric tons CO ₂) in year t .
$C_{P,DEAD,t}$	Carbon stock in the baseline stored in dead wood (in metric tons CO ₂) in year t .
$C_{P,HWP,t}$	Annual carbon (in metric tons CO ₂) remaining stored in wood products in the project 100 years after harvest in year t .

$GHG_{P,t}$	Greenhouse gas emission (in metric tons CO ₂ e) resulting from the implementation of the project in year t .
$e_{P,TREE}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in above and below ground live trees (in metric tons CO ₂) for the last remeasurement of the inventory prior to year t .
$e_{P,DEAD}$	Percentage uncertainty expressed as 90% confidence interval percentage of the mean of the carbon stock in dead wood (in metric tons CO ₂) for the last remeasurement of the inventory prior to year t .

E. EX-ANTE ESTIMATION

E1. EX-ANTE ESTIMATION METHODS

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

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

- Data from well-referenced peer-reviewed literature or other well-established published sources; *or*
- National inventory data or default data from IPCC literature that has, whenever possible and necessary, been checked for consistency against available local data specific to the project circumstances; *or*
- In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value must be briefly noted in the GHG plan. For any data provided by experts, the GHG Plan shall also record the expert’s name, affiliation, and principal qualification as an expert— plus inclusion of a 1-page summary CV for each expert consulted, included in an annex.

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When choosing key parameters based on information that is not specific to the project circumstances, such as in use of default data, Project Proponents must select values that will lead to an accurate estimation of net GHG removals by sinks, taking into account uncertainties. If uncertainty is significant, Project Proponents must choose data such that it tends to under-estimate, rather than over-estimate, net GHG removals by sinks³².

³² CDM Approved Consolidated Methodology AR-ACM0001, "Afforestation and Reforestation of Degraded Land"

F. QA/QC AND UNCERTAINTY

F1. METHODS FOR QUALITY ASSURANCE

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

F2. METHODS FOR QUALITY CONTROL

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

F3. CALCULATION OF TOTAL PROJECT UNCERTAINTY

The following equation must be applied:

$$UNC_t = \frac{\sqrt{(\Delta C_{BSL,t} \cdot UNC_{BSL})^2 + (\Delta C_{P,t} \cdot UNC_{P,t})^2}}{\Delta C_{BSL,t} + \Delta C_{P,t}} \quad (19)$$

where:

UNC_t	Total project Uncertainty in year t , in %
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO ₂ e) for year t . (Section C3)
UNC_{BSL}	Baseline uncertainty, in % (Section C5)
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO ₂ e) for year t . (Section D5)
$UNC_{P,t}$	With-project uncertainty in year t , in % (Section D8)

If calculated UNC in equation (19) is <10%, then UNC shall be considered 0% in equation (20).

G. CALCULATION OF ERTs

This section describes the process of determining additional annual net greenhouse gas emission reductions and Emission Reduction Tons (ERTs) issued for a time period for which a valid verification report has been filed with ACR. Annual net greenhouse gas emission reductions ($C_{ACR,t}$) are calculated using equation 20 by adjusting the difference between the project and baseline carbon stock changes for leakage and uncertainty then multiplying by a non-permanence buffer deduction.

$$C_{ACR,t} = (\Delta C_{P,t} - \Delta C_{BSL,t}) \cdot (1 - LK) \cdot (1 - UNC_t) \cdot (1 - BUF) \quad (20)$$

where:

$C_{ACR,t}$	Annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at time t .
$\Delta C_{P,t}$	Change in the project carbon stock and GHG emissions (in metric tons CO ₂ e) for year t . (Section D5)
$\Delta C_{BSL,t}$	Change in the baseline carbon stock and GHG emissions (in metric tons CO ₂ e) for year t . (Section C3)
LK	Leakage discount (Section D7)
UNC_t	Total Project Uncertainty, (in %) for year t (Section F3). UNC_t will be set to zero if the project meets ACR's precision requirement of within $\pm 10\%$ of the mean with 90% confidence. If the project does not meet this precision target, UNC_t should be the half-width of the confidence interval of calculated net GHG emission reductions.
BUF	The non-permanence buffer deduction as calculated in Section B5. BUF will be set to zero if an ACR approved insurance product is used.

