VCS | VERIFIED CARBON STANDARD

A Global Benchmark for Carbon

Approved VCS Methodology
VM0009

Version 2.1, 13 December 2012
Sectoral Scope 14

Methodology for
Avoided Deforestation

Relationship to Approved or Pending Methodologies

This is a revision to VM0009 v1.1 to allow for baseline types which include logging and frontier-type deforestation. This revision also includes accounting and mensuration methodology to allow all permitted end land uses other than projects with peat soils in the baseline.

About Wildlife Works

Wildlife Works Carbon LLC, one of the world's leading REDD project development companies, was originally established to help local landowners in the developing world to monetize their forest and biodiversity assets, whether they are governments, communities, ownership groups or private individuals.

Wildlife Works pioneered a novel business model that uses the marketplace to bring innovative economic solutions to wildlife conservation, reduce human/wildlife conflict and protect forests in the developing world.

The company's first project at Rukinga, Kenya has been operating for over a decade protecting wildlife and forests. This history has enabled Wildlife Works to launch the Kasigau Corridor REDD project, through which the company has expanded the area under protection to over 500,000 acres. Wildlife Works continues to bring the benefits of direct carbon financing to Kenyan communities, while simultaneously securing a contiguous wildlife migration corridor between Tsavo East and West National Parks.

Building on this successful model, Wildlife Works plans to leverage its experience in Southeastern Kenya to future REDD projects around the globe, with a goal to protect 5 million hectares from deforestation. Wildlife Works is committed to protecting wildlife, forests and biodiversity, with a direct, hands-on approach to creating alternative livelihoods.

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About ecoPartners

We partner with project developers, forest owners and verification bodies to build successful forest carbon offset projects. ecoPartners specializes in the technical aspects of project design, planning and development: accounting methodologies, biometrics and remote sensing. We help our clients navigate carbon standards, mitigate risk, build long-term capacity and generate credits.

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Table of Contents

Table of PD Requirements

Also see Appendix I.

Table of Monitoring Requirements

Also see Appendix J

Table of Equations

Equations are in Appendices A-F:

1 SOURCES

This methodology was developed to the requirements set in:

- VCS Standard, v3.2
- AFOLU Requirements, v3.2
- Program Definitions, v3.2

and with guidance of the following VCS approved Tools:

- VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v1.0

The authors of this methodology would also like to acknowledge and credit these previous publications that were considered in the drafting of this document.

- "Sourcebook for Land use, Land-Use Change and Forestry Projects," a publication by Winrock International and the BioCarbon Fund
- "Guidelines for National Greenhouse Gas Inventories," reports by the IPCC
- "Global Forest Resources Assessment 2010" report by the FAO
- Winjum, J.K., Brown, S., and Schlamadinger B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. Forest Science 44:272-284.

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

This methodology provides a means to quantify Net GHG Emission Reductions and Removals (NERs) from project activities that prevent conversion of forest to non-forest. The methodology accounts for emissions from all allowable pools specified by the VCS AFOLU Requirements for the REDD project category, with the exception of peat soils and litter. This methodology can be applied to account for avoided emissions from planned deforestation (APD) and unplanned deforestation and degradation (AUDD) baseline scenarios. It uses a project method to determine additionality (see section 7).

This methodology differentiates between five baseline type*s* based on the proximate agent of deforestation, the drivers of deforestation, whether the specific agent of deforestation can be identified and the progression of deforestation. The agent of deforestation can include a primary agent and secondary agent*s* which contribute to a cascade of degradation ultimately leading to a non-forest state.

Under this methodology, project proponents implement project activities in the project area and surrounding region that address the agents and drivers of deforestation. When the agents and drivers of deforestation are not known, they can be identified using expert knowledge or a participatory rural appraisal, which is a type of community survey. In some cases related to planned deforestation, the specific agent of deforestation may be known. Identifying the agents and drivers of deforestation is essential to designing effective project activities to mitigate deforestation.

The baseline scenario for a project is defined by at least one baseline type. Once the agents and drivers of deforestation are known, this information can be used to identify baseline types. Each baseline type is characterized by baseline emissions models that are applied to a project accounting area. Parameters to these models are partially determined using a reference area. Descriptions of parameterization methods are described in section 2.1.1 and vary by baseline type. The intent of these models is to provide simplified and unified accounting with clear and user-friendly implementation. This approach dramatically reduces the number of parameters and equations in the methodology relative to prior versions.

Leakage is quantified using an activity-shifting leakage area(s) and a market-effects leakage area, which may or may not overlap with the reference area. Like the reference area, the activity-shifting leakage area is defined by the agents and drivers of deforestation for each identified baseline type in the baseline scenario. However unlike the reference area, the activity-shifting leakage area(s) is also defined by proximity to the project area and anticipated directional shifts in deforestation activities. The activity-shifting leakage area is more purposeful than a belt or an arbitrary buffer around the project area. The market-effects leakage area is defined when long-lived wood products exist in the baseline scenario to estimate leakage resulting from a change in supply of domestic long-lived wood products as a result of illegal or legal-sanctioned logging.

Residual biomass in the baseline scenario is quantified for each baseline type using a proxy area. The proxy area is distinct from the leakage areas, and may or may not overlap the reference area. The proxy area(s) characterizes the carbon stocks associated with the end land uses that are non-forest in the baseline scenario. For example, these end land uses may be pasture, subsistence agriculture or mechanized agriculture. The project proponent measures biomass for selected carbon pools in the proxy area. The proxy area should have the same landscape configuration as the project accounting area and be large enough to accommodate an adequate (per Appendix B and D) sample of measurement plots, but the proxy area need not be as large as the project area. Because the proxy area allows project proponents to include baseline types with end land uses that have significant biomass, such as swidden agriculture, the accounting is complex.

Compared to approaches taken by other REDD methodologies, the approaches used in this methodology deviate significantly in three regards: First, the baseline emissions models predict cumulative emissions over time rather than an aerial rate of deforestation in hectares per year. Second, important parameters to the baseline emissions models are fit using simple point observations of deforestation over a historic reference period rather than requiring a series of complex Land Use Land Cover (LULC) classifications of full-coverage satellite imagery. Third, accounting for the various sources of emissions from biomass is dramatically simplified by rolling all sources of potential emissions into a single model and parameterizing the model based on easily understood baseline types.

These approaches make the baseline emissions models particularly attractive to project proponents for several reasons. First, the time required to build the models is relatively short. Almost any type of historical imagery can be used to build the model, including grey-scale aerial, color aerial, panchromatic, satellite, SAR or even Landsat 7 SLC-OFF imagery (despite its failed sensor). Second, despite the fact that cloud contamination may result in limited coverage of the reference area, all collected imagery can be used to build the models in lieu of cloud cover within individual images. Once the imagery is imported into a geographic information system (GIS), data collection for model fitting is performed using simple, heads-up interpretation of point samples from the imagery. As of the publication of this methodology, Wildlife Works maintains an ArcMap GIS extension to automate point interpretation and compute weights (see section 6.7.6), thus further facilitating the use of the baseline emissions models. For all of these reasons, thematic land cover classifications of complete sets of images for each date in the reference period are not necessarily required.

In addition to the relative simplicity and robustness of the baseline emissions models, this methodology differentiates among carbon pools, and thus project proponents will find it particularly attractive. For example, both standing dead wood and lying dead wood are components of the dead wood pool but standing dead wood is measured using a plot while lying dead wood a line transect; because the dead wood pool is optional, the project proponent may choose to conservatively omit lying dead wood. This avoids the added complexity of sampling line transects while still including the optional standing dead wood pool. Such an approach may be preferable to project proponents as measurements of standing dead wood can easily be made at the same time as measurements of above-ground live trees on the same plot.

In general, this methodology monitors carbon stocks using a sample of fixed area plots in the project accounting area(s) and proxy area(s). Lying dead wood is estimated using a line intersect sample, and soil organic carbon is estimated using samples removed from soil cores or pits located within the plots used for biomass estimation. This methodology also differentiates between merchantable trees and non-merchantable trees. In addition to improving sampling techniques, this differentiation allows project proponents to characterize the emissions from biomass as a result of logging in the baseline scenario.

Because this methodology uniquely differentiates among carbon pools, each major accounting section is purposely organized by carbon pool to facilitate ease of use; the baseline scenario, baseline emissions and monitoring sections are subdivided by carbon pool. In this way, project proponents may first select carbon pools to include in the project boundary and then easily trace the accounting sections to find the appropriate methods. This is a departure from other methodologies, which typically attempt to account for all pools simultaneously despite the fact that some pools might not be selected for some projects.

Lastly, project proponents will find that this methodology provides cohesive transitions between the concepts that guide accounting while also providing necessary and important details of the accounting procedures themselves. To unify the text and tone of the methodology, complex equations and variables have been omitted from the body and placed in separate appendices. Equations are placed in Appendix

F. Project proponents should use these appendices side-by-side with the body of the methodology during project development and reporting. Background information is provided in Appendix A in order to facilitate understanding of the accounting concepts without affecting usability. Appendix B provides methods for estimating carbon stock*s* which can be used during monitoring of the project accounting area(s), activity-shifting leakage area(s) and proxy area(s). Appendix C provides methods to account for long-lived wood products under the baseline scenario and from project activities.

Appendix F is a comprehensive list of equations, literature sources, assumptions and comments by equation number, and Appendix G and H is a list of variables, variable descriptions and units. All equations cited in the body of the methodology are hyperlinked by equation number and all equations are hyperlinked by section number back to the sections where they are used. Many defined terms and abbreviations in the text are hyperlinked to their definitions.

Project proponents considering this methodology for their project are encouraged to contact Wildlife Works for resources and technical assistance.

2.1 Core Concepts in Accounting

Accounting is underpinned by observing specially-defined areas and by specifying the baseline emissions models using shifts. The baseline emissions models are parameterized for and applied to project accounting areas within the project area, each having a unique baseline type. All projects shall have at least one project accounting area and therefore at least one set of baseline emissions models.

2.1.1 Emissions Models

The underlying mechanics of this methodology are four types of emissions models. The Biomass Emissions Model and Soil Emissions Model characterize the baseline scenario for each accounting unit to estimate avoided baseline emissions from forest degradation, deforestation and subsequent soil carbon loss. These baseline emissions models are apparently complex, but their parameterization and implementation are fairly straightforward. Depending on the baseline type, model parameters are selected from defaults or estimated from data.

The Biomass Emissions Model and Soil Emissions Model do not account for carbon stored in long-lived wood products or the decay of carbon in dead wood or below-ground biomass. These emissions are accounted for using Appendix C and the Decay Emissions Model. The fourth is the Leakage Emissions Model which accounts for emissions from activity-shifting leakage. Project emissions and emissions from leakage are accounted for separately from the models to determine gross credit generation. Net credit generation is determined by subtracting deductions for buffer account allocation.

Some model parameters are defined in terms of days because of the instability caused by using larger units of time in logistic models. Data need not be collected on a daily basis, and the project proponent should simply make the necessary conversion to their data so that time units are in days where applicable.

2.1.2 Areas

The concept of an area is to specify a location where emissions are characterized or measured. This methodology uses six types of areas (see Table 1). The project area is the area under control of the project proponent and is where the project activities may be implemented to address the agents and drivers of deforestation, thus preventing emissions from the project accounting area(s).

4

The project accounting area is an area within the project area that is subject to deforestation under the baseline scenario and is associated with a baseline type. In some cases where there exists multiple baseline types for one project area, there will be multiple project accounting areas within a single project area (see Figure 1).

Associated with each project accounting area is a reference area which is located in the same region as the project area and where historical deforestation is observed. The reference area is similar to the project accounting area in most respects but represents what would have happened to the project accounting area in the baseline scenario over time. The baseline scenario is further characterized using proxy areas, one proxy area for each identified baseline type. The project area is defined in much the same way as the reference area. Like the project accounting area, the carbon pools in the proxy area are measured through monitoring to establish the residual carbon stocks after land use conversion to non-forest.

Area	Description	Quantity	Size relative to project area
Project area	The area under control of the project proponent which contains at least one project accounting area.	Only one.	Equal
Project accounting area	The area to which the *baseline emissions models* are applied. A forested area within the project area that is subject to deforestation the *baseline scenario* as delineated by section 6.2.	One for each identified baseline type.	Less than or equal
Reference area	An area in the same region as the project area that is similar to the project area in regards to acting agents of deforestation, acting drivers of deforestation, socio-economic conditions, cultural conditions and landscape configuration.	One for each identified baseline type.	Greater than or equal
Proxy area	The area where residual carbon stocks are estimated for each *baseline scenario.*	One for each identified baseline type.	No prescribed size
Activity-shifting leakage area	The area where *leakage* resulting from the activities of the *agent of deforestation* would likely occur due to the *project activity*(ies).	One for each identified baseline type.	No prescribed size
Market-effects leakage area	The area where *leakage* would likely occur resulting from a change in the supply of wood products due to the *project activity*(ies).	One if the baseline scenario includes commercial logging.	No prescribed size

Table 1: Description of carbon accounting areas.
For exact definitions, please see section 3.

Finally, emissions from leakage are measured using an activity-shifting leakage area and a market-effects leakage area, in some cases when the baseline scenario includes commercial logging. The activity-shifting leakage area is defined similarly to the reference and proxy areas, but relative to the proximity of agents of deforestation. An activity shifting leakage area is associated with each project accounting area. The definition of the market-effects leakage area is similar, but should be selected based on where

baseline logging entities could shift their production. If the baseline scenario includes illegal or legally-sanctioned commercial logging, there will be one market-effects leakage area.
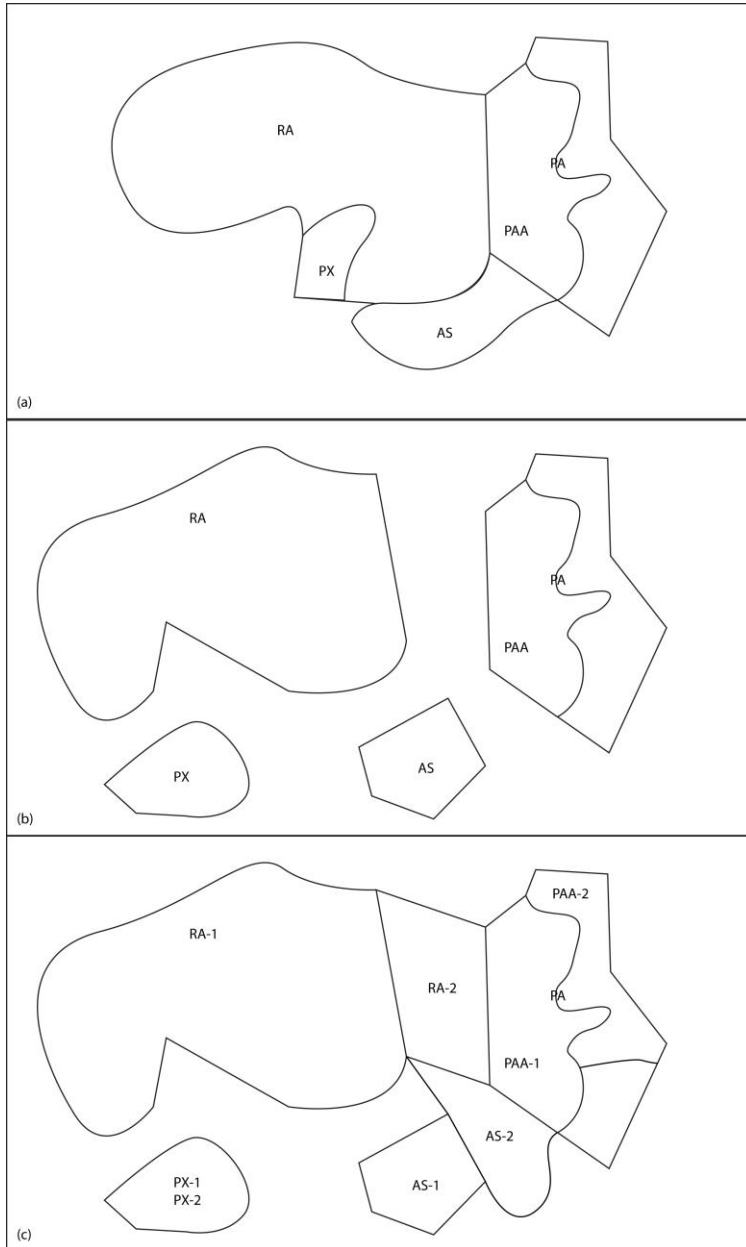
Figure 1: Three example configurations of areas for a single project instance (see section 3.1 for abbreviations).
(a-b) A project area containing one accounting area, one associated reference area, proxy area and activity-shifting leakage area.
(c) A project area containing two accounting areas, and an associated reference area, proxy area and activity-shifting leakage area for each accounting area. The proxy areas happen to be identical.

2.1.3 Shifts

The concept of a shift is to account for temporal differences in the onset of degradation and deforestation in the baseline scenario relative to historic observations in the reference area. A shift could also account

for the delay between the beginning of degradation and ultimately deforestation. Shifts are mathematical expressions or parameters that adjust terms of the baseline emissions models so that the parameterized models reflect a defensible baseline scenario.

Although not always explicitly defined as shifts in the text, several shifts are employed in this methodology depending on the baseline type for a particular accounting area. For most projects, the baseline emissions models are affected by a shift to apply historic observations made in the reference area to the project accounting area after the project start date. Another shift is associated with emissions from soil relative to degradation because these emissions are assumed to occur after deforestation.

2.2 Notation

The notation used in this methodology is intended to clearly communicate the variables and mathematical processes intended for quantifying carbon stock and project greenhouse gas benefits. The notation adopted differs in some ways from that seen in other forest carbon methodologies. These deviations improve the clarity and readability of this document.

2.2.1 Equations

Equations in this methodology are numbered and bracketed (e.g. [F.7]). The equations themselves are located in Appendix F and are referenced in the text by number. The intent is that Appendix F will be printed and used as a separate document in conjunction with the text of the methodology. Equations in Appendix F contain additional information including citations, literature sources and comments.

In some instances, similar operations are performed on different variables in multiple places. For example, estimating above-ground carbon stock in the merchantable tree, non-merchantable tree, and non-tree biomass pools involve summing plot level measurements, dividing by plot area, summing across plots in a stratum, and multiplying by stratum area. Rather than repeat nearly identical equations for each estimate, we provide a single, generic equation like [B.11] with a placeholder variable x or y. To estimate each pool, the relevant variable or equation can be substituted for x as indicated by the methodology.

2.2.2 Variables

Variables in this methodology and their units are enumerated in the list of variables in Appendix G and H. The intent is that Appendix G and H will be printed and used as a separate document in conjunction with the text of the methodology. For most of these variables, their units are in tonnes of carbon dioxide equivalents. The variables x and y (with and without subscripts) are sometimes used as placeholder variables — they may stand in for another variable or the results of an equation as indicated by the methodology text. The variables x and y are also used to indicate geographic coordinates in the development of the deforestation and soil carbon loss models in the baseline scenario section (see section 6). The meaning of these variables should be clear based on the context provided in the methodology text.

2.2.3 Summations

Summations use set notation. Sets of variables are indicated using script notation. For example, $\mathcal{S}$ represents the set of all strata in the project area, while $\mathcal{P}_k$ represents the set of all plots in stratum k. Set notation greatly reduces the number of variables used in the methodology as well as the complexity of summations.

2.2.4 Elements

Elements of a set are denoted using subscript notation. A sum over the elements of a set is indicated by the notation $\sum_{k \in \mathcal{S}} A_k$. This particular example sum indicates the sum of the area of all strata, where A_k indicates the area of stratum k. The number of elements in a set is indicated by functional notation $\#(\mathcal{S})$ where the pound sign stands for "count of".

2.2.5 Standard Deviations and Variances

Standard deviation is indicated by the σ symbol, with subscripts used to indicate the quantity for which it is estimated. Variance is indicated by the σ^2 symbol and is the square of standard deviation. Standard deviations may not be in units tCO2e.

2.2.6 Standard Errors

Estimated standard error is indicated by the U symbol, with additional subscripts used to indicate the quantity for which the uncertainty is estimated. Standard errors are always in units tCO2e.

2.2.7 Theoretical Parameters and Parameterized Models

Parameters to model are denoted by variables, such as the project shift parameter γ. When such parameters have a "hat" on them – such as the parameter $\hat{\gamma}$ – they refer to a value rather than a theoretical, unknown quantity.

2.2.8 Monitoring Periods

Monitoring periods are notated using bracketed superscripts $[m]$. The first monitoring period is denoted by $[m = 1]$, the second monitoring period $[m = 2]$ and so forth. These superscripts should not be confused with references to equations numbers, as equation numbers are never in superscript. Also see the definition for monitoring period. A monitoring event is the reporting and verification of NERs claimed for a monitoring period.

2.2.9 Baseline, Project and Leakage Estimates

Estimates related to baseline, project and leakage emissions and carbon stocks are specifically denoted with B, P and L in the subscripts of variables, respectively.

2.2.10 Averages for Carbon Pools

Average carbon (measured by tCO2e/ha) to which accounting is applied is denoted by a lower-case c, with subscripts to differentiate between carbon pools as indicated in the list of variables. For example, $c_{P\ AGMT}^{[m]}$ indicates the average carbon stock in above-ground merchantable trees in the project area in monitoring period $[m]$. Subscripts from carbon pools are acronyms listed in section 3.1.

2.2.11 Totals for Carbon Pools

Total carbon (measured by tCO2e) to which accounting is applied is denoted by a capital C, with subscripts to differentiate between carbon pools as indicated in the list of variables. For example, $C_{AGMT}^{[m]}$

indicates the total carbon stock in above-ground merchantable trees in monitoring period $[m]$. Subscripts from carbon pools are acronyms listed in section 3.1.

2.2.12 Emissions for Carbon Pools and Decay Sources

Total emissions (measured by tCO2e) from accounting are denoted by a capital E, with subscripts to differentiate between carbon pools as indicated in the list of variables. For example, $E_{B\ AGMT}^{[m]}$ indicates the total emissions from above-ground merchantable trees at monitoring period $[m]$ in the baseline scenario. Subscripts from carbon pools are acronyms listed in section 3.1.

2.2.13 Quantified Uncertainties

Uncertainties in major carbon pools are expressed as standard error SE (measured by tCO2e) and are denoted using a capital letter U. For example, $U_P^{[m]}$ is used to indicate the uncertainty in estimated total carbon stocks for selected carbon pools in the project accounting area at monitoring period $[m]$.

2.2.14 Vectors

Vectors are indicated using bold face; for example $\boldsymbol{\theta}$ is the vector of covariate parameters to the logistic function of deforestation described in section 6.7. This vector may include numerous elements such as the numeric effects of population density, road density or per-capita household income on predicted deforestation.

2.2.15 Matrices

Matrices are intentionally not used in this methodology to avoid complexity and confusion.

2.3 Application Overview

This methodology can be applied multiple ways and at different stages of project development. For the purposes of project validation when monitoring data are not yet available, literature estimates for carbon stocks in selected carbon pools can be used (see section 8.4.6). If validation and the first verification occur simultaneously, measurements from monitoring can be used to estimate carbon stocks. During subsequent monitoring events, direct measurements from the various areas are used to calculate NERs.

Upon the first application of the methodology to a project, the project proponent shall identify the project area per section 5 and the baseline scenario per section 6. For many project developers, the project area will be the area to which the project proponent has legal title to the carbon stocks in the selected carbon pools. For REDD, the boundaries of the project area may be protected as a project activity.

The baseline scenario can be identified using expert knowledge or a PRA (see Appendix E). Depending on the identified agents and drivers of deforestation, the baseline scenario may contain several baseline types. For instance, a portion of the project area may be subject to legally-sanctioned commercial logging which ultimately results in non-forest while a different portion of the project area may be subject to land use conversion caused by charcoal production. Because the agents and drivers are different, the project developer must define two baseline types in the project's baseline scenario. In this example, one baseline Type is P1 and the other might be Type U1.

For each identified baseline type, the project proponent shall delineate project accounting areas within the greater project area (see section 6.2). Likewise, the project proponent shall delineate a reference area to parameterize the baseline emissions models (see section 6.7.1), a proxy area to estimate residual carbon stocks in the baseline scenario (see section 6.4) and an activity shifting leakage area (see section 8.3.2.1) for each identified baseline type. For most projects, there will be only one baseline type and hence one accounting area, reference area, proxy area and activity shifting leakage area. For some projects, the project accounting area may encompass the entire project area.

Once baseline types and areas have been defined, the baseline emissions models shall be parameterized. For validation purposes, a small sample size of 300 interpretation points in each reference area might be used to estimate the deforestation parameters while for verification purposes a larger sample size could be used (see section 6.7). If a small sample size is selected to estimate the deforestation parameters for verification purposes, the calculation of NERs may be reduced as a result of a confidence deduction (see section 8.4.1.1). Likewise for the estimation of carbon stocks in the project accounting areas and the proxy areas, a small sample size of measurement plots may result in a confidence deduction. The confidence deduction is an incentive for project proponents to invest adequate amount of time and money into model parameterization and carbon stock monitoring without prescribing absolute requirements on sample sizes.

For validation and verification purposes, the project proponent will have to document the project design and calculated NERs using the Project Description Requirements (PD Requirements) and the Monitoring Requirements. Demonstration of these requirements can be given in a document(s) referenced from the PD or monitoring reports, or in the PD or monitoring reports themselves. Demonstration of these requirements along with completed, VCS-approved templates should be provided to the validator or verification body.

Once the baseline emissions models have been validated, the project proponent need only monitor carbon stocks in the project accounting areas and proxy areas, and monitor degradation in the activity shifting leakage areas. The project proponent may choose to monitor log production as a result of project activities in the project area to determine carbon stored in wood products. The project proponent may also choose to monitor the burning of biomass as a result of project activities. However, most project emissions will be captured in the re-measurement of plots in the project accounting areas even if there is a natural disturbance event or logging after the project start date.

3 DEFINITIONS

above-ground biomass: Please see current VCS definition.

additionality: GHG benefits that would not have occurred without the presence of the project.

activity-shifting leakage area: The area where leakage resulting from the activities of the agent of deforestation would likely occur due to the project activity(ies). A project may contain more than one activity shifting leakage area if the baseline scenario includes more than one baseline type.

agent of deforestation: People, groups of people or organizations responsible for degradation and ultimately deforestation.

allometric equation: A statistical model used to predict biomass given the measurement of closely related attributes of a tree or shrub, such as diameter (DBH) or stem count.

baseline scenario: The "without-project scenario" that would have occurred had the project not been implemented. The baseline scenario is counterfactual. The baseline scenario shall include at least one baseline type defined in the methodology.

baseline type: One of five types that address the AFOLU Requirements for planned, unplanned mosaic and unplanned frontier deforestation. Accounting for emissions for each type is slightly different, but all use the baseline emissions models to characterize the baseline scenario. A project may have more than one baseline type.

baseline emissions: For any monitoring period, baseline emissions $E_{B\Delta}^{[m]}$ are a sum of estimated emissions over selected carbon pools and time between monitoring events.

baseline emissions models: The Biomass Emissions Model and Soil Emissions Model that characterize the baseline scenario.

baseline reevaluation: Revision of the baseline scenario which occurs at least every 10 years, see section 6.20.

below-ground biomass: Please see current VCS definition.

Biomass Emissions Model (BEM): A model that characterizes the emissions from biomass in the baseline scenario.

buffer account: Please see current VCS definition.

carbon fraction: The proportion of biomass that is carbon, which may vary by species. The IPCC default is 50% (IPCC, 2006).

carbon pools: A reservoir of carbon (sink) that has the potential to accumulate (or lose) carbon over time, which for AFOLU projects typically encompass above-ground biomass, below-ground biomass, litter, dead wood and soil organic carbon. Carbon pools can also be sources of carbon that decay over time.

carbon stock: Please see current VCS definition.

cascade of degradation: A primary agent and secondary agents, and associated drivers, that eventually degrade the forest to the state of non-forest.

class of agents: A group of agents of deforestation that share the same driver of deforestation.

covariate: A variable possibly predictive of the outcome under study; in this case quantifiable social, economic, or political factors that may improve model fit.

dead wood: Please see current VCS definition.

Decay Emissions Model (DEM): A model that characterizes the exponential decay of certain carbon pools in the baseline scenario or as result of project activity(ies).

deforestation: Please see current VCS definition.

deforestation parameters: the parameters of the baseline emissions models that describe the behavior of degradation and deforestation over time.

degradation: Please see current VCS definition.

drivers of deforestation: Geographic, climatic or other physical, social and/or economic conditions that cause deforestation.

emissions: The release of a greenhouse gas (GHG) source into the atmosphere.

emissions model: one of the four emissions models (Biomass Emissions Model, Soil Emissions Model, Decay Emissions Model or Leakage Emissions Model).

end land use: The utility of a discrete piece of land that is on average over its area non-forest. Examples include pasture land, grazing land, open pit mines, urban living space, subsistence agriculture or mechanized agriculture.

foreign agents: Groups originating outside the region in which the project resides (for example, a group of settlers that emigrates a far distance inland from the coast).

forest: Please see current VCS definition.

forested: Is forested on average across the area to which it is applied.

grassland: Please see current VCS definition.

grouped project: Please see current VCS definition.

imminent unplanned deforestation (Baseline Type U1): The immediate agent of deforestation is unknown, and at least 25% of the project boundary is within 120 meters of deforestation and at least 25% of the reference area is adjacent to the project area.

leakage: Please see current VCS definition.

Leakage Emissions Model: A model that characterizes the emissions from leakage under conditions that would have occurred in the activity-shifting leakage area had the project activity(ies) not been implemented.

litter: Please see current VCS definition.

log production: The carbon in logs removed from a logging unit onto a landing which is subsequently processed and a portion turned into long-lived wood products.

long-lived wood products: Products derived from the harvested wood of a merchantable tree such as sawn timber and plywood that are assumed to remain or decay during the project crediting period.

market-effects leakage area: The area where leakage would likely occur resulting from a change in the supply of wood products due to the project activity(ies). Each project will at most have one market-effects leakage area even if the baseline scenario includes more than one baseline type.

merchantable tree: A tree containing wood of commercial value, size, and desirable quality.

methodology: A specific set of criteria and procedures which apply to a specific project activity(ies) for identifying the project boundary, determining the baseline scenario, demonstrating additionality, quantifying NERs, and specifying project monitoring procedures.

monitoring event: The reporting and verification of NERs claimed for a monitoring period. Synonymous to verification event in VCS Standard.

monitoring period: An interval of time following the project start date and project crediting period start date designated for systematically verifying project claims of GHG emissions reductions and/or removals and project additionality. Specifically, an interval of time from $t^{[m-1]}$ to $t^{[m]}$ where $t^{[m-1]} \geq 0$ (the project crediting period start date) and $t^{[m-1]} < t^{[m]}$. The length of the monitoring period is $t^{[m]} - t^{[m-1]}$ where m denotes the number of any single monitoring period and t the number of days after the project crediting period start date that is the end of the monitoring period. The length of each monitoring period shall be less than or equal to five years.

Net GHG Emission Reductions and Removals (NERs): Tonnes of Carbon Dioxide Equivalent (tCO$_2$e) emissions that are reduced or removed from the atmosphere due to project activities during the project crediting period.

non-decay pool: A carbon pool that does not decay over time.

non-forest: Not meeting the country-specific definition of forest.

non-merchantable tree: All other trees that do not meet the definition of a merchantable tree.

non-tree biomass: Biomass that includes grasses, sedges, herbaceous plants and non-tree woody biomass.

non-tree woody biomass: Biomass that includes woody shrubs and any trees too small for carbon stock estimation using the allometric equation derived or selected for trees.

participatory rural appraisal: A voluntary survey of the populace surrounding the project area that can be used to identify the agents and drivers of deforestation, delineate the reference area, and identify strategies to mitigate deforestation in the project area.

peat soil: See current VCS definition for peat land.

permanent plot: A plot with fixed area and location used to repeatedly measure change in carbon stocks over time.

planned commercial deforestation (Baseline Type P1): The immediate agent of deforestation is known and there is commercial harvest in the baseline.

planned non-commercial deforestation (Baseline Type P2): The immediate agent of deforestation is known and there is no commercial harvest of wood products in the baseline scenario.

primary agent: an agent of deforestation that initiates cascade of degradation ultimately leading to deforestation. Without the primary agent, deforestation would not occur.

project accounting area: The area to which the baseline emissions models are applied for a given baseline type. A forested area within the project area that is subject to deforestation in the baseline scenario delineated in section 6.2. A project area may contain more than one accounting area if the baseline scenario includes more than one baseline type or if the the project is a grouped project.

project activity: The specific set of technologies, measures and/or outcomes, specified in a methodology applied to the project, that alter the conditions identified in the baseline scenario and which result in GHG emission reductions or removals (please see current VCS definition). Conditions may be social or economic, not necessarily the condition of deforestation.

project activity instance: Please see current VCS definition.

project activity instance start date: Date on which a project instance began generating GHG emissions reductions or removals.

project area: The physical and temporal constraints of the project that encompass the greenhouse gases (GHG) and carbon pools considered, including the physical boundaries of the project area and the project crediting period defined by the project proponent. The project area is the area controlled by the project proponent where project activities may be implemented.

project boundary: The physical and temporal constraints of the project that encompass the greenhouse gases (GHG) and carbon pools considered which include the physical boundaries of the project area and the project crediting period defined by the project proponent.

project crediting period: Please see current VCS definition. The length of this period shall be equal to or less than the period defined by the temporal project boundaries.

project crediting period start date: Please see current VCS definition.

project description: Please see current VCS definition.

project end date: The date of the end of the last monitoring period and the conclusion of the Project Crediting Period.

project emissions: Project emissions for any monitoring period $[m]$ as estimated by the events of woody biomass consumption.

project shift period: The period of time between deforestation observed in the reference area and the project start date, denoted γ.

project performance: A comparison of ex-post credit generation to ex-ante estimates over time.

project proponent: Please see current VCS definition.

project start date: Please see current VCS definition. This date might come before or on the project crediting period start date. The project start date must be associated with at least one project activity instance start date.

proxy area: The area where residual biomass is estimated for the baseline scenario.

Reduced Emissions from Deforestation and Degradation (REDD): Please see current VCS definition.

reference area: An area in the same region as the project area that is similar to the project accounting area in regards to acting agents of deforestation, acting drivers of deforestation, socio-economic conditions, cultural conditions and landscape configuration. This area is used to estimate the deforestation parameters (see section 6.7.1). This term is synonymous with the reference region described in AFOLU Requirements.

reference period: A historic period of time in the same region as the project that is similar in acting agents of deforestation, acting drivers of deforestation, socio-economic conditions, cultural conditions and landscape configuration to the project area.

soil organic carbon: Please see current VCS definition.

secondary agent: an agent of deforestation that follows after the primary agent in the cascade of degradation ultimately leading to deforestation. A secondary agent may not be present for deforestation to occur.

Soil Emissions Model (SEM): A model that characterizes the emissions from soil organic carbon in the baseline scenario.

specific agent of deforestation: An agent of deforestation that can be identified by name and that resides in a known area, directly responsible for deforestation or the beginning of cascade of degradation.

stratification: The process of grouping homogenous subgroups of a given population to reduce sampling measurement error.

temporal project boundary: The period of time when deforestation is mitigated in the project area as a result of project activities. The boundaries are defined by the project start date and project end date.

threatened perimeter: The perimeter of the project area which is vulnerable to deforestation by being accessible to the local agents of deforestation.

type of agent: Either a primary agent or a secondary agent.

uncertainty: Please see current VCS definition.

unplanned deforestation (Type U1, U2 and U3): The immediate agent of deforestation is unknown.

Validation/Verification Body (VVB): Please see current VCS definition.

verification period: Please see current VCS definition.

woody biomass: Biomass resulting from secondary growth.

wood products: Please see current VCS definition.

3.1 Acronyms

AGMT	Above-ground *merchantable tree* (see *merchantable tree*)
AGOT	Above-ground other tree (see *non-merchantable tree*)
AGNT	Above-ground non-Tree
AFOLU	Agriculture, Forestry and Other Land Use
APD	Avoided Planned Deforestation
AS	Activity-shifting
AUDD	Avoided Unplanned Deforestation and Degradation
B	Baseline
BA	Buffer account
BE	Baseline emissions
BEM	Biomass Emissions Model
BGB	Below-ground biomass
BGMT	Below-ground merchantable Tree
BGOT	Below-ground other Tree
BGNT	Below-ground non-Tree
BR	Baseline reevaluation
BRN	Burning of biomass
CF	Carbon fraction
D	Decay
DBH	Diameter at breast height
DEG	Degradation
DEM	Decay Emissions Model
DF	Deforestation
DNA	Designated National Authority
DW	Dead wood
EM	Emissions models
FAO	Food and Agriculture Organization

GHG	Greenhouse gas
GIS	Geographic Information System
GERs	Gross Emissions Reductions
IPCC	Intergovernmental Panel on Climate Change
IRLS	Iteratively Reweighted Least Square
ISO	International Organization for Standardization
L	Emissions from leakage
LD	Lying dead wood
LEM	Leakage Emissions Model
LTR	Litter
MC	Moisture content
ME	Market-effects
MR	Monitoring requirement
NERs	Net GHG Emission Reductions and/or Removals
P	Project
PA	Primary Agent
PD	Project Description
PDR	Project description requirement
PE	Project emissions
PX	Proxy area
RA	Reference area
REDD	Reduced Emissions from Deforestation and Degradation
RMSE	Root Mean-Squared Error
PA	Project area
PAA	Project accounting area
PAI	Project activity instance
PRA	Participatory Rural Appraisal
RS	Root-to-shoot ratio

SEM	Soil Emissions Model
SA	Secondary agent
SD	Standing dead wood
SE	Standard error
SL	Slash
SP	Spatial algorithm
SPC	Species
SOC	Soil organic carbon
UNFCCC	United Nations Framework Convention on Climate Change
VVB	Validation/Verification Body
VCS	Verified Carbon Standard
VCSA	Verified Carbon Standard Association
VCU	Verified Carbon Unit
WP	Long-lived wood products

4 APPLICABILITY CONDITIONS

For this methodology to be applied, project activities shall satisfy the following conditions:

1. This methodology was developed for avoiding deforestation and assumes that degradation and deforestation occur as a result of land use conversion to non-forest. The drivers and agents of deforestation in the baseline scenario must be consistent with those described in section 6 of this methodology and the end land use in the baseline scenario is non-forest. Accordingly, the project activity must be APD or AUDD.

2. Land in all project accounting areas has qualified as forest on average across the project accounting areas as defined by FAO 2010 or as defined by the residing designated national authority (DNA) for the project country for a minimum of 10 years prior to the project start date.