If the project stock change ($C_{ACR,t}$) is less than zero in time t in equation 20, no ERTs will be issued with a vintage year of t . These negative emissions reductions will not be treated as a reversal if this occurs before the end of the first Crediting Period. Any negative project stock change ($C_{ACR,t}$) values from time t will carry over to the following year through a balance of negative emission reduction tons ($C_{NEG,t}$) which is calculated using equation 21, and issuance will only be made once a positive ERT balance is achieved (as illustrated in Addendum 1). Once the value becomes positive the $C_{NEG,t}$ value is reset to 0.

$$C_{NEG,t} = C_{NEG,t-x} + C_{ACR,t} \quad (21)$$

where:

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$C_{NEG,t}$	Negative balance of annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at time t .
$C_{NEG,t-x}$	Negative balance of annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at the last valid verification report x years ago (time $t-x$).
$C_{ACR,t}$	Annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at time t .

If the value of $C_{NEG,t}$ is less than zero in any year prior to the end of the Crediting Period, ERT values are calculated using equation 22, otherwise equation 23 is used.

$$ERT_t = 0 \tag{22}$$

$$ERT_t = C_{NEG,t-x} + C_{ACR,t} \tag{23}$$

where:

ERT_t	Emission Reduction Tons issued with vintage year t .
$C_{NEG,t-x}$	Negative balance of annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at the last valid verification report x years ago (time $t-x$).
$C_{ACR,t}$	Annual net greenhouse gas emission reductions (in metric tons CO ₂ e) at time t .

The tradable balance of the project ACR account is determined using equation 24.

$$TB_t = ERT_t + IERT_t - OERT_t - RERT_t \tag{24}$$

where:

TB_t	Tradable balance of Emission Reduction Tons for vintage year t .
ERT_t	Emission Reduction Tons issued with vintage year t .
$IERT_t$	Emission Reduction Tons transferred into ACR account with vintage year t .
$OERT_t$	Emission Reduction Tons transferred out of ACR account with vintage year t .
$RERT_t$	Emission Reduction Tons retired in ACR account for vintage year t .

The total account tradable balance at time t is calculated using equation 25.

$$TB_{TOT,t} = \sum_{t=1}^t TB_t \quad (25)$$

The total account tradable balance ($TB_{TOT,20}$) must be ≥ 0 following final verification at the end of the 20-year Crediting Period. This means that in the event that the project is carrying a negative balance in $C_{NEG,20}$, at the end of the 20-year Crediting Period it is treated as a reversal with negative ERT_{20} 's issued and the project must either transfer in ($IERT_{20}$) or retire ($RERT_{20}$) enough ERTs to compensate for the reversal.

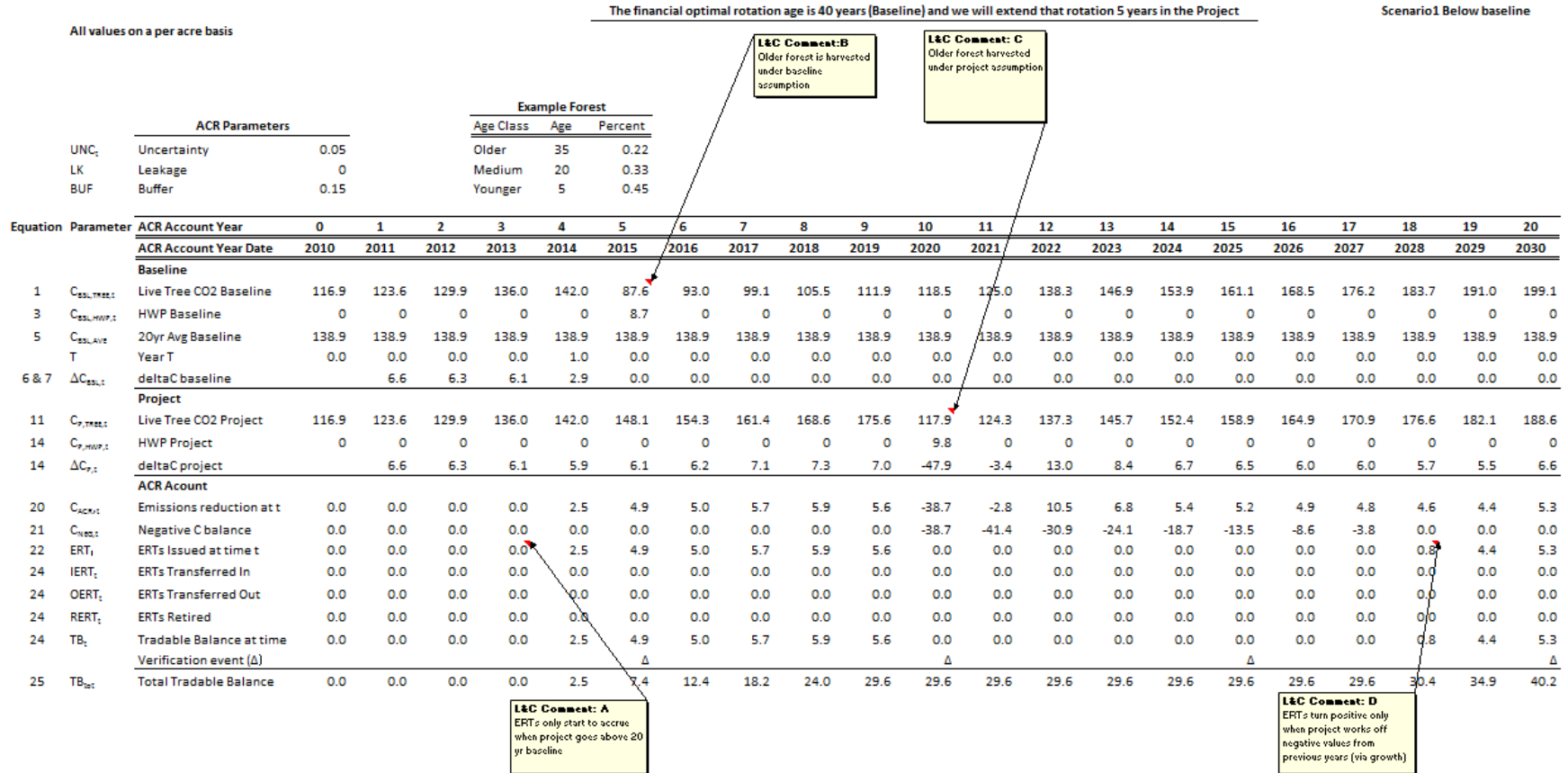


ADDENDUM 1: ERT CALCULATION ILLUSTRATION

The following examples illustrate how ERT calculations are completed under two scenarios. Scenario 1 is a case where landowner carbon stocks begin below the baseline, Scenario 2 is a case where landowner carbon stocks begin above the baseline. In both examples, annual calculations of ERTs are shown with an accompanying graph for illustration purposes.

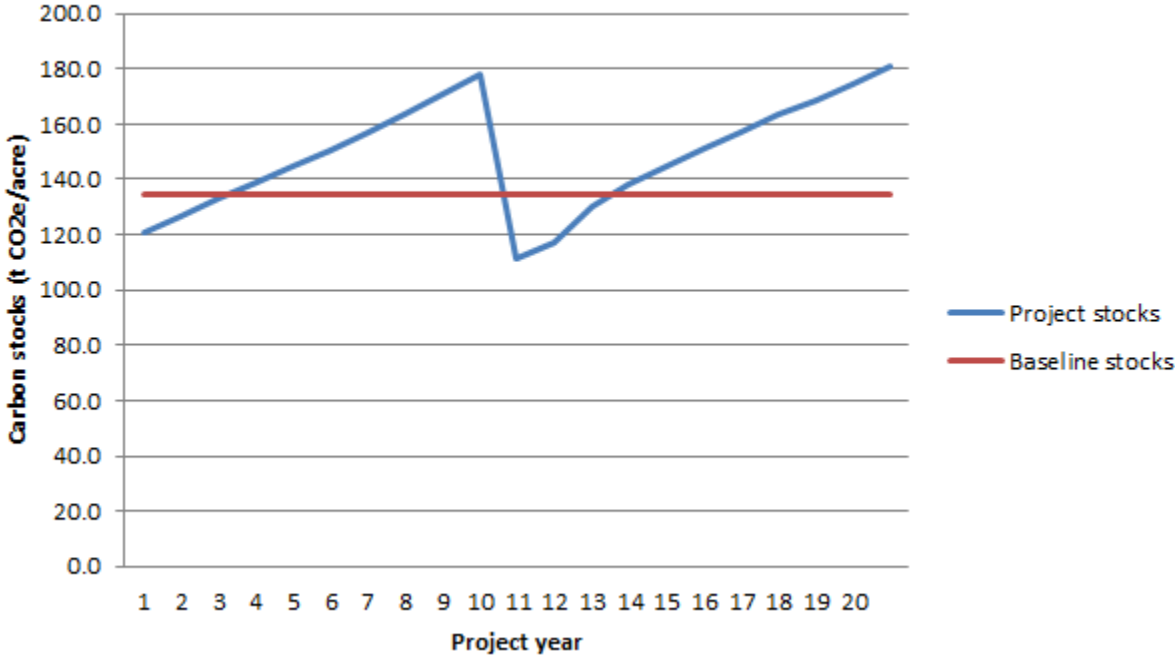
Addendum Table 1. Annual ERT calculations in cases where project stocks begin below the baseline