3. In the case of baseline type*s* that are type U, unplanned deforestation, deforestation exists at some point within 120 meters of the perimeter of the project accounting area such that without the implementation of the project activity the project accounting area would be immediately threatened by the agent of deforestation as of the project start date.

4. In the case of baseline type U1, at least 25% of the project area boundary is within 120 meters of deforestation and at least 25% of the project area is adjacent to the reference area.

5. In the case of baseline type U2, at least 25% of the project area boundary is within 120 meters of deforestation.

6. If foreign agents have been identified as an agent of deforestation, they are unlikely to shift their activities outside the activity-shifting leakage area.

7. The project accounting area(s) shall not contain peat soil.

8. For each project accounting area, a reference area can be delineated for each baseline scenario that meets the requirements of section 6.7.1 of this methodology including the minimum size requirement.

9. As of the project start date, historic imagery of the reference area exists with sufficient coverage to meet the requirements of section 6.7.4 of this methodology.

10. Project activities are planned or implemented to mitigate deforestation by addressing the agents and drivers of deforestation as described in section 8.3.1 of this methodology.

11. The project proponent has access to the activity-shifting leakage area(s) and proxy area(s) to implement monitoring (see sections 8.3.2.1 and 6.4), or has access to monitoring data from these areas for every monitoring event.

12. If logging is included in the baseline scenario and a market-effects leakage area is required per section 8.3, then the project proponent has access to or monitoring data from the market-effects leakage area for every monitoring event (see section 8.3.3).

13. This methodology is applicable to all geographies, however if SOC is a selected carbon pool and the default value from section 6.18.1.1 is selected then the project must be located in a tropical ecosystem.

PD Requirements: Applicability Conditions

The project description shall include the following:

PDR.1 For each applicability condition, a statement of whether it applies to the project. If the applicability condition does not apply to the project, justification for this conclusion.

PDR.2 Where applicability conditions apply, credible evidence in the forms of analysis, documentation or third-party reports to satisfy the condition.

PDR.3 Definition of forest used by the project proponent and its source.

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5 PROJECT BOUNDARY

The physical and temporal constraints of the project as well as the greenhouse gases and carbon pools shall be clearly delineated and defined by the project proponent. Bounds shall conform to the latest guidance from the VCS and this methodology and shall be clearly and objectively defined to facilitate monitoring and evaluation per the requirements in this section.

5.1 Delineating the Spatial Boundaries

The project area shall be under the control of the project proponent defined in the PD at project verification. If validation occurs before verification, and less than 80% of the project area is under control at the time of validation, project proponents shall demonstrate:

- The difference in land area does not affect additionality.
- In the event the project proponents are not able to eventually control all assumed project areas, provisions are in place to ensure that emissions from these areas shall be considered as leakage.
- The monitoring plan is sufficiently flexible to account for changes in the project size.

In all cases, the project shall be verified within the time allotted under current VCS rules. The size of the project area cannot increase after the end of the first monitoring period.

The project area may be a combination of forest and non-forest, however the baseline emissions models can only be applied to the forested area subject to deforestation in the baseline scenario (see section 6.2). On average, all project accounting areas shall meet the definition of forest given in section 3 (this does not mean that every stratum must meet the definition of forest). The project area may consist of multiple contiguous or discontinuous parcels.

The geographic or physical boundaries of the project area shall be clearly delineated using, at minimum, the following:

- Name of the project area (compartment or allotment number, local name)
- Digital maps of the area, including geographic coordinates of vertices
- Total land area
- Details of ownership, including user rights and/or land tenure information
- Topography
- Roads
- Major rivers and perennial streams
- Land use/vegetation type classification

PD Requirements: Spatial Project Boundaries

The project description shall include the following:

PDR.4 A digital (GIS-based) map of the project area with at least the above minimum requirements for delineation of the geographic boundaries.

PDR.5 Credible documentation demonstrating control of the project area, or documentation that the provisos listed in the case of less than 80% project control at the time of validation delineated in section 5.1of the methodology are met.

Monitoring Requirements: Spatial Project Boundaries

The monitoring report shall include the following:

MR.1 A digital (GIS-based) map of the project area with at least the above minimum requirements for delineation of the geographic boundaries.

5.2 Defining the Temporal Boundaries

Temporal boundaries define the period of time when degradation and deforestation in the project area is mitigated by project activities. All project accounting areas shall have qualified as forest for a minimum period of time prior to the project start date, as specified by the VCS standard (as of this publication, 10 years; see section 6.2). The temporal boundaries include the project crediting period, which is fixed by the project proponent.Projects may use an historical crediting period under specific circumstances, consistent with current VCS rules.

The following temporal boundaries shall be defined:

- The project start date.
- The project crediting period.
- The length of the project crediting period.
- The dates and periodicity of baseline reevaluation and monitoring periods. A baseline reevaluation after the project start date and monitoring shall conform to the current VCS standard.

The project crediting period start date may occur after the project start date. If the project crediting period start date is more than 10 years after the project start date, then as of the project crediting period start date a baseline reevaluation shall occur prior to the end of the first monitoring period (see section 6.20).

PD Requirements: Temporal Project Boundaries

The project description shall include the following:

PDR.6   The project start date.

PDR.7   The project crediting period start date and length.

PDR.8   The dates for mandatory baseline reevaluation after the project start date.

PDR.9   A timeline including the first anticipated monitoring period showing when project activities will be implemented.

PDR.10   A timeline for anticipated subsequent monitoring periods.

Monitoring Requirements: Temporal Project Boundaries

The monitoring report shall include the following:

MR.2   The project start date.

MR.3   The project crediting period start date, end date and length.

5.3 Gases

Project proponents shall account for significant sources of the following included greenhouse gases as specified in Table 2.

Gas	Sources	Inclusion	Justification
CO_2 (Carbon Dioxide)	Flux in carbon pools	Yes	Major pool considered in the project scenario
CH_4 (Methane)	Burning of biomass	No	Conservatively excluded
N_2O (Nitrous Oxide)	Burning of biomass	No	Conservatively excluded

Table 2: Included GHG sources.

5.4 Selecting Carbon Pools

Project proponents shall account for the required pools (below) and may additionally select from the listed optional pools in Table 3.

Pool		Required	Justification
AGMT	Above-ground merchantable tree	Yes if *baseline scenario* or *project activity(ies)* include the harvest of *long-lived wood products*, otherwise No	Major pool considered when accounting for emissions from *long-lived wood products*
AGOT	Above-ground other (non-merchantable) tree	Yes	Major pool considered
AGNT	Above-ground non-tree	Optional (Yes, if the baseline scenario includes perennial tree crop)	May be conservatively excluded (Not conservative to exclude if baseline scenario includes perennial tree crop)
BGMT	Below-ground merchantable tree	Optional	May be conservatively excluded
BGOT	Below-ground other (non-merchantable) tree	Optional	May be conservatively excluded
BGNT	Below-ground non-tree	Optional	May be conservatively excluded
LTR	Litter	No	Always conservatively excluded
DW	Dead wood	Yes, if AGMT is selected	May be a significant reservoir from slash under the *baseline scenario*
SD	Standing dead wood	Optional	May be conservatively excluded
LD	Lying dead wood	Optional	May be conservatively excluded
SOC	Soil organic carbon	Optional	May be conservatively excluded
WP	Long-lived wood products	Yes if AGMT is selected	May be a significant reservoir under the *baseline scenario*

Table 3: Required carbon pools and justifications.

Optional pools may be excluded if emissions or emissions reductions can be demonstrated to be conservative. The project proponent shall use *ex-ante* estimates (see section 8.4.6) to demonstrate conservative exclusion of optional pools. Conservative exclusions shall always meet current VCS requirements.

Merchantable trees containing biomass in AGMT and BGMT are differentiated from non-merchantable trees containing biomass in AGOT and BGOT. For accounting, the important distinction between these classes of trees is that, under the baseline scenario and as a result of project activities that include logging, carbon stored in *long-lived wood products* shall be considered (see sections 8.1.13 and 8.2.3). Merchantable trees shall be defined by expert knowledge, the PRA or third-party publications.

Required and optionally selected carbon pools are referred to as the set of selected carbon pools denoted by $\mathcal{C}$ (see section 2.2 for notation).

PD Requirements: Carbon Pools

The project description shall include the following:

PDR.11   A list of the greenhouse gases considered.

PDR.12   A list of the selected carbon pools and evidence for the conservative exclusion of any optional pools.

PDR.13   The definition and evidence to support the definition of a merchantable tree if the baseline scenario or project activities include logging.

5.5 Grouped Projects

Grouped projects are allowed, where each instance is treated as a discrete part of a single project area. All project activity instances that are grouped shall be in the same region and shall each meet all the applicability conditions of this methodology, including applicability conditions related to the baseline scenario (see sections 4 and 6). One project description should be generated for all project activity instances but shall reference the individual instances in the group. All project activity instances shall be exactly the same with regard to common reference areas, baseline scenarios, proxy areas, activity-shifting leakage areas and market-effects leakage area (see reporting requirements in sections 6, 6.7.1 and 8.3.3). Project documentation may vary with respect to carbon stock estimation, as stratification and plot location will vary by project activity instance (see reporting requirements in section 9), and project emissions (see reporting requirements in section 8.2). Each project activity instance shall have a project activity instance start date and those project activity instances sharing the same project activity instance start date and baseline type shall be grouped into a single project accounting area. Project proponents shall always comply with the full rules and requirements for grouped projects in the most recent version of the VCS Standard.

PD Requirements: Grouped Projects

If grouped projects are developed, then the project description shall include the following:

PDR.14   A list and descriptions of all enrolled project activity instances in the group at the time of validation.

PDR.15   A map of the designated geographic area within which all project activity instances in the group will be located, indicating that all instances are in the same region.

PDR.16   A map of the common reference area, proxy area, activity-shifting leakage area and market-effects leakage area.

Monitoring Requirements: Grouped Projects

The monitoring report shall include the following:

MR.4   A list and descriptions of all instances in the group.

MR.5   A map of the locations or boundaries of all instances in the group indicating that all instances are in the same region.

6 PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

The baseline scenario in this methodology hinges on the identification of the agents and drivers and an understanding of how, when and where they might have acted in the project area. Since there might be multiple groups of agents acting differently in the baseline scenario, more than one project accounting area may be required within a given project area. A project accounting area is the area for which a unique set of baseline emissions models are parameterized and applied to determine baseline emissions. Elements of this procedure are explained in detail in section 6, below.

If the agents are sequential, they contribute to a *cascade of degradation*. In the *cascade of degradation*, the first agent is the *primary agent* and the subsequent agents are the *secondary agents*. Each agent may have different drivers. It is important to identify the agents and *drivers of deforestation* in order to design project activities that will successfully mitigate *deforestation* and to characterize the *baseline scenario*.
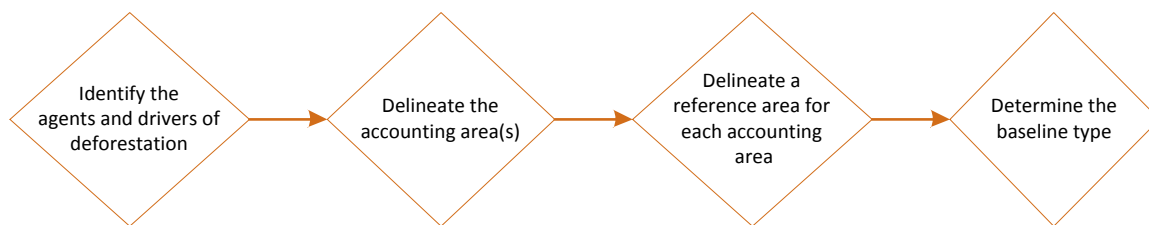
Figure 2: Determination of the baseline type
For the project area determine the agents and drivers in the baseline scenario using expert knowledge or a PRA (see Appendix E). Then, delineate the project accounting area or areas for these agents and drivers based on identified constraints to deforestation (see section 6.2). Based on this information, the baseline type can be determined for each accounting area.

The *participatory rural appraisal* (PRA) is an optional tool that suffices to identify the agents and *drivers of deforestation* in the event that the agents and drivers are not obvious. If, during validation, the identified agents and *drivers of deforestation* are found not to be evident, a PRA shall be conducted per the guidance in Appendix E. If a PRA is not used, then statistics about the agents and drivers obtained from published or unpublished sources should be used to demonstrate their prevalence.

The *baseline scenario* for each baseline type is characterized by *baseline emissions models* that predict what would have happened in each project accounting area had the project not been initiated (the "without-project" scenario). The *baseline emissions models* incorporate all the necessary accounting for *emissions* from *degradation*, *deforestation*, and loss of soil organic carbon. The baseline scenario for each selected carbon pool is described in section 6.19.

The *baseline emissions models* are a function of time and some external, quantifiable *drivers of deforestation* such as population density, length of road in the region or median household income. These external, quantifiable *drivers of deforestation* are called *covariates* due to their correlation with observed *deforestation* in the region. The fundamental basis for these models are three parameters (α, β, and $\boldsymbol{\theta}$) estimated by observing *deforestation* in a *reference area* over a historical *reference period*. The *reference area* may surround the project area, may be near to the project area or be in the same geographic region as the project area.

The *baseline scenario* may include legally-sanctioned commercial logging if the project proponent can demonstrate that as a result of legally-sanctioned commercial logging, the project area would have been

ultimately deforested in the "without-project" scenario resulting from a *cascade of degradation*. This may be the case if during the course of commercial logging, the *primary agent* creates new roads or infrastructure which provides new access points to *secondary agents* that ultimately degrade the *forest* to non-forest.

Closely related to AFOLU Requirements, the *baseline scenario* may incorporate project accounting areas with baseline types that involve

- Planned or unplanned *degradation* in addition to *deforestation*.
- Spatially explicit accounting for *deforestation*.

The baseline emissions models for each accounting area are parameterized differently depending on the associated baseline type. The project proponent should first identify the baseline type for each project accounting area in section 6.3 and then select the necessary parameters as indicated in Figure 3 in section 6.6. If more than one accounting area is identified, then apply these sections independently to each project accounting area.

Finally, a *proxy area* is used to characterize the end carbon stocks in the baseline scenario for each identified baseline type (see section 6.4).

If a jurisdictional baseline has been established and is applicable to the project activity, it may be used per VCS requirements.

6.1 Identifying the Agents and Drivers

This section is to be applied to identify the agents and drivers of deforestation and subsequently define project accounting areas.

The *baseline scenario* may include one or more *agent of deforestation*. These agents may act sequentially to cause *deforestation* in the *baseline scenario*. The PRA can be used to identify these agents (see Appendix E). The project proponent shall provide the information in the below PD requirements whether or not a PRA is used.

PD Requirements: Agents and Drivers of Deforestation

The project description shall include the following:

PDR.17 A list of the agents and drivers of *deforestation*, including quantitative descriptions of agent mobilities.

PDR.18 A narrative describing the agents and drivers of *deforestation*.

PDR.19 Descriptions of agents and drivers including any useful statistics and their sources.

PDR.20 A list of external drivers (covariates) of *deforestation* used in the model, if any, that may be identified as part of a PRA, expert knowledge or literature (e.g. median household income, road density, rainfall).

6.1.1 Primary Agents and Drivers

Distinguishing between the primary and secondary agents and drivers is important for Type P1, in which legally-sanctioned commercial logging precedes *deforestation*. In this baseline type, the *specific agent of deforestation* is the *primary agent*. The *primary agent* provides the access and infrastructure to the *secondary agents* of *deforestation*. As a result, the *emissions* from biomass in the early years of the baseline scenario are not logistic over time, but rather linear as a result of regulated harvest schedule.

In the other baseline types, there may be primary and secondary agents acting in a *cascade of degradation*; however the *emissions* from biomass resulting from primary and secondary agents are assumed to be logistic over time as demonstrated by observing *deforestation* in the reference area.

6.1.2 Secondary Agents and Drivers

Baseline emissions resulting from the secondary agents are assumed to be logistic over time as demonstrated by observing *deforestation* in the reference area. With respect to baseline characterization, it is most important to identify the secondary agents for Type P1.

6.2 Delineating Project Accounting Areas

This section is to be applied to delineate each project accounting area based on constraints to deforestation.

Project accounting areas shall be defined based on the constraints to deforestation associated with the identified agents and drivers of deforestation. Accounting areas shall not overlap and shall be forested as of the project start date and for 10 years prior to the project start date per current VCS requirements. Each project accounting area shall be subject to *deforestation* in the *baseline scenario*. For example, if the *agent of deforestation* is constrained by slopes, the *project accounting area* would not contain these inoperable slopes. Each *project accounting area* shall be measured to determine its area in hectares.

The *project accounting area* may be optionally delineated based on the results of a *participatory rural appraisal* or expert knowledge (see Appendix E).

The geographic or physical boundaries of the project accounting areas shall be clearly delineated using, at minimum, the following:

- Topography
- Roads
- Major rivers and perennial streams
- Land use/vegetation type classification
- Total area

The set of all delineated project accounting areas in the project area is denoted $\mathcal{A}$. The sum of these areas shall be less than or equal to the project area.

PD Requirements: Accounting Areas

The project description shall include the following:

PDR.21   A digital (GIS-based) map of the accounting areas, including aerial or satellite imagery showing that they are forested as of the project start date and 10 years prior to the project start date.

PDR.22   Justify the project accounting areas using the identified agents and drivers of deforestation, constraints to deforestation, and attributes listed above in section 6.2.

Monitoring Requirements: Accounting Areas

The monitoring report shall include the following:

MR.6   A digital (GIS-based) map of the accounting areas with at least the above minimum requirements for delineation of the geographic boundaries.

6.3 Identifying Baseline Types

This section is to be applied separately to each project accounting area to identify its baseline type.

The baseline emissions models account for emissions differently depending on the baseline type. A decision tree is presented in Figure 3. To determine the baseline type for a project accounting area, first determine whether the baseline scenario for the project accounting area meets the current definition of APD in the AFOLU Requirements.

If the baseline scenario meets the definition of APD, then determine whether deforestation takes place as a result of legally-sanctioned commercial harvest (e.g. sale of timber as round wood). If so, then the baseline type is planned commercial deforestation (Baseline Type P1), and if not planned non-commercial deforestation (Baseline Type P2) (e.g. the land is illegally logged or cleared for agriculture).

If the baseline scenario does not meet the definition of APD, then determine the length of perimeter along the boundaries of the project area that is within 120 meters of deforestation that occurred within 10 years prior to the project start date. If this length is less than 25% of the entire perimeter of the project area, then the baseline type is U3. If 25% or more of the project perimeter is 120 meters or less from deforestation, and if 25% or more of the project perimeter also abuts the reference area, then the baseline type is U1. If 25% or more of the project perimeter is 120 meters or less from deforestation but does not abut the reference area then the baseline type is U2.

Per AFOLU Requirements, the configuration of Type U1 and U2 shall be mosaic while Type U3 could be mosaic or frontier. Type U3 requires a spatial algorithm of the baseline emissions models to conservatively determine baseline emissions over time (see section 8.1.2.1).
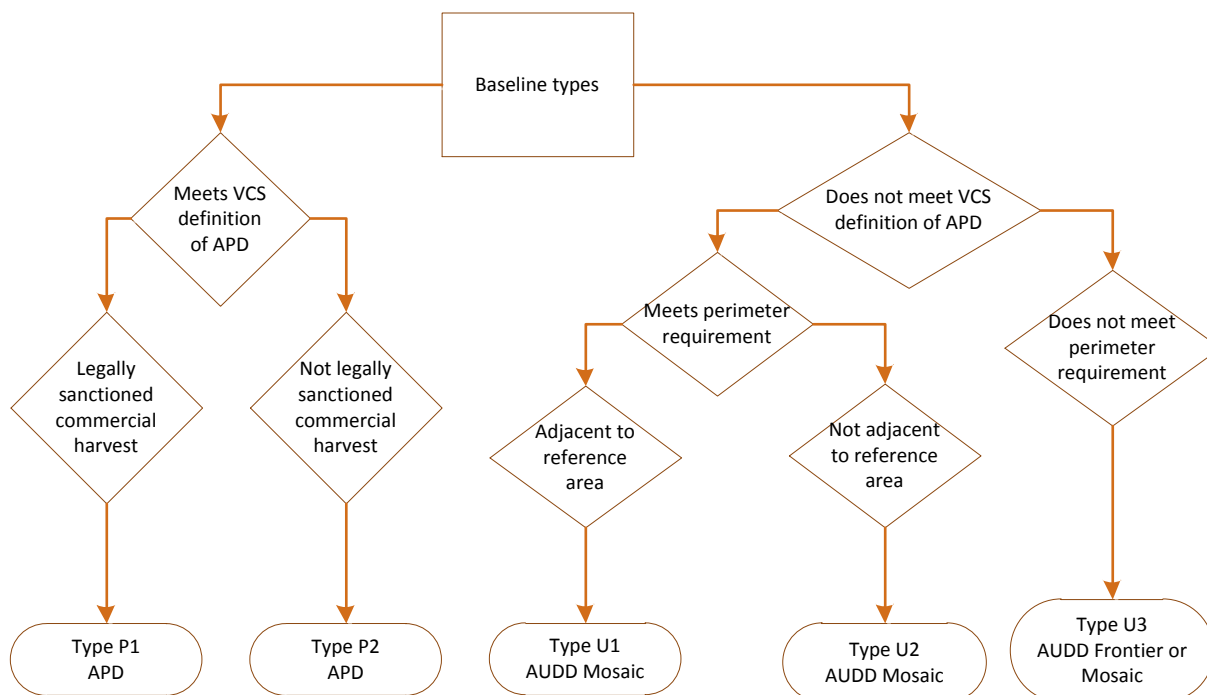
Figure 3: Decision tree to determine baseline types.
The baseline type is determined first by whether the baseline scenario for a particular project accounting area meets the current VCS definition of APD. If it does, then the type is either P1 if deforestation incorporates a legally-sanctioned logging component, and P2 if otherwise. If it does not meet the current APD definition and the perimeter requirement is met, it is U1 (if the reference area proximity is met) or U2. If the perimeter requirement is not met, then it is U3.

PD Requirements: Identifying the Baseline Type
The project description shall include the following:

PDR.23   If Type P1 or Type P2 are selected, justification for meeting the definition of APD in the current VCS-approved AFOLU Requirements.

PDR.24   If Type P1 is selected, evidence of legally-sanctioned commercial harvest in the baseline scenario.

PDR.25   If Type U1 is selected, a spatial analysis of the project area showing that at least 25% of the perimeter is within 120 meters of deforestation that occurred within 10 years prior to the project start date and showing that the reference area is adjacent to at least 25% of the project area.

PDR.26   If Type U2 is selected, a spatial analysis of the project area showing that at least 25% of the perimeter is within 120 meters of deforestation that occurred within 10 years prior to the project start date.

PDR.27   If Types U1, U2 or U3 is selected, a spatial analysis of the project area showing that it is within 120 meters of deforestation that occurred within 10 years prior to the project start date.

6.4 Delineating Proxy Areas

This section is to be applied separately for each identified project accounting area, however proxy areas for each project accounting area may partially or entirely overlap.

The proxy area is used to estimate residual carbon stocks of the end land use in the baseline scenario associated with a particular project accounting area. It shall be located in the same general region as the project area, but not necessarily adjacent to the project area. On average across the proxy area, the proxy area shall not be forested as of the project start date. There is no minimum or maximum size for the proxy area; however it shall have a similar landscape configuration to the project accounting area. The proxy area shall not include the project area but can overlap with the reference area. The proxy area shall not be altered after the first monitoring period unless there is a baseline reevaluation, see section 6.20.

The proxy area shall be delineated per the requirements of Appendix D.

PD Requirements: Delineation of the Proxy Areas
The project description shall include the following information with respect to the proxy area:

PDR.28   A map of the delineated boundaries.

PDR.29   Maps of the landscape configuration, including:
   a. Topography (elevation, slope, aspect);
   b. Recent land use and land cover (either a thematic map created by the project proponent or publicly available map);
   c. Access points;
   d. Soil class maps (if available);
   e. Locations of important markets;
   f. Locations of important resources like waterways or roads; and
   g. Land ownership/tenure boundaries.

PDR.30   A narrative describing the rationale for selection of proxy area boundaries.

PDR.31   Results of a spatial analysis to demonstrate the proxy area is not forested, on average, as of the project start date.

6.5 The Baseline Emissions Models

This section is to be applied separately for each identified project accounting area.

The baseline emissions models characterize the baseline scenario and include the Biomass Emissions Model and the Soil Emissions Model for a particular project accounting area. The Biomass Emissions Model predicts cumulative emissions from biomass as a result of degradation and deforestation while the Soil Emissions Model predicts cumulative emissions from soil organic carbon as a result of deforestation.

The Biomass Emissions Model is given by [F.2] and includes a linear component for emissions from planned commercial harvest in the Type P1 baseline type and a logistic component for emissions from degradation. Theoretical background on the logistic nature of degradation and deforestation are presented in Appendix A.

The Soil Emissions Model is given by [F.6], [F.7] and [F.8]; it is based on a logistic model of deforestation. It assumes that soil organic carbon begins to decay in the project accounting area when it is cleared to non-forest.

The baseline emissions models shall be parameterized in terms of days relative to the project start date. The models predict baseline emissions as tCO2e. These unified models dramatically simplify baseline accounting relative to other approaches, as all that is required is to determine the baseline type and select parameters based on Table 4 in section 6.6.

6.6 Parameterizing the Baseline Emissions Models

This section is to be applied separately for each identified project accounting area.

Use Table 4 to identify parameters to the baseline emissions models. Project proponents should first determine the baseline type per section 6.3. All parameters are set at the time of project validation or baseline reevaluation. Note that parameters with superscript $[m]$ are determined for each monitoring period and are specified in section 9.
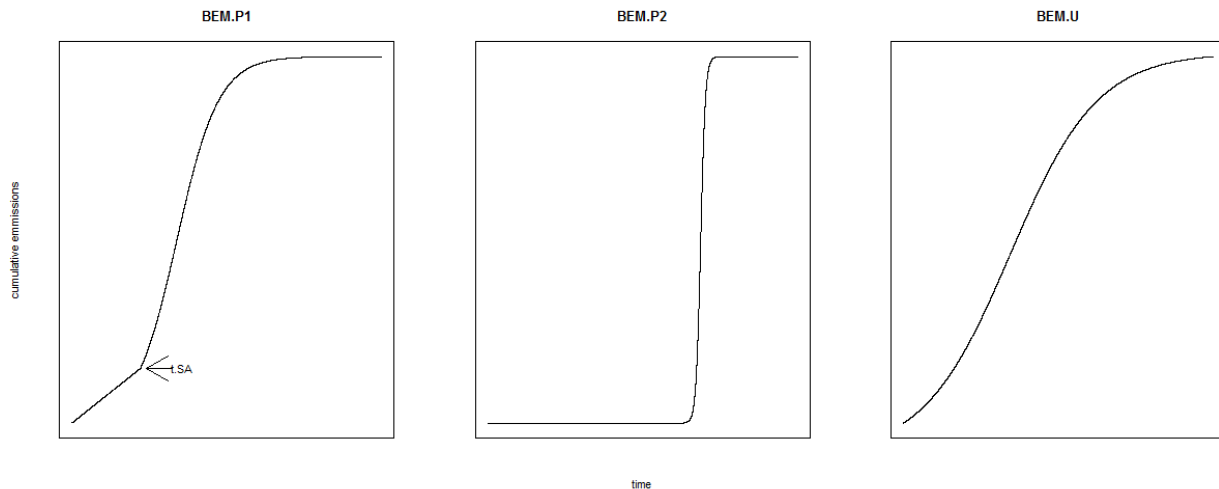
Figure 4: Examples of the biomass emissions models by baseline type.
Examples of possible cumulative emissions curves for baseline type P1, P2 and the U type baselines are presented. Actual cures for each project may vary. Parameters as they apply to each baseline type are presented in table 4.

Parameter	Explanation	Type P1	Type P2	Type U1	Type U2 and U3
m	Commercial degradation per year (tCO2e/yr)	See section 6.13	0	0	0
α	Average effects of time and other covariates on degradation and deforestation (deforestation parameters)	0	0	See section 6.7	0
β	Effect of time on degradation and deforestation (deforestation parameters)	See section 6.7	See section 6.7	See section 6.7	See section 6.7
θ	Effect of covariates on degradation and deforestation (deforestation parameters)	See section 6.7	See section 6.7	See section 6.7	See section 6.7
x_0	Covariates as of the project start date.	See section 6.11	See section 6.11	See section 6.11	See section 6.11
x_{PAI}	Covariates as of the project activity instance start date for a project activity instance in a grouped project (days)	See section 6.12	See section 6.12	See section 6.12	See section 6.12
t_{PAI}	Time of project activity instance start date relative to project start date for a project activity instance in a grouped project (days)	See section 6.8 6.13	See section 6.8	See section 6.8	See section 6.8
t_{SA}	Arrival time of secondary agents after start of commercial logging (days)	See section 6.9	0	0	0
t_{PA}	Time prior to the project start date when the primary agent began commercial logging in the project accounting area (days relative to the project start date, negative)	See section 6.10	0	0	0
γ	Time shift from beginning of historic reference period to project start date (days relative to project start date)	If including soil, see section 6.14	See section 6.14	0	0
q	Time difference between start of degradation and deforestation (days)	0	See section 6.15[+]	See section 6.15[+]	See section 6.15[+]
r_U	Deforested area or threatened perimeter in the project area at the project start date (hectares)	0	0	0	See section 6.16

Table 4: Selection of parameters by baseline type.
([+] indicates that value shall be conservatively set to zero unless justified).

6.6.1 Resolution of Parameter Values

Time in this methodology is parameterized in terms of days to aid modeling. Monitoring and measurement need not have that precision- i.e. if the precision of the data available for m is on a monthly basis, the conversion should simply be made from months to days. It is always conservative to use a larger number for time (e.g. to round up when converting units of time).

6.7 Determining α, β and θ

This section is to be applied separately for each identified project accounting area.

A reference area and historic reference period are used to find α, β and θ. The reference area is used to determine the landscape pattern of deforestation while the reference period is used to determine the change in the cumulative proportion of deforestation over time. The parameter β is the effect of time on the cumulative proportion while θ, a vector, is the effect of certain covariates on the cumulative proportion. The parameter α is related to the combined effects of the other parameters at the start of the historic reference period.

The delineation of the reference area is intentionally a subjective exercise, as the agents and drivers of deforestation differ by project location, and sometimes even within the same region. This methodology deliberately omits a quantitative determination of the size of the reference area. It is considered unlikely that such a formula would include variables for the agents and drivers of deforestation, as these are difficult metrics to quantify.

If the specific agent of deforestation can be identified (Type P1 and P2), the reference area is defined for an area and period of time controlled by the agent of deforestation or by a different agent in the same class of agents. All agents in a class share the same drivers of degradation or deforestation. The reference area may be landholdings of the agent or areas directly affected by the agent. The reference period may begin when the agent acquired access to the reference area or when the land management objectives for the reference area changed.

If the specific agent of deforestation cannot be identified, the reference area is identified using the relevant agents and drivers of deforestation as identified by expert knowledge or the participatory rural appraisal. This methodology does not specify a fixed length for the historic reference period. Instead, the reference period is defined by the availability of historic images of the reference area and the occurrence of important past events related.

Specific requirements for the reference area and historic reference period are given in the following sections.

6.7.1 Delineating Reference Areas

The reference area is defined differently for Types P1 and P2, and U1, U2, and U3. A reference area shall be delineated for each project accounting area. Reference areas may overlap.

6.7.1.1 Baseline Types P1 and P2

The reference area is defined by what would have happened in the project accounting area in a planned deforestation scenario. The project proponent shall identify the reference area as landholdings of the specific agent of deforestation or of an agent in the class of agents. The reference area shall have as much forest as the project accounting area at some point in time during the historic reference period. If a reference area based on a single agent cannot be located to meet this requirement, landholdings from multiple agents in the class of agents may be combined to meet this requirement.

The forest management practices used by the agent in reference area shall be similar to that of the likely forest management practices applied to the project accounting area in the baseline scenario. The

reference area shall not include the project area and shall not be altered during the historic reference period.

PD Requirements: Delineation of the Reference Area for Planned Types

The project description shall include the following information with respect to the reference area:

PDR.32 A map of the delineated boundaries, demonstrating that the reference area was held by the identified baseline agent or agents and does not include the project area.

PDR.33 Results of a spatial analysis to demonstrate the reference area had as much forest as the project accounting area at some point in time during the historic reference period.

PDR.34 Evidence that the forest management practices of the baseline agent in the reference area are similar to those that would have been applied to the accounting area or areas in the baseline.

PDR.35 A description of the rationale for selection of reference area boundaries.

6.7.1.2 Baseline Types U1, U2 and U3

The reference area shall be in the same general region as the project area, but not necessarily adjacent to the project area. At some point in time during the historic reference period, the reference area shall contain as much forested area as the project accounting area. The reference area shall not include the project area and shall not be altered during the historic reference period. The boundaries of the reference area shall include one or more of the following:

- Environmental, natural or political boundaries.
- Major transportation infrastructure such as highways or railroads.
- Land ownership/tenure boundaries.
- Latitudinal or Longitudinal degree boundaries.

The reference area shall be delineated per the requirements of Appendix D.

PD Requirements: Delineation of the Reference Area for Unplanned Types

The project description shall include the following information with respect to the reference area:

PDR.36   A map of the delineated boundaries, demonstrating that the reference area is held by the identified baseline agent or agents and does not include the project area.

PDR.37   Maps of the landscape configuration, including:
        a.   Topography (elevation, slope, aspect);
        b.   Recent land use and land cover (either a thematic map created by the project proponent or publicly available map);
        c.   Access points;
        d.   Soil class maps (if available);
        e.   Locations of important markets;
        f.   Locations of important resources like waterways or roads; and
        g.   Land ownership/tenure boundaries.

PDR.38   A description of the rationale for selection of reference area boundaries.

PDR.39   Results of a spatial analysis to demonstrate the reference area had as much forest as the project accounting area at some point in time during the historic reference period.

6.7.2 Defining the Historic Reference Period

The reference period is defined differently for Types P1 and P2, and U1, U2 and U3. A reference period shall be delineated for each project accounting area. Reference periods shall not overlap where reference areas overlap.

6.7.2.1 Baseline Types P1 and P2

If the specific agent of deforestation can be identified, the reference period shall be established when the agent acquired control of the reference area or when the land management practices employed in the reference area changed. Where landholdings from more than one agent in a class of agents are used to define the reference area, the reference period shall be established by the agent that first acquired control of the landholding or when the land management practices employed in the landholding changed. Control can be obtained by the establishment of title while land management can change as a result of a change in laws, access to markets for wood products or access to new technologies, for example.

PD Requirements: Defining the Reference Period for Planned Types

The project description shall include the following with respect to the reference period:

PDR.40   Established reference period boundaries.

PDR.41   The date when the agent acquired control of the reference area or when the land management practices employed in the reference area changed.

6.7.2.2 Baseline Types U1, U2 and U3

If the specific agent of deforestation cannot be identified, the reference period shall be established by important historic events as identified by the information obtained from expert knowledge or the participatory rural appraisal and corresponding analysis of agents and drivers of deforestation. These events include the following:

- The arrival time of specific foreign agents of deforestation, if any;
- The times when the drivers of deforestation became apparent, if any; and
- The times of significant economic growth or decline.

Historic imagery of the reference area shall be acquired for times before and after these events and this imagery shall be used to parameterize the baseline emissions models per section 6.7.3. If no important events are identified, then the reference period should be established by the times of available historic images of the reference area.

PD Requirements: Defining the Reference Period for Unplanned Types
The project description shall include the following with respect to the reference period:

PDR.42   Established reference period boundaries.

PDR.43   A list of available historic imagery for the reference area.

PDR.44   A timeline of important events as they relate to the agents and drivers of deforestation.

PDR.45   Narrative rationale for the selection of the reference period.

6.7.3 Analyzing Deforestation in the Reference Area

The baseline scenario is characterized by observing deforestation in the reference area assuming the same would occur in the project accounting area in the absence of the project activity. The parameters α, β and θ are estimated from observations of forest state change in the reference area over the reference period based on a logistic function (see Appendix A). Once estimated, these parameters depict the shape of the logistic function and the cumulative emissions that would have occurred at any point in time after the project start date.

To analyze deforestation and estimate α, β and θ, historical imagery shall be acquired and interpreted for forest state (see section 6.7.4). Interpretation is accomplished using a set of points distributed across the reference area (see sections 6.7.5 through 6.7.7). Weights are computed from interpretation points to account for cloud contamination, coverage and time differences in image acquisition dates (see section 6.7.6). Measures shall be taken to minimize uncertainty and uncertainty shall be estimated (see sections 6.7.9 and 6.7.10).

Sections 6.7.4 through 6.7.8 maintain a fictitious example to illustrate these steps. This example assumes a reference area of 10 by 10 km in dimension (100km^2) and a project start date of January 1 2011.

To facilitate this approach to analyzing deforestation, Wildlife Works maintains a free ArcMap GIS extension to generate and automate point interpretation and weighting.

6.7.4 Selecting Historical Imagery

Deforestation is sampled from available historical imagery of the reference area over the reference period. The project proponent shall have "double coverage" for at least 90% of the reference area over the entire reference period (see Appendix A).

Fulfillment of this requirement can be demonstrated by aligning a dot grid of points over the reference area using a GIS. Then, for each co-registered image in the system, those grid points that fall over the cloud-free, visible portion of each image are copied to a new file. This is done for all images and produces the same number of shapefiles as number of images. All derived shapefiles are then merged to form a single file. One of the attributes for each point in the merged file should contain a count of corresponding time periods on which it falls. For example, if one particular grid point was observed to fall onto the cloud-free portions of six images, then the attribute count of that point in the merged shapefile would be six. In the merged file, those points with a count less than two should be discarded (hence the remaining points in the merged file representing "double-coverage"). The number of remaining points should comprise at least 90% of the total number of points within the reference area.

The minimum spatial resolution of the imagery shall be 30 m. Where possible, multi-spectral imagery should be enhanced using a Tasseled-Cap transformation, Principal Components Analysis (PCA) or other similar transformation to facilitate the differentiation of forest vegetation from other land covers.