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Addendum Figure 1. Illustration of baseline and project dynamics when project stocks begin below the baseline

Scenario 1: project begins below the baseline



Addendum Table 2. Annual ERT calculations in cases where project stocks begin above the baseline

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The financial optimal rotation age is 40 years (Baseline) and we will extend that rotation 5 years in the Project

Scenario2 Above baseline

All values on a per acre basis

ACR Parameters			Example Forest		
			Age Class	Age	Percent
UNC _t	Uncertainty	0.05	Older	35	0.33
LK	Leakage	0	Medium	20	0.33
BUF	Buffer	0.15	Younger	5	0.34

L&C Comment: 1
Older forest is harvested under baseline assumption

L&C Comment: 2
Older forest harvested under project assumption

Equation	Parameter	ACR Account Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
		ACR Account Year Date	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030		
Baseline																									
1	C _{SSL,TRBL,t}	Live Tree CO2 Baseline	129.9	135.7	141.2	146.5	151.8	66.9	71.3	76.5	82.1	87.9	93.9	99.8	112.6	120.9	127.5	134.7	142.4	150.6	158.7	166.8	175.5		
3	C _{SSL,HWP,t}	HWP Baseline	0	0	0	0	0	13.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
5	C _{SSL,AVG}	20Yr Avg Baseline	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2	123.2		
	T	Year T	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6 & 7	ΔC _{SSL,t}	deltaC baseline		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Project																									
11	C _{P,TRBL,t}	Live Tree CO2 Project	129.9	135.7	141.2	146.5	151.8	157.5	163.1	169.9	176.9	183.5	93.0	98.8	111.2	119.1	125.3	131.4	137.0	142.6	148.1	153.3	159.8		
14	C _{P,HWP,t}	HWP Project	0	0	0	0	0	0	0	0	0	0	14.7	0	0	0	0	0	0	0	0	0	0		
14	ΔC _{P,t}	deltaC project		5.8	5.6	5.3	5.3	5.7	5.7	6.7	7.0	6.6	-75.7	-9.0	12.4	7.9	6.2	6.1	5.6	5.6	5.5	5.2	6.5		
ACR Account																									
20	C _{ACR,t}	Emissions reduction at t	5.4	4.7	4.5	4.3	4.3	4.6	4.6	5.4	5.6	5.3	-61.2	-7.2	10.0	6.4	5.0	4.9	4.5	4.5	4.4	4.2	5.2		
21	C _{NBL,t}	Negative C balance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-61.2	-68.4	-58.4	-52.0	-47.0	-42.0	-37.5	-33.0	-28.6	-24.3	-19.1		
22	ERT _t	ERTs Issued at time t	5.4	4.7	4.5	4.3	4.3	4.6	4.6	5.4	5.6	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-19.1		
24	IERT _t	ERTs Transferred In	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
24	OERT _t	ERTs Transferred Out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
24	RERT _t	ERTs Retired	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
24	TB _t	Tradable Balance at time	5.4	4.7	4.5	4.3	4.3	4.6	4.6	5.4	5.6	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-19.1		
		Verification event (Δ)						Δ					Δ						Δ				Δ		
25	TB ₂₀	Total Tradable Balance	5.4	10.1	14.6	18.9	23.2	27.7	32.3	37.7	43.4	48.7	48.7	48.7	48.7	48.7	48.7	48.7	48.7	48.7	48.7	48.7	48.7	29.6	

L&C Comment: 3
With negative C balance, no ERTs are issued

L&C Comment: 4
Even with positive emissions reductions no ERTs are issued until the negative balance is eliminated

L&C Comment: 5
A negative C balance at the end of the 20-year crediting period is treated as a reversal and negative ERTs issued which must be compensated for.

Addendum Figure 2. Illustration of baseline and project dynamics when project stocks begin above the baseline