The dates of historic imagery should be plotted on a line plot and this plot should be interpreted for stationarity in the time series of imagery (see Figure 5). This is necessary to ensure the estimated time components of the image weights per equation [A.3] are unbiased. The time series is stationary if the image dates are distributed, on average, across the entire historic reference period.
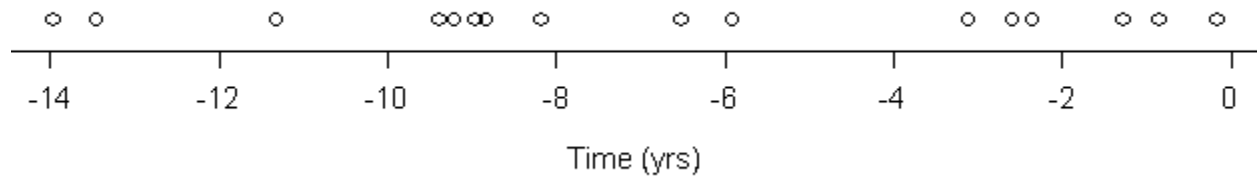
Figure 5: Line plot to demonstrate approximate stationarity of historical imagery.
A line plot of the time series of historic images to visually confirm stationarity. The time series is stationary if the images are well distributed throughout the reference period.

All imagery shall be spatially registered to the same coordinate system with accuracy less than 10% Root Mean-Squared Error (RMSE) as measured by the error relative to the pixel diagonal of the image being evaluated or relative to the absolute difference between the greatest error and the smallest error, on average across all images (Congalton, 1991). The accuracy of spatial registration is assessed empirically; each image is relative to other collocated images or a ground control point. Oblique imagery should be avoided to maintain accurate spatial registration.

PD Requirements: Historic Imagery to Parameterize α, β and θ

The project description shall include the following:

PDR.46   A map of the reference area showing the area of "double-coverage".

PDR.47   Quantification of "double coverage"(greater than 90%).

PDR.48   A line plot of the historic image dates to confirm stationarity.

PDR.49   Evidence that all image pixels are not more than 30m x 30m.

PDR.50   Empirical evidence that imagery is registered to within 10% RMSE, on average.

6.7.5 Determining Sample Size

Sample size determination is optional, but a minimum sample size may be estimated within +/- 15% of the estimated proportion of deforestation in the reference area during the historic reference period.

To optionally determine sample size, a pilot sample of interpretation points may be distributed across the reference area either randomly or systematically on a grid to estimate the ultimate sample size used to estimate α, β and θ (for an example, see Figure 6). The pilot sample should be large enough to obtain a rough estimate of the population variance. Depending on the size of the reference area and the prevalence of deforestation during the reference period, a good minimum sample size is approximately 300 points in the reference area. If a grid is used, then it shall feature a random origin.
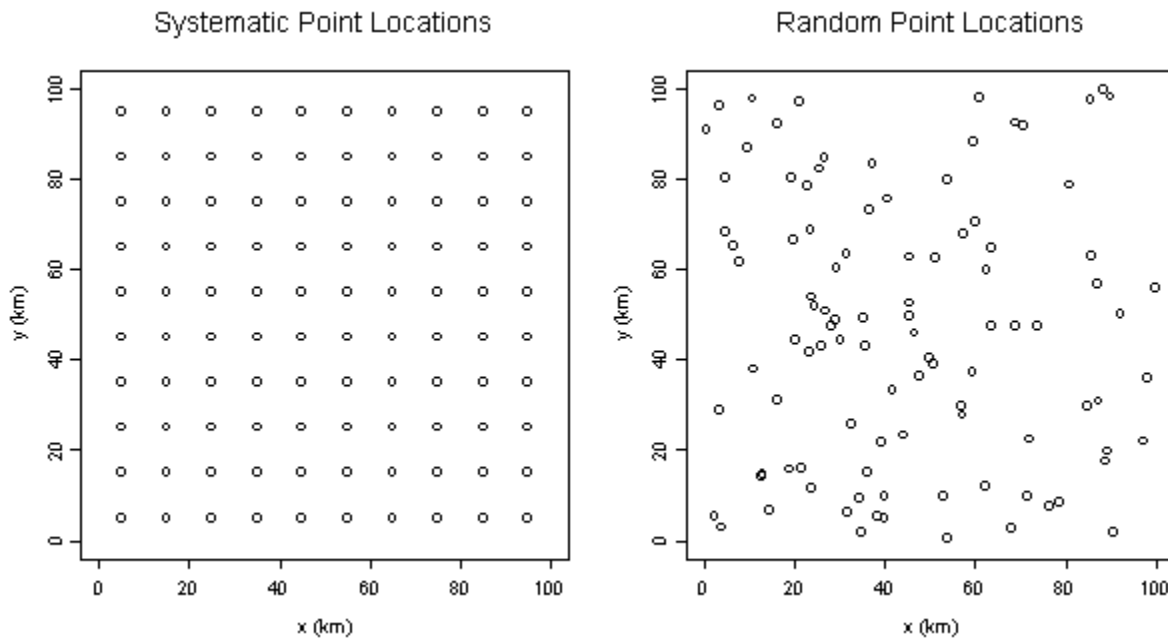
Figure 6: Systematic versus random sampling.
Types of sample points distributed across the example reference area: systematic (left) and random (right).

Forest state (either forest or non-forest) is observed at each interpretation point that falls on the cloud-free portion of each image. Visually interpret all images at each point and record forest state (0 for forest or 1

for non-forest) and the image date in a table, one table for each point, for all points in the pilot sample and all images.

When interpreting a point, use its context to determine the presence of forest. For example, if the point falls onto a pixel and it is unclear whether the pixel is forested, but it is clear that all surrounding pixels are agriculture, its context implies that forest is absent at the point.

For each image, record the number of points that fall on the cloud-free portion in a list.

Next, for each point, sort its table by image date from oldest to most-recent (for example see Figure 7). Discard those points for which the first forestation entry in the table is 1 (forest absent); deforestation cannot be observed without initially observing forest. Each row in each table for each non-discarded point is now an observation as defined by equation [F.11]. For each row, calculate an observation weight using equation [A.6] for each state observation where $\#(observations\ at\ x_i, y_i)$ is the number of rows in the table and $\#(observations\ at\ t_i)$ is the number of points recorded in the list for the image with its image date.

Image	Date	State Observation	Weight
1	9/1992	0	0.34045
2	3/1994	0	0.2236
3	3/1995	0	0.54361
4	6/1998	0	0.64526
5	9/1998	1	0.4363
6	7/2001	1	0.62354
7	1/2003	1	0.11469
8	3/2003	1	0.1233
9	1/2005	1	0.63760
10	4/2007	1	0.3548

Figure 7: Table of state observations for a sample point in the reference area.
Table for a non-discarded x_i, y_i sample points sorted by image date.

Next, for each remaining table – one for each non-discarded point – aggregate its rows into a single master table. For each row in the master table, normalize its weight by dividing each weight by the sum of all weights, so that all the weights add to one. The master table may still include locations in the reference area that do not experience deforestation during the reference period.

The master table, constructed from the pilot sample, contains rows that correspond to observations of forest state, observation times and weights. A Horvitz-Thompson estimator of the standard deviation of deforestation state σ_{EM} in the reference area is given in equation [F.13] where o_i corresponds to an observed state, w_i corresponds to a normalized weight for the ith row and $\mathcal{I}$ is the set of all rows in the master table.

The minimum sample size m_{DF} in the space of the reference area required for parameterizing α, β and $\boldsymbol{\theta}$ to within +/- 15% on average is estimated by [F.12]. This is the number of sample points to be placed in the reference area to parameterize α, β and $\boldsymbol{\theta}$. This number differs from n_{DF} which represents the total number of state observations across both time and space.

6.7.6 Sampling Deforestation

Sampling deforestation to parameterize α, β and $\boldsymbol{\theta}$ is similar to the procedure for estimating sample size using a pilot sample in section 6.7.5, except that the deforestation sample size shall be at least $\hat{m}_{DF}$ to achieve +/- 15% average precision in estimated parameters. The observed state vector $\boldsymbol{o}$, time vector $\boldsymbol{t}$ and the weight vector $\boldsymbol{w}$ used to fit the model comprise columns of the master table.

PD Requirements: Sampling Deforestation to Parameterize α, β and θ

The project description shall include the following:

PDR.51   The sample size.

PDR.52   A map of the reference area showing the sample point locations.

6.7.7 Discarded Sample Points

When sampling deforestation in the reference area, some sample points are discarded because their initial observations were non-forest; deforestation cannot be observed without initially observing forest. Likewise, these points should not be considered when estimating the minimum sample size.

In the master table, an attribute should be retained for all non-discarded sample points so that these sample points can be mapped back to locations in the reference area.

6.7.8 Parameterizing α, β and θ

The logistic function defined by equation [A.4] is fit using the sample deforestation data from the reference area as well as covariate data for the reference period. The sample deforestation data include the state observation vector $\boldsymbol{o}$ and the time vector $\boldsymbol{t}$ (see Appendix A). A plot of these vectors shows that states are zeros and ones (for an example, see Figure 7). The time vector is expressed as the numbers of days relative to the project start date. If the historic reference period occurs before the project start date, the values of the time vector will be negative. Upon baseline reevaluation, some values will be positive because forest state is observed after the project start date upto the time of baseline reevaluation.

Deforestation vs. Time
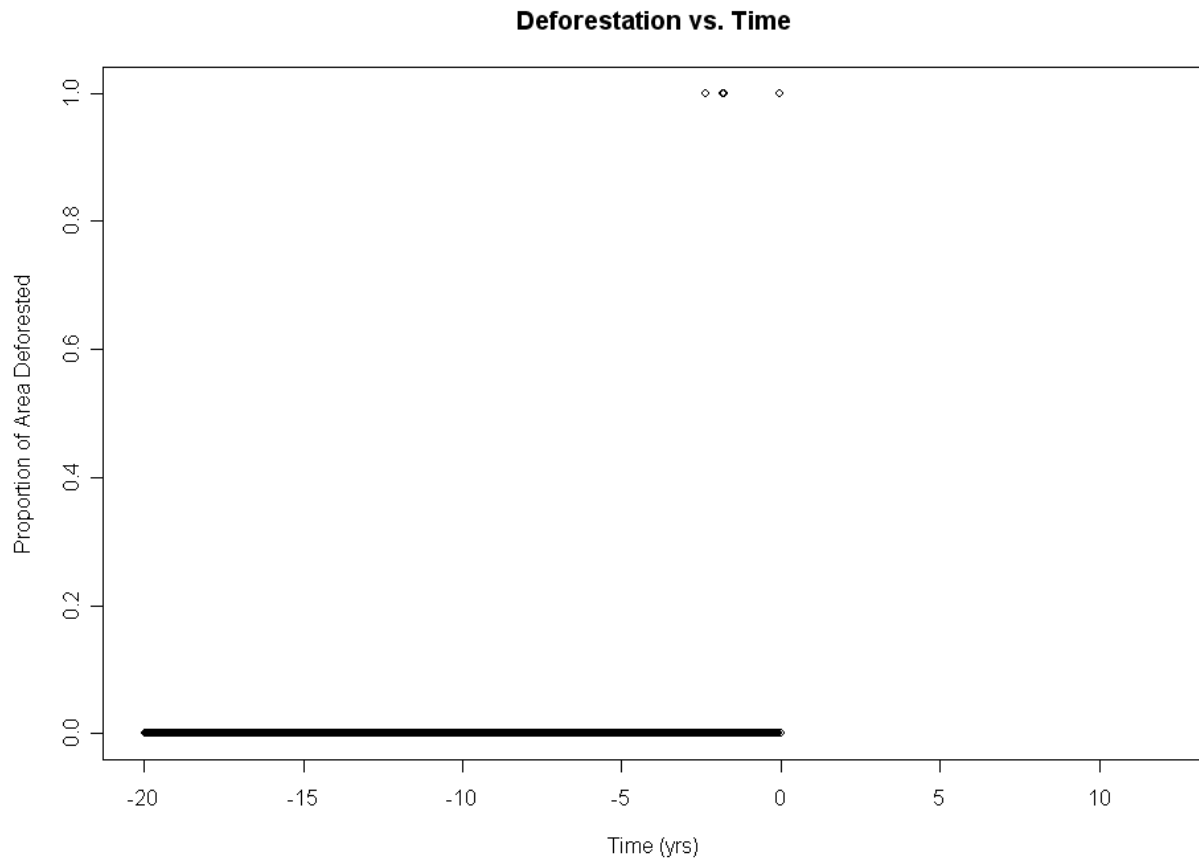
Figure 8: Plot of example state observations over time.
A graph of the state vector over time for the example reference area showing ones and zeros.

Covariate data are collected for interpretation point in the reference area. As such, covariate data may need to be interpolated from their sources (e.g. census data that may only be collected once every 10 years). These data are used to estimate the linear predictor of the logistic function where $\boldsymbol{\theta}$ is the parameter vector (see Appendix A).

Covariate data shall originate from the following sources to avoid the possibility of perverse incentive in model fitting:

- Government publications.
- Publications by an independent third party.
- Peer reviewed literature.

These sources shall be publicly available per current VCS requirements.

The parameters are found using IRLS with an initial weight vector $\boldsymbol{w}$ that corrects for spatial and temporal artifacts from sampling historic imagery (see Venables & Ripley, 2002 for information on model fitting with IRLS).

Given all possible covariate parameters $\boldsymbol{\theta}$, select the best subset of covariate parameters $\hat{\boldsymbol{\theta}}$ using AIC as a measure of fit. For information on model selection see Davidson (2003) and Freedman (2009). The fit model shall be plotted with forest state over time and the project start date (for an example see Figure 9).

Deforestation vs. Time
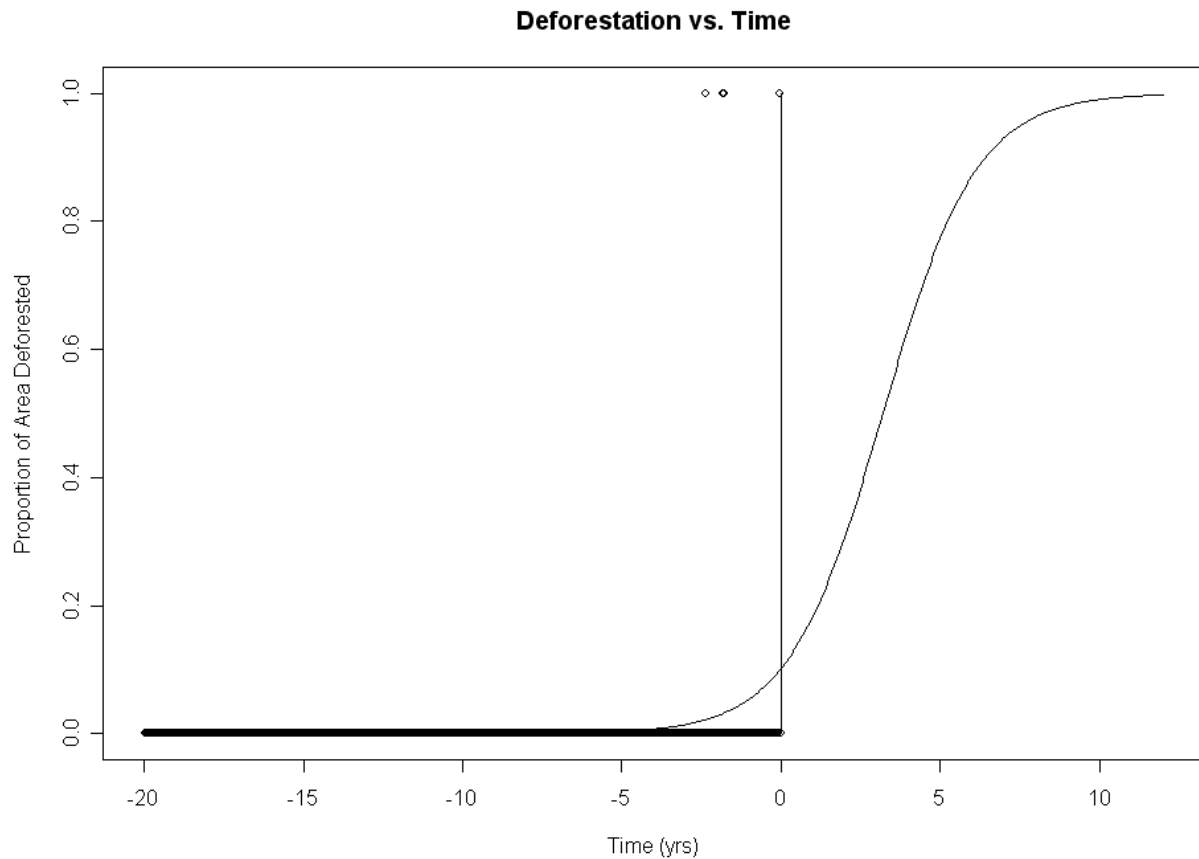
Figure 9: Graph of an example logistic function determined by α, β and θ.
A graph of the estimated logistic function over time for the example reference area relative to the project state at time zero.

PD Requirements: Parameterizing α, β and θ
The project description shall include the following:

    PDR.53   The covariates that were considered and their data sources.

    PDR.54   The parameters in θ that were evaluated during model selection.

    PDR.55   The parameters in $\hat{\theta}$ of the selected model.

    PDR.56   The rationale used for selecting $\hat{\theta}$ including comparisons of AIC.

6.7.9 Minimizing Uncertainty

Observation error shall be mitigated as much as possible by developing a protocol for the interpretation of forest state from remotely-sensed imagery. Training should ideally be provided to the interpreter(s).

Observation data shall be checked for inconsistencies. For example, observations of forest state over time at any one point in space probably do not transition from forest to non-forest, and then back to forest during the reference period (for an example, see Figure 10). A list of "impossible" or "unlikely" forest state transitions shall be developed, and each point that matches the criteria should be reexamined.

Image	Date	State Observation
1	9/1992	0
2	3/1994	0
3	3/1995	0
4	6/1998	0
5	9/1998	1
6	7/2001	1
7	1/2003	0
8	3/2003	1
9	1/2005	1
10	4/2007	1

Figure 10: Table of state observations to identify possible errors.
Table for an x_i, y_i sample point featuring a potential interpretive error at image date 1/2003.

A random subset of sampled points shall be interpreted by a different person than the first point interpreter, and these observations shall be checked against the observations made by the interpreter or interpretive team members to identify any systematic misinterpretation. All systematic errors shall be corrected.

PD Requirements: Minimizing Uncertainty in Parameters $\hat{\alpha}$, $\widehat{\beta}$ and $\widehat{\theta}$

The project description shall include the following:

PDR.57 A protocol for interpreting forest state from imagery.

PDR.58 The results of an independent check of the interpretation.

PDR.59 Evidence that systematic errors, if any, from the independent check of the interpretation were corrected.

6.7.10 Estimating Uncertainty

Uncertainty in estimated parameters $\hat{\alpha}$, $\hat{\beta}$ and $\widehat{\boldsymbol{\theta}}$ is estimated using [F.13]. This is the standard error of weighted point observations where the ith observation of forest state is o_i, multiplied by the current estimated baseline emissions in the project accounting area across all selected carbon pools (see section 8.1).

6.8 Determining t_{PAI}

This section is to be applied separately for each identified project accounting area when the project is a grouped project.

The parameter t_{PAI} is the number of days after the project start until the project activity instance start date for the project activity instance associated with a particular project accounting area.

Monitoring Requirements: Determining t_{PAI}

The monitoring report shall include the following if the project is a grouped project:

    MR.7   For each project activity instance in the group, its project activity instance start date.

    MR.8   For each project accounting area, the value of $\hat{t}_{PAI}$.

6.9 Determining t_{SA}

This section is to be applied separately for each identified project accounting area having a baseline type of Type P1.

The parameter t_{SA} is the number of days after the primary agent begins commercial logging until when the secondary agent of deforestation is likely to begin degrading the project accounting area under the baseline scenario. This parameter can be determined from the results of the PRA or expert knowledge. In many cases of legally-sanctioned commercial logging, it is the length of the logging period to harvest the first regulated harvest unit. Often, due to unsustainable harvest plans, corruption or indifference the logging infrastructure may be exploited by secondary agents in the cascade of degradation. Often after the commercially viable timber has been removed from the primary agent's first harvest unit, the primary agent will abandon that area and secondary agents will enter to further degrade and ultimately deforest the area.
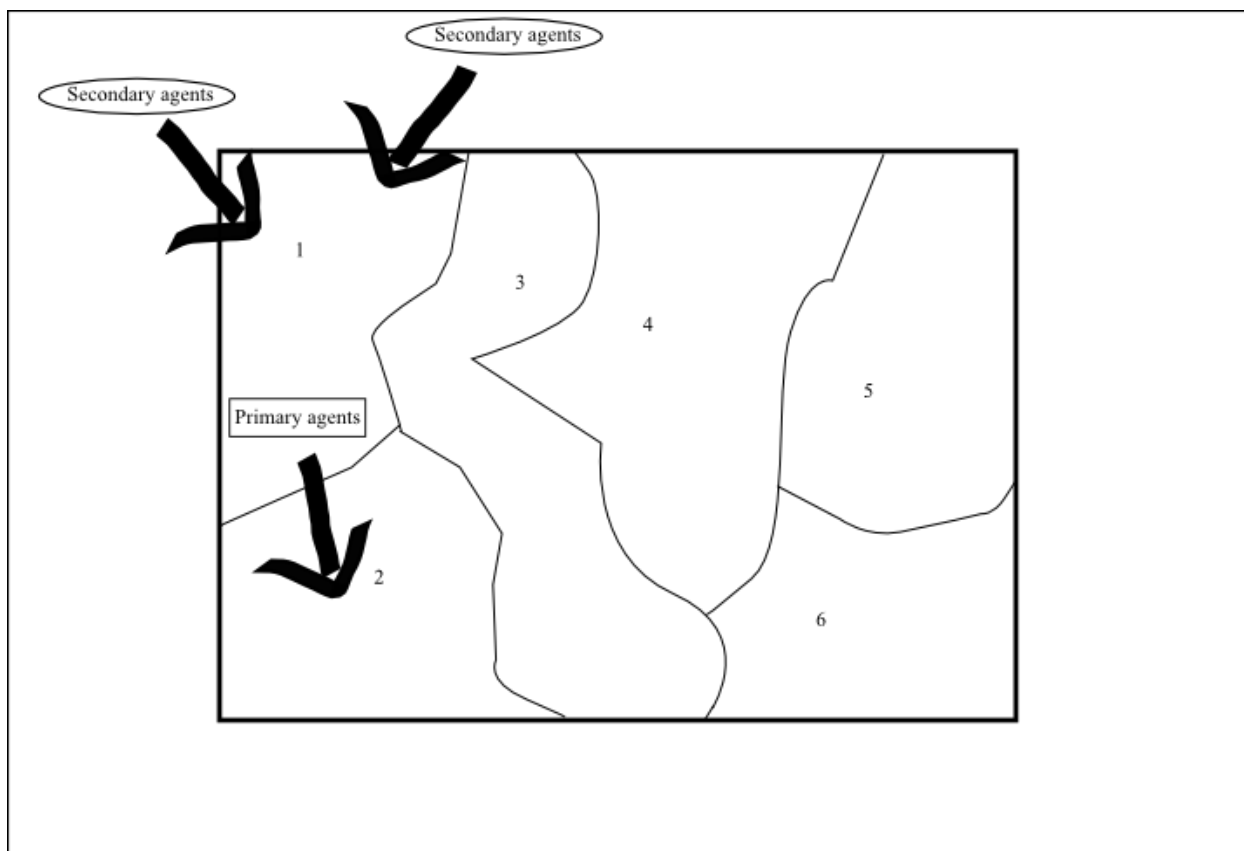
Figure 11: The cutting cycle under a type P1 project scenario.
When unsustainable harvest occurs, after the primary agents abandon a timber harvest area to move to another (1 to 2 in the figure above), secondary agents will move in and continue to degrade and deforest that area. The length of time between the entry of primary agents to a harvest area and the arrival of secondary agents is t_{SA}.

In the case when the parameter is the length of the first cutting cycle and the primary agent's harvest plans for the project accounting area cannot be obtained, the first observed instance of deforestation apparently caused by secondary agents can be used as a conservative value for the parameter (parameterized in terms of days after the start of the historic reference period). When evaluating possible values for this parameter, a larger number is always more conservative than a smaller number. This parameter shall be greater than or equal to zero.

PD Requirements: Parameterizing t_{SA}

The project description shall include the following:

PDR.60 The parameter $\hat{t}_{SA}$ as the number of days after the primary agent begins commercial logging until when the secondary agent of deforestation is likely to begin degrading the project accounting area.

PDR.61 A description of how $\hat{t}_{SA}$ was obtained.

PDR.62 Harvest plans for the project accounting area under the baseline scenario, results from the PRA or analysis of the reference area to determine the parameter.

6.10 Determining t_{PA}

This section is to be applied separately for each identified project accounting area having a baseline type of Type P1.

The parameter t_{PA} is the number of days relative to the project start date when the primary agent began or would have begun legally-sanctioned commercial logging in the project accounting area. This can only be established by harvest plans prepared for the project accounting area or by public record. In most cases, the primary agent would have started commercial logging in the project accounting area at the project start date and in these cases, the parameter should be set to zero. (For baseline type P2, the parameter is always zero.) In other cases when the primary agent has already started logging as of the project start date, the parameter will be negative (days relative to the project start date at time zero). In other cases when the primary agent would have started log after the project start date, the parameter will be positive.

PD Requirements: Parameterizing t_{PA}

The project description shall include the following:

PDR.63 The parameter $\hat{t}_{PA}$ as the number of days relative to the project start date when the primary agent began or would have begun legally-sanctioned commercial logging in the project accounting area.

PDR.64 A description of how $\hat{t}_{PA}$ was obtained.

PDR.65 Harvest plans for the project accounting area under the baseline scenario or public records to support the determination of the parameter.

6.11 Determining x_0

This section is to be applied separately for each identified project accounting area.

The parameter x_0 is a vector of covariate data as of the project start date. See section 6.7.8 and Appendix A for more information on covariates.

PD Requirements: Determining x_0

If covariates to deforestation are used, the project description shall include the following:

PDR.66 A table of covariate values as of the project start date and a description of how the values were determined including any interpolation or extrapolation methods.

6.12 Determining x_{PAI}

This section is to be applied separately for each identified project accounting area when the project is a grouped project.

The parameter x_{PAI} is a vector of covariate data as of the project activity instance start date for the project activity instance associated with a particular project accounting area. See section 6.7.8 and Appendix A for more information on covariates.

Monitoring Requirements: Determining x_{PAI}

The monitoring report shall include the following if the project is a grouped project:

   MR.9   A table of covariate values as of the project activity instance start dates and a description of how the values were determined including any interpolation or extrapolation methods.

6.13 Determining m

This section is to be applied separately for each identified project accounting area having a baseline type of Type P1.

The parameter m is the average carbon in merchantable trees cut each year as a result of legally-sanctioned commercial logging. It is not the volume of harvested wood. If AGMT and BGMT are selected carbon pools then it must include carbon in both the above-ground and below-ground portions of merchantable trees cut each year. If only AGMT is selected then it need only include the above-ground portion.

The project proponent must estimate m using timber harvest plans, if available, which apply to the project accounting area and were developed by the specific agent of deforestation under the baseline scenario. In the absence of timber harvest plans, m may be conservatively determined from the measurement of carbon stocks in merchantable trees in the project accounting area using equation [F.1] where $C_{AGMT}^{[m=0]}$ and $C_{BGMT}^{[m=0]}$ are determined prior to the first monitoring event or at the first monitoring event, and t_m is the number of days in the project lifetime or the length of time the primary agent would have harvested the entire merchantable trees in the baseline scenario. If BGMT is not a selected pool, then $C_{BGMT}^{[m=0]}$ can be set to zero. If t_m is the project lifetime, this method can only be used if the project end date is after the date on which the primary agent would have concluded legally-sanctioned commercial logging in the project accounting area under the baseline scenario. Regardless of which method is used to estimate m, timber harvests in the baseline scenario must comply with the legal maximum allowable cut as published by the relevant national authority of the country where the project is located.

This parameter shall be greater than zero.

This methodology deliberately omits prescribing accounting for re-growth and residual damage in order to conservatively simplify accounting. In commercial logging, the emissions from residual damage will exceed carbon sequestration from re-growth.

PD Requirements: Parameterizing m
The project description shall include the following:

PDR.67   The parameter $\hat{m}$ as the average carbon in merchantable trees cut each year as a result of legally-sanctioned commercial logging.

PDR.68   Documentation of how m was determined. This may include an analysis of carbon stocks in merchantable trees in the project accounting area, timber harvest plans for the project accounting area or reference to a publication containing the maximum allowable cut applicable to the project area. The parameter shall be greater than zero.

6.14 Determining γ

This section is to be applied separately for each identified project accounting area having a baseline type of Type P1 or P2. The parameter γ is the number of days between the beginning of the historical reference period and the project start date.

PD Requirements: Determining γ
The project description shall include the following:

PDR.69   The project shift parameter γ as the number of days between the beginning of the historical reference period and the project start date.

6.15 Determining q

This section is to be applied separately for each identified project accounting area.

The parameter q is the number of days between the onset of degradation and the beginning of deforestation. This parameter can be determined by expert knowledge, results from the PRA or reports from peer-reviewed literature. It is always conservative to set this parameter equal to zero and any other value shall be justified. When evaluating possible values for this parameter, it is always conservative to select a lower number. This parameter shall be greater than or equal to zero.

PD Requirements: Parameterizing q
The project description shall include the following:

PDR.70   The parameter q as the number of days between the onset of degradation and the beginning of deforestation.

PDR.71   If the default of zero is not selected for q, then a justification for the determination of q.

6.16 Determining r_U

This section is to be applied separately for each identified project accounting area having a baseline type of Type U2 or U3.

The parameter r_U is set to position the baseline emissions models relative to the onset rate of deforestation immediately adjacent to the project area at the project start date. There are two permissible methods by which this parameter can be determined:

1. In the first method, the ratio of deforested perimeter to the total threatened perimeter along the boundaries of the project area shall be measured as of the project start date. Threatened perimeter is defined as that which is vulnerable as of the project start date to deforestation by being accessible to the local agents of deforestation. Examples of non-threatened perimeter include perimeter that abuts a national park, is surrounded by steep slopes that prohibit access to the project area boundary (as defined by project proponent), or is adjacent to water. Non-threatened perimeter also may include naturally-occurring non-forest within 120 m of the project area boundary. Deforested perimeter is defined as the total perimeter that has been deforested prior to the project start date within 120 meters inside or outside the project area boundary, which can be measured from any point in time up until the project start date.

$$r_U = \frac{deforested\ perimeter}{threatened\ perimeter}$$

   For example, consider the situation in which the project area has a total perimeter of 500 km. If 200 km of this perimeter is adjacent to a national park, and 30 km is naturally-occurring non-forest within 120 m on either side of the perimeter, then the total threatened perimeter is 270 km. If 150 km of this perimeter becomes deforested, then r_U will be (150/270, or 0.556).

2. Alternatively, r_U can be quantified using the ratio of deforested area within the project area to the sum of all accounting area. Deforestation is defined as conversion from forest to non-forest up to the project start date.

$$r_U = \frac{deforested\ area}{sum\ of\ all\ project\ accounting\ areas}$$

Both of these methods rely on the identification of deforestation relative to the project area boundary or in the project area. Images or data used to determine deforestation must not be older than ten years prior to the project start date. Both of these methods require images or data from two points in time be analyzed. Measurement units for the denominator and the numerator must be the same.

PD Requirements: Parameterizing r_U

The project description shall include the following:

PDR.72 The parameter $\hat{r}_U$ as the ratio of deforested perimeter to total threatened perimeter, or the ratio of deforested area to total project accounting area(s), as of the project start date.

PDR.73 Description of how $\hat{r}_U$ was obtained.

PDR.74 Results of GIS analysis to determine or measure $\hat{r}_U$ in the project area including the dates of images used to identify deforestation.

6.17 The Decay Emissions Model

This section is to be applied separately for each identified project accounting area.

The Decay Emissions Model accounts for decay from in biomass and dead wood from all pools considered. It uses the same parameters from section 6.6 as the Biomass Emissions Model. No additional parameters are required. The Decay Emissions Model is given by [F.10], and predicts linear decay over a ten-year period. The Decay Emissions Model for dead wood and below-ground biomass are based on the VCS default procedures for these pools.

6.18 The Soil Emissions Model

This section is to be applied separately for each identified project accounting area.

The Soil Emissions Model is given by [F.6], [F.7] and [F.8]; it predicts the exponential decay of SOC over time. The Decay Emissions Model for carbon in soil, given by [F.9], contains λ_{soc}, a parameter that characterizes the decay of SOC over time. The parameter λ_{soc} should be determined using a default value or empirical estimation per section 6.18.1.

6.18.1 Determining λ_{soc}

The parameter λ_{soc} can be determined one of three ways as outlined in sections 6.18.1.1, 6.18.1.2 and 6.18.1.3.

6.18.1.1 Default Values for λ_{soc}

The default value for λ_{soc} is 0.2 E. Davidson & Ackerman (1993). Projects located in tropical climates may apply this default value. All other projects must empirically estimate λ_{soc} or use appropriate decay rates from peer-reviewed literature.

6.18.1.2 Empirically Estimating λ_{soc}

In order for the project proponent to estimate λ_{soc} from empirically measured data, the project proponent shall perform a "space for time" substitution, as it is impractical to repeatedly sample the same recently-converted forest patch over the project crediting period (required to generate enough measurements to derive a soil decay curve). The space for time substitution allows the project proponent to make many measurements at the same point in time, over a range of agricultural fields, distributed spatially within the reference area, that were converted from forest at *known times*.

Given expert knowledge of the reference area, including knowledge of farming practices and culture, the project proponent may apply empirically measured soil carbon results to mathematically derive a value for λ_{soc}. This should involve a statistically sound method such as temporal regression or trend analysis, and shall be accepted by the validator at project validation.

If the project proponent opts to measure λ_{soc} empirically, measurements shall be taken within the same reference area that meets the requirements listed in section 6.7.1. This serves to ensure that parameterization of the Decay Emissions Model is representative of common farming practices in the region.

PD Requirements: Empirically Estimating λ_{soc}

If λ_{soc} is estimated using data, the project description shall include the following:

PDR.75   Description of how samples from the reference area were selected including stratification, if any.

PDR.76   A map of sample locations in the reference area.

PDR.77   A table showing the conversion time for each area (farm or otherwise) from which samples were taken.

PDR.78   Description of and statistics for the method applied to estimate $\hat{\lambda}_{soc}$.

PDR.79   Graph of projected decay model over project lifetime.

6.18.1.3 Literature Estimates for λ_{soc}

Literature estimates may be taken from peer-reviewed scientific or government publications rather than using the default value or empirically estimating λ_{soc}. Publications shall come from the same ecotype and soil type as the project, include the same soil profile considered, have an adequate sample size and published measures of precision (per Appendix B) , and be generally representative of the project area.

PD Requirements: Literature Estimates for λ_{soc}

If an alternate λ_{soc} is used, the project description shall include the following:

PDR.80   Inclusion of decay model on which parameter is based.

PDR.81   Explicit description of referenced literature, including project location, sampling methodology, included species, sample size, and decay parameter upon which decay is based.

PDR.82   Graph of projected decay model over project lifetime.

PDR.83   If decay model is based on any other element besides carbon, defense of ability to predict carbon decay shall be provided.

6.19 Baseline Scenarios for Selected Carbon Pools

The following sections describe how the baseline emissions models are applied to each pool and any additional assumptions used in determining baseline emissions. The BGB pool is described in section 6.19.3, and the DW pool is described in section 6.19.1. Accounting for emissions from decay relative to source of emissions is outline in Table 5.

The residual carbon stocks associated with the end land use in the baseline scenario are characterized by the proxy area for all baseline toyle(see section 6.4).

Carbon Pool	Soil	Below-Ground	Dead Wood	Wood Products
AGMT			**Decay in** DW (from slash)	**Decay in WP** (from log export by wood product type)
AGOT			**No decay** (not applicable)	
AGNT				
		Decay from BGB		
BGMT				
BGOT				
BGNT				
SOC	**Decay in SOC** (from non-forest land use)			
SD		**Omit decay** (not applicable)		
LD				

Table 5: Decay emissions by carbon pool.
Emissions by source (rows) and decay (columns).

PD Requirements: Describing the Baseline Scenarios for Selected Carbon Pools
The project description shall include the following:
PDR.84   A qualitative description of the baseline scenario for each selected carbon pool.

6.19.1 Baseline Scenario for AGMT

In Baseline Type P1, above-ground commercial portions of commercially viable trees are assumed to be removed (see section 8.1.9), and then converted to long-lived wood products (see section 8.1.13), accounted for as in Appendix C. The non-merchantable portion of merchantable trees (i.e. the slash) is decayed linearly over ten years (see section 8.1.6). Primary agents are presumed to initiate the removal of merchantable trees; this initial degradation by primary agents is followed by secondary agents of deforestation which remove remaining merchantable trees. It is conservative to account for the emissions from logging slash as a decay source, even if in reality these materials would have been burned or used for fuel.

Similarly in Baseline Types P2, U1, U2, and U3 above-ground commercial portions of commercially viable trees are assumed to be removed (see sections 8.1.10, 8.1.11 and 8.1.12), and then converted to long-lived wood products by the agents of deforestation (see section 8.1.13). The portions of merchantable trees that do not have commercial value are likewise decayed linearly over ten years (see section 8.1.6). The same process in P2, U1, and U2 is assumed to occur in Baseline Type U3, but merchantable trees are conservatively assumed to be removed first in the stratum with the lowest carbon stocks and last in the stratum with the highest carbon stocks (see section 8.1.2).

The baseline scenario for above-ground merchantable trees is directly related to the biomass emissions model (see section 8.1.1), which predicts the emissions from deforestation and degradation over time, the decay of wood products over time (see section 8.1.13), and decay of slash (see section 8.1.6). In all

cases, it is possible that above-ground merchantable tree biomass will exist after the agents of deforestation have acted upon the forest. This residual biomass should be determined using permanent plot measurements in the proxy area (see section 6.4), as prescribed in Appendix B. The proportion of above-ground merchantable trees that is converted to long-lived wood products is addressed under the scenario for wood products (see section 6.19.7).

6.19.2 Baseline Scenario for AGOT and AGNT

In Baseline Types P1, P2, U1, U2 and U3, above-ground portions of trees that are not commercially viable (i.e. other trees that are not merchantable) and above-ground non-tree biomass are assumed to be immediately burned during clearing of the land or converted to fuel wood and burned (see section 8.1.1). The same process is assumed to occur in Baseline Type U3 where AGOT and AGNT are conservatively assumed to be converted to an emission first in the stratum with the lowest carbon stocks and last in the stratum with the highest carbon stocks (see section 8.1.2).

The baseline scenario for above-ground other trees and non-trees is characterized by the *biomass emissions model*. In all cases, it is possible that AGOT and AGNT biomass will exist after the agents of deforestation have acted upon the forest. This residual biomass should be determined using permanent plot measurements in the proxy area (see section 6.4), as prescribed in Appendix B.

6.19.3 Baseline Scenario for BGMT, BGOT, and BGNT

The only below-ground portions of trees and other below-ground biomass affected in during commercial activity in P1 are conservatively assumed to be that of merchantable trees killed by logging. This below-ground biomass is decayed over ten years (see section 8.1.7). After the completion of commercial activity, below-ground biomass is assumed to be removed or to decay over time in the soil as land is deforested and converted to its land end use.

In Baseline Types P2, U1, U2 and U3, below-ground biomass is assumed to be partially removed or to begin decay at the time of deforestation (see section 8.1.7). Below-ground biomass in Type U3 is conservatively assumed to be partially removed first in the stratum with the lowest carbon stocks and last in the stratum with the highest carbon stocks (see section 6.4).

The baseline scenario for below-ground biomass is directly related to the baseline emissions model. It is assumed that below-ground biomass is not converted to long-lived wood products.

6.19.4 Baseline Scenario for SD

Prior to deforestation, standing dead wood is assumed to be insignificantly impacted by commercial agents in Baseline Type P1. Following completion of commercial activity, the mass of standing dead wood not observed in the proxy area (see section 6.4), as compared to the project, is assumed to be removed, burned or converted to fuel wood by secondary agents.

Likewise in Baseline Types P2, U1, U2 and U3, the difference between standing dead wood stocks in the project and the proxy area is assumed to be immediately removed, burned or converted to fuel wood. The same process is assumed to occur in Baseline Type U3, though standing dead wood is conservatively assumed to be removed first in the stratum with the lowest carbon stocks and last in the stratum with the highest carbon stocks (see section 8.1.2).

The baseline scenario for standing dead wood is directly related to the biomass emissions model, which predicts emissions from degradation and deforestation over time. In all cases, it is possible that standing dead wood will exist after the agents of deforestation have acted upon the forest. This residual biomass should be determined using permanent plot measurements in the proxy area (see section 6.4), as prescribed in Appendix B. It is assumed that standing dead wood is not converted to long-lived wood products.

6.19.5 Baseline Scenario for LD

Lying dead wood is assumed to be impacted only slightly by commercial agents in Baseline Type P1. Following completion of commercial activity, the difference in lying dead wood stocks between the project and proxy area is assumed to be removed (see section 6.4), burned or converted to fuel wood by secondary agents.

In Baseline Types P2, U1, U2 and U3, the difference in lying dead wood stocks between the project and proxy area is assumed to be removed, burned or converted to fuel wood beginning immediately. In Baseline Type U3, lying dead wood is conservatively assumed to be removed first in the stratum with the lowest carbon stocks and last in the stratum with the highest carbon stocks.

The baseline scenario for lying dead wood is directly related to the baseline emissions model, which predicts emissions from degradation and deforestation over time. In all cases, it is possible that lying dead wood will exist after the agents of deforestation have acted upon the forest. This residual biomass should be determined using permanent plot measurements in the proxy area (see section 6.4), as prescribed in Appendix B. It is assumed that lying dead wood is not converted to long-lived wood products.

6.19.6 Baseline Scenario for SOC

Soil is assumed to lose its organic carbon over time as a result of land conversion to agriculture (E. Davidson & Ackerman, 1993). This loss is assumed to follow not only conversion to agriculture, but any non-forest end state with lower soil carbon stocks than the project area. The total loss is established by measurements in the proxy area (see section 6.4), while the rate is determined using one of three options given in section 6.14.

Commercial agents in Baseline Type P1 account for only slight soil carbon loss because they degrade the area but do not deforest it. As secondary agents subsequently act on and ultimately deforest the area soil carbon is assumed to eventually reach equilibrium as determined by measurements within the proxy area.

In Baseline Types P2, U1, U2 and U3 it is assumed that soil carbon will deplete to the SOC measured in the proxy area after a long period of time (see sections 6.4 and 8.1.3).

The baseline scenario for soil carbon is characterized by the soil emissions model (see sections 8.1.3, 8.1.4 and 8.1.5), which predicts the SOC emissions from deforestation over time (see section A.2 for a description of the model). Residual soil carbon should be determined using permanent plot measurements in the proxy area (see section 6.4), as prescribed in Appendix B.

6.19.7 Baseline Scenario for WP

Biomass remaining in wood products is assumed to be restricted to AGMT biomass (see sections 8.1.10, 8.1.11 and 8.1.12). The proportion of biomass remaining in wood products follows the procedure in section 8.1.13 and Appendix C.

6.20 Baseline Reevaluation

The baseline scenario shall be reevaluated per current VCS requirement. Prior to baseline reevaluation, the project proponent may choose to conduct a new PRA and subsequent analyses to re-appraise the baseline scenario (see section 6.1). The project proponent shall reassess certain elements of the baseline scenario per sections 6.20.1 and 6.20.2.

PD Requirements: Baseline Reevaluation
Upon a baseline revision, the project description shall include the following as of the current monitoring period:
PDR.85   All required documentation as specified in section 6 for the project prior to the baseline reevaluation.
PDR.86   All required documentation as specified in section 6 for the project after the baseline reevaluation including the reevaluation period.
PDR.87   A narrative of the reevaluation including any obstacles and how they were overcome.

6.20.1 Reevaluation of the Reference Area and Period

This section is to be applied separately for each identified project accounting area.

The reference area may be resized to be larger or smaller than prior to baseline reevaluation to reflect the following changes:

- Refine the boundaries of the reference area and delineate new boundaries to exclude any new REDD projects or additions to the project area, based on the results of the new PRA or expert knowledge.
- Extend the reference period – the new period should reflect the time since the start of the original reference period up to the time of the most recent baseline reevaluation.

The new reference area shall meet all requirements specified in section 6.7.1. If the new reference area does not meet these requirements, then the project is not eligible for additional crediting for monitoring periods subsequent to the baseline reevaluation until a new reference area can be defined that meets the requirements specified in section 6.7.1.

Projects that share the same reference area are eligible for crediting for all monitoring periods.

PD Requirements: Reevaluation of the Reference Area and Period

Upon a baseline revision, the project description shall include the following as of the current monitoring period:

PDR.88 A map of the new reference area.

6.20.2 Re-parameterization of α, β and θ

This section is to be applied separately for each identified project accounting area.

The baseline emissions models shall be re-parameterized by adding new observations of forest state per section 6.6 and the values for α, β and θ shall be reestimated per section 6.7. The data from observations of prior reference areas should remain unchanged even though the boundaries of the prior reference areas may be different than those of the current reference area. The re-parameterized values shall be used for all monitoring periods subsequent to baseline reevaluation.

PD Requirements: Re-parameterization of α, β and θ

Upon a baseline revision, the project description shall include the following as of the current monitoring period:

PDR.89 Summary of new data observed in the new reference area.

PDR.90 The re-parameterized values $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\boldsymbol{\theta}}$.

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7 PROCEDURE FOR DEMONSTRATING ADDITIONALITY

This methodology uses a project method for determining additionality.

Project proponents shall demonstrate additionality using the latest version of the VCS "Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities" (VCS, 2012), a project method for demonstrating additionality. Relevant applicability conditions (see section 4) for this methodology are as follows:

- Within the project area, project activities shall not lead to the violation of any law, even those laws which are not enforced.
- The most conservative baseline scenario is defined by deforestation.

The common practice test shall demonstrate that project activities will address at least one driver of deforestation in such a way that the driver would not have been addressed had the project not been undertaken.

PD Requirements: Demonstration of Project Additionality

The project description shall include the following:

PDR.91 A list of alternative land use scenarios to the project.

PDR.92 Justification for the selected baseline scenario. This justification can include expert knowledge, results from the participatory rural appraisal and ex-ante estimates of avoided emissions (see sections 6.1 and 8.4.6).

PDR.93 An investment or barriers analysis proving that the project is not the most economical option

PDR.94 A common practice analysis including a list of project activities and the drivers of deforestation that they address.

PDR.95 Evident compliance with the minimum requirements of the aforementioned VCS tool. This evidence may be the same as the evidence provided to meet reporting requirements listed in section 4.

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8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND/OR REMOVALS

Cumulative emissions reductions and/or removals are quantified as those since the project crediting period start date up to the end of the current monitoring period. Current gross emissions reductions and/or removals (GERs) are quantified as the difference between cumulative emissions up to the end of the current monitoring period and cumulative emissions up to the end of the previous monitoring period, minus any project emissions that have occurred during the current monitoring period, emissions from leakage and carbon not decayed in certain decay pools (see section 8.4.1).

Net emissions reductions and/or removals (NERs) are GERs minus a confidence deduction (if any) and buffer pool allocation (see section 8.4.3). NERs are determined for each project accounting area and if the project area contains multiple accounting areas, summed across project accounting areas (see sections 8.4.3 and 8.4.4).

For each project accounting area, apply sections 8.1, 8.2, 8.3.2, and 8.4.1. If the baseline scenario includes legally-sanctioned or illegal logging, use section 8.3.3 to determine market-effect leakage, if any. Use section 8.4.1 to determine GERs for each project accounting area.

8.1 Baseline Emissions

This section is to be applied separately for each identified project accounting area. The baseline emissions $E_{B\,\Delta}^{[m]}$ for the current monitoring period are given by [F.15]. This is a function of the cumulative baseline emissions at the begginging and end of the current monitoring period as given by [F.16]. After this quantity is verified, it becomes fixed when determining emissions at subsequent monitoring events. It is possible that $E_{B\,\Delta}^{[m]}$ could be less than zero due to conditions in the proxy area and parameter effects in the baseline emissions models over time. However for most projects, this value will be positive indicating baseline emissions would have occurred in the absence of the project.

If any of the following pools are not selected, their corresponding values in [F.15] are zero: SOC, BGB, DW or WP.

Monitoring Requirements: Baseline Emissions

The monitoring report shall include the following:

MR.10 Calculations of current *baseline emissions* $E_{B\,\Delta}^{[m]}$ as of the current monitoring period.

MR.11 Calculations of *baseline emissions* $E_{B\,\Delta}^{[m-1]}$ from prior monitoring periods.

MR.12 Calculations of cumulative *baseline emissions* for each selected pool ($E_{B\,BM}^{[m]}$ and $E_{B\,SOC}^{[m]}$) and undecayed carbon ($C_{B\,BGB}^{[m]}$, $C_{B\,DW}^{[m]}$, $C_{B\,SOC}^{[m]}$ and $C_{B\,WP}^{[m]}$), as of the current monitoring period.

8.1.1 Calculating Baseline Emissions from Biomass for Types P1, P2, U1 and U2

Baseline emissions from biomass are determined based on the baseline type and selected carbon pools. For each selected carbon pool in biomass (BM), the appropriate BEM is applied to calculate baseline emissions per the following sections. Baseline emissions from biomass for the current monitoring period

are based on the average carbon stock in selected carbon pools from AGMT, AGOT, AGNT, BGMT, BGOT and BGNT given by [F.17] for the project accounting area and [F.18] for the proxy area. This set of selected carbon pools in biomass $\mathcal{B}$ is a subset of all selected carbon pools $\mathcal{C}$ (see section 5.4).

The cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ as of monitoring period $[m]$ are calculated by equations [F.19], [F.20], [F.21], and [F.22] discussed in sections 8.1.1.1, 8.1.1.2, 8.1.1.3 and 8.1.1.4. Once verified, these quantities do not change when calculating baseline emissions for subsequent monitoring periods.

Monitoring Requirements: Baseline Emissions from Biomass for Types P1, P2, U1, U2 and U3

The monitoring report shall include the following:

MR.13   Calculations of cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ for the current monitoring period.

MR.14   Calculations of cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ for all prior monitoring periods.

8.1.1.1 Calculating Cumulative Baseline Emissions from Biomass for Type P1

The cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ as of monitoring period $[m]$ are calculated by [F.19]. The variables $c_{P\,BM}^{[m=0]}$ is the average carbon stocks in biomass as measured in the project account area prior to the first monitoring event, $c_{B\,BM}^{[m]}$ is the average carbon stocks in biomass as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These variables are monitored per section 9.

8.1.1.2 Calculating Cumulative Baseline Emissions from Biomass for Type P2

The cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ as of monitoring period $[m]$ are calculated by [F.20]. The variables $c_{P\,BM}^{[m=0]}$ is the average carbon stocks in biomass as measured in the project account area prior to the first monitoring event, $c_{B\,BM}^{[m]}$ is the average carbon stocks in biomass as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These varaibles are monitored per section 9.

8.1.1.3 Calculating Cumulative Baseline Emissions from Biomass for Type U1

The cumulative baseline *emissions* from biomass $E_{B\,BM}^{[m]}$ as of monitoring period $[m]$ are calculated by [F.22]. The variables $c_{P\,BM}^{[m=0]}$ is the average carbon stocks in biomass as measured in the project account area prior to the first monitoring event, $c_{B\,BM}^{[m]}$ is the average carbon stocks in biomass as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These varaibles are monitored per section 9.

8.1.1.4 Calculating Cumulative Baseline Emissions from Biomass for Type U2

The cumulative baseline emissions from biomass $E_{B\ BM}^{[m]}$ as of monitoring period $[m]$ are calculated by [F.21]. The variables $c_{P\ BM}^{[m=0]}$ is the average carbon stocks in biomass as measured in the project account area prior to the first monitoring event, $c_{B\ BM}^{[m]}$ is the average carbon stocks in biomass as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These variables are monitored per section 9.

8.1.2 Calculating Cumulative Baseline Emissions from Biomass for Type U3

When the baseline type is Type U3, a spatial model called the spatial algorithm is used to conservatively estimate baseline emissions from biomass by carbon pool per AFOLU requirement (see section 8.1.2.1). The cumulative baseline emissions from biomass $E_{B\ BM}^{[m]}$ as of monitoring period $[m]$ are calculated by [F.24] using the spatial algorithm (see section 8.1.2.1). Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods.

8.1.2.1 The Spatial Algorithm

Of all possible spatial models, the spatial algorithm is the most conservative possible for depleting carbon stocks in the baseline scenario.

To implement the spatial algorithm, first order the estimates of average carbon in biomass across all selected carbon pools in biomass from lowest to highest, $1, 2 \dots n$ by stratum for all strata in the project accounting area. Use [F.23] to estimate the average carbon in biomass for each stratum s.

This ordering should be conducted at the first monitoring period and then the order should be fixed for subsequent monitoring periods. Every monitoring period, apply the spatial algorithm given by [F.24] to determine cumulative emissions for each selected carbon pool in biomass. The spatial algorithm is denoted as $BEM_{SP}\left(c_{P\ 1\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}\right)$. The average carbon in biomass in the proxy area $c_{B\ BM}^{[m]}$ is given by [F.18].

Monitoring Requirements: Applying the Spatial Algorithm

The monitoring report shall include the following:

MR.15 The order of strata from lowest carbon stocks to highest carbon stocks based on the average across all pools.

MR.16 Calculations for each step which are carried through from monitoring period to monitoring period.

MR.17 Calculations of cumulative *baseline emissions* from biomass $E_{B\ BM}^{[m]}$ for prior monitoring periods.

8.1.3 Calculating Baseline Emissions from SOC for Types P1 and P2

Baseline emissions from SOC for Types P1 and P2 are calculated using the SEM. The cumulative baseline emissions from SOC $E_{B\,SOC}^{[m]}$ as of monitoring period $[m]$ are estimated by [F.25]. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods.

The current baseline emissions from SOC $E_{B\,\Delta SOC}^{[m]}$ are estimated as [F.26], which is the difference in cumulative baseline emissions for the current monitoring period $E_{B\,SOC}^{[m]}$ and the cumulative baseline emissions for the prior monitoring $E_{B\,SOC}^{[m-1]}$ (fixed at prior monitoring event). Current baseline emissions from SOC $E_{B\,\Delta\,SOC}^{[m]}$ are used to calculate carbon not decayed in soil (see section 8.1.8)

Monitoring Requirements: Baseline Emissions from SOC for Types P1 and P2

The monitoring report shall include the following:

MR.18 An estimate of current *baseline emissions* from SOC $E_{B\,\Delta\,SOC}^{[m]}$ as of the current monitoring period.

MR.19 An estimate of cumulative *baseline emissions* from SOC $E_{B\,SOC}^{[m]}$ for the current monitoring period.

MR.20 Calculations of cumulative *baseline emissions* from SOC $E_{B\,SOC}^{[m]}$ for all prior monitoring periods.

8.1.4 Calculating Baseline Emissions from SOC for Type U1

Baseline *emissions* from **SOC** for Type U2 are estimated using the SEM. The cumulative baseline *emissions* from **SOC** $E_{B\,SOC}^{[m]}$ as of monitoring period $[m]$ are estimated by [F.27]. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods.

The current baseline *emissions* from **SOC** $E_{B\,\Delta SOC}^{[m]}$ are estimated as [F.26] which is the difference in cumulative baseline *emissions* for the current monitoring period $E_{B\,SOC}^{[m]}$ and the cumulative baseline *emissions* for the prior monitoring period $E_{B\,SOC}^{[m-1]}$. Current baseline emissions from SOC $E_{B\,\Delta\,SOC}^{[m]}$ are used to calculate carbon not decayed in soil (see section 8.1.8)

Monitoring Requirements: Baseline Emissions from SOC for Type U1

The monitoring report shall include the following:

MR.21 An estimate of current *baseline emissions* from SOC $E_{B\,\Delta\,SOC}^{[m]}$ as of the current monitoring period.

MR.22 An estimate of cumulative *baseline emissions* from SOC $E_{B\,SOC}^{[m]}$ for the current monitoring period.

MR.23 Calculations of cumulative *baseline emissions* from SOC $E_{B\,SOC}^{[m]}$ for all prior monitoring periods.

8.1.5 Calculating Baseline Emissions from SOC for Types U2 and U3

Baseline emissions from SOC for Types U2 and U3 are estimated using the SEM. The cumulative baseline emissions from SOC $E_{B\ SOC}^{[m]}$ as of monitoring period $[m]$ are estimated by [F.28]. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods.

The current baseline emissions from SOC $E_{B\ \Delta SOC}^{[m]}$ are estimated as [F.26] which is the difference in cumulative baseline emissions for the current monitoring period $E_{B\ SOC}^{[m]}$ and the cumulative baseline emissions for the prior monitoring period $E_{B\ SOC}^{[m-1]}$. Current baseline emissions from SOC $E_{B\ \Delta\ SOC}^{[m]}$ are used to calculate carbon not decayed in soil (see section 8.1.8)

Monitoring Requirements: Baseline Emissions from SOC for Types U2 and U3

The monitoring report shall include the following:

MR.24 An estimate of current *baseline emissions* from SOC $E_{B\ \Delta\ SOC}^{[m]}$ as of the current monitoring period.

MR.25 An estimate of cumulative *baseline emissions* from SOC $E_{B\ SOC}^{[m]}$ for the current monitoring period.

MR.26 Calculations of cumulative *baseline emissions* from SOC $E_{B\ SOC}^{[m]}$ for all prior monitoring periods.

8.1.6 Calculating Carbon Not Decayed in DW

Calculate carbon in non-decayed DW using [F.35] where $\mathcal{M}$ is the set of all monitoring periods including the current and past monitoring periods. The cumulative emissions from DW $E_{B\ DW}^{[m]}$ are calculated by [F.33] where cumulative emissions from AGMT $E_{B\ AGMT}^{[m]}$ are calculated in sections 8.1.9, 8.1.10 and 8.1.11 and slash portion of total above-ground carbon stock $p_{SL}^{[m]}$ is estimated in B.2.7 as part of monitoring (see section 9. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods. For the first monitoring period, the cumulative emissions from the prior monitoring period, DW $E_{B\ DW}^{[i-1]}$ are zero.

Monitoring Requirements: Carbon Not Decayed in DW

The monitoring report shall include the following:

MR.27 An estimate of carbon stored in non-decayed DW $C_{\text{B }DW}^{[m]}$ for the current monitoring period.

MR.28 An estimate of cumulative *baseline emissions* from DW $E_{B\,DW}^{[m]}$ for the current monitoring period.

MR.29 An estimate of cumulative *baseline emissions* from AGMT $E_{B\,AGMT}^{[m]}$ for the current monitoring period.

MR.30 Calculations of cumulative *baseline emissions* from DW $E_{B\,DW}^{[m]}$ for all prior monitoring periods.

MR.31 Calculations of cumulative *baseline emissions* from AGMT $E_{B\,AGMT}^{[m]}$ for all prior monitoring periods.

8.1.7 Calculating Carbon Not Decayed in BGB

Calculate carbon in non-decayed BGB using [F.31] where $\mathcal{M}$ is the set of all monitoring periods including the current and past monitoring periods. The cumulative emissions from BGB $E_{B\,BGB}^{[m]}$ are calculated by [F.29] where cumulative emissions from biomass $E_{B\,BM}^{[m]}$ are calculated in section 8.1.1 or 8.1.2. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods. For the first monitoring period, the cumulative emissions from the prior monitoring period, BGB $E_{B\,BGB}^{[i-1]}$ are zero.

Monitoring Requirements: Carbon Not Decayed in BGB

The monitoring report shall include the following:

MR.32 An estimate of carbon stored in non-decayed BGB $C_{\text{B }BGB}^{[m]}$ for the current monitoring period.

MR.33 An estimate of cumulative *baseline emissions* from BGB $E_{B\,BGB}^{[m]}$ for the current monitoring period.

MR.34 Calculations of cumulative *baseline emissions* from BGB $E_{B\,BGB}^{[m]}$ for all prior monitoring periods.

8.1.8 Calculating Carbon Not Decayed in SOC

Calculate carbon in non-decayed SOC using [F.32], where λ_{SOC} is determined in section 6.18.1 and $\mathcal{M}$ is the set of all monitoring periods including the current and past monitoring periods. The cumulative emissions from SOC $E_{B\,SOC}^{[m]}$ are calculated in section 8.1.3, 8.1.4 or 8.1.5. Once verified, this quantity does not change when calculating baseline emissions for subsequent monitoring periods. For the first monitoring period, the cumulative emissions from the prior monitoring period, SOC $E_{B\,SOC}^{[i-1]}$ are zero.

| **Monitoring Requirements: Carbon Not Decayed in SOC** |
| **The monitoring report shall include the following:** |

MR.35 An estimate of carbon stored in non-decayed SOC $C_{B\,SOC}^{[m]}$ for the current monitoring period.

8.1.9 Calculating Cumulative Emissions from AGMT for Type P1

Calculate cumulative emissions from AGMT $E_{B\,AGMT}^{[m]}$ using [F.36]. If the BGMT pool is not selected then set $c_{P\,BGMT}^{[m=0]}$, $c_{B\,BGMT}^{[m=0]}$ and r_{RS} to zero. This quantity is used in sections 8.1.6 and 8.1.13, but not directly in the calculation of cumulative baseline emissions.

The variables $c_{P\,AGMT}^{[m=0]}$ is the average carbon stocks in above-ground merchantable trees as measured in the project account area prior to the first monitoring event, $c_{B\,AGMT}^{[m]}$ is the average carbon stocks in in above-ground merchantable trees as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These varaibles are monitored per section 9.

8.1.10 Calculating Cumulative Emissions from AGMT for Type P2

Calculate cumulative emissions from AGMT $E_{B\,AGMT}^{[m]}$ using [F.37]. If the BGMT pool is not selected then set $c_{P\,BGMT}^{[m=0]}$, $c_{B\,BGMT}^{[m=0]}$ and r_{RS} to zero. This quantity is used in sections 8.1.6 and 8.1.13, but not directly in the calculation of cumulative baseline emissions.

The variables $c_{P\,AGMT}^{[m=0]}$ is the average carbon stocks in above-ground merchantable trees as measured in the project account area prior to the first monitoring event, $c_{B\,AGMT}^{[m]}$ is the average carbon stocks in in above-ground merchantable trees as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These variables are monitored per section 9.

8.1.11 Calculating Cumulative Emissions from AGMT for Type U1

Calculate cumulative emissions from AGMT $E_{B\,AGMT}^{[m]}$ using [F.38]. If the BGMT pool is not selected then set $c_{P\,BGMT}^{[m=0]}$, $c_{B\,BGMT}^{[m=0]}$ and r_{RS} to zero. This quantity is used in sections 8.1.6 and 8.1.13, but not directly in the calculation of cumulative baseline emissions.

The variables $c_{P\,AGMT}^{[m=0]}$ is the average carbon stocks in above-ground merchantable trees as measured in the project account area prior to the first monitoring event, $c_{B\,AGMT}^{[m]}$ is the average carbon stocks in in above-ground merchantable trees as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These variables are monitored per section 9.

8.1.12 Calculating Cumulative Emissions from AGMT for Types U2 and U3

Calculate cumulative emissions from AGMT $E_{B\ AGMT}^{[m]}$ using [F.39]. If the BGMT pool is not selected then set $c_{P\ BGMT}^{[m=0]}$, $c_{B\ BGMT}^{[m=0]}$ and r_{RS} to zero. This quantity is used in sections 8.1.6 and 8.1.13, but not directly in the calculation of cumulative baseline emissions.

The variables $c_{P\ AGMT}^{[m=0]}$ is the average carbon stocks in above-ground merchantable trees as measured in the project account area prior to the first monitoring event, $c_{B\ AGMT}^{[m]}$ is the average carbon stocks in in above-ground merchantable trees as measured in the proxy area, $t^{[m]}$ is the time of the monitoring event and $x^{[m]}$ is the monitored covariates as of the time of the monitoring event. These variables are monitored per section 9.

8.1.13 Determining Carbon Stored in WP

If logging is included in the baseline scenario, carbon stored in long-lived wood products shall be accounted using Appendix C. To use Appendix C, certain measurements of carbon stocks in the project accounting area are required from monitoring (see section 9), determined using Appendix B.

Monitoring Requirements: Carbon Stored in Wood Products

The monitoring report shall include the following:

MR.36 Carbon stored in *long-lived wood products* $C_{B\ WP}^{[m]}$ after 100 years.

MR.37 Calculations to determine $C_{B\ WP}^{[m]}$.

8.2 Project Emissions

Project emissions for any monitoring period $[m]$ are calculated from the events of biomass consumption through forest fire, burning, logging or other disturbance. Current project emissions for the current monitoring period $E_{P\ \Delta}^{[m]}$ are estimated as [F.40]. Emissions from forest fire and logging are inherently captured by the monitoring of carbon stocks in the project area. Total project emissions for the current monitoring period can be negative if some major disturbance event occurs. The project proponent shall have sufficient ongoing observation of the project lands such that disturbance that is likely to be greater than *de minimus* will be detected. These observations may consist of staff on the ground, aerial observation, remote sensing, or some other method that captures deforestation in a timely manner.

This section is to be applied to each project accounting unit.

8.2.1 Calculating Emissions from Changes in Project Stocks

Emissions from forest fires, natural disturbance, logging and other events within the project accounting areas are inherently captured by the monitoring of forest carbon stocks. Nevertheless, maps of significant events are necessary to aid verification of carbon stock estimates. Current emissions from changes in project carbon stocks are calculated in [F.40] as the last term on the left-hand side, the difference between carbon stocks from the prior monitoring period and the current monitoring period. In order to estimate these carbon stocks, the project accounting areas may need to be re-stratified per Appendix B as part of monitoring (see section 9).

> **Monitoring Requirements: Emissions Events in Project Area**
>
> **The monitoring report shall include the following:**
>
> **MR.38** A map of the boundaries of any significant disturbance in the project accounting areas during the monitoring period.
>
> **MR.39** Evidence that plots were installed into these disturbed areas and were measured per section 9.

8.2.2 Calculating Emissions from Burning

Current emissions from the burning of woody biomass as a result of project activities in the project area shall be recorded as the weight (in tonnes) of woody biomass consumed during each burning event. If the production of sustainable charcoal occurs within the project accounting areas, then it shall be accounted for under emissions from burning. Emissions from the controlled burning of woody biomass are equivalent to the sum of all burning events $\mathcal{E}^{[m]}$ during the monitoring period as defined by [F.41].

> **Monitoring Requirements: Emissions from Burning from Project Activities**
>
> **The monitoring report shall include the following:**
>
> **MR.40** A table of events when woody biomass was burned during the monitoring period, showing the weight of woody biomass in tonnes and the date consumed.

8.2.3 Determining Carbon Stored in WP

If logging is a project activity, the project proponent can choose to measure the mass of logs exported from the project accounting areas and then apply an equation to account for milling inefficiencies, wastage and decay at the mill using procedures in Appendix C.

Wood lost due to wastage and milling inefficiencies over time is calculated and decayed per Appendix C.

> **Monitoring Requirements: Carbon Stored in Wood Products from Project Activities**
>
> **The monitoring report shall include the following:**
>
> **MR.41** Carbon stored in *long-lived wood products* $C_{P\,\Delta\,WP}^{[m]}$ after 100 years.
>
> **MR.42** Scale reports or records of carbon in *log production* by wood product type $C_{P\,ty}^{[m]}$.
>
> **MR.43** Calculations to determine $C_{P\,\Delta\,WP}^{[m]}$.

8.3 Leakage

This section is to be applied separately for each identified project accounting area. Depending on the baseline type, different sources of leakage shall be accounted for. *Emissions* from activity-shifting leakage are calculated using the Leakage Emissions Model and an activity-shifting leakage area while

emissions from market-effects leakage are estimated using a market-effects leakage area and default values specified in the AFOLU Requirements. Activity-shifting leakage applies to all projects while market-effects leakage applies to projects that cause a reduction in the supply of commodities (either legally sanctioned, illegal or both) in the baseline scenario.

Total emissions from leakage for the current monitoring period $E_{L\,\Delta}^{[m]}$ are calculated by [F.42]. The cumulative emissions from leakage for the current monitoring period are given by [F.43], the sum of cumulative emissions from activity-shifting $E_{L\,AS}^{[m]}$ and market-effects leakage $E_{L\,ME}^{[m]}$ for the current monitoring period. Once estimated for the current monitoring period, these cumulative emissions from leakage $E_{L}^{[m]}$ are fixed for subsequent monitoring periods.

If market-effects leakage is not considered, then cumulative emissions from market-effects leakage $E_{L\,ME}^{[m]}$ should be set to zero (see section 8.3.3). If the total emissions from leakage for the current monitoring period are negative (indicating "negative leakage") then the value of $E_{L\,\Delta}^{[m]}$ should be set to zero. VCS does not allow crediting for "negative leakage."

8.3.1 Leakage Mitigation Strategies

Projects shall include activities designed to reduce deforestation that results from at least one of the drivers identified in section 6.1. The types of activities most appropriate vary based on the specific drivers identified, as well as local socio-economic conditions. Examples of these activities may include, but are not limited to:

- Developing economic opportunities for local communities that encourage protection, such as employment as protected-area guards or ecotourism guides
- Developing alternative incomes not derived from forest destruction
- Introducing improved agricultural practices that result in a decreased demand for newly cleared land
- Developing sustainable means of producing fuel wood
- Developing sustainably-produced timber to replace supply eliminated by conservation of project lands
- Enhancing insecure land tenure to enable ongoing sustainable management of lands or investment in productive capacity of lands

Project activities shall be monitored in some way to demonstrate their effect on leakage mitigation. Possible monitoring approaches vary by project and may include:

- The number of people that directly benefit from the activity.
- The number of units distributed as a result of an activity (such as number of trees, foodstuffs, vaccines or dollars).
- The time devoted to implementing an activity.
- Community surveys about the effectiveness of an activity.

PD Requirements: Leakage Mitigation Strategies

The project description shall include the following:

PDR.96 A list of project activities designed to mitigate leakage.

Monitoring Requirements: Leakage Mitigation Strategies
The monitoring report shall include the following:

MR.44 A description of project activities that have been implemented since the project start date and the estimated effects of these activities on leakage mitigation.

8.3.2 Estimating Emissions from Activity-Shifting Leakage

Activity-shifting leakage is estimated by directly observing degradation and deforestation in the activity-shifting leakage area (see section 8.3.2.1). The project proponent shall establish leakage plots per the requirements below in this section and in Appendix B. The activity-shifting leakage area is identified by the project proponent as an area to which activity-shifting leakage is most likely to be displaced, and shall be monitored throughout the project lifetime for leakage that may be caused to the project activity.

In the instance where there is no accessible forested area to the agents of deforestation other than the project, then activity shifting leakage from the project cannot occur. In this instance, there need not be an activity shifting leakage area. This can be demonstrated using the PRA and/or expert knowledge, coupled to analysis of forested areas accessible to the agents of deforestation, those nearest to the project. In all other cases, there shall be one activity shifting leakage area for each project accounting area.

Cumulative emissions from activity-shifting leakage for the current monitoring period $E_{L\,AS}^{[m]}$ are estimated by [F.44] using the Leakage Emissions Model. Once verified, this quantity becomes fixed for subsequent monitoring periods. For the first monitoring period, cumulative emissions from activity-shifting leakage $E_{L\,AS}^{[m]}$ are zero. Carbon stocks in the project accounting area and the proxy area, $c_P^{[m]}$ and $c_B^{[m]}$ are the sum of all selected carbon pools for the current monitoring period (tCO2e/ha).

Monitoring Requirements: Estimating Emissions from Activity-Shifting Leakage
The monitoring report shall include the following:

MR.45 Calculated cumulative *emissions* from activity-shifting *leakage* for the current monitoring period $E_{L\,AS}^{[m]}$ and supporting calculations.

MR.46 Calculated cumulative *emissions* from activity-shifting *leakage* for the prior monitoring periods $E_{L\,AS}^{[m]}$.

If an activity-shifting leakage area is not installed, then include results from the participatory rural appraisal and/or expert knowledge, with an analysis of the nearest suitable forest cover for activity shifting leakage.

8.3.2.1 Delineating the Activity-Shifting Leakage Area

The activity-shifting leakage area shall be in the same general region as the project area, but not necessarily adjacent to the project area. As of the project start date, the activity-shifting leakage area shall be entirely forested and no larger than the project accounting area, or no larger than the geographic area in the case of grouped projects. The activity-shifting leakage area may not include the project area

but can overlap with the reference area. In many cases, the reference area will contain the activity-shifting leakage area. The activity-shifting leakage area may not be altered after the first monitoring period unless a baseline reevaluation is triggered per section 6.20.

The activity-shifting leakage area shall be delineated per the requirements of Appendix D.

If upon application of Appendix D the resultant activity-shifting leakage area is smaller than the project accounting area or cannot be defined (has zero size), the project proponent shall provide clear justification for the size of the area. This may be the case if the project proponent is protecting the last remaining forest in the region as a project activity. In this case, there may be few or no areas to which the agents can shift their activity.

The boundaries of the activity-shifting leakage area may be revised without requiring a baseline reevaluation if one of the following criteria is met:

1. Conservation activity is established in the activity-shifting leakage area such that the agents of deforestation no longer have access to the activity-shifitng leakage area or a portion thereof.

2. In the case of a grouped project where new project activity instance(s) is added in such a case that a new activity-shifting leakage area must be created its associated project accounting area.

The monitoring report shall reflect all changes to the activity shifting-leakage area.

PD Requirements: Delineation of the Activity-Shifting Leakage Area

The project description shall include the following information with respect to the *activity-shifting leakage area*:

PDR.97   A map of the delineated boundaries.

PDR.98   Maps of the landscape configuration, including:
  a. Topography (elevation, slope, aspect);
  b. Recent land use and land cover (either a thematic map created by the project proponent or publicly available map);
  c. Access points;
  d. Soil class maps (if available);
  e. Locations of important markets;
  f. Locations of important resources like waterways or roads; and
  g. Land ownership/tenure boundaries.

PDR.99   A narrative describing the rationale for selection of activity-shifting leakage area boundaries. If the activity-shifting leakage area is smaller than the project accounting area or cannot be defined, justification for the size of the area.

PDR.100 Results of a spatial analysis to demonstrate the activity-shifting leakage area is entirely forested as of the project start date.

PDR.101 Results of a spatial analysis to demonstrate the activity-shifting leakage area is no larger than the project accounting area.

Monitoring Requirements: Change to the Activity-Shifting Leakage Area

The monitoring report shall include the following if there is a change to the activity-shifting leakage area:

MR.47   A description and justification of the change to the activity-shifting leakage area.

MR.48   A map of the delineated boundaries.

MR.49   Maps of the landscape configuration, including:
   a.   Topography (elevation, slope, aspect);
   b.   Recent land use and land cover (either a thematic map created by the project proponent or publicly available map);
   c.   Access points;
   d.   Soil class maps (if available);
   e.   Locations of important markets;
   f.   Locations of important resources like waterways or roads; and
   g.   Land ownership/tenure boundaries.

MR.50   A narrative describing the rationale for selection of activity-shifting leakage area boundaries. If the activity-shifting leakage area is smaller than the project accounting area or cannot be defined, justification for the size of the area.

MR.51   Results of a spatial analysis to demonstrate the activity-shifting leakage area is entirely forested as of the project start date.

MR.52   Results of a spatial analysis to demonstrate the activity-shifting leakage area is no larger than the project accounting area.

8.3.2.2 The Leakage Emissions Model

The Leakage Emissions Model given by [F.45] estimates cumulative emissions from activity-shifting leakage and is based on the parameterization of α, β and θ and others from section 6.6.

Upon baseline reevaluation, the leakage model is updated to reflect the re-parameterization of α, β and θ (see section 6.20) and other parameters remain unchanged per section 6.20.

8.3.2.3 Estimating $p_{L\,DEG}^{[m]}$

The parameter $p_{L\,DEG}^{[m]}$ is estimated at least every five years using Appendix B and monitoring requirements (see sections B.2.8 and 9). This parameter shall be applied each monitoring event including for the first monitoring period despite zero leakage. Although Appendix B does not prescribe sample sizes to estimate this parameter, it is in the project proponent's best interest to choose a large enough sample size in order to minimize sampling variation that may result in sudden leakage events. For instance, this may occur if the project proponent installs fifteen leakage plots per Appendix B and in monitoring period five, one of them is entirely deforested.

Monitoring Requirements: Estimating $p_{L\,DEG}$

The monitoring report shall include the following:

MR.53   The estimated value $\hat{p}_{L\,DEG}^{[m]}$ for the current monitoring period and supporting calculations.

MR.54   The calculated value $\hat{p}_{L\,DEG}^{[m=0]}$ calculated for the first monitoring period.

8.3.3 Determining Emissions from Market-Effects Leakage

Market-effects leakage is caused by the interaction between supply and demand when commercial logging is included in the baseline scenario. A reduction in supply of wood products may result in increased logging elsewhere within national boundaries. This shift in production shall be accounted for, per AFOLU Requirements.

Refer to sections 8.3.3.2 and 8.3.3.3 to determine if emissions from market-effects leakage shall be accounted for. If market-effects leakage shall be accounted for, then the cumulative emissions from market-effects leakage $E_{L\,ME}^{[m]}$ is estimated as [F.46] where $p_{L\,ME}$ is determined at the time of validation from Table 6 and $E_{B\,AGMT}^{[m]}$ is estimated each monitoring period by equations given in sections 8.1.1.1 or 8.1.1.2.

If emissions from market-effects leakage do not need to be accounted for, the cumulative emissions from market-effects leakage $E_{L\,ME}^{[m]}$ for every monitoring period will be zero. The value $p_{L\,ME}$ shall be estimated at the time of validation and then this quantity does not change for calcuations at subsequent monitoring events (see section 8.3.3.4).   If this quantity is zero, it must be justified per the requirements in sections 8.3.3.1 and 8.3.3.2.

Monitoring Requirements: Determining Emissions from Market-Effects Leakage

The monitoring report shall include the following:

MR.55   Estimated cumulative *emissions* from market-effects *leakage* for the current monitoring period $E_{L\,ME}^{[m]}$ and supporting calculations.

MR.56   Calculated cumulative *emissions* from market-effects *leakage* for the prior monitoring periods $E_{L\,ME}^{[m]}$.

8.3.3.1 Ensuring Constancy of Baseline Operator Management

For baseline types P1 and P2, if the specific agent of deforestation is known, the management plan and/or land-use designations for the baseline agent's other lands shall be demonstrated to have been unchanged due to project implementation.

Monitoring Requirements: Ensuring Constancy of Baseline Operator Management

The monitoring report shall include the following:

MR.57 Provide evidence in the form of GIS imagery, PRA evidence, or the baseline operator's management plan that management plans or land-use designations have not changed in the baseline operator's other lands.

8.3.3.2 Determining Market-Effects Leakage for Type P1 Baseline

Use Table 6 to determine the market-effects *leakage* factor. If legally-sanctioned commercial logging causes the *cascade of degradation* as in the Type P1 baseline type and there are no comparable concessions available to the primary agent, then no market effects *leakage* can occur.
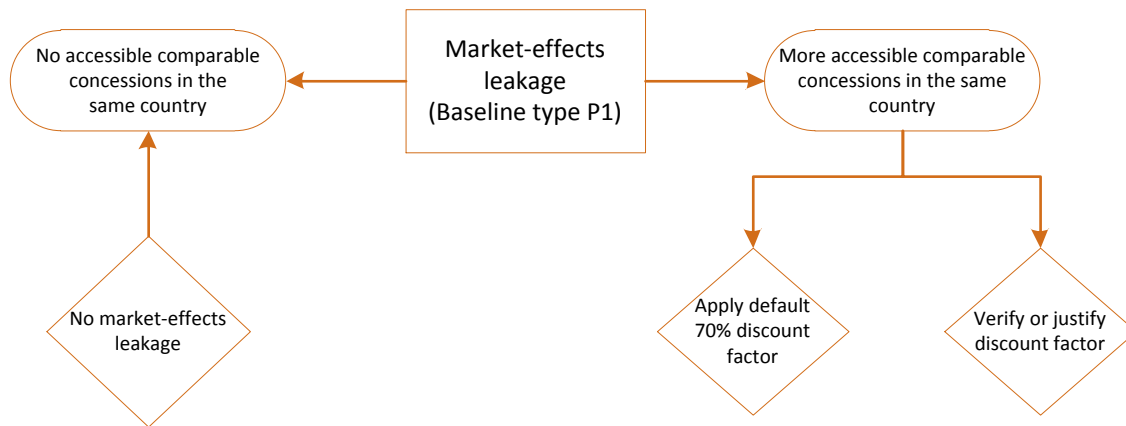
Figure 12: Decision tree for market effects leakage in baseline type P1
This is a decision tree for baseline type P1, in which there is commercial logging in the baseline. If there are no more comparable concessions within the same national boundaries to which the primary agent can move, then market-effects leakage is precluded because legal logging cannot increase.

In a type P1 baseline, market effects leakage is an effect of the reduction in timber harvested from the project area. In the case that all available comparable concessions (those with equivalent or substitutable products) within the same national boundaries have been allocated, and all legally sanctioned operators are cutting to the maximum allowable limit, then the supply of legal timber from the national market is fixed. In this case, there is no more timber legally available for harvest, and so a change in the harvest volume to meet demand cannot occur. If there are barriers to an alteration of the rate of illegal logging which follows legal logging (i.e. primary and secondary agents) or illegal logging cannot increase in the same country, than leakage from illegal logging may be *de minimus* or not occur.

If, on the other hand, comparable concessions are available or other legal or illegal operators can increase their harvest volumes, than leakage can occur as a result of the project. In this eventuality, project proponents may either take the most conservative discount factor of 70% or follow the procedure to determine the market discount factor in section 8.3.3.4.

8.3.3.3 Determining Market-Effects Leakage for Types P2 and U Baselines

Use Table 6 to determine the market-effects *leakage* factor. For these baseline scenarios, market-effects leakage is due to the change in supply of market commodities due to the project, if any.
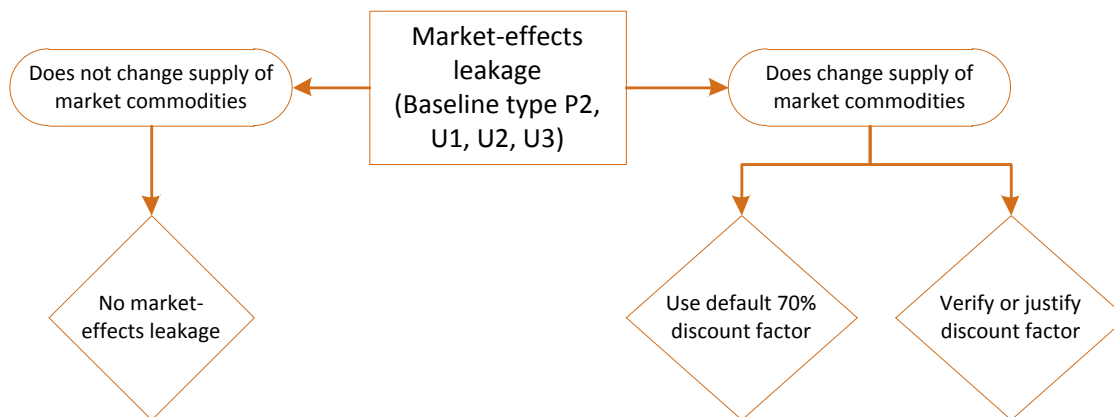
Figure 13: Decision tree for baseline types P2, U1, U2 and U3
In the case that the project does not affect the supply of market commodities, then market-effects leakage does not occur.

For baseline types P2, U1, U2, and U3, if the project affects the supply of commercial goods, leading to increased GHG emissions in other locations in the same country, then market leakage has occurred. If this is the case, the project proponent should use the procedures in 8.3.3.4 or use the most conservative leakage discount factor of 70%.

If there is no change in market commodities due to the project, market-effects *leakage* does not occur and need not be accounted for.

8.3.3.4 Determining the Market-Effects Discount Factor

Discount factors are specified in the AFOLU Requirements to determine market-effects leakage and are given in Table 6. The default factor of 0.7 can always be selected as conservative.

The market-effects discount factor shall be justified or verified, determined using one of two approaches:

1. Justified using peer-review publication, government publication or scientific literature.

2. Verified by an estimate of merchantable biomass to biomas in a market-effects leakage area.

If necessary, establish the *market-effects leakage area* per section 8.3.3.5. In the *market-effects leakage area*, estimate $c_{L\,AGMT}$ and $c_{L\,BM}$ where $c_{L\,BM}$ is given by [F.47] and $\mathcal{B}$ is the set of all selected carbon pools in biomass (from AGMT, AGOT, AGNT, BGMT, BGOT and BGNT). These estimates shall be established at the time of validation using Appendix B or literature.

$p_{L\,ME}$	Condition
0.1*	Project activity leads to a shift in harvests across time periods but minimal change in total timber harvest over time
0.2	$$\frac{c_{L\,AGMT}}{c_{L\,BM}} > \frac{c_{P\,AGMT}^{[m=1]}}{c_{P\,BM}^{[m=1]}}$$
0.4	$$\frac{c_{L\,AGMT}}{c_{L\,BM}} > \frac{c_{P\,AGMT}^{[m=1]}}{c_{P\,BM}^{[m=1]}} + 0.15$$
0.4	$$\frac{c_{L\,AGMT}}{c_{L\,BM}} < \frac{c_{P\,AGMT}^{[m=1]}}{c_{P\,BM}^{[m=1]}} - 0.15$$
0.7	$$\frac{c_{L\,AGMT}}{c_{L\,BM}} < \frac{c_{P\,AGMT}^{[m=1]}}{c_{P\,BM}^{[m=1]}}$$

Table 6: Market-effects discount factors by proportion of merchantable biomass, *market-effects leakage area* to project area.
* If the lowest factor in the table is selected, it shall be justified by the project proponent.

PD Requirements: Determining the Market-Effects Discount Factor

The project description shall include the following:

PDR.102   The selected discount factor $p_{L\,ME}$.

PDR.103   Calculations of $c_{L\,AGMT}$ in the *market-effects leakage area*, including references to literature if cited.

If the lowest discount factor (0.1) is selected from Table 6 or is not determined using a market-effects leakage area, the project description shall include the following:

PDR.104   Justification for the selection of the discount factor.

8.3.3.5 Delineating the Market-Effects Leakage Area

The market-effects leakage area shall be in the same country as the project area, but not necessarily adjacent to the project area. As of the project start date, the market-effects leakage area shall be entirely forested and be as large as or larger than the project accounting area. The market-effects leakage area shall not include the project area or the reference area. The market-effects leakage area shall not be altered after the time of validation.

PD Requirements: Delineation of the Market-Effects Leakage Area

The project description shall include the following information with respect to the market effects leakage area if such an area is defined:

PDR.105 A map of the delineated boundaries.

PDR.106 Maps of the landscape configuration, including:
   a. Topography (elevation, slope, aspect);
   b. Recent land use and land cover (either a thematic map created by the project proponent or publicly available map);
   c. Access points;
   d. Soil class maps (if available);
   e. Locations of important markets;
   f. Locations of important resources like waterways or roads; and
   g. Land ownership/tenure boundaries.

PDR.107 A narrative describing the rationale for selection of market-effects leakage area boundaries.

PDR.108 Results of a spatial analysis to demonstrate the market-effects leakage area is entirely forested as of the project start date.

PDR.109 Results of a spatial analysis to demonstrate the *market-effects leakage area* is as large or larger than the *project accounting area*.

8.4 Summary of GHG Emission Reductions and/or Removals

To quantify NERs, first quantify GERs including the confidence deduction (if any) and subtract the buffer account allocation. For validation and planning purposes, *ex-ante* estimates may be generated (see sections 8.4.1 and 8.4.3). *Ex-ante* estimates are not eligible for crediting (see section 8.4.6). These quantities should be calculated for each project accounting area. If multiple project accounting areas exist in the project area, then NERs should be summed across project accounting areas per section 8.4.4.

8.4.1 Quantifying Gross Emissions Reductions

The GERs for a monitoring period $[m]$ and project accounting area are quantified as [F.48]. Quantified GERs should be rounded down to the nearest whole number.
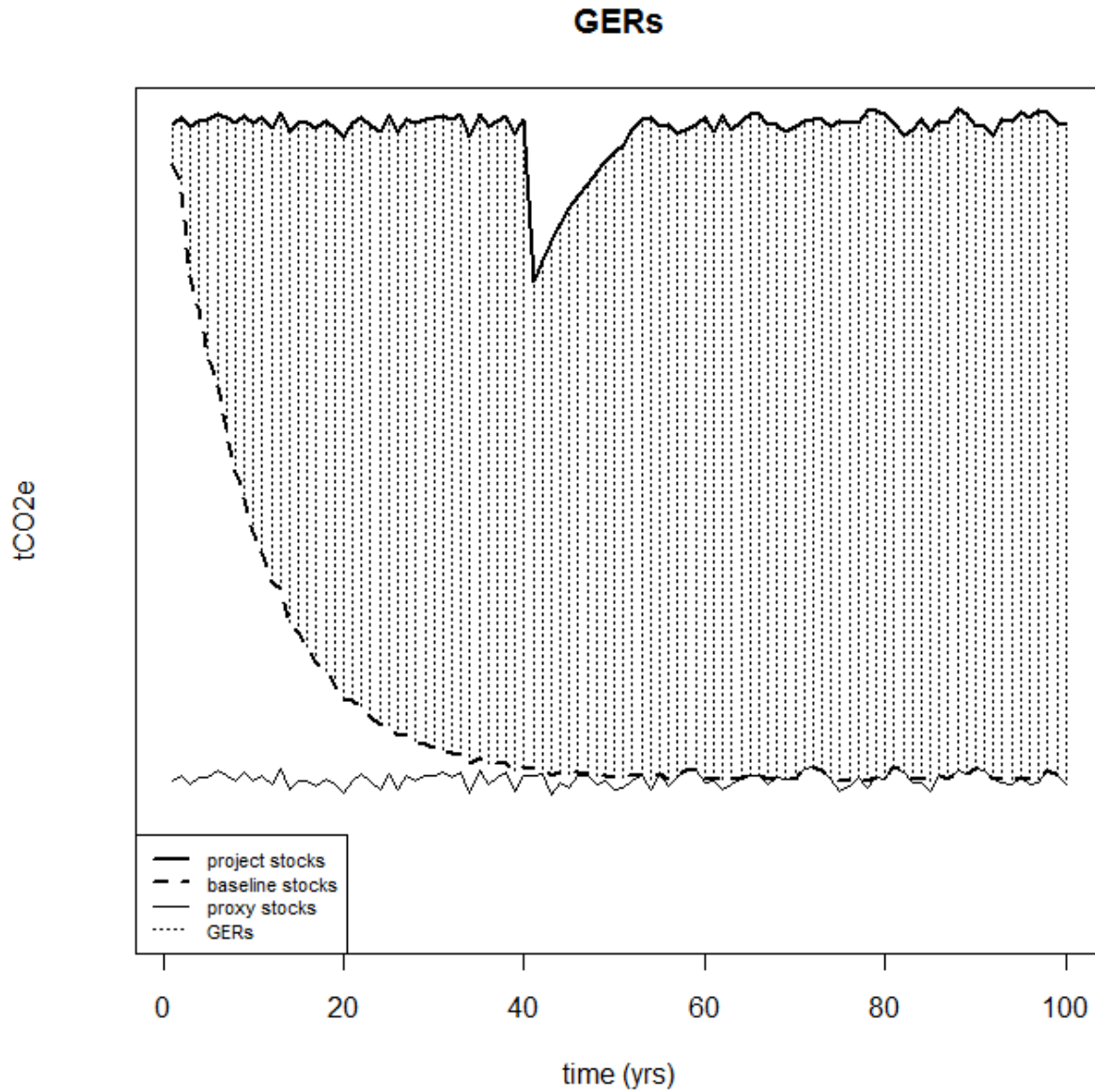
GERs

Figure 14: A hypothetical graph of gross emissions reductions over time.
This figure represents hypothetical GERs over time, where the difference between the project and the baseline stocks are the GERs, and monitored proxy stocks determine the lowest possible stocks in the baseline. The temporary drop in GERs in year 40 of this graph represents a major emissions event such as fire or hurricane that resulted in an efflux of GHG gases from the project. This hypothetical graph does not show discounts for leakage or uncertainty.

Monitoring Requirements: Quantification of GERs
The monitoring report shall include the following:

MR.58   Quantified GERs for the current monitoring period including references to calculations.

MR.59   Quantified GERs for the prior monitoring period.

MR.60   A graph of GERs by monitoring period for all monitoring periods to date.

8.4.1.1 Determining Deductions for Uncertainty

The confidence deduction $E_U^{[m]}$ is determined by [F.52], which is a linear combination of weighted standard errors of estimates from baseline emissions models and carbon stock measurements. The confidence deduction is not based on propagation of error. If the confidence deduction $E_U^{[m]}$ is negative, then it should be set to zero.

Monitoring Requirements: Confidence Deduction
The monitoring report shall include the following:

MR.61   The confidence deduction $E_U^{[m]}$ and estimated standard errors used to determine the confidence deduction.

MR.62   Reference to calculations used to determine the confidence deduction.

8.4.1.2 Using a Linear Model for Gross Emissions Reductions

A linear model for GERs may be used as long as the GERs generated by the linear model are conservatively less than GERs quantified by [F.48] for each project accounting area. Quantified GERs should be rounded down to the nearest whole number. The linear model may change from monitoring period to monitoring period as long as the GERs predicted by the linear model are conservatively less than [F.48].

Monitoring Requirements: Quantification of NERs Using a Linear Model
The monitoring report shall include the following if a linear model is selected:

MR.63   The linear model used to generate GERs for the current monitoring period.

MR.64   A graph of GERs from the linear model by monitoring period for all monitoring periods to date that used a linear model.

8.4.2 Determining Reversals

In the event that the quantified GERs for any monitoring period are negative as a result of carbon stock losses, the project proponent shall follow the VCS procedures for reversals as set out in the latest version of the VCS. If subsequent to baseline reevaluation per section 6.20, the new baseline emissions models

fall below the old model this does not constitute a reversal. Rather if credits were generated from avoided deforestation prior to baseline reevaluation at a level greater than predicted by the new baseline model after baseline reevaluation, then the project proponent may not generate any new credits from avoided deforestation until the new baseline emissions models reaches the previous level of predicted deforestation that generated these credits.

At the end of the project crediting period, the project proponent shall estimate the final level of cumulative baseline emissions using the most current baseline emissions model and use this estimate to quantify the total number of cumulative credits per equation [F.48]. If this estimate is greater than the number of credits issued during the project crediting period, then this difference shall be subtracted from the buffer account.

Monitoring Requirements: Reversal Event

The monitoring report shall include the following if there is a reversal:

    MR.65   A description of the reversal including which pools contributed to the reversal and reasons for its occurrence.

8.4.2.1 Determining Reversals as a Result of Baseline Reevaluation

If immediately upon baseline reevaluation GERs for the current monitoring period $E_{\Delta\,GER}^{[m]}$ (as determined by [F.48]) are negative, this event does not constitute a reversal if the project proponent can demonstrate that this event was caused by new data observed in the reference area. However if this event is not a reversal, the project is not eligible for crediting until the sum of GERs to-date $E_{GER}^{[m]}$ as determined by [F.49] are once again positive.

If after baseline reevaluation GERs for subsequent monitoring periods after the monitoring period immediately following the baseline reevaluation are negative, those GERs $E_{\Delta\,GER}^{[m]}$ constitute reversals.

Monitoring Requirements: Reversal Event as a Result of Baseline Reevaluation

The monitoring report shall include the following if there is a reversal as a result of baseline reevaluation:

    MR.66   A description of the reversal including a summary of new data obtained in the reference area.

8.4.3 Quantifying Net Emissions Reductions for a PAA

The total NERs generated during a monitoring period $[m]$ are determined by [F.50], which are GERs minus buffer account allocation.

Monitoring Requirements: Quantification of NERs for a PAA

The monitoring report shall include the following:

MR.67   Quantified **NERs** for the current monitoring period including references to calculations.

MR.68   Quantified **NERs** for the prior monitoring period.

MR.69   A graph of **NERs** by monitoring period for all monitoring periods to date.

8.4.3.1 Determining Buffer Account Allocation

Determining the allocation of GERs to the buffer account should conform to current VCS requirements. Those GERs allocated to the buffer account are denoted by $E_{BA}^{[m]}$.

Monitoring Requirements: Buffer Account

The monitoring report shall include the following:

MR.70   Reference to the VCS requirements used to determine the buffer account allocation.

MR.71   Reference to calculations used to determine the buffer account allocation.

8.4.4 Quantifying Net Emissions Reductions across PAAs

In the case where there are multiple project accounting areas in a single project area, NERs for each accounting area should be summed by determine the total NERs for the current monitoring period for the project.

Monitoring Requirements: Quantification of NERs across PAAs

The monitoring report shall include the following:

MR.72   Quantified NERs for the current monitoring period including references to calculations.

MR.73   Quantified NERs for the prior monitoring period.

MR.74   A graph of NERs by monitoring period for all monitoring periods to date.

8.4.5 Determining Vintages in a Monitoring Period

When the current monitoring period spans more than one calander year, NERs shall be allocated by year proportional to the number of calenders days in each year relative to the total number of days in the current monitoring period.

Monitoring Requirements: Vintages

The monitoring report shall include the following:

> **MR.75**   Quantified NERs by vintage year for the current monitoring period including references to calculations.

8.4.6 *Ex-Ante* Estimation of NERs

Under the VCS, *ex-ante* estimates of the net carbon benefits of the project are only required to determine whether decreases in carbon pools or increases in GHG emissions are insignificant and need not be measured and monitored. Additionally, e*x-ante* estimates of project benefits may be useful to project proponents for planning purposes. Use the project crediting period to estimate *ex-ante* project benefits.

The most significant factor in estimating project carbon benefits is likely to be an estimate of avoided baseline emissions which is derived from an estimate of carbon stocks and the baseline models. Estimates of *ex-ante* avoided baseline emissions can be made by assuming that the total carbon stock in the project area is equal to the initial carbon stock for each future monitoring period. This conservatively ignores growth of the existing forest, assuming that each carbon pool is at a steady state prior to project initiation. The projected avoided baseline emissions are estimated by applying the baseline emissions models as described in sections 6 where monitoring period $[m]$ always indicates the initial carbon stock or IPCC defaults.

If project activities include woody biomass burning, the sustainable production of charcoal or logging, estimates of emissions due to these activities should be included in the *ex-ante* estimate of project benefits using the procedures in sections 8.4.1 and 8.4.3. The project proponent may assume that the demand for charcoal remains constant at a rate determined prior to project implementation. Because *ex-ante* data for leakage monitoring are unlikely to be available, *ex-ante* estimates of leakage should be estimated using expert knowledge and, if available, experience with past projects. For the purpose of assessing the significance of decreases in carbon pools or increases of emissions due to project activities, it is conservative to underestimate avoided baseline emissions and overestimate leakage and project emissions in *ex-ante* estimates of carbon benefits.

Using the assumptions outlined above, estimate the *ex-ante* NERs $E_{\Delta NER}^{[m]}$ for each monitoring period $[m]$ as [F.50] where $E_{\Delta GER}^{[m]}$ is GERs for the current monitoring period, $E_U^{[m]}$ is the confidence deduction and $E_{BA}^{[m]}$ is the buffer account allocation.

Reporting of *ex-ante* estimates is only required if the project proponent demonstrates that a carbon pool is expected to increase in the baseline or a project emissions source is excluded from accounting under the *de minimus* rule.

PD Requirements: *Ex-Ante* Estimation of NERs

In the case when *ex-ante* estimates are used to prove the significance of emissions sources or estimate the quantity of NERs over the project crediting period, the project description shall include the following:

PDR.110   The projected avoided baseline emissions, project emissions and leakage for each monitoring period and vintage year over the lifetime of the project.

PDR.111   A narrative description of sources used to estimate the leakage rate and demonstration that the estimated rate is conservative.

PDR.112   If included in project activities, a description of procedures used to estimate the rate of biomass burning, charcoal production or logging and demonstration that these estimates are conservative.

8.4.7 Evaluating Project Performance

Project performance shall be evaluated each monitoring event and deviations from ex-ante NERs shall be described. Deviations in credit generation from *ex-ante* estimates may result from changes in the quality of data (literature estimates versus carbon stock estimates), occurrence of disturbance events or baseline re-evaluation.

Monitoring Requirements: Evaluating Project Performance

The monitoring report shall include the following:

MR.76   Comparison of NERs presented for verification relative to NERs from *ex-ante* estimates.

MR.77   Description of the cause and effect of deviations from *ex-ante* estimates.

9 MONITORING

The procedures appropriate for estimating the carbon stock in each pool to be monitored are detailed in Appendix B. They provide a means of estimating the total carbon stock in selected pools within the project accounting area and the uncertainty of that estimate at a given point in time. These procedures are used both for establishing the initial carbon stock within the project accounting area and the carbon stock at each monitoring event $[m]$. Project proponents may deviate from the procedures detailed in Appendix B per current VCS requirement, including a description of the deviation and justification for the deviation.

This methodology employs fixed area plots coupled with allometric equations for estimating carbon stocks in trees. Carbon stocks in dead wood are estimated using fixed area plots for the standing dead wood pool and line intersect sampling for the lying dead wood pool. Allometric equations or destructive sampling may be used for estimating non-tree carbon stocks. Soil carbon is estimated using soil samples collected from soil cores or pits. Carbon in log production to wood products is estimated by estimating merchantable volume on fixed area measurement plots. These sampling procedures are designed to detect both increases in carbon stocks, such as those that occur as a result of forest growth, and decreases in carbon stocks, such as changes that may take place as a result of degradation or natural disturbance events.

Carbon stocks shall be estimated for the first monitoring period by sampling all plots in all strata in the project, activity-shifting leakage and proxy areas. After the first monitoring period, all plots and all strata in the project and the activity-shifting leakage areas shall be re-measured at least every five years, a process which may be accomplished on an intermittently rotating basis. If the baseline scenario includes commercial wood products and the project proponent elects to use the market leakage area, the proponent shall measure AGMT in the market-effects leakage area.

Project proponents shall install a stratified random sample of permanent plots in the project area and leakage areas and, if required based on the selected pools and guidance above, the proxy area. It is recommended that all quantities selected for measurement be measured on the same plots, but different sampling schemes for each pool may be employed if the project proponent determines that this improves the efficiency of sampling. In particular, soil carbon stocks may require a sampling framework distinct from that applied for other pools.

9.1 Data and Parameters Available at Validation

See Appendix G, list of variables, for a complete list of all variables, data and parameters and a description of the frequency of monitoring for each. These are the only variables that shall be reported in the PD.

PD Requirements: Data and Parameters Available at Validation

The project description shall include the following:

  PDR.113　　The value for each variable in Appendix G.

9.2 Data and Parameters Monitored

See Appendix H for a complete list of all variables monitored, data and parameters and a description of the frequency of monitoring for each. These variables shall be reported in the monitoring report along with metrics for leakage mitigation per section 8.3.1.

Generally, Appendix B should be used to monitor the project accounting area, activity-shifting leakage area and proxy area. However, the project proponent can request a deviation from these methods provided in Appendix B. All deviations shall be identified in the monitoring plan.

Monitoring Requirements: Data and Parameters Monitored

The monitoring report shall include the following:

MR.78   List of parameters from Appendix H, their values and the time last measured.

MR.79   Quality assurance and quality control measures employed for each.

MR.80   Description of the accuracy of each.

9.3 Description of the Monitoring Plan

The requirements for sampling depend on the baseline type identified for the project and the selected carbon pools. Pools may be conservatively excluded if the sum of all emissions from optional pools not selected is less than 5% of the total project benefit for the project lifetime. The conservative exclusion of *de minimus* pools can be demonstrated using *ex-ante* estimates (see section 8.4.6). Conservative exclusions shall always meet current VCS requirements. All plots shall be measured for the first verification. All leakage plots, proxy area plots and project accounting area plots shall be remeasured at least every five years, or after a significant event that changes stocks in the proxy or project accounting areas. Note that plots may not be re-measured every monitoring period if the length of the monitoring period is less than five years and there are no significant events that change carbon stocks.

All deviations from Appendix B shall be described in the monitoring report. At every monitoring (verification) event, new deviations to the monitoring plan shall be be described in the monitoring report.

PD Requirements: Description of the Monitoring Plan

In the case when *ex-ante* estimates are used to prove the significance of *emissions* sources or estimate the quantity of NERs over the project crediting period, the project description shall include the following:

PDR.114   Summary of sampling procedures for the project accounting areas, with a copy of a sampling protocol used to carry out measurements.

PDR.115   Summary of sampling procedures for the proxy areas, with a copy of a sampling protocol used to carry out measurements.

PDR.116   Summary of sampling procedures for the activity-shifting leakage areas, with a copy of a sampling protocol used to carry out measurements.

Monitoring Requirements: Description of the Monitoring Plan

The monitoring report shall include the following:

MR.81   Documentation of training for field crews.

MR.82   If included in project activities, a description of procedures used to estimate the rate of biomass burning and charcoal production and demonstration that these estimates are conservative.

MR.83   Documentation of data quality assessment such as a check cruise and plots of the data such as diameter distributions by strata or plot.

MR.84   Maps of a stratification (if any) and references to plot allocation.

MR.85   List of plot GPS coordinates.

MR.86   Description of plot sizes and layout (such as the use of nests and their sizes) for each carbon pool.

MR.87   If applicable, a detailed description of the process used to develop allometric equations, to include:
       a. Sample size
       b. Distribution (e.g. diameter) of the sample
       c. Model fitting procedure
       d. Model selection

MR.88   The estimated carbon stock, standard error of the total for each stock, and the sample size for each stratum in the area selected.

MR.89   Log export monitoring records and standard operating procedure in the project area, if there is commercial harvest in the project scenario.

MR.90   Deviations from the measurement methods set out in Appendix B or the monitoring plan, per current VCS requirement.

MR.91   The frequency of monitoring for each plot for all plots – all plots should be measured for the first verification. All leakage plots should be measured every verification, and all proxy and project accounting area plots at least every five years, or after a significant event that changes stocks.

9.3.1 Allometric Equations

When available, allometric equations from existing IPCC, government, or peer reviewed literature may be used. Equations should be derived from trees of a wide range of diameters and, if included, heights and should not be used beyond the size range for which they were developed. When equations are selected from literature, justification shall be provided for their applicability to the project area considering climatic, edaphic, geographical and taxonomic similarities between the project location and the location in which the equation was derived. When possible, species-specific equations should be used. If generalized equations developed for wide scale application are used, they shall be validated using the procedures below.

Allometric equations may change or be supplemented each monitoring period as allometry improves. Every monitoring period all selected equations must be justified per the following sections.

Monitoring Requirements: Sources of Allometry

The monitoring report shall include the following:

MR.92 A list of all selected allometric equations used to estimate biomass for trees and non-trees.

MR.93 For each selected allometric equation, a list of species to which it being applied and the proportion of the total carbon stocks predicted by the equation.

MR.94 For each selected allometric equation, indication of when it was first employed to estimate carbon stocks in the project area (monitoring period number and year of monitoring event).

MR.95 For each selected allometric equation, indication of whether was validated per sections 9.3.1.1 or 9.3.1.2.

MR.96 Documentation of the source of each selected allometric equation and justification for their applicability to the project area considering climatic, edaphic, geographical and taxonomic similarities between the project location and the location in which the equation was derived.

9.3.1.1 Validating Previously Developed Allometric Equations

When equations are taken or modified from existing literature that is not similar to the project area as described above or are selected from a biome-wide database, such as those provided in Tables 4.A.1 to 4.A.3 of the GPG-LULUCF (IPCC, 2006), they shall be verified by measurements of trees within the project area or in stands similar to the project stands in the same forest type as project stands and near the project area. It is always best and most accurate to use equations developed from trees in the project area or from existing literature that is based on research in areas similar to the project area. The project proponent should commit to improve and update allometric equations over time to reduce uncertainty.

Equations may be validated by showing good correspondence of predictions from the equation to field measurements of biomass based on: (a) destructive harvesting of trees in or near the project area, (b) direct physical measurements of at least the bole, and major branch segments combined with valid expansion factors for branches and foliage. (c) a combination of direct measurement of boles and use of conservative expansion factors or a sampling approach for branches that precludes double-counting branch and bole measurement.

An equation must be validated using a representative sample within the size range observed in the inventory. The sample size shall be at least 30 unless the number of trees to which it is being applied is less than 100, in which case it shall be equal to 30% of the number of trees to which it is being applied.

An equation is valid if

1. The predicted biomass is within +/- 15% of that measured, using the measurement methods described above, determined by the ratio of the sum of all measurements to the sum of all predictions (ratio of sums).
2. OR the cumulative biomass for all measured trees in the validation sample are greater than that predicted by the equation.
3. OR an adjustment factor is applied to the equation that results in the predicted biomass being

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within +/-15% of the measured biomass using the methods described above.

In the case where the representative sample does not include a tree that is as large or larger than the largest tree in the inventory (a right-censored sample), the project proponent must demonstrate that the equation selected does not over-predict biomass for very large trees by demonstrating two additional criteria.

1. That the biomass measurement of the largest tree in the representative sample is greater than its predicted biomass by the equation.
2. That the equation behaves similarly beyond the range of measurements taken for the representative sample. To demonstrate this, do the following:
    a. Find the first order derivative of the equation.
    b. Determine the value of the derivative given the measurements of the largest tree in the representative sample.
    c. Determine the value of the derivative given the measurements of the largest tree in inventory to which the equation is applied.
    d. Compare the values from (b) and (c). The value from (c) shall be no more than 10% greater than the value from (b).

Monitoring Requirements: Validating Previously Developed Allometry

The monitoring report shall include the following:

MR.97   A list of allometric equations validated by destructive sampling.

MR.98   For each, the number of trees (or non-trees) destructively sampled and the location where the measurement were made relative to the project area.

MR.99   A field protocol used to measure destructively sampled trees (or non-trees).

MR.100   Justification that the field protocol for the destructive measurement method is conservatively estimates biomass.

MR.101   For each allometric equation in the list, a figure showing all the descriptive measurements of biomass compared to predicted values from its selected allometric equation.

9.3.1.2 Validating Newly Developed Allometric Equations

If allometric equations are developed for the project area, the guidance provided by Parresol (1999) should be used to fit appropriate statistical models. New models shall be validated using leave-one-out cross validation as follows:

Assume a model of the form $y = f(x)$, where y is measured biomass and x is a vector of regressors.

1. Temporarily remove observation (y_i, x_i) from the dataset used to fit the model.

1. Refit the model, f_{-i} , with the remaining data points and use it to estimate $\hat{y}_i$, the predicted biomass at the point that was removed from the dataset prior to model fitting as given by equation [B.22].

2. Estimate the cross-validated error for this data point, $\hat{e}_i$, expressed as a proportion of the true biomass using equation [B.23].

3. Repeat 1-3 for each observation.

4. Calculate the mean cross-validated error $\bar{E}$ as equation [B.24], where $\mathcal{X}$ is the set of all observations used in model fitting.

The developed equation is considered valid if $\bar{E} < 15\%$.

Monitoring Requirements: Validating Newly Developed Allometry

The monitoring report shall include the following:

MR.102   A list of allometric equations cross validated.

MR.103   For each, the number of trees (or non-trees) destructively sampled to build the equation and the location where the measurement were made relative to the project area.

MR.104   A field protocol used to measure trees (or non-trees) when developing the equation.

MR.105   Justification that the field protocol for the measurement method to build the equation conservatively estimates biomass.

MR.106   For each allometric equation in the list, the value of $\bar{E}$.

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10 REFERENCES AND OTHER INFORMATION

Arellano-Neri, O., & Frohn, R. C. (2001). Image-based logistic regression parameters of deforestation in Rondonia, Brazil. *IGARSS 2001. Scanning the Present and Resolving the Future. Proceedings. IEEE 2001 International Geoscience and Remote Sensing Symposium (Cat. No.01CH37217)* (Vol. 00, pp. 2236–2237). IEEE. doi:10.1109/IGARSS.2001.977960

Avery, T. E., & Burkhart, H. E. (2002). *Forest Measurements* (5th ed., p. 456). New York: McGraw-Hill Higher Education.

Congalton, R. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment*, *37*(1), 35–46. doi:10.1016/0034-4257(91)90048-B

Davidson, A. C. (2003). *Statistical Models* (p. 736). Cambridge, UK: Cambridge University Press.

Davidson, E., & Ackerman, I. (1993). Changes in soil carbon inventories following cultivation of previously untilled soils. *Biogeochemistry*, *20*(3), 161–193. Retrieved from http://www.springerlink.com/index/6617U13K3561VW04.pdf

Freedman, D. A. (2009). *Statistical Models: Theory and Practice* (2nd ed.). Cambridge, UK: Cambridge University Press.

Freese, F. (1962). Elementary Forest Sampling. Washington, D. C.: US Department of Agriculture Handbook 232.

IPCC. (2003). LUCF Sector Good Practice Guidance. *Good practice guidance for landuse, land-use change and forestry*. Retrieved October 15, 2010, from http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.html

Kaimowitz, D., Mendez, P., Puntodewo, A., & Vanclay, J. K. (2002). Spatial regression analysis of deforestation in Santa Cruz, Bolivia. In C. Wood & R. Porro (Eds.), *Deforestation and land use in the Amazon* (Vol. 1, pp. 41–65). Gainesville: University Press of Florida. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.61.9344&rep=rep1&type=pdf

Linkie, M., Smith, R. J., & Leader-Williams, N. (2004). Mapping and predicting deforestation patterns in the lowlands of Sumatra. *Biodiversity and Conservation*, *13*(10), 1809–1818. doi:10.1023/B:BIOC.0000035867.90891.ea

Lohr, S. L. (2009). *Sampling: Design and Analysis (Advanced Series)* (2nd ed., p. 608). Pacific Grove, Calif: Duxbury Press.

Ludeke, a, Maggio, R., & Reid, L. (1990). An analysis of anthropogenic deforestation using logistic regression and GIS. *Journal of Environmental Management*, *31*(3), 247–259. doi:10.1016/S0301-4797(05)80038-6

Mahapatra, K., & Kant, S. (2005). Tropical deforestation: a multinomial logistic model and some country-specific policy prescriptions. *Forest Policy and Economics*, *7*(1), 1–24. doi:10.1016/S1389-9341(03)00064-9

Olson, J. S. (1963). Energy Storage and the Balance of Producers and Decomposers in Ecological Systems Author (s): Jerry S . Olson Published by : Ecological Society of America Stable URL :

http://www.jstor.org/stable/1932179 Your use of the JSTOR archive indicates your acce. *America*, *44*(2), 322–331.

Parresol, B. R. (1999). Assessing tree and stand biomass: a review with examples and critical comparisons. *Forest Science*, *45*(4), 573–593. Retrieved from http://www.ingentaconnect.com/content/saf/fs/1999/00000045/00000004/art00014

Shiver, B. D., & Borders, B. E. (1996). *Sampling Techniques for Forest Resource Inventory* (p. 356). John Wiley and Sons. Inc.

Simpson, W. T., & Sagoe, J. A. (1991). *Relative Drying Times of 650 Tropical Woods Estimation by Green Moisture Content, Specific Gravity, and Green Weight Density*. *USDA FS GTR-71* (pp. 1–27). Madison WI.

VCS. (2010). *Tool for the demonstration and assessment of additionality in VCS Agriculture, Forestry and other land use (AFOLU) project Activities Tool VT001* (pp. 1–12). Washington, D.C. Retrieved from www.v-c-s.org/.../VCS-Tool-VT0001_Tool-for-Demonstration-and-Assessment-of-Additionality-in-AFOLU-Project-Acitivities.pdf

Venables, W. N., & Ripley, B. D. (2002). *Modern Applied Statistics with S* (4th ed., p. 495). New York, NY: Springer.

Williamson, G. B., & Wiemann, M. C. (2010). Measuring wood specific gravity...Correctly. *American Journal of Botany*, *97*(3), 519–24. doi:10.3732/ajb.0900243

Winjum, J., Brown, S., & Schlamadinger, B. (1998). Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science*, *44*(2), 272–284. Retrieved from http://www.ingentaconnect.com/content/saf/fs/1998/00000044/00000002/art00012

APPENDIX A: THEORETICAL BACKGROUND

A.1 Logistic Function for α, β and θ

This background section contains general information about the model and the selected approach to fitting the model rather than specific methods used to build the baseline emissions models, and is not required to run the model itself.

Deforestation over time is inherently bounded by the size of the area that is subject to deforestation and has been shown to exhibit logistic behavior over time (Arellano-Neri & Frohn, 2001; Kaimowitz, Mendez, Puntodewo, & Vanclay, 2002; Linkie, Smith, & Leader-Williams, 2004; Ludeke, Maggio, & Reid, 1990; Mahapatra & Kant, 2005). Figure 15 illustrates this behavior: the deforestation rate is low at beginning, steadily increases and tapers off at the end of the time period.
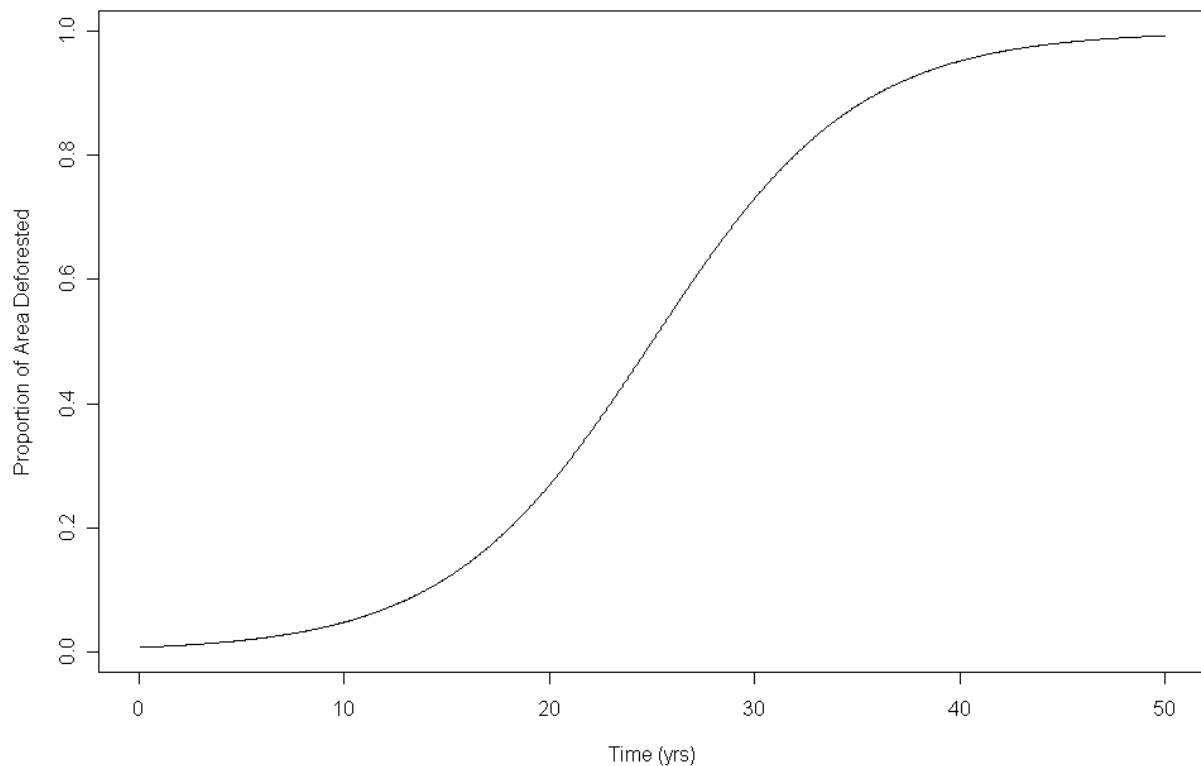
Figure 15: Generalized graph of logistic deforestation over time.
The logistic model of deforestation, showing the transition from forest to non-forest of a given area

This behavior can be interpreted using economic theory (*e.g.*, see Reis and Guzman 1992). At the beginning of deforestation in an area, agents are scarce and resources are plentiful; this leads to increasing resource exploitation. Conversely, toward the end, agents are plentiful and resources are scarce, decreasing exploitation.

Based on these concepts and their support in the literature as described above, this methodology assumes that deforestation is logistic when bounded by the reference area or project area. Specifically, it assumes that deforestation over time exhibits the implicit form defined by equation [A.4].

The parameter vector $\boldsymbol{\theta}$ included in equation [A.4] represents the aforementioned numeric covariates to deforestation which are identified using expert knowledge or the participatory rural appraisal. The function η is called the linear predictor given time and deforestation covariate parameters $\boldsymbol{\theta}$. Fitting equation [A.4] is equivalent to estimating the linear predictor as $\hat{\eta}$ where the linear predictor is defined by equation [A.5].

A.1.1 Probabilities and Weights for Forest State

Fitting [A.4] requires some historic information about the forest state in the space of the reference area over time. Observations of forest state (also called "forestation") in the reference area can be made over the reference period as a first step to fitting equation [A.4]. These observations can be made using a sample of unique points in time and space where the state observation for the ith sample point is defined by [48], which is a function of time t_i, latitude x_i and longitude y_i. State observations in space can be made at random or on a lattice (systematic grid). Since states are observed in historic images, however, observations in time can only be made at the times for which imagery is available.

Spatial availability of historic imagery over the reference area might not be uniform. Additionally, the entire space of the reference area might not be equally observed over time. To correct for any resulting bias, we estimate the probability of observing any one particular sample point using equation [A.1]. The probability of observing an image in time is not independent of space. For example, consider a scenario in which a government entity obtained aerial imagery along a highway for a road expansion project in the reference area five years prior to the project start date. Then, a second set of imagery was obtained after the road expansion was complete. Equation [A.3] accounts for the fact that the probability of observing an image in the reference area at any given time is dependent on that image's proximity to the construction project.

The conditional probability of observing a sample point in space given time is [A.2] and the probability of observing any sample point in time is simply the intensity of the process [A.3]. Hence the correction factor is proportional to the inverse of the probability of observing any one particular sample point which is [A.6], and is called the observation weight.
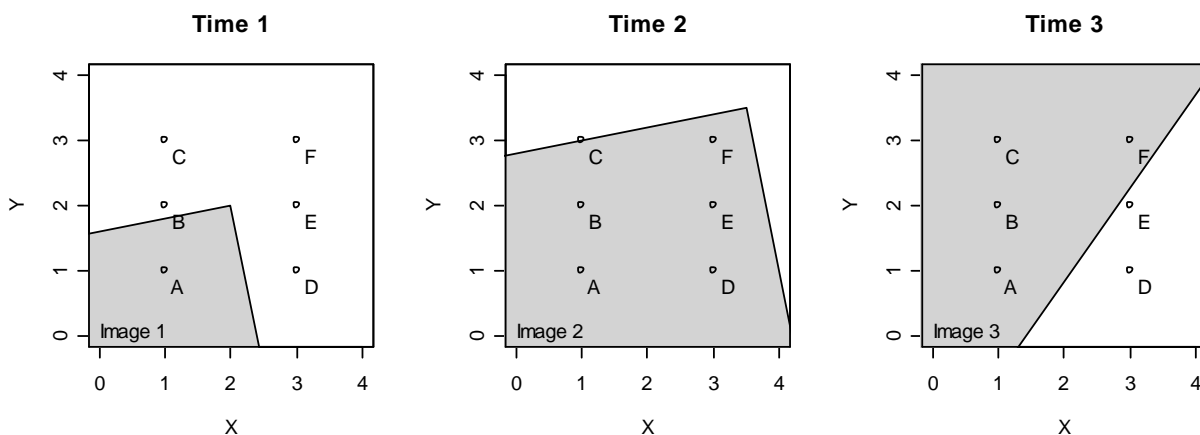
Figure 16: Examples for calculating observation weights.
An example of three images at different times used to calculate the observation weights of sample points.

For example, to calculate the observation weight of a point (x, y, t) as defined by equation [A.6], one must know the number of times the point was observed in the reference area and the number images that the point falls onto during the reference period where the point falls onto in the cloud-free portion of each image. If there are six points in the reference area and three images in the historic reference period, as shown in Figure 16, then the weight of point A at time 3 in the figure is calculated as

$$\frac{1}{3 \times 4} = \frac{1}{12}$$

while the weight of point D at time 2 is calculated as

$$\frac{1}{1 \times 5} = \frac{1}{5}.$$

Point D at time 2 is given more weight than point A at time 3 because it is observed less often.

The model defined by equation [A.4] is fit using iteratively reweighted least squares (IRLS) with initial weights w, the observation weights, and given the observed covariates and states o in vector format. See Venables & Ripley (2002) for information on how to fit a logistic model with IRLS using the free statistical program R.

Akaike Information Criterion (AIC) is used to select the best nested model in θ. See Davidson (2003) or Freedman (2009) for information about linear predictors and logistic models.

The residuals of the model defined by equation [A.4] are assumed to be stationary over the reference period. That is, the mean and variance of the residuals are time invariant.

After model selection and fitting, the cumulative deforestation as a proportion of an area can be predicted for future times using equation [A.4].

A.1.2 Linear Behavior of Emissions from Legally-Sanctioned Commercial Logging

In a planned commercial scenario, a baseline operator would degrade the forest at a given linear rate mandated by the cutting limits placed by the national government or the concession. When harvest is not sustainable (e.g. more volume is extracted than incremental growth in a given time and space) than the forest is degraded. If the baseline operator protects the area harvested from deforestation during forest operations but not afterwards, deforestation is preceded by linear degradation.
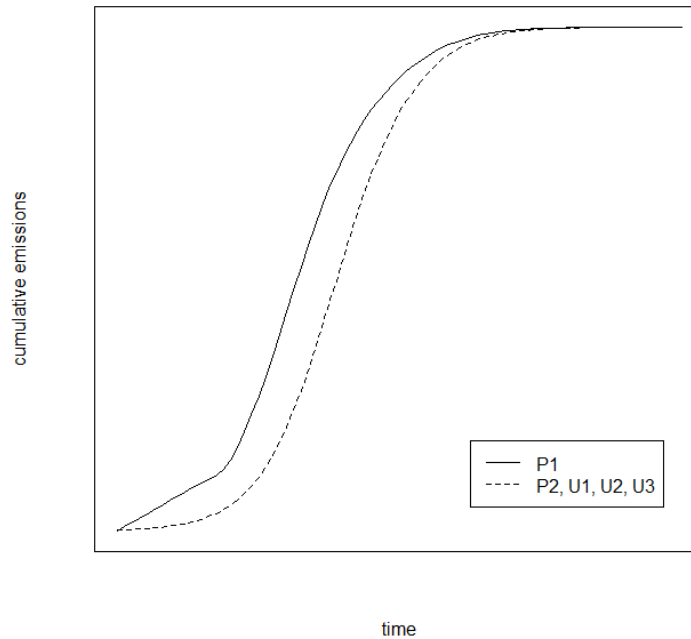
Figure 17: Graph of cumulative emissions from deforestation for the different baseline types
The above is a generalized graph of cumulative emissions over time. An equal volume per unit time is degraded under a planned commercial scenario until secondary agents arrive and begin deforestation, following a logistic model after t_{sa} for type P1, while for other baseline types emissions follow the logistic model from t_0.

The combined emissions from the linear degradation and the subsequent logarithmic deforestation are explained by the cumulative emissions model, equation [F.19], and illustrated by the above generalized graph of linear degradation followed by deforestation.

A.2 Soil Exponential Decay Model

This background section contains general information about the exponential decay model for soil which underpins the soil emissions model (SEM) and the selected approach to fitting the exponential decay model, rather than specific instructions on how to build the model.

Literature suggests that the amount of carbon loss in soil following conversion from forest to non-forest follows an exponential decay (loss) curve due to decomposition processes. The majority of loss occurs within the uppermost soil horizons (e.g. top 20-30 cm) for soil and within the first few years for all decaying pools (Olson 1963, Davidson and Ackerman 1993). An exponential decay function integrates cumulative loss, where λ represents the *exponential soil C decay parameter* and describes decay of the carbon that will eventually be lost. Following deforestation, only a portion of the carbon stock is lost; i.e. organic carbon stock*s* decline towards a new equilibrium level over time, reaching some maximum carbon loss proportion that ultimately depends on both the depth of the soil column and cultivation practices over time for soil. These factors vary on a project-by-project basis. Hence a project developer's selected value for λ shall be evaluated on a project-by-project basis (see section 6.18).

Per section 6.18, project proponents shall select an exponential decay parameter, λ, by either

1. Using a value from peer-reviewed scientific literature that is as appropriate for the project (see section 6.18.1.3),

2. Estimate the parameter, $\hat{\lambda}$, using empirically measured data per section 6.18.1.2, or

3. Utilize the conservative default value for the selected pool. The default value provided in this methodology is only appropriate for the tropics (see section 6.18.1.1).

If the project proponent choses option 2, measurement sampling of soil carbon from the proxy area (see section 6.4) is used to estimate λ_{SOC} using a process known as a "space for time substitution", well documented in the ecological literature, which assumes that soil C stocks in the proxy area (that has been previously deforested) are representative of the soil C levels that would be obtained over time in the project area if it were to be deforested and converted to some end land use. If the sample data are obtained from soil columns with equal depth and the data are collected from agricultural soils of known age, then the sample mean should be used to estimate λ_{SOC}, per Davidson & Ackerman, 1993. It should be noted that this methodology does not explicitly prescribe duration of time required to accurately derive a value for λ_{SOC}. The authors were purposely inexplicit in this regard, as it is in the proponent's best interest to collect data that represents a period of time after the soil carbon stock has reached a new equilibrium state (no longer declining). If λ_{SOC} is derived from converted areas that are "too recent", clearly the estimate of proportional soil loss, λ_{SOC} will be biased toward less decay than may ultimately occur. It is therefore recommended to sample in farms between 5 and 20 years in age to capture complete soil carbon decay in tropical ecosystems.
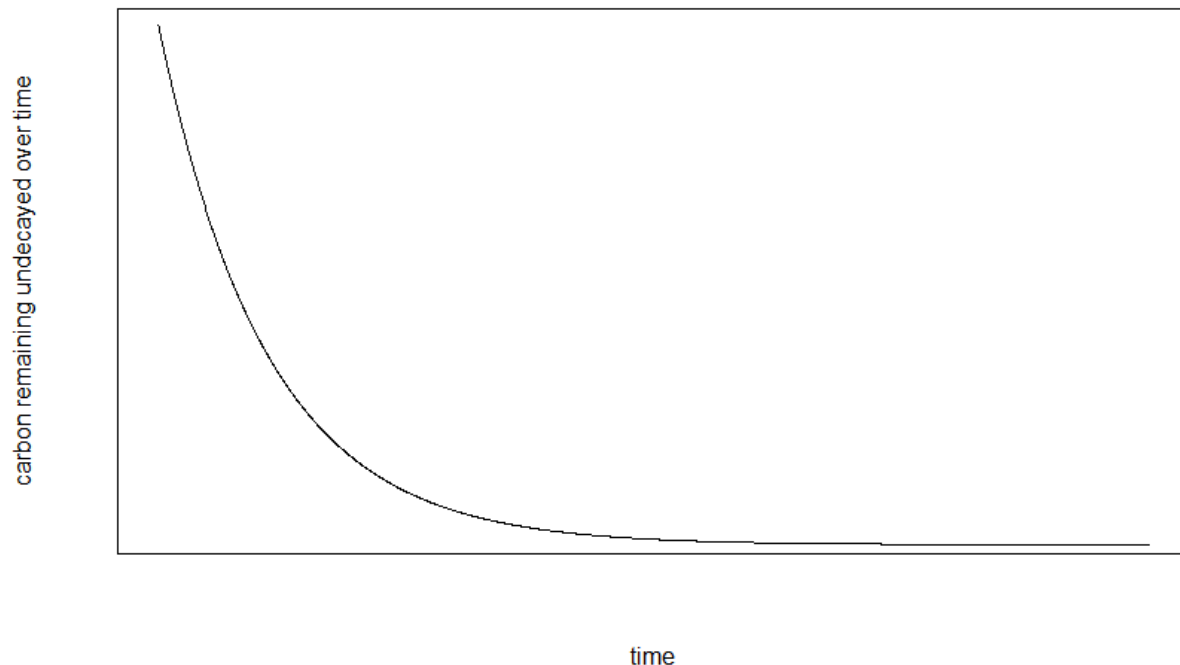
Figure 18: Exponential decay model
This figure depicts the exponential nature of decay in the soil carbon pool.

A.3 Model for Spatial Component

The spatial model applies to baseline type U3. This model does not attempt to determine where deforestation is most likely to have occurred in the project, but rather conservatively assumes that the stratum with the lowest carbon stocks is harvested first. Strata are then assumed to be deforested sequentially moving from lowest to the highest stocked strata.

This approach is thus the most conservative accounting possible for the potential patterns of deforestation. It avoids the complexities and sources of error inherent in attempts to predict the spatial patterns of deforestation that could lead to an over-issuance of NERs.

A.4 Equations for Theoretical Background

$$P(t_i, x_i, y_i) = P(x_i, y_i | t_i)P(t_i) \qquad [A.1]$$

Variables	$P(t_i, x_i, y_i)$= probability of observation in a point in space and time t_i= the time of the ith sample point x_i= the latitude of the ith sample point y_i= the longitude of the ith sample point
Section References	A.1.1
Comments	Probability of observing any one sample point in space and time.

$$P(t_i, x_i, y_i) = \frac{\#(observations\ at\ x_i, y_i) \times \#(observations\ at\ t_i)}{\#(historic\ images) \times \#(total\ observations)} \qquad [A.2]$$

Variables	$P(t_i, x_i, y_i)$= probability of observation in a point in space and time t_i= the time of the ith sample point x_i= the latitude of the ith sample point y_i= the longitude of the ith sample point
Section References	A.1.1
Comments	The conditional probability of observing a sample point in space given time.

$$P(t_i) = \frac{1}{\#(historic\ images)} \qquad [A.3]$$

Variable	$P(t_i)$ = probability of observing any sample point in time
Section References	A.1.1, 6.7.4
Comments	The probability of observing any sample point in time with a given number of historical images

$$F_{DF}(t,\eta) = \frac{1}{1 + \exp[-\eta(t,\boldsymbol{\theta})]} \qquad \text{[A.4]}$$

Variables	F_{DF} = proportion of cumulative deforestation η = linear predictor given time and deforestation covariates; t = time $\boldsymbol{\theta}$ = parameter vector of covariates
Section References	A.1, 6.7.8
Comments	Logistic model of cumulative deforestation bounded by a reference or project area. (Arellano-Neri & Frohn, 2001; Kaimowitz et al., 2002; Linkie et al., 2004; Ludeke et al., 1990; Mahapatra & Kant, 2005)

$$\eta = \alpha + \beta t + \boldsymbol{\theta} \boldsymbol{x}^T + \delta_{PR} \qquad \text{[A.5]}$$

Variables	α = combined effects of β and θ at the start of the historic reference period β = effect of time on the cumulative proportion of deforestation over time t = time since project start date θ = parameter vector of covariates x^T = covariate value δ_{PR} = project lag parameter
Section References	A.1
Comments	linear predictor given time and deforestation covariates

$$w_i \propto \frac{1}{\#(observations\ at\ x_i, y_i) \times \#(observations\ at\ t_i)} \qquad \text{[A.6]}$$

Variables	w_i = observation weight of point i $\#(observations\ at\ x_i, y_i)$ = number of observations throughout time at point x_i, y_i $\#(observations\ at\ t_i)$ = number of observations across space at time t_i
Section References	A.1.1
Comments	Observation weight

APPENDIX B: CARBON STOCK MEASUREMENT

B.1 General Sampling Guidelines

Sample plots are used to estimate carbon stocks in selected pools at a particular point in time. Changes in measured carbon stocks are used in conjunction with the cumulative emissions model to quantify the net GHG emissions or removals as a result of project activities. Changes on measured plots should reflect both changes due to natural processes such as growth and mortality and changes due to human activity, such as management, harvest, or degradation. In order to avoid bias, plots should be marked inconspicuously, so that if degradation or management activities do occur in the area, they apply uniformly to both areas within an established monitoring plot and areas outside of those plots.

Project proponents may carry out their inventory using either a random or a systematic (grid-based) sample within each stratum. Systematic sampling helps ensure uniform coverage of the area sampled and can be cost efficient, but risks bias if the sampling units coincide with periodicity in the population. To minimize this risk:

- Project proponents shall identify any periodic variation potentially present in the project area due to topography, management history, or other factors and document how the sampling design avoids bias that may result from these periodicities.
- If line-plot cruises or other linearly based methods are used, effort should be made to make cruise lines run perpendicular to slopes, rather than along contours, whenever possible.
- Systematic samples should employ a randomized start point.

The optimum plot size in a carbon inventory is a function of the variability in carbon stocks inherent in the population and measurement costs, including the cost of traveling between plots within the area to be measured. In general, as plot size increases, the variance in carbon stocks across plots within a population decreases. Aside from stratification, inventory precision can be improved by increasing either the size or number of plots measured. Plot size should be chosen by the project proponent based on experience with similar forest types, reviews of technical literature, and, optionally, a pilot sample. If a pilot sample is used, plots can optionally be installed using the largest plot radius under consideration and measurements of distance from plot center to each tree recorded. This allows for the synthetic construction of plots of smaller size. The required sample size to obtain the targeted precision level for each plot radius under consideration can then be computed using the appropriate equations described below. If a pilot sample is not feasible or desired, the between-plot variance of a new plot size can be estimated from the between plot variance of a known plot size using equation [B.1]. It should be noted that many project proponents perform "feasibility studies" in a potential project area; this presents an optimal opportunity to establish and measure a pilot sample and explore alternative sampling methodologies (which may require a deviation from the methods provided in this appendix).

Project proponents may use different-sized plots for different carbon pools. For example, project proponents may choose to use a nested plot design in which small trees are measured on a plot of smaller radius than the radius of the plot for large trees.

B.1.1 Stratification for Improving Sampling Efficiency

Stratification is recommended (but not strictly required) as a tool for minimizing sampling error. If two or more strata can be identified within the project area with similar carbon stocks and relatively small variance in relation to the variance of the total project area, stratification should reduce uncertainty in carbon stock estimation. The equations presented here assume stratification is used. However, if the project area is not stratified, the equations listed in this section are still applicable. In this case, all sums across strata include only a single element. The standard error equations given in this methodology assume that stratum sizes are known exactly. To ensure this assumption is valid, strata should be delineated prior to and independent of sampling. Stratification may be revised at any monitoring period prior to subsequent forest re-measurement.

B.1.2 Stratification for Delineating Harvestable Areas

A GIS analysis should be used to delineate harvestable areas considering slope, access constraints, local regulations (e.g., required stream buffers or restrictions on harvest unit size), forest type, available harvest and skidding techniques, management plans, etc. Estimates of carbon stocks in merchantable tree and wood products ratios should be calculated only from data collected in strata classified as harvestable according to this analysis. Document all assumptions used to delineate harvestable areas. In the project area the sum delineated harvestable areas will probably be equal to the size of one or more project accounting areas.

B.1.3 Estimating Required Sample Size and Plot Allocation

This methodology makes no specific requirements with regard to the sample size used in a carbon stock inventory. Rather, guidelines for estimating required sample size as a function of desired precision are provided. The methodology discounts credit generation based on the magnitude of sampling error that results from an inventory. If an inventory does not achieve a desired degree of precision *ex-post*, project proponents may choose to install additional plots in order to decrease uncertainty and reduce confidence deductions, regardless of the sample sizes suggested by the equations provided in this section.

Each stratum shall contain at least two sample plots. In planning inventory activities, the project proponent may use the following guidelines for estimating sample size and allocating plots to strata. This step is not required, but may be useful in planning an inventory of carbon stocks that minimizes expenditures required to achieve a specified precision level. The three methods below can be used to estimate the number of plots and allocation of those plots to strata that will maximize sampling efficiency based on the amount of information available prior to sampling. A pilot sample or literature review may be conducted to initially estimate the mean and standard deviation of carbon stocks in each stratum before making use of these guidelines. For more information on how to determine the size of a pilot sample see (Avery & Burkhart, 2002)

B.1.3.1 Proportional Allocation

If the only information available is the area of each stratum as delineated on a GIS, proportional allocation can be used. Determine the total estimated sample size $\hat{n}_{TOTAL}$ using equation [B.2] then determine the number of plots $\hat{n}_k$ in each stratum k using equation [B.3].

B.1.3.2 Neyman Allocation

If the area of each stratum as well as an estimate of the population variance of each stratum is available, Neyman allocation can be expected to improve sampling efficiency over proportional allocation, and is thus preferred. First determine the proportion of plots, w_k, that will fall in each stratum using equation [B.4]. Estimate the total sample size $\hat{n}_{TOTAL}$ using equation [B.5] where $\hat{\sigma}_k^2$ can be estimated from a pilot sample using equation [B.8]. Finally, estimate the number of plots $\hat{n}_k$ in each stratum k using equation [B.7].

B.1.3.3 Optimal Allocation

If for the area, an estimate of variance and an estimate of the relative cost of sampling is available for each stratum, optimal allocation can be used. First determine the proportion of plots, w_k, that will fall in each stratum using equation [B.6]. Estimate the total sample size $\hat{n}_{TOTAL}$ using equation [B.5] where $\hat{\sigma}_k^2$ can be estimated from a pilot sample using equation [B.8]. Finally, estimate the number of plots $\hat{n}_k$ in each stratum k using equation [B.7]. The cost estimate need not be in any particular unit, only a relative cost is required (e.g. if the sampling cost of one stratum is twice that of another due to remote access, the values 1 and 2 may be used for the relative costs).

B.1.4 Estimating Means, Totals and Standard Errors for Stratified Samples

The estimated total quantity of interest within a sampled area is given by equation [B.9], where $y_{j,k}$ is the plot-level quantity of interest from plot j in stratum k, given in units per unit area. For example, if the quantity of interest is total carbon stock in trees, $y_{j,k}$ would represent the result of applying an allometric equation to each measured tree in plot j, converting to carbon units, summing the results, and dividing by the area of plot j as described in the procedures given below for estimating carbon stocks in above-ground trees. In the case of monitoring degradation in the activity-shifting leakage area, $y_{j,k}$ is the observed degradation on a leakage plot (see secion B.2.8).

The standard error of the total is estimated first by calculating the between-plot variance $\hat{\sigma}_k^2$ within each stratum using equation [B.8], then estimating the standard error using equation [B.10]. This estimate includes the finite population correction factor $\frac{N_{P,k} - \#(\mathcal{P}_k)}{N_{P,k}}$. Note that $N_{P,k}$, the total number of possible plots in stratum k, is given by dividing the area of the stratum by the plot size. The finite population correction factor can be conservatively excluded from the standard error formula and should not be used in estimating soil carbon stocks. Also note that separate variance estimators are used for line intersect samples of lying dead wood and are provided in that section below.

In the case that a project area is not stratified, the provided equations are still applicable, but summations across strata include only a single element.

B.1.5 Summing Pools and Uncertainties

Total carbon stocks within an area can be estimated by simply summing the totals estimated using the methods given below as shown in equation [B.31]. The standard error of such a sum can be estimated from the individual standard errors using equation [B.32].

B.2 Stock Estimation Techniques Applicable to Specific Carbon Pools

B.2.1 Estimating the Average Carbon in AGMT and AGOT

Variables: $c_{AGMT}^{[m]}$ and $c_{AGOT}^{[m]}$

Carbon stocks in live trees are estimated using allometric equations. Allometric equations commonly require recording the diameter at breast height and species or species group for each tree within the measurement plots. Some equations require additional measurements, such as height or wood density. When wood density measurements are required, the guidance provided by Williamson & Wiemann (2010) should be followed in data collection. Allometric equations should be chosen or developed based on the guidance in section 9.3.1. It is very important to use or develop high quality allometric equations that are applicable to the region and species being inventoried.

To ensure a consistent inventory across monitoring periods, the project proponent should clearly document tree measurement procedures, including procedures for locating and monumenting plots; recording and archiving data; calibrating equipment; including or excluding trees that fall on the edge of a plot; and rules for measuring trees that lean, have irregular stems, buttresses, or stilt roots.

Note that merchantable and non-merchantable trees are sampled using identical methods and utilize the same plots, but stock estimates for each pool shall be computed separately for use in the cumulative emissions model. Prior to sampling, the project proponent shall conduct a GIS analysis as described in section B.1.2 to determine which strata of the project area are harvestable. Further, project proponents shall document clear rules for classifying individual trees as merchantable or non-merchantable. These rules should consider, at a minimum, species, size class, and defect. Merchantability status of each measured tree should be assigned in the field, and recorded on field data sheets. Training should be provided to field crews to ensure that the application of these rules is consistent.

Project proponents may elect to use different plot sizes (i.e. a nested design) for measurement of trees based on their size to improve inventory efficiency.

To estimate the average carbon stock in merchantable or non-merchantable above-ground trees:

1. Estimate the carbon stock of each measured tree using an appropriate allometric equation as given in equation [B.11] (see section 9.3.1 to determine appropriate allometric equations). Note that this equation assumes the selected allometric equation computes biomass in kilograms, and may need to be modified if equations with other units are applied.

2. Sum the biomass of all trees within each plot and divide by plot area as given in equation [B.12], where $x_{i,j,k}$ is the carbon stock in tonnes CO2e of tree i on plot j in stratum k as estimated in step 3. This provides an estimate of the plot level total biomass per unit area.

3. Use equation [B.9] as discussed in section B.1.4 to estimate the average carbon stock in above-ground trees, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (2).

4. Use equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in above-ground trees, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (2).

B.2.1.1 Palm Biomass

The allometric equation based methods described for trees can be applied to estimating above-ground biomass of palms as well. Table 4.A.2 of the IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry provides a source of allometric equations relevant to palms. Additionally, more locally relevant equations may be available in the technical literature. Allometric equations for palms typically are based upon height, rather than diameter. Height can be measured using an electronic hypsometer, height pole, or clinometer and tape. Procedures for conducting these measurements shall be clearly documented and be consistent with the expected inputs of the selected equations. Total palm biomass and its associated standard error can be calculated using the steps above as described for above-ground tree biomass.

B.2.2 Estimating the Average Carbon in AGNT

Variables: $c_{AGNT}^{[m]}$

Non-tree biomass includes grasses, sedges, herbaceous plants, woody shrubs and any trees smaller than the minimum diameter specified for using the methods described for tree biomass. Non-tree biomass can be estimated using either destructive sampling in a clipped plot, allometric equations, or a combination of the two approaches. Clip plots are appropriate for annual plants and small shrubs. Allometric equations are appropriate for perennials and large shrubs. If both methods are used simultaneously, clear rules shall be established to ensure no double counting of non-tree biomass occurs.

B.2.2.1 Destructive Sampling Method

In this method, above-ground biomass is estimated by harvesting the biomass in a plot of known area, drying and weighing the harvested sample, and calculating the mass per unit area. Alternatively, wet mass may be measured on each plot and empirically adjusted to compensate for moisture content. These plots constitute separate measurement units from the plots used for tree biomass estimation, though they may exist inside the tree plot. The area of the clipped plot will typically be much smaller than the area of tree biomass plots and may be selected by the project proponent. Large plots allow for more precision in the estimation of carbon stocks, but require more effort to sample. If permanent plots are used, the location of the clip plot within the larger tree plot should not be the same during each measurement period to avoid bias that may result from clipping the same area during each measurement period, as repeated clipping may impact the productivity of the site. If the plot happens to fall in a location with little to no non-tree biomass (for example, because a large tree occupies most of the plot area), the plot should not be moved. In the field, a sampling frame can be placed over the ground to accurately determine the area to be clipped. All vegetation originating within this frame should be clipped to a consistent height above the ground, preferably as near to ground level as is feasible. Each sample should then be dried and weighed.

1. Clip all above-ground biomass within each clip plot and determine its dry mass. This can be done by either (a) collecting biomass and later drying and weighing it in a lab, or (b) collecting a representative and well mixed subsample of biomass to estimate average moisture content. This subsample is then dried and weighed in the lab and equation [B.14] can be used to estimate the dry biomass.

2. Estimate the plot level carbon stock in tonnes CO2e on each plot using equation [B.13].

3. Use equation [B.9] as discussed in section B.1.4 to estimate the average carbon stock in above-ground non-tree biomass, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (2).

4. Use equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in above-ground non tree biomass, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (2).

B.2.2.2 Allometric Equation Method

Allometric equations can be applied to estimate the above-ground biomass of non-trees. These equations might be size-class or species-specific, and may be based on, e.g., stem diameter, percent cover, or number of stems. The general procedure for estimating carbon stocks in above-ground trees is applicable to non-trees when applying allometric equations.

1. Estimate the carbon stock represented by each measurement using an appropriate allometric equation as given in equation [B.11] (see section 9.3.1 to determine appropriate allometric equations). Note that this equation assumes the selected allometric equation computes biomass in kilograms, and may need to be modified if equations with other units are applied.

2. Sum the biomass of all trees within each plot and divide by plot area as given in equation [B.12], where $x_{i,j,k}$ is the carbon stock in tonnes CO2e of tree i on plot j in stratum k as estimated in step 3. This provides an estimate of the plot level total biomass per unit area.

3. Use equation [B.9] as discussed in section B.1.4 to estimate the average carbon stock in above-ground non-tree biomass, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (4).

4. Use equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in above-ground trees, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (4).

B.2.3 Estimating the Average Carbon in BGMT, BGOT and BGNT

Variables: $c_{BGMT}^{[m]}$, $c_{BGOT}^{[m]}$, and $c_{BGNT}^{[m]}$

Below-ground biomass is estimated by applying a root to shoot ratio (such as those given in Table 4.4 of the IPCC Guidelines for NI Greenhouse Gas Inventories) or equation (such as those documented by Cairns et al 1997) to the above-ground biomass estimate for the above-ground large tree, above-ground small tree, and above-ground non-tree carbon pools. Ratios or equations are to be selected by the project proponent. They shall be suited to the region and vegetation type to which they are to be applied and shall be justified by the project proponent through a review of peer-reviewed scientific literature or through supporting field evidence.

1. Estimate the above-ground carbon stock of the relevant pool (trees or non-tree biomass) using the guidance of that section.

2. Estimate the below-ground biomass by multiplying the selected root: shoot ratio by the above-ground biomass estimate (when a ratio is selected), or by applying the selected equation to the above-ground estimate for each tree or non-tree carbon stock estimate.

3. Sum the below-ground biomass of all measurement units within each plot and divide by plot area as given in equation [B.12] where $x_{i,j,k}$ is the below-ground carbon stock in tonnes CO2e of tree i on plot j in stratum k as estimated in step 3. This provides an estimate of the plot level total below-ground biomass per unit area.

4. Use equation [B.9] as discussed in section B.1.4 to estimate the average carbon stock in below-ground biomass, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (3).

5. Use equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in below-ground biomass, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (3).

B.2.4 Estimating the Average Carbon in SD

Variables: $c_{SD}^{[m]}$

Carbon in standing dead wood is estimated on fixed area plots by first categorizing standing dead trees into two decomposition classes:

- Trees with branches and twigs that resemble live trees (except for leaves) (Class I)
- Trees that show loss of twigs, branches or bole mass (Class II)

B.2.4.1 Decay Class I

The carbon stock in trees of decay Class I (intact trees) is estimated using the allometric equation approach as described for live trees:

1. Estimate the carbon stock represented by each tree using an appropriate allometric equation as given in equation [B.11] (see section 9.3.1 to determine appropriate allometric equations). Note that this equation assumes the selected allometric equation computes biomass in kilograms, and may need to be modified if equations with other units are applied.

B.2.4.2 Decay Class II

The carbon stock of standing trees in decay Class II is conservatively estimated as the biomass in only the remaining bole. Diameter at breast height and height and density should be measured on each tree in decomposition class 2. The diameter at the top of the stem can be measured using a relascope or similar instrument, or it can be conservatively assumed to be zero. Wood density should be estimated using a sample taken from each tree. See Williamson & Wiemann (2010) for proper techniques for estimating specific gravity and converting between specific gravity and density estimates. The volume of the bole of each dead tree is then estimated as the frustum of a cone. To estimate the carbon stock for each decay Class II dead tree:

1. Estimate the volume of the bole using equation [B.15].

2. Estimate the carbon stock for each dead tree using equation [B.16] where $v_{i,j,k}$ is the volume of the ith tree in decay class II in plot j, stratum k as calculated in step (1).

B.2.4.3 Total Standing Dead Wood

To estimate the total carbon stock in the standing dead pool:

1. Sum the carbon stocks of dead trees within each plot (both decay Class I and decay Class II) and divide by plot area as given in equation [B.12] where $x_{i,j,k}$ is the carbon stock in tonnes CO2e of tree i on plot j in stratum k as estimated for the relevant decay class as described above. Use

trees in both decay classes for this summation.   This provides an estimate of the plot level total biomass per unit area.

2. Use equation [B.9] as discussed in section 6.19.4 to estimate the average carbon stock in standing dead wood, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (1).

3. Use equations [B.8] and [B.10] to estimate the standard error of the total carbon stock in above-ground standing dead wood, where $y_{j,k}$ is the plot level estimate of CO2e/ha produced in step (1).

B.2.5 Estimating the Average Carbon in LD

Variables: $c_{LD}^{[m]}$

Lying dead wood is sampled using the line intersect method. At each plot, establish two transects of at least 50m length through the plot center. The first transect should be oriented at a random angle, while the second transect should be oriented perpendicularly to the first transect. Record the diameter and density class of each piece of lying dead wood that intersects the vertical plane established by each transect. The diameter should be measured at the point of intersection. If a piece of lying dead wood is forked and intersects the transect at more than one point, each point of intersection should be recorded separately. The minimum measurement diameter may be established on a project-specific basis, but should be documented and held constant across all measurement periods. Each piece of measured wood should be classified as sound, intermediate or rotten using the machete test as recommended by the IPCC Good Practice Guidance for Land-Use, Land Use Change and Forestry (4.3.3.5.3) (IPCC, 2006). The mean oven dry density of dead wood, $\bar{\rho}_d$, in each decay class d, shall be estimated as the mean of a sample taken down logs within the project area. See Williamson & Wiemann (2010) for proper techniques for estimating specific gravity and converting between specific gravity and density estimates. The sample should be large enough to achieve a standard error of the mean within +/- 15% at a 95% confidence level.

1. Estimate the total carbon stock $y_{j,k}$, per unit area for stratum k transect j as equation [B.17] where $x_{i,j,k,d}$ is the diameter of the ith piece of lying dead wood equation in density class d, transect j, stratum k.

2. From $y_{j,k}$, estimate y_k, the total carbon stock in lying dead wood in stratum k as equation [B.18].

3. From $y_{j,k}$, estimate the variance of carbon in lying dead wood in stratum k, $\hat{\sigma}_k^2$, as equation [B.19].

4. Estimate the average stock in lying dead wood as equation [B.20].

5. Estimate the standard error of the total carbon stock in lying dead wood U_{LD} as equation [B.21].

The estimation of carbon in lying dead wood may be conservatively omitted at the discretion of the project proponent.

B.2.6 Estimating the Average Soil Organic Carbon

Variables: $c_{SOC}^{[m]}$

When the soil carbon pool is selected, soil carbon shall be measured using a purposive sample in the proxy areas and a random sample in the project accounting areas. In designing this sample, project proponents should take care to ensure that the sampling scheme incorporates all types of land use and

states that occur within the proxy area under the baseline scenario (i.e. fallow fields, active fields, etc.) To derive a representative sample and reduce uncertainty, it is recommended that the proxy area be stratified (e.g., soil taxonomic class, landscape position, land use) and the ensuing sampling scheme be designed according to these strata. A stratified random approach is suggested in order to achieve maximum explanation of agricultural variance in the reference area. The stratification scheme and sample size applied for estimation of soil carbon may be different from that used for estimation of carbon in biomass pools. It is further suggested that samples are taken from similar strata in the project area and reference area, so as to achieve an accurate comparison of different land use types present in the project ecosystem. Further guidance on sample allocation (e.g., Neyman allocation) can be found section B.1.2 above.

Estimation of soil carbon stocks requires collection of soil samples from the field that are later analyzed in a laboratory. In general, three variables are required to estimate soil carbon content: bulk density, the organic carbon content, and soil depth. Multiple aliquots of soil, from different depths, may be measured separately, but when calculating the number of plots for the purpose of calculation statistical confidence intervals each location only counts as one sample. Soil carbon stocks are typically not estimated over the entire depth of the soil column, but are rather estimated in the upper horizons of the soil where the majority of soil carbon is present. Sample depth may be selected by the project proponent, but a consistent total depth for soil sampling should be established, and this depth should be no less than the depth to which soil is disturbed during farming, typically a minimum of 30cm.

Samples may be extracted using a soil core or by digging a soil pit. Because of the high degree of spatial variability in soil carbon stocks, it is recommended that several samples be taken from different randomly selected locations within each sampling site (i.e., farm reference region or stand in project area) and mixed prior to measurement in the laboratory. Alternatively, several samples for different soil horizons may be analyzed separately and analysis results combined after-the-fact. If soil pits are used, multiple horizons should be extracted (at least 3 are recommended) to ensure that the soil is being measured to a sufficient spatial resolution along its depth. Bulk density and carbon concentration should be measured for each individual soil horizon, as it is important to apply these individual measurements to achieve mass-equivalent measurement. A consistent total depth for soil sampling should be established, and this depth should be no less than the depth to which soil is disturbed during farming, typically a minimum of 30cm. In soils with coarse fragments (> 2mm), both density and carbon concentration should be based on the fine fraction of the soil. To accomplish this, the soil sample must be sieved through a 2mm sieve, with the volume of coarse fragments determined separately (by water immersion or by weighing the fragments and dividing by the density of rock fragments, often given as 2.65 g/65). See correction factor in equation [B.25]. Also, the density of fine soil can be calculated by dividing the mass of fine soil by the total volume of the sample, without separate calculation of the volume or mass of coarse fragments. Whatever method used, it should be completely documented and consistently applied.

If bulk density for the within-project measurements differs significantly from the reference area measurements (such as due to compaction that results from harvesting operations), measurements should be evaluated on a mass-equivalent basis. See Ellert, Janzen & Entz, (2002) and Ellert & Bettany (1995) for appropriate methods.

The guidance provided in section 4.3.3.5.4 of the GPG-LULUCF (IPCC, 2006) shall be adhered to when choosing laboratory methods for analyzing soil carbon content. Bulk density and carbon concentration should be evaluated by a laboratory that follows internationally recognized standards (e.g. FAO standards) to minimize errors and bias.

To collect field samples suitable for laboratory estimates of organic carbon:

1. Remove all vegetation and litter from the surface of the selected sample location. Including even small amounts of surface organic material can significantly bias estimates of soil carbon stocks.

2. Insert a soil carbon probe to the selected depth (typically 30cm), using a rubber mallet if necessary due to soil compaction.

3. Extract soil from the corer or probe into a bag and clearly label with the sampling location and an indicator that the sample is for soil carbon determination (rather than bulk density)

4. It is recommended that this process be repeated several times at each sampling location (e.g., each plot may contain four separate soil organic carbon samples) and results aggregated to reduce the impact of small scale spatial variability in soil carbon content.

5. Send the sample to a laboratory for organic carbon analysis.

To collect field samples suitable for laboratory analysis of bulk density:

1. Dig a soil pit at each sampling location to at least the selected soil sampling depth (typically 30 cm).

2. Insert a soil ring with known volume into the side of the pit to collect a known volume of soil. Care should be taken to ensure no soil falls from the ring, but do not pack soil into the ring.

3. Take additional samples throughout the depth of the pit to represent the change in bulk density with depth. For example, in a 30 cm pit one sample may be taken at the midpoint of the upper half of the sampling pit and a second sample and the midpoint of the lower half of the pit. Each sample increment should be taken from a different, undisturbed vertical column of soil from the side of the pit.

4. Combine the soil samples taken in a bag clearly labeled as a bulk density sample and record the representative volume of soil (volume of the ring multiplied by the number of rings taken.

5. Send the sample to a laboratory for bulk density analysis.

To estimate the total stock in soil carbon:

1. Calculate the corrected bulk density for each plot using equation [B.25].

2. Estimate the soil carbon stock per unit area, $y_{j,k}$, for plot j, stratum k using equation [B.26].

3. Estimate the average stock in soil carbon as equation [B.9].

4. Estimate the variance within each stratum as equation [B.8].

5. Estimate the standard error of the total carbon stock in soil carbon as equation [B.10], excluding the finite population correction factor $\left(\frac{N_{P,k} - \#(\mathcal{P}_k)}{N_{P,k}} \right)$.

B.2.7 Estimating the Proportion of Carbon in Slash and Wood Product Classes

Variables: $p_{SL}^{[m]}$, $p_{sawnwood}^{[m]}$, $p_{panels}^{[m]}$, $p_{roundwood}^{[m]}$, $p_{paper}^{[m]}$

Merchantable volume is used to compute carbon stocks in log production. These estimated stocks can then be compared to the total carbon in merchantable trees as described in section C.1 to estimate wood products ratios that are used in accounting for carbon stocks in long lived wood products. Measurements required for these calculations can be taken on the same plots used for carbon stock estimation. When sampling is used to estimate wood product ratios for input into harvested wood products calculations, project proponents shall stratify the area to determine which areas are harvestable according to the guidance provided in section B.1.2. Data used for calculations in this section should be taken only from strata classified as harvestable.

For each merchantable tree measured in the field, record its likely product class among the following:

      a) Sawnwood (dimension lumber, etc.)

      b) Woodbase panels (plywood, decorative panels, etc.)

      c) Other industrial roundwood (poles, pilings, fence posts, etc.)

      d) Paper and paperboard

Determination of likely product classes should be based on local knowledge of markets and should consider, at a minimum, species, size class, and defects. Determine of likely product classes should be based on local knowledge of markets and should consider, at a minimum, species, size class, and defects. Merchantability should also consider the cost of extraction and where the cost of logging and transportation is greater than the market value of the wood, the trees should be classified as non-merchantable. Project proponents shall document rules for assigning trees to product classes based on relevant local knowledge and training should be provided to field crews to ensure consistent application of these rules. Documented rules for merchantability should be applied consistently for a given monitoring period.

For each merchantable tree species, a volume equation shall be selected. If locally derived volume equations or tables are available they should be used, with field sampling designed to collect the specific data required by the selected equation or table. Project proponents should document the source and justify the applicability of all volume equations utilized. If locally derived equations are not available, volume can be estimated using the equations provided in this methodology.

1. On each merchantable tree per measurement plot record the DBH, merchantable height, top diameter (or a fixed diameter that defines merchantable height), species, and likely product class. This can be done while making measurements for total above-ground carbon as described in section B.1.

2. Calculate the total above-ground carbon stock of each measured tree using an allometric equation as described in step (1) of section B.2.1.

3. Calculate the merchantable volume of each measured tree using equation [B.15] or a locally relevant equation or volume table.

4. Calculate the carbon stock in the merchantable part of the bole using equation [B.16] where $v_{i,j,k}$ is the volume of the ith tree in plot j, stratum k as calculated in step (3).

5. Confirm that the carbon stock in the merchantable part of the bole is less than the carbon stock in the total above-ground biomass of the tree. If it is not, investigate the volume and allometric equations selected and check for calculation errors.

6. Calculate the carbon stock in slash by subtracting the bole carbon stock calculated in step (4) from the total carbon stock calculated in step 2 as given in equation [B.27].

7. For each plot, estimate the total carbon stock in slash and in the merchantable boles of each category and divide by plot area as given in equation [B.12] where $x_{i,j,k}$ is the carbon stock in either slash(step 6) or the merchantable part of the bole (step 4) as appropriate. This results in 5 quantities per plot ($c_{SL,j,k}$, $c_{sawnwood,j,k}$, $c_{panels,j,k}$, $c_{roundwood,j,k}$, and $c_{paper,j,k}$).

8. For each of the 5 quantities estimated in step 7 use equation [B.9] as discussed in section B.1.4 to estimate the total carbon in the relevant category where $y_{j,k}$ is the plot level estimate in tCO2e/ha produced in step (7).

9. Calculate the wood products ratio for each category by dividing the estimate of total carbon in the relevant category as calculated in step (8) by the sum of the five totals as given in equation [B.28]. The five resulting ratios should sum to 1.0.

B.2.8 Estimating Proportion of Degradation

Degradation in the activity-shifting leakage area shall be assessed by a visual sample on plots within the activity-shifting leakage area. This sample is used at the end of the first monitoring period in order to estimate the lag period for the leakage model and at every subsequent monitoring period in order to estimate actual emissions due to leakage. Because the leakage area is unlikely to be under the control of the project proponent, the sampling methods described are designed to be fast and require no modification to the site. Project proponents must be able to access the leakage area, however, to perform the required sampling.

Within the activity-shifting leakage area, randomly select a sample of point locations with uniform probability with a minimum sample size $\hat{m}_L$ determined by equation [B.29]. These point locations become the corners of the fixed-area plots used to estimate degradation and deforestation in the leakage area permanently throughout the project lifetime. Select plot dimensions so that each plot area is large enough that degradation will be observed if degradation is occurring on the adjacent landscape. It is recommended that plots be at least one hectare (e.g. a 100m x 100m square plot). The dimensions of all plots should be the same. Visit these plots to observe the proportion of degradation. The proportion of degradation can be estimated using either (a) estimates of crown cover taken with a spherical densitometer; (b) visual estimates of degradation.

Neither the plot boundaries nor locations should be visibly marked on the ground, as they most likely exist in areas outside the project's control and visible marking may lead to preferential treatment of these plots. Rather, they should be monumented using a GPS and optionally a buried monument.

These sample plots shall be observed at least every five years to estimate leakage. Use equation [B.9] to estimate $p_{L\,DEG}$ where $y_{j,k}$ are plot-level measurements of degradation obtained using either method described below.

Regardless of the method applied, uncertainty in measurement should be reduced as much as possible by developing a field protocol for sampling forest degradation. Training should be provided to collection teams.

B.2.8.1 Spherical Densiometer Method

A spherical densitometer consists of a small hemispherical mirror engraved with a grid and is used to estimate crown closure by counting portions of the grid through which canopy gaps are visible. The spherical densiometer method of estimating percent degradation is more repeatable and less subjective than visual assessment, and thus should be preferred when feasible. At times, however, estimating degradation using this method will not be possible. For example, in drought-deciduous forests the dry season is most suitable for fieldwork, but at this time the canopy is in a leaf-off condition.

To use this method, crown cover must be estimated in both the leakage area and in non-degraded forest within the project area.

1.   Navigate to the randomly determined plot location with a GPS.

2. Using a compass, walk a predetermined path through the degradation plot, stopping periodically to take crown cover estimates. A potential crown cover sampling scheme is illustrated in Figure 19.
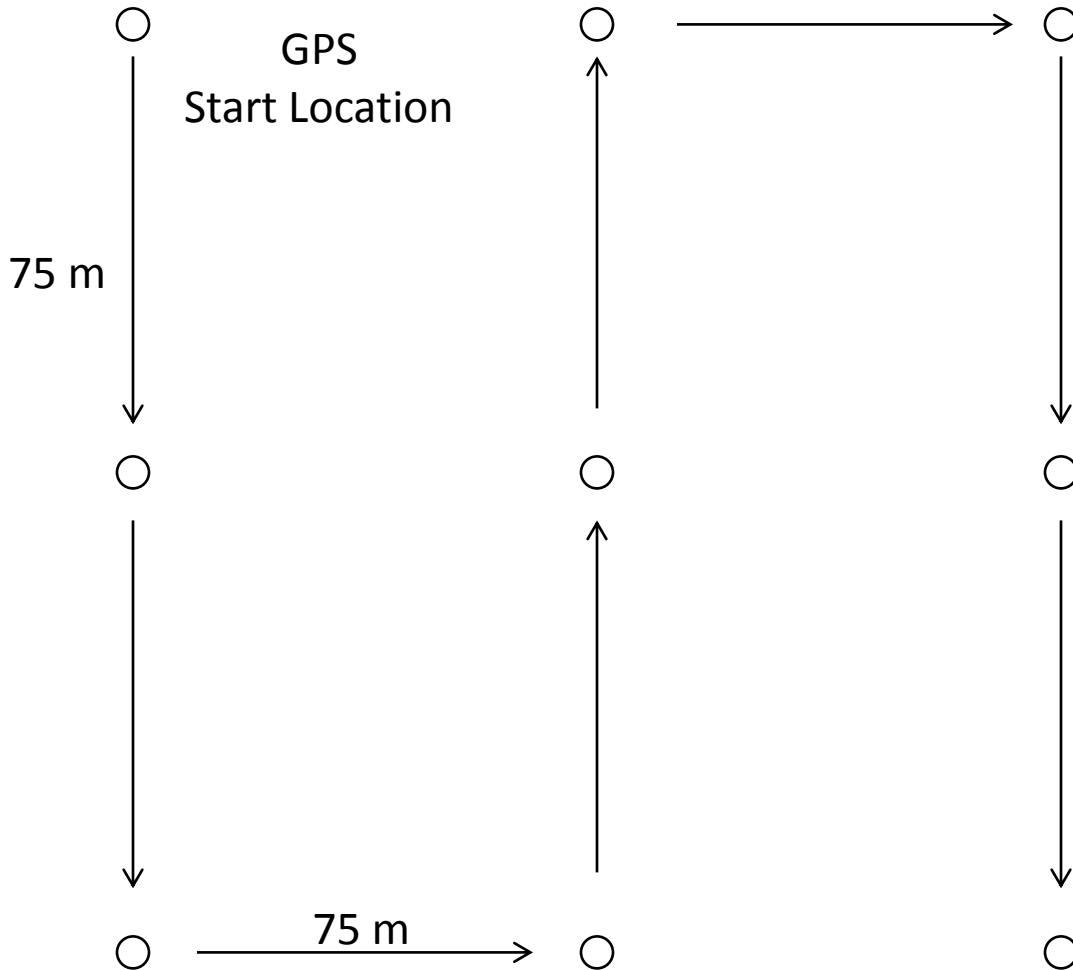
Figure 19: Plot sampling scheme for spherical densiometer.
In this sampling scheme, the random GPS start location is located at the northwest corner of the plot. By pacing and using a compass, the observer walks the perimeter and center of the 2.25 hectare plot and observes crown cover at 9 points in the plot, as illustrated. Crown cover should be observed according to the instructions provided with the spherical densiometer and converted to a percent. This typically involves mentally subdividing each grid cell on the densiometer into four smaller points and counting the number of points in which canopy openings are visible. The most common densiometers have 24 large squares which are then subdivided into a total of 96 points. The percent cover for these densiometers can be given by equation [B.30]. It is good practice to take four densiometer readings at each observation point, one facing in each cardinal direction, and average the results. The percent crown cover from all readings made within a plot should be averaged (i.e., nine points with four readings at each point), with that average constituting a single observation for the entire plot.

3. Calculate the proportion of degradation in each leakage plot by dividing the average canopy cover in the leakage area plot by the average canopy cover measured in undegraded strata of the project area estimated using the same procedure.

B.2.8.2 Visual Estimates of Degradation

If the densiometer method is not practical, visual estimates of degradation can be made in the leakage area. Walk throughout each plot in the leakage area and observe the percentage of above-ground biomass that is absent as evidenced by presence of stumps for each plot area. Record a factor for each plot using the following ordinal scale in Table 7.

Factor	Proportion of degradation
0.0	0%
0.2	0-19%
0.4	20-39%
0.6	40-59%
0.8	60-79% (severe degradation)
1.0	80-100% (including complete deforestation)

Table 7: Factors for visually estimating degradation.

Protocols for estimating the percentage of absent biomass shall be developed by the project proponent and their conservativeness justified at validation and verification.

B.3 Guidelines for Developing Allometric Equations

Allometric equations for shrubs can be developed by harvesting a representative sample from the project area, drying and weighing the sample, and relating the sampled biomass to variables easily measured in the field. The independent variables that are suitable for predicting shrub biomass may vary across environments and vegetation types and may include but are not limited to number of stems, stem diameter, height, size class, crown diameter, and percent cover. In some situations, developing a continuous equation that represents shrub mass as a function of one or more of the above variables is not practical. In this case, a simple average of the biomass of the sample collected per stem or per plant can be used instead. Where appropriate to project vegetation types, separate averages for different size classes and species of shrubs should be used.

When developing allometric equations for trees, measurements of tree volume, density or biomass must be made across a range of tree sizes. Models shall be used to predict biomass based on covariate metrics such as diameter, height and specific gravity.

All allometric equations must be validated per section 9.3.1.

B.4 Minimizing Uncertainty and Collecting Consistent Data

To ensure that carbon stocks are estimated in a way that is accurate, verifiable, transparent, and consistent across measurement periods, the project proponent shall establish and document clear standard operating procedures and procedures for ensuring data quality. At a minimum, these procedures shall include:

- Comprehensive documentation of all field measurements carried out in the project area. This document shall be detailed enough to allow replication of sampling in the event of staff turnover between monitoring periods.

- Training procedures for all persons involved in field measurement or data analysis. The scope and date of all training shall be documented.
- A protocol for assessing the accuracy of plot measurements using a check cruise and a plan for correcting the inventory if errors are discovered.
- Protocols for assessing data for outliers, transcription errors, and consistency across measurement periods.
- Data sheets shall be safely archived for the life of the project. Data stored in electronic formats shall be backed up.

B.5 Equations for Carbon Stock Measurement

$$\hat{\sigma}_2^2 = \hat{\sigma}_1^2 \sqrt{\frac{a_1}{a_2}} \qquad \text{[B.1]}$$

Variables	$\hat{\sigma}_2^2$= variance of plot of size 2 (unknown plot) $\hat{\sigma}_1^2$ = variance of plot size 1 (known plot) a_1 = area of plot of size 1 a_2 = area of plot of size 2
Section References	B.1
Comments	This equation is used to estimate the effect of changing plot area on between-plot variance. a_1 is assumed to be a plot area associated with an estimated variance $\hat{\sigma}_1^2$, while a_2 is the plot area for which variance is to be estimated. Freese (1962)

$$\hat{n}_{TOTAL} = \frac{1}{\left(\frac{0.15 \times \bar{x}}{1.96 \times \hat{\sigma}_{\bar{x}}}\right)^2 + \frac{a_{plot}}{\sum_{k \in \mathcal{S}} A_k}} \qquad [B.2]$$

Variables	$\hat{n}_{TOTAL}$ = estimated total number of plots required
	$\bar{x}$ = estimated mean of a quantity to be sampled in the area
	$\hat{\sigma}_{\bar{x}}$ = estimated standard deviation of a quantity to be sampled in the area
	a_{plot} = area of a plot $\mathcal{S}$ = set of all strata in the area.
	A_k = area of stratum k
	$\mathcal{S}$ = set of all strata in the area.
Section References	B.1.3.1
Comments	This equation is used to estimate sample size when stratum-specific estimates of standard deviation are unavailable. 0.15 represents an allowable error of 15% of the mean, while 1.96 represents the Z statistic from a normal distribution associated with the 95% confidence level.
	Avery & Burkhart (2002)

$$\hat{n}_k = \hat{n}_{TOTAL} \frac{A_k}{\sum_{k \in \mathcal{S}} A_k} \qquad [B.3]$$

Variables	$\hat{n}_k$ = estimated total number of plots required in stratum k
	$\hat{n}_{TOTAL}$ = estimated total number of plots required
	A_k = area of stratum k
	$\mathcal{S}$ = set of all strata in the area.
Section References	B.1.3.2
Comments	This equation is used to estimate the required number of plots in stratum k under proportional allocation.
	Avery & Burkhart (2002)

$$w_k = \frac{A_k \hat{\sigma}_k}{\sum_{j \in \mathcal{S}} A_j \, \hat{\sigma}_j} \qquad [\text{B.4}]$$

Variables	w_k = the proportion of plots allocated to stratum k
	A_j or A_k = area of stratum j or k
	$\hat{\sigma}_j$ or $\hat{\sigma}_k$ = estimated standard deviation of a quantity to be sampled in stratum j or k
	$\mathcal{S}$ = set of all strata in the area.
Section References	B.1.3.2
Comments	This equation is used to estimate the proportion of plots in each stratum under Neyman allocation.
	Avery & Burkhart (2002); Shiver & Borders (1996)

$$\hat{n}_{total} = \frac{\sum_{k \in \mathcal{S}} \frac{A_k^2 \hat{\sigma}_k^2}{w_k}}{\left(\frac{0.15 \times \sum_{k \in \mathcal{S}} A_k \times \bar{x}}{1.96 \times a_{plot}}\right)^2 + \sum_{k \in \mathcal{S}} A_k \, \hat{\sigma}_k^{\;2}} \qquad [\text{B.5}]$$

Variables	$\hat{n}_{TOTAL}$ = estimated total number of plots required (count)
	A_k = area of stratum k
	w_k = the proportion of plots allocated to stratum k
	$\bar{x}$ = estimated mean of a quantity to be sampled in the project area
	$\hat{\sigma}_k$ = estimated standard deviation of a quantity to be sampled in stratum k
	$\mathcal{S}$ = set of all strata in the area
Section References	B.1.3.2, B.1.3.3
Comments	This equation is used to estimate the total sample size of a stratified sample.
	Avery & Burkhart (2002); Shiver & Borders (1996)

$$w_k = \frac{A_k \hat{\sigma}_k / \sqrt{c_k}}{\sum_{j \in \mathcal{S}} A_j \, \hat{\sigma}_j / \sqrt{c_j}} \qquad \text{[B.6]}$$

Variables	w_k = the proportion of plots allocated to stratum k
	A_j or A_k = area of stratum j or k
	$\hat{\sigma}_j$ or $\hat{\sigma}_k$ = estimated standard deviation of a quantity to be sampled in stratum j or k
	$\mathcal{S}$ = set of all strata in the area.
	c_j or c_k = estimated cost of sampling carbon stocks in stratum j or k
Section References	B.1.3.3
Comments	This equation is used to estimate the proportion of plots in each stratum under optimal allocation.
	Shiver & Borders (1996)

$$\hat{n}_k = \hat{n}_{TOTAL} w_k \qquad \text{[B.7]}$$

Variables	$\hat{n}_{TOTAL}$ = estimated total number of plots required
	$\hat{n}_k$ = estimated total number of plots required in stratum k
	w_k = the proportion of plots allocated to stratum k
Section References	B.1.3.3
Comments	This equation is used to estimate the number of plots in each stratum.
	Shiver & Borders (1996)

$$\hat{\sigma}_k^2 = \frac{\sum_{j \in \mathcal{P}_k}(y_{j,k})^2 - \left(\sum_{j \in \mathcal{P}_k} y_{j,k}\right)^2 / \#(\mathcal{P}_k)}{\#(\mathcal{P}_k) - 1}$$ [B.8]

Variables	$\hat{\sigma}_k^2$ = estimated variance in stratum k
	$y_{j,k}$ = a quantity estimated for or measured on plot j in stratum k
	$\mathcal{P}_k$ = set of all plots in stratum k
Section References	B.1.4
Comments	The equation is used to estimate the within-stratum variance of the variable y for stratum k.

$$z = \frac{1}{\sum_{k \in \mathcal{S}} A_k} \sum_{k \in \mathcal{S}} \frac{A_k}{n_k} \sum_{j \in \mathcal{P}_k} y_{j,k}$$ [B.9]

Variables	z = the estimated average in the sampled area, for carbon this is c and for degredation this is $p_{L\,DEG}$
	A_k = the area of stratum k
	n_k = number of plots in stratum k
	$y_{j,k}$ = a quantity estimated for or measured on plot j in stratum k
	$\mathcal{P}_k$ = set of all plots in stratum k
	$\mathcal{S}$ = set of all strata
Section References	B.1.4, B.2.1, B.2.2.2, B.2.3, B.2.4.3, B.2.6, B.2.7
Comments	This is a generic equation used to estimate totals from plot level estimates.

$$U = \sqrt{\sum_{k \in \mathcal{S}} \left[\frac{A_k^2 \hat{\sigma}_k^2}{\#(\mathcal{P}_k)} \left(\frac{N_{P,k} - \#(\mathcal{P}_k)}{N_{P,k}} \right) \right]} \qquad \text{[B.10]}$$

Variables	U = estimated standard error of the total for the selected carbon pool
	$\hat{\sigma}_k^2$ = estimated variance in stratum k
	A_k = area of stratum k
	$N_{P,k}$ = total number of possible plots in stratum k
	$\mathcal{P}_k$ = set of all plots in stratum k
	$\mathcal{S}$ = set of all strata in the area
Section References	B.2.1, B.2.2.1, B.2.2.2, B.2.3, B.2.4.3, B.2.6,
Comments	This equation is used to estimate the standard error of the total from a stratified sample from a finite population.
	Shiver & Borders (1996)

$$x_{i,j,k} = \frac{44}{12} \times \frac{1}{1,000} \times f_{SPC}(\bullet) \times p_{CF\,SPC} \qquad \text{[B.11]}$$

Variables	$x_{i,j,k}$ = carbon stock in CO_2e represented by tree i on plot j in stratum k
	$f_{SPC}(\bullet)$ = allometric equation for species SPC
	$p_{CF\,SPC}$= carbon fraction for species SPC
Section References	B.2.1, B.2.2.2, B.2.4.1
Comments	This equation is used to estimate the carbon stock for the ith tree in plot j, stratum k.
	$\frac{44}{12}$ is the ratio of the mass of carbon dioxide to the mass of carbon and is used to convert to CO2e units.
	$\frac{1}{1,000}$ represents a conversion from kg to tonnes.

$$y_{j,k} = \frac{1}{a_{j,k}} \sum_{i \in \mathcal{X}_{j,k}} x_{i,j,k}$$ [B.12]

Variables	$y_{j,k}$ = a quantity estimated for or measured on plot j in stratum k
	$a_{j,k}$ = area of plot j in stratum k
	$x_{i,j,k}$ = a quantity estimated for or measured for individual i on plot j in stratum k
	$\mathcal{X}_{j,k}$ = set of all measurements of a type in plot j in stratum k
Section References	B.2.1, B.2.2.2, B.2.3, B.2.4.3, B.2.7
Comments	This is a generic equation used to estimate plot level totals expressed per unit area from measurements made on individuals.

$$y_{j,k} = \frac{44}{12} \times \frac{1}{1,000} \times \frac{p_{CF\ SPC} \times m_{dry,j,k}}{a_{j,k}}$$ [B.13]

Variables	$y_{j,k}$ = carbon stock in non-tree biomass that results from a destructive sample
	$p_{CF\ SPC}$ = carbon fraction for species SPC
	$a_{j,k}$ = area of plot j in stratum k
	$m_{dry,j,k}$ = dry mass of non-tree sample harvested from clip plots in plot j, stratum k
Section References	B.2.2.1
Comments	This equation is used to estimate the carbon stock in non-tree biomass that results from a destructive sample.
	$\frac{44}{12}$ is the ratio of the mass of carbon dioxide to the mass of carbon and is used to convert to CO2e units.
	$\frac{1}{1,000}$ represents a conversion from kg to tonnes.

$$m_{dry,j,k} = m_{wet,j,k} \frac{m_{dry,subsample}}{m_{wet,subsample}}$$ [B.14]

Variables	$m_{dry,j,k}$ = dry mass of non-tree sample harvested from clip plots in plot j, stratum k
	$m_{wet,j,k}$ = wet mass of non-tree sample harvested from clip plots in plot j, stratum k
	$m_{dry,subsample}$ = dry mass of subsample of non-tree biomass collected to estimate dry:wet ratio
	$m_{wet,subsample}$ = wet mass of subsample of non-tree biomass collected to estimate dry:wet ratio
Section References	B.2.2.1
Comments	This equation is used to estimate dry biomass as a function of the ratio of dry to wet biomass in a subsample of harvested vegetation.

$$v_{i,j,k} = \frac{\pi h_{i,j,k}(r^2_{BASE,i,j,k} + r^2_{TOP,i,j,k} + r_{BASE,i,j,k} \times r_{TOP,i,j,k})}{3}$$ [B.15]

	$v_{i,j,k}$ = volume of the ith tree in plot j, stratum k
	$h_{i,j,k}$ = height of the ith tree in plot j in stratum k
	$r_{BASE,i,j,k}$ = base radius of the ith tree in plot j in stratum k
	$r_{TOP,i,j,k}$ = top radius of the ith tree in plot j in stratum k
Section References	B.2.4.2, B.2.7
Comments	This equation is the volume of a truncated cone and is used to estimate the bole volume of standing dead trees in decay class II and merchantable volume of trees for wood products carbon estimates.
	Units for radius and height shall be given in meters.

$$x_{i,j,k} = \frac{44}{12} \times p_{CF\ SPC} \times \rho_{SPC} \times v_{i,j,k} \qquad [\text{B.16}]$$

Variables	$x_{i,j,k}$ = carbon stock for the ith tree in decay class II in plot j, stratum k
	$p_{CF\ SPC}$ = carbon fraction for species SPC
	ρ_{SPC} = wood density of species SPC
	$v_{i,j,k}$ = volume of the ith tree in decay class II in plot j, stratum k
Section References	B.2.4.2, B.2.7
Comments	This equation is used to estimate the carbon stock for the ith tree in decay class II in plot j, stratum k.
	$\frac{44}{12}$ is the ratio of the mass of carbon dioxide to the mass of carbon and is used to convert to CO2e units.

$$y_{j,k} = \frac{44}{12} \times \frac{1}{10,000} \times \frac{1}{1,000} \times \sum_{d \in \mathcal{D}} \frac{p_{CF\ DW} \times \bar{\rho}_d \times \pi^2 \sum_{i \in \mathcal{X}_{j,k}} x_{i,j,k,d}^2}{8l_j} \qquad \text{[B.17]}$$

Variables	$y_{j,k}$ = total carbon stock in lying dead wood for stratum k transect j
	$p_{CF\ DW}$ = carbon fraction of dry matter for dead wood
	$\bar{\rho}_d$ = average density of dead wood in decay class d
	$x_{i,j,k,d}$ = diameter of ith piece of lying dead wood on transect j in stratum k, decay class d
	l_j = length of transect j
	$\mathcal{D}$ = the set of all decay classes
	$\mathcal{X}_{j,k}$ = set of all measurements of lying dead wood in plot j in stratum k
Section References	B.2.5
Comments	This equation is used to estimate the carbon stock in lying dead wood per unit area for stratum k transect j
	The variables $x_{i,j,k,d}$ and l_j shall be measured in meters.
	$\frac{44}{12}$ is the ratio of the mass of carbon dioxide to the mass of carbon and is used to convert to CO2e units.
	$\frac{1}{1,000}$ represents a conversion from kg to tonnes.
	$\frac{1}{10,000}$ represents a conversion from m^2 to hectares.

$$y_k = \frac{\sum_{j \in \mathcal{L}_k} l_j y_{j,k}}{\sum_{j \in \mathcal{L}_k} l_j}$$ [B.18]

Variables	y_k = average carbon stock per unit area in lying dead wood in stratum k l_j = length of transect j used for measuring lying dead wood. $y_{j,k}$ = total carbon stock in lying dead wood for stratum k transect j $\mathcal{L}_k$ = set of all transects used for measurement of lying dead wood in stratum k
Section References	B.2.5
Comments	This equation is used to estimate the total carbon stock in lying dead wood in stratum k. This equation is a weighted average where the weights are proportional to transect length. In the common case where all transects are the same length, it simplifies to the average: $$y_k = \frac{1}{\#(\mathcal{L}_k)} \sum_{j \in \mathcal{L}_k} y_{j,k}$$ (Shiver & Borders, 1996)

$$\hat{\sigma}_k^2 = \frac{\sum_{j \in \mathcal{L}_k} (y_{j,k})^2 - \left(\sum_{j \in \mathcal{L}_k} y_{j,k}\right)^2 / \#(\mathcal{L}_k)}{\#(\mathcal{L}_k) - 1}$$ [B.19]

Variables	$\hat{\sigma}_k^2$ = variance of carbon stock in lying dead wood for stratum k transect j $y_{j,k}$ = total carbon stock in lying dead wood for stratum k transect j $\mathcal{L}_k$ = set of all transects used for measurement of lying dead wood in stratum k
Section References	B.2.5
Comments	This equation is used to estimate the variance of carbon in lying dead wood in stratum k

$$c_{LD} = \frac{1}{\sum_{k \in \mathcal{S}} A_k} \sum_{k \in \mathcal{S}} A_k y_k \qquad \text{[B.20]}$$

Variables	c_{LD} = estimated average carbon stock in lying dead wood at monitoring period
	A_k = area of stratum k
	y_k = average carbon stock per unit area in lying dead wood in stratum k
	$\mathcal{S}$ = set of all strata in the area
Section References	B.2.5
Comments	This equation is used to estimate the average carbon stock in lying dead wood.

$$U_{LD} = \sqrt{\sum_{k \in \mathcal{S}} \left[\frac{A_k^2 \hat{\sigma}_k^2}{\#(\mathcal{L}_k)} \right]} \qquad \text{[B.21]}$$

Variables	U_{LD} = estimated standard error of the total for carbon stock in lying dead wood
	A_k = the area of stratum k
	$\hat{\sigma}_k^2$ = estimated variance of lying dead wood samples in stratum k
	$\mathcal{S}$ = set of all strata in the area
	$\mathcal{L}_k$ = set of all transects used for measurement of lying dead wood in stratum k
Section References	B.2.5
Comments	This equation is used to estimate the standard error of the total from a line intersect sample used to estimate carbon in lying dead wood.
	Shiver & Borders (1996)

$$\hat{y}_i = f_{-i}(x_i) \qquad\qquad [B.22]$$

Variables	$\hat{y}_i$ = predicted value for observation i f_{-i} = model fit using all points in dataset except observation i x_i = independent variable associated with observation i
Section References	9.3.1.2
Comments	This is the predicted value at observation i that results from fitting a model using all points but observation i during cross validation.

$$\hat{e}_i = \frac{\hat{y}_i - y_i}{y_i} \times 100\% \qquad\qquad [B.23]$$

Variables	$\hat{e}_i$ = cross-validated residual for observation i $\hat{y}_i$ = predicted value for observation i y_i = observed dependent variable for observation i
Section References	9.3.1.2
Comments	This is the cross validated residual for point *i*, expressed as a percentage.

$$\bar{E} = \frac{\sum_{i \in \mathcal{X}} \hat{e}_i}{\#(\mathcal{X})} \qquad\qquad [B.24]$$

Variables	$\bar{E}$ = mean cross-validated error $\hat{e}_i$ = cross-validated residual for observation i $\mathcal{X}$ = the set of all observations
Section References	9.3.1.2
Comments	This equation estimates mean cross-validated error, a measure of bias in the dataset $\mathcal{X}$.

$$\rho_{soil,j,k} = \frac{m_{soil,j,k} - m_{rf,j,k}}{v_{soil,j,k} - v_{rf,j,k}} \qquad [\text{B.25}]$$

Variables	$\rho_{soil,j,k}$ = bulk density of fine portion of soil sample in plot j in stratum k
	$m_{soil,j,k}$ = dry mass of soil sample take from plot j in stratum k.
	$m_{rf,j,k}$ = dry mass of rock fraction of soil sample in plot j in stratum k
	$v_{soil,j,k}$ = total volume of soil sample in plot j in stratum k
	$v_{rf,j,k}$ = volume of coarse fragments (> 2mm) in soil sample taken in plot j in stratum k
Section References	B.2.6,
Comments	This equation estimates the bulk density of soil, corrected to exclude the rock fraction (fragments >2 mm).

$$y_{j,k} = \frac{44}{12} \times 10 \times p_{CF\ soil,j,k} \times \rho_{soil,j,k} \times d_{j,k} \times \left(1 - \frac{v_{rf,j,k}}{v_{soil,j,k}}\right) \qquad [\text{B.26}]$$

Variables	$y_{j,k}$ = soil carbon stock in plot j stratum k
	$\rho_{soil,j,k}$ = bulk density of fine portion of soil sample in plot j in stratum k
	$p_{CF\ soil,j,k}$ = carbon fraction of soil sample in plot j in stratum k
	$d_{j,k}$ = depth of soil sample in plot j in stratum k
	$v_{soil,j,k}$ = total volume of soil sample in plot j in stratum k
	$v_{rf,j,k}$ = volume rock fragments (> 2mm) in soil sample taken in plot j in stratum k
Section References	B.2.6
Comments	This equation is used to estimate the carbon stock in soil in stratum k plot j $\frac{44}{12}$ is the ratio of the mass of carbon dioxide to the mass of carbon and is used to convert to CO2e units. The conversion factor 10 represents a conversion from kg to tones and from m^{-2} to ha^{-1}.

$$C_{slash,i,j,k} = C_{total,i,j,k} - C_{bole,i,jk} \qquad \text{[B.27]}$$

Variables	$C_{slash,i,j,k}$ = Carbon stock in slash for the ith tree on plot j in stratum k
	$C_{total,i,j,k}$ = Total above-ground carbon stock for the ith tree on plot j in stratum k
	$C_{bole,i,j,k}$ = Carbon stock in the merchantable part of the bole for the ith tree on plot j in stratum k
Section References	B.2.7
Comments	This equation is an intermediate step in estimating the slash and wood products ratios.

$$p_i = \frac{C_i}{\sum_{i \in \mathcal{W}} C_i} \qquad \text{[B.28]}$$

Variables	p_i = Wood products ratio for class i
	C_i = Total carbon in wood products class i
	$\mathcal{W}$ = The set of all wood products classes (slash, sawnwood, woodbase panels, other industrial roundwood, and paper/paperboard)
Section References	B.2.7
Comments	This equation calculates their percentage of total carbon in log production expected to be allocated to each of the four wood products classes.

	$$\hat{m}_L \geq \left(\frac{\hat{\sigma}_{DF} 1.64}{0.15}\right)^2 \qquad \text{[B.29]}$$
Variables	$\hat{m}_L$ = the estimated minimum sample size in the leakage area. $\hat{\sigma}_{DF}$ = the estimated standard deviation of the state observations used to fit the logistic function
Section References	B.2.8, 6.7.10
Comments	The estimated sample size in the leakage area. Based on a normal approximation and rewritten from an approximate confidence interval at 90% with threshold of +/- 15% of the estimated mean. $\hat{m}_{FD}$ has an upper bound of 98, the maximum sample size. For a small estimated deforestation rate, a larger sample than estimated is recommended. Lohr (2009)

	$$P = 100 - (1.04 * n) \qquad \text{[B.30]}$$
Variables	P = percent cover estimate n = number of observed openings in densiometer reading
Section References	B.2.8.1
Comments	This formula applies to spherical densitometers with 24 grid cells, assuming four potential count points per grid cell.

For estimates of the project accounting area

$$c_P = \sum_{j \in \mathcal{C}} c_j$$

For estimates of the project accounting area

$$c_B = \sum_{j \in \mathcal{C}} c_j$$

[B.31]

Variables	c_P = average carbon stock in the project accounting area c_B = average carbon stock in the proxy area $\mathcal{C}$ = the set of selected carbon pools
Section References	B.1.5
Comments	This equation is used to estimate the average carbon stock in all selected carbon pools.

For estimates of the project accounting area

$$U_P = \sqrt{\sum_{j \in \mathcal{C}} U_j^2}$$

For estimates of the proxy area

[B.32]

$$U_B = \sqrt{\sum_{j \in \mathcal{C}} U_j^2}$$

Variables	U_P = estimated standard error of total carbon stocks in the project accounting area
	U_B = estimated standard error of total carbon stocks in the project accounting area
	$\mathcal{C}$ = the set of selected carbon pools
	U_j = estimated standard error of carbon pool j
Section References	B.1.5
Comments	This equation is used to combine the standard errors of the totals for selected carbon pools.

APPENDIX C: WOOD PRODUCTS

It is conservative to omit long-lived wood products as a result of project activities but required to consider them in the baseline scenario. If the project proponent chooses to estimate carbon stored in long-lived wood products as a result of the project activity, see section C.1 of this appendix.

Carbon in wood products remaining after 100 years is estimated using [C.1], which was derived from Winjum et al. (1998).

Wood products are classified as sawnwood, woodbase panels, other industrial roundwood, or paper & paperboard, each product type being considered separately. The fraction of wood lost to waste during the milling process (w), given in Table 8, is constant across product types but dependent upon country type. Table 9 provides fractions of wood products lasting at least 5 years (l_{ty}) by product type, and annual oxidation fractions (f_{ty}) for each of the three major forest regions by product type.

In order to estimate emissions-equivalent remaining sequestered in each wood product type (ty) after 100 years, the above-ground merchantable tree emissions are multiplied by the fraction remaining after milling ($1 - w$), the fraction of wood products that last 5 years or more (l_{ty}), and the fraction remaining after applying the oxidation fraction (f_{ty}) over the subsequent 95 years. All product types are summed to obtain the total emissions equivalent sequestered in wood products after 100 years.

Country Type	w
Developing	0.24
Developed	0.19

Table 8: Milling wood waste fraction (w).
Proportion of wood lost during the milling process, from Winjum et al. (1998).

Product Type	l_{ty}	f_{ty}, Boreal	f_{ty}, Temperate	f_{ty}, Tropical
Sawnwood	0.8	0.005	0.01	0.02
Woodbase panels	0.9	0.010	0.02	0.04
Other industrial roundwood	0.7	0.020	0.04	0.08
Paper and paperboard	0.6	0.005	0.01	0.10

Table 9: Long-lived wood fractions (l_{ty}) and oxidation fractions (f_{ty}).
Proportion of timber remaining intact as wood products after 5 years, and annual rate of loss of wood products by forest region, both from Winjum et al. (1998).

If the project proponent wishes, the values for l_{ty} and f_{ty} in Table 10 may be applied to all product types in either the baseline or project scenario to ensure a conservative estimate. The use of these values assumes that all harvested wood goes into wood products in the baseline scenario, and none of it does in the project scenario.

Scenario	l_{ty}	f_{ty}
Baseline	1	0
Project	0	1

Table 10: Conservative values for long-lived wood fractions (l_{ty}) and oxidation fractions (f_{ty}). Applicable to all wood product types.

C.1 Estimating Carbon Stored in WP Using Log Production

If as a result of project activities carbon is stored in wood products, use the methods provided in this appendix and equation [C.2] which is based on the measure log production.

C.2 Equations for Wood Products

$$C_{B\,WP}^{[m]} = (1-w)\left(E_{B\,AGMT}^{[m]}\right)\sum_{ty\in\mathcal{T}} p_{ty}^{[m]}l_{ty}\left(1-f_{ty}\right)^{95} \qquad \text{[C.1]}$$

Variable	$C_{B\,WP}^{[m]}$ = tCO2e sequestered in long-lived wood products after 100 years w = milling wood waste fraction ty = wood product type $E_{B\,AGMT}^{[m]}$ = tCO2e sequestered in above-ground merchantable trees $p_{ty}^{[M]}$ = portion of harvested carbon in product type ty (estimated using Appendix B) l_{ty} = fraction of wood products in product type ty remaining after 5 years f_{ty} = annual oxidation fraction of wood products in product type ty
Section References	8.1.13
Comments	Determining carbon stored in wood products in the baseline.

$$C_{P\,\Delta\,WP}^{[m]} = (1-w)\sum_{ty\in\mathcal{T}} C_{P\,ty}^{[m]}l_{ty}\left(1-f_{ty}\right)^{95} \qquad \text{[C.2]}$$

Variable	$C_{P\,\Delta\,WP}^{[m]}$ = tCO2e sequestered in long-lived wood products after 100 years w = milling wood waste fraction ty = wood product type $C_{ty}^{[m]}$ = Carbon measured in log production for each wood product class l_{ty} = fraction of wood products in product type ty remaining after 5 years f_{ty} = annual oxidation fraction of wood products in product type ty
Section References	8.2.3
Comments	Determining carbon stored in wood products in the project.

APPENDIX D: AREA SELECTION CRITERION

The boundaries and size of the area shall address the following criteria in order to ensure that the agents and drivers of deforestation in the area are similar to those of the project area:

1. The locations of the agents of deforestation relative to the project area.

2. The mobilities of the agents of deforestation relative to the project area.

3. The drivers of deforestation including the following relative to the project area:

    a. Socio-economic conditions; and

    b. Cultural conditions.

4. Landscape configuration including the following relative to the project accounting area:

    a. Topographic constraints to deforestation (slope, aspect, elevation);
    b. Land use and/or land cover constraints to deforestation;
    c. Access points that may constrain deforestation;
    d. Areas of limited soil productivity;
    e. Proximity to important markets;
    f. Proximity to important resources (water, electricity, transportation); and
    g. Ownership/tenure boundaries that constrain deforestation (government holdings, private holdings and reserves).

The interpretation of these criteria is subjective and the project proponent should choose boundaries that result in a conservative baseline scenario when evaluating these criteria. The following analyses may be helpful to identify the boundaries and size of the reference area:

- Mapping the locations of agents of deforestation.
- Buffering the locations of agents based on the distance of their mobility.
- Provincial, district-level or local maps showing the relative socioeconomic conditions of local communities.
- Mapping the locations of important cultural places.
- Digital elevation models.
- Maps of topographic surveys.
- Maps of land use and land cover.
- Mapping the locations of access points that may constrain deforestation.
- Maps of soil productivity.
- Buffering the locations of important markets according to agent mobility.
- Maps of important resources (water, electricity, transportation).
- Maps of ownership boundaries (government holdings, private holdings and reserves).

The area may be similar to the project area by virtue that they are located in the same region and are probably subject to the same agents and drivers of deforestation. However, for substantiation, the project proponent should clearly demonstrate similarity using the following criteria:

1. The area and project area shall be located with the same proximity to the agents of deforestation (for instance if the agents reside in a town, the project area and area shall be similar in distance

from a town in which agents of deforestation reside. These may be the same agents, or they may be different, but similar agents.)

2. Agents of deforestation shall have access (legal or otherwise) to the area. The same agents need not have access to all areas, but the agents with access to each area shall be similar in regards to the drivers of deforestation identified in section E.2.

3. The area has similar conditions to the project area:

   a. Socio-economic conditions; and

   b. Cultural conditions.

4. The area has similar landscape configuration to the project accounting area (for instance, the same topography and land cover).

5. In the case of the reference area, it shall have at least the same area of forest cover as the project accounting area at some point in time during the historic reference period. This can be demonstrated by a thematic classification of land cover in the reference area at some point in the reference period and the project accounting area, analysis of a dot grid or by some other credible method.

APPENDIX E: THE PARTICIPATORY RURAL APPRAISAL

The participatory rural appraisal is a voluntary survey of the populace surrounding the project area and may be used to identify the agents and drivers of deforestation, delineate the reference area and identify strategies to mitigate deforestation in the project area.

The participatory rural appraisal utilizes a questionnaire to identify the agents and drivers of deforestation. The survey should sample as many community members, community leaders, customary leaders and public officials as possible given time and expense constraints. The sample size selected by the project proponent affects the creditability of the agents and drivers identified using the appraisal and a very low sample size may negatively affect the validation opinion. The questionnaire should be anonymous and may contain both closed and open-ended questions. The questionnaire can be issued in written form or administered orally to individuals or groups of people, as is deemed appropriate by local culture and custom. Incentives should be considered to increase the number of responses, taking care not to bias results with said incentives. The questions are designed by the project proponents on an individual project basis and should address the following issues:

1. Possible agents of deforestation, including:

   a. Foreign groups;
   b. Local groups;
   c. Regional groups;
   d. Customary and traditional groups;
   e. Community groups;
   f. Authorities and governments;
   g. Illegal activities; and
   h. Other possible agents.

2. Possible drivers of degradation and deforestation, including:

   a. Historic problems with community sustainability;
   b. Livelihoods;
   c. Economies;
   d. Rural wages;
   e. General scarcity issues;
   f. Prices of agricultural products;
   g. Costs of agricultural inputs;
   h. Human-wildlife interaction;
   i. Illegal or black markets;
   j. Historical and current forest uses;
   k. Population density;
   l. Socio-economic conditions; and
   m. Property-ownership systems;
   n. Other possible drivers.

3. Possible time components of degradation and deforestation, including;

   a. Arrival of foreigners;
   b. Time between the beginning of degradation and ultimate deforestation (see section 6.15);

    c. The length of time between the creation of access points into forest until secondary agents enter the forest resulting in degradation and ultimately deforestation (see sections 6.9 and 6.10)
    d. Changes in transportation infrastructure;
    e. Events of significant importance such as droughts or floods;
    f. Regional climatic trends;
    g. Events of significant population growth;
    h. Events of significant economic growth or decline;
    i. Expected community needs;
    j. War or other conflicts;
    k. Changes in policies; and
    l. Other possible time components.

4. Possible constraints to degradation and deforestation, including:

    a. Access issues;
    b. Soil productivity;
    c. Topography;
    d. Proximity to markets;
    e. Proximity to other resources (water, electricity, transportation);
    f. Protected areas;
    g. Ownership types (government, private, reserve) ; and
    h. Other possible constraints.

5. Relative importance of drivers and agents of deforestation in respondents' estimation (a relative numerical rank).

6. Possible solutions to community un-sustainability.

E.1 Analyzing the Agents of Deforestation

Analyze responses from the survey with respect to the agents of deforestation by first enumerating the responses to agent-based questions. Then, group these responses by the agents identified in the responses. Next, rank groups by the number of responses that fall within any particular group. One response may fall into more than one group. Consider responders' ranking of relative importance when ranking groups. Sort the list of groups by decreasing rank and for each agent of deforestation in the list, and describe its mobility. Also provide a description of the agent relative to possible drivers of deforestation and any useful statistics about the agent obtained from published or unpublished sources.

The sorted list of agents forms the basis for developing project activities that mitigate deforestation in order of importance. Elements of the list may identify possible covariates which could be included as numeric drivers of deforestation in the baseline emissions models. These covariates shall be quantifiable, such as population density data from periodic census or head of cattle in a local community.

E.2 Analyzing the Drivers of Deforestation

Analyze responses from the survey with respect to the drivers of deforestation by first enumerating the responses to driver-based questions. Then, group these responses by the drivers identified in the responses. Rank these groups by the numbers of responses that fall within in any particular group. One response may fall into more than one group. Consider responders' ranking of relative importance when

ranking groups. Sort the list of groups by decreasing rank. Also provide any useful statistics about the driver obtained from published or unpublished sources.

The sorted list of drivers forms the basis for developing project activities that mitigate deforestation in order of importance. Elements of the list may identify possible covariates which could be included as numeric drivers of deforestation in the baseline emissions models.

APPENDIX F: EQUATIONS IN THE METHODOLOGY

$$\hat{m} = \frac{365\left(C_{P\,AGMT}^{[m=0]} + C_{P\,BGMT}^{[m=0]}\right)}{t_{PL} - t_{PA}}$$

[F.1]

Variables	$C_{P\,AGMT}^{[m=0]} c_{B\,AGMT}^{[m]}$, $C_{P\,BGMT}^{[m=0]}$, $t_{PL} t_m t_m$, t_{PA},
Section References	6.13
Comments	Average carbon in merchantable trees cut each year as a result of legally-sanctioned commercial logging, per hectare. $C_{P\,BGMT}^{[m=0]}$ should be set to zero if BGMT is not a selected pool.

$$BEM_{P1}(c_P, c_B, t, x)$$
$$= \frac{m(t - t_{PA})}{365(1 + e^{t - t_{SA} - t_{PA} - t_{PAI}})}$$
$$+ \frac{A_{PAA}(c_P - c_B)e^{t - t_{SA} - t_{PA} - t_{PAI}} + \frac{HA_{P1}(c_P, c_B)t}{t_{PL} - t_{PAI}}}{(1 + e^{t - t_{SA} - t_{PA} - t_{PAI}})\left[1 + e^{\ln\left(\frac{365A_{PAA}(c_P - c_B)}{m(t_{SA} - t_{PAI})} - 1\right) - \beta(t - t_{SA} - t_{PA} - t_{PAI}) - \theta(x - x_{PAI} - x_{SA})^T}\right]}$$
$$- HA_{P1}(c_P, c_B)$$

where

$$HA_{P1}(c_P, c_B)$$
$$= \frac{m}{365(1 + e^{-t_{SA} - t_{PA} - t_{PAI}})}$$
$$+ \frac{A_{PAA}(c_P - c_B)e^{-t_{SA} - t_{PA} - t_{PAI}}}{(1 + e^{-t_{SA} - t_{PA} - t_{PAI}})\left[1 + e^{\ln\left(\frac{365A_{PAA}(c_P - c_B)}{m(t_{SA} - t_{PAI})} - 1\right) + \beta(t_{SA} + t_{PA} + t_{PAI}) - \theta(x_o - x_{SA} - x_{PAI})^T}\right]}$$

[F.2]

Variables	$c_P^{[m]}$, $c_B^{[m]}$, $m, t, \beta, \theta, x, t_{PA}, t_{SA}, x_{SA}, A_{PAA}, t_{PL}, t_{PAI}$
Section References	6.5
Comments	BEM for Type P1

$$BEM_{P2}(c_P, c_B, t, x) = \frac{(c_P - c_B)A_{PAA} + \frac{HA_{P2}(c_P, c_B)t}{t_{PL} - t_{PAI}}}{1 + e^{-\alpha - \beta(t + \gamma + 0.5q - t_{PAI}) - \theta(x - x_{PAI})^T}} - HA_{P2}(c_P, c_B) \qquad \text{[F.3]}$$

where

$$HA_{P2}(c_P, c_B) = \frac{(c_P - c_B)A_{PAA}}{1 + e^{-\alpha - \beta(\gamma + 0.5q - t_{PAI}) - \theta(x_0 - x_{PAI})^T}}$$

Variables	$c_P^{[m]}, c_B^{[m]}, t_{PA}, t, \alpha, \beta, \gamma, q, \theta, x, A_{PAA}, t_{PL}, t_{PAI}$
Section References	8.1.1, 6.5
Comments	BEM for Type P2

$$BEM_{U2,3}(c_P, c_B, t, x) = \frac{A_{PAA}(c_P - c_B) + \frac{HA_{U2,3}(c_P, c_B)t}{t_{PL} - t_{PAI}}}{1 + e^{\ln\left(\frac{1}{r_U}\right) - \beta(t + 0.5q - t_{PAI}) - \theta(x - x_{PAI})^T}} - HA_{U2,3}(c_P, c_B) \qquad \text{[F.4]}$$

where

$$HA_{U2,3}(c_P, c_B) = \frac{A_{PAA}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{r_U}\right) - \beta(0.5q - t_{PAI}) - \theta(x_0 - x_{PAI})^T}}$$

Variables	$c_P^{[m]}, c_B^{[m]}, x_o, t, \beta, \theta, q, x, A_{PAA}, t_{PL}, r_U, t_{PAI} t_{PAI}$
Section References	8.1.1, 6.5
Comments	BEM for Types U2 and U3

$$BEM_{U1}(c_P, c_B, t, x) = \frac{A_{PAA}(c_P - c_B) + \frac{HA_{U1}(c_P, c_B)t}{t_{PL} - t_{PAI}}}{1 + e^{-\beta(t + 0.5q - t_{PAI}) - \theta(x - x_{PAI})^T - \alpha}} - H_{U1}(c_P, c_B)$$
[F.5]

where

$$HA_{U1}(c_P, c_B) = \frac{A_{PAA}(c_P - c_B)}{1 + e^{-\beta(0.5q - t_{PAI}) - \theta(x_0 - x_{PAI})^T - \alpha}}$$

Variables	$c_P^{[m]}, c_B^{[m]}, x_o, t, \alpha, \beta, \theta, q, x, A_{PAA}, t_{PL}, t_{PAI} t_{PAI}$
Section References	8.1.1, 6.5
Comments	BEM for Types U1

$$SEM_P(c_P, c_B, t, x)$$
[F.6]
$$= \frac{A_{PAA}(c_P - c_B)}{1 + e^{-\alpha - \beta(t + \gamma - t_{PA} - t_{PAI}) - \theta(x - x_{PAI})^T}} \left[1 + \frac{t}{t_{PL} + t_{PL}e^{-\alpha - \beta(\gamma - t_{PA} - t_{PAI}) - \theta(x_0 - x_{PAI})^T}} \right]$$
$$- \frac{A_{PAA}(c_P - c_B)}{1 + e^{-\alpha - \beta(\gamma - t_{PA} - t_{PAI}) - \theta(x_0 - x_{PAI})^T}}$$

Variables	$c_B^{[m]}, c_P^{[m]}, t_{PA}, \alpha, \beta, \theta, \gamma, t, x, x_o, A_{PAA}, t_{PAI}$
Section References	8.1.1, 6.5
Comments	SEM for Types P1 and P2 (for P2, $t_{PA} = 0$)

$SEM_{U2,3}(c_P, c_B, t, x)$	[F.7]
$$= \frac{A_{PAA}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{r_U}\right) - \beta(t - t_{PAI}) - \theta(x - x_{PAI})^T}} \left[1 + \frac{t}{t_{PL} + t_{PL}e^{\ln\left(\frac{1}{r_U}\right) - \theta(x_0 - x_{PAI})^T + \beta t_{PAI}}}\right] - \frac{A_{PAA}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{r_U}\right) - \theta(x_0 - x_{PAI})^T + \beta t_{PAI}}}$$	
Variables	$c_{B\,SOC}^{[m]}\ c_B^{[m]}, c_P^{[m]}, x_o, \beta, \theta, t, x, A_{PAA}, r_U, t_{PAI}$
Section References	8.1.1, 6.5
Comments	SEM for Types U2 and U3

$SEM_{U1}(c_P, c_B, t, x)$	[F.8]
$$= \frac{A_{PAA}(c_P - c_B)}{1 + e^{-\beta(t - t_{PAI}) - \theta(x - x_{PAI})^T - \alpha}} \left[1 + \frac{t}{t_{PL} + t_{PL}e^{-\alpha - \theta(x_0 - x_{PAI})^T - \beta t_{PAI}}}\right] - \frac{A_{PAA}(c_P - c_B)}{1 + e^{-\alpha - \theta(x_0 - x_{PAI})^T - \beta t_{PAI}}}$$	
Variables	$c_B^{[m]}, c_P^{[m]}, x_o, \beta, \theta, t, x, A_{PAA}, \alpha, t_{PAI}$
Section References	
Comments	SEM for Type U1

$DEM_{SOC}\left(E_{B\,\Delta}^{[m]}, t, t^{[m-1]}\right)$	[F.9]
$$= E_{B\,\Delta}^{[m]} - \frac{365 E_{B\,\Delta}^{[m]}}{\lambda_{SOC}(t - t^{[m-1]})} \left[\frac{\lambda_{SOC}(t - t^{[m-1]})}{365} + e^{-\frac{\lambda_{SOC}(t - t^{[m-1]})}{365}} - 1\right]$$	
Variables	$t, t^{[m-1]}, \lambda_{SOC}, E_{B\,\Delta}^{[m]}$
Section References	6.18
Comments	DEM for SOC

$$DEM_{DW,BGB}\left(E_{B\,\Delta}^{[m]}, t, t^{[m-1]}, t^{[m]}\right)$$ $$= \frac{E_{B\,\Delta}^{[m]}}{3650(1 + e^{t-365})}\left(3650 + t^{[m]} - t + \frac{t^{[m]} - t^{[m-1]}}{2}\right)$$	[F.10]
Variables	$E_{B\,\Delta}^{[m]}, t^{[m]}, t^{[m-1]}, t$
Section References	6.17
Comments	DEM for DW and BGB

$$o_i = \begin{cases} 1 \ if \ deforested \ at \ (t_i, x_i, y_i) \\ 0 \ if \ forested \ at \ (t_i, x_i, y_i) \end{cases}$$	[F.11]
Variables	t_i, x_i, y_i
Section References	6.7.5
Comments	Observation of forest state at a given point in space and time.

$$\hat{m}_{EM} \geq \frac{1}{2}\left(\frac{\hat{\sigma}_{EM}1.64}{0.01}\right)^2 \qquad \text{[F.12]}$$

Variables	$\hat{\sigma}_{EM}$
Section References	6.7.5
Comments	The minimum sample size $\hat{m}_{EM}$ in the space of the reference area required for fitting the logistic function.
	Based on a normal approximation and rewritten from an approximate confidence level at 90% with threshold of +/- 1% of the estimated mean. +/- 15% of the mean cannot be used as the threshold because of problems associated with peak variance. The ½ factor assumes at least double-coverage to get the sample size in the reference area.
	$\hat{m}_{EM}$ has an upper bound of 4802, the maximum sample size.
	(Lohr, 2009)

$$\hat{\sigma}_{EM} = \sqrt{\left[\sum_{i \in \mathcal{I}} w_i o_i\right]\left[1 - \sum_{i \in \mathcal{I}} w_i o_i\right]} \qquad \text{[F.13]}$$

Variables	$o_i, w_i, \mathcal{I}$
Section References	6.7.5
Comments	Standard deviation of observed *deforestation* derived from an estimate of variance for a Bernoulli random variable (Lohr, 2009).

$$U_{EM}^{[M]} = \frac{E_{B\,\Delta}^{[m]}\hat{\sigma}_{EM}}{\sqrt{n_d}} \qquad \text{[F.14]}$$

Variables	$E_{B\,\Delta}^{[m]}, n_d, \hat{\sigma}_{EM}$
Section References	6.7.10
Comments	An approximate estimate of uncertainty for the logistic function of deforestation, assuming a normal approximation (Lohr, 2009). Uncertainty in emissions models based on sample statistics for deforestation parameters.

$$E_{B\,\Delta}^{[m]} = E_B^{[m]} - E_B^{[m-1]} \tag{F.15}$$

Variables	$E_B^{[m]}$, $E_B^{[m-1]}$
Section References	8.1
Comments	baseline emissions for the current monitoring period

$$E_B^{[m]} = E_{B\,BM}^{[m]} + E_{B\,SOC}^{[m]} - C_{B\,SOC}^{[m]} - C_{B\,BGB}^{[m]} - C_{B\,DW}^{[m]} - C_{B\,WP}^{[m]} \tag{F.16}$$

Variables	$E_{B\,BM}^{[m]}$, $\boldsymbol{E_{B\,SOC}^{[m]}}$, $\boldsymbol{C_{B\,SOC}^{[m]}}$, $C_{B\,BGB}^{[m]}$, $C_{B\,DW}^{[m]}$, $C_{B\,WP}^{[m]}$
Section References	8.1
Comments	cumulative baseline emissions

$$c_{P\,BM}^{[m]} = \sum_{b \in \mathcal{B}} c_{P\,b}^{[m]} \tag{F.17}$$

Variables	$\boldsymbol{c_{P\,b}^{[m]}}$, $\boldsymbol{\mathcal{B}}$
Section References	8.1.1
Comments	Project scenario average carbon stock in selected carbon pools from AGMT, AGOT, AGNT, BGMT, BGOT and BGNT

$$c_{B\ BM}^{[m]} = \sum_{b \in \mathcal{B}} c_{B\ b}^{[m]} \qquad \text{[F.18]}$$

Variables	$c_{B\ b}^{[m]}, \mathcal{B}$
Section References	8.1.1, 8.1.2.1
Comments	Baseline scenario average carbon stock in selected carbon pools from AGMT, AGOT, AGNT, BGMT, BGOT and BGNT

$$E_{B\ BM}^{[m]} = BEM_{P1}\left(c_{P\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}\right) \qquad \text{[F.19]}$$

Variables	$c_{B\ BM}^{[m]}, t^{[m]}, c_{P\ BM}^{[m=0]}, x^{[m]}$
Section References	8.1.1, 8.1.1.1, A.1.2
Comments	cumulative baseline emissions from biomass, P1

$$E_{B\ BM}^{[m]} = BEM_{P2}\left(c_{P\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}\right) \qquad \text{[F.20]}$$

Variables	$c_{P\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}$
Section References	8.1.1, 8.1.1.2
Comments	cumulative emissions baseline emissions from biomass, P2

$$E_{B\,BM}^{[m]} = BEM_{U2,3}\left(c_{P\,BM}^{[m=0]}, c_{B\,BM}^{[m]}, t^{[m]}, x^{[m]}\right)$$ [F.21]

Variables	$c_{P\,BM}^{[m=0]}, c_{B\,BM}^{[m]}, t^{[m]}, x^{[m]}$
Section References	8.1.1.4
Comments	cumulative baseline emissions from biomass, U2 and U3

$$E_{B\,BM}^{[m]} = BEM_{U1}\left(c_{P\,BM}^{[m=0]}, c_{B\,BM}^{[m]}, t^{[m]}, x^{[m]}\right)$$ [F.22]

Variables	$c_{P\,BM}^{[m=0]}, c_{B\,BM}^{[m]}, t^{[m]}, x$
Section References	8.1.1.3
Comments	cumulative baseline emissions from biomass, U1

$$c_{P\,s\,BM}^{[m]} = \sum_{b \in \mathcal{B}} c_{P\,s\,b}^{[m]}$$ [F.23]

Variables	$c_{P\,s\,b}^{[m]}, \mathcal{B}$
Section References	8.1.2.1
Comments	average carbon in biomass for each stratum s

$$E_{B\ BM}^{[m]} = BEM_{SP}\left(c_{P\ 1\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}\right) = BEM_{U2,3}(c_{P\ 1\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]}) \qquad [F.24]$$

$$\text{when } E_{B\ BM}^{[m]} \geq A_{P\ 1}^{[m=0]}\left(c_{P\ 1\ BM}^{[m=0]} - c_{B\ BM}^{[m]}\right)$$

$$\text{then } E_{B\ BM}^{[m]} = BEM_{U2,3}(c_{P\ 2\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]})$$

$$\text{when } E_{B\ BM}^{[m]} \geq A_{P\ 1}^{[m=0]}c_{P\ 1\ BM}^{[m=0]} + A_{P\ 2}^{[m=0]}c_{P\ 2\ BM}^{[m=0]} - c_{B\ BM}^{[m]}\left(A_{P\ 1}^{[m=0]} + A_{P\ 2}^{[m=0]}\right)$$

$$\text{then } E_{B\ BM}^{[m]} = BEM_{U2,3}(c_{P\ 3\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, t^{[m]}, x^{[m]})$$

$$...$$

$$E_{B\ BM}^{[m]} = A_{P\ 1}^{[m=0]}c_{P\ 1\ BM}^{[m=0]} + A_{P\ 2}^{[m=0]}c_{P\ 2\ BM}^{[m=0]} + \cdots + A_{P\ n}^{[m=0]}c_{P\ n\ BM}^{[m=0]}$$
$$- c_{B\ BM}^{[m]}\left(A_{P\ 1}^{[m=0]} + A_{P\ 2}^{[m=0]} + \cdots + A_{P\ n}^{[m=0]}\right)$$

Variables	$c_{P\ 1\ BM}^{[m=0]}, c_{B\ b}^{[m]}, t^{[m]}, A_{P\ 1}^{[m=0]}, c_{P\ 2\ BM}^{[m=0]}, A_{P\ 2}^{[m=0]}, c_{P\ 3\ BM}^{[m=0]}, A_{P\ n}^{[m=0]}, c_{P\ n\ BM}^{[m=0]}, c_{B\ BM}^{[m]}, x^{[m]}$
Section References	8.1.2.1
Comments	Cumulative emissions for each selected carbon pool in biomass (spatial algorithm) used in Type U3.

$$E_{B\ SOC}^{[m]} = SEM_P\left(c_{P\ SOC}^{[m=0]} c_{B\ SOC}^{[m]}, t^{[m]}, x^{[m]}\right) \qquad [F.25]$$

Variables	$c_{P\ SOC}^{[m=0]}, t^{[m]}, c_{B\ SOC}^{[m]}, t^{[m]}, x^{[m]}$
Section References	8.1.3
Comments	cumulative baseline emissions from SOC, Type P

$$E_{\text{B} \Delta SOC}^{[m]} = E_{B\,SOC}^{[m]} - E_{B\,SOC}^{[m-1]}$$

[F.26]

Variables	$E_{B\,SOC}^{[m]}\ E_{B\,SOC}^{[m-1]},\ E_{B\,\Delta\,SOC}^{[m]}$
Section References	8.1.3, 8.1.4, 8.1.5
Comments	current baseline emissions from SOC, Type P

$$E_{B\,SOC}^{[m]} = SEM_{U1}\left(c_{P\,SOC}^{[m=0]}\,c_{B\,SOC}^{[m]},\,t^{[m]},x^{[m]}\right)$$

[F.27]

Variables	$c_{P\,SOC}^{[m=0]}\ c_{B\,SOC}^{[m]},\ t^{[m]},\ x^{[m]}$
Section References	8.1.4
Comments	cumulative baseline *emissions* from **SOC**, Types U1

$$E_{B\,SOC}^{[m]} = SEM_{U2,3}\left(c_{P\,SOC}^{[m=0]}\,c_{B\,SOC}^{[m]},\,t^{[m]},x^{[m]}\right)$$

[F.28]

Variables	$c_{P\,SOC}^{[m=0]},\ c_{B\,SOC}^{[m]},\ t^{[m]},\ x^{[m]}$
Section References	8.1.5
Comments	cumulative baseline *emissions* from **SOC**, Type U2 and U3

$$E_{B\ BGB}^{[m]} = \frac{r_{RS} E_{B\ BM}^{[m]}}{1 + r_{RS}}$$

<div style="text-align:right">[F.29]</div>

Variables	r_{RS}, $E_{B\ BM}^{[m]}$
Section References	8.1.7
Comments	cumulative emissions from BGB

$$E_{B\ \Delta\ BGB}^{[m]} = E_{B\ BGB}^{[m]} - E_{B\ BGB}^{[m-1]}$$

<div style="text-align:right">[F.30]</div>

Variables	$E_{B\ BGB}^{[m]}$, $E_{B\ BGB}^{[m-1]}$
Section References	8.1.7
Comments	current emissions from BGB

$$C_{B\ BGB}^{[m]} = \sum_{i \in \mathcal{M}} DEM_{DW,BGB}\left(E_{B\ \Delta\ BGB}^{[i]}, t^{[m]}, t^{[i-1]}\right)$$

<div style="text-align:right">[F.31]</div>

Variables	$t^{[m]}$, $t^{[i-1]}$, $E_{B\ \Delta\ BGB}^{[i]}$, $\mathcal{M}$
Section References	8.1.7
Comments	carbon in non-decayed BGB

$$C_{B\,SOC}^{[m]} = \sum_{i \in \mathcal{M}} DEM_{SOC}\left(E_{B\,\Delta\,SOC}^{[i]}, t^{[m]}, t^{[i-1]}\right)$$ [F.32]

Variables	$t^{[m]}$, $t^{[i-1]}$, $E_{B\,\Delta\,SOC}^{[i]}E_{B\,\Delta\,SOC}^{[m]}$, $\mathcal{M}$
Section References	8.1.8
Comments	Cumulative carbon not decayed in SOC

$$E_{B\,DW}^{[m]} = p_{SL}^{[m]} E_{B\,AGMT}^{[m]}$$ [F.33]

Variables	$p_{SL}^{[m]}$, $E_{B\,AGMT}^{[m]}$
Section References	8.1.6
Comments	Cumulative emissions from DW

$$E_{B\,\Delta\,DW}^{[m]} = E_{B\,DW}^{[m]} - E_{B\,DW}^{[m-1]}$$ [F.34]

Variables	$E_{B\,DW}^{[m]}$, $E_{B\,DW}^{[m-1]}$
Section References	8.1.6
Comments	Current emissions from DW

$$C_{B\,DW}^{[m]} = \sum_{i \in \mathcal{M}} DEM_{DW,BGB}\left(E_{B\,\Delta\,DW}^{[i]}, t^{[m]}, t^{[i-1]}\right)$$ [F.35]

Variables	$E_{B\,DW}^{[m-1]}, t^{[m]}, t^{[i-1]}, \mathcal{M}$
Section References	8.1.6
Comments	cumulative carbon not decayed in DW

$$E_{B\,AGMT}^{[m]} = BEM_{P1}\left(c_{P\,AGMT}^{[m=0]} + c_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]} + c_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}\right)\left(1 - \frac{r_{RS}}{1 + r_{RS}}\right)$$ [F.36]

Variables	$c_{P\,AGMT}^{[m=0]}, C_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]}, C_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}, r_{RS}$
Section References	8.1.9
Comments	cumulative emissions from AGMT, Type P1

$$E_{B\,AGMT}^{[m]} = BEM_{P2}\left(c_{P\,AGMT}^{[m=0]} + c_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]} + c_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}\right)\left(1 - \frac{r_{RS}}{1 + r_{RS}}\right)$$ [F.37]

Variables	$c_{P\,AGMT}^{[m=0]}, C_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]}, C_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}, r_{RS}$
Section References	8.1.10
Comments	cumulative emissions from AGMT, Type P2

$$E_{B\,AGMT}^{[m]} = BEM_{U1}\left(c_{P\,AGMT}^{[m=0]} + c_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]} + c_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}\right)\left(1 - \frac{r_{RS}}{1+r_{RS}}\right) \qquad \text{[F.38]}$$

Variables	$c_{P\,AGMT}^{[m=0]}, C_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]}, C_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}, r_{RS}$
Section References	8.1.11
Comments	cumulative emissions from AGMT, Types U1

$$E_{B\,AGMT}^{[m]} = BEM_{U2,3}\left(c_{P\,AGMT}^{[m=0]} + c_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]} + c_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}\right)\left(1 - \frac{r_{RS}}{1+r_{RS}}\right) \qquad \text{[F.39]}$$

Variables	$c_{P\,AGMT}^{[m=0]}, C_{P\,BGMT}^{[m=0]}, c_{B\,AGMT}^{[m]}, C_{B\,BGMT}^{[m]}, t^{[m]}, x^{[m]}, r_{RS}$
Section References	8.1.11
Comments	cumulative emissions from AGMT, Type U2 and U3

$$E_{P\,\Delta}^{[m]} = E_{P\,\Delta\,BRN}^{[m]} + A_{PAA}\left(c_P^{[m-1]} - c_P^{[m]}\right) - C_{P\,\Delta\,WP}^{[m]} \qquad \text{[F.40]}$$

Variables	$A_{PAA}, E_{P\,\Delta BRN}^{[m]}, C_{P\,\Delta\,WP}^{[m]}, c_P^{[m-1]}, c_P^{[m]}$
Section References	8.2
Comments	project emissions

$$E_{P\,\Delta\,BRN}^{[m]} = \left(\frac{44}{12}\right) 0.66 \sum_{b \in \mathcal{W}^{[m]}} r_{CF\,b}\, B_{b[m]}$$

[F.41]

Variables	$r_{CF\,b}, \mathcal{W}^{[m]}, B_b^{[m]}$
Section References	8.2.2
Comments	Project Emissions from Burning

(1-0.33=0.66) account for the proportion of mass burned assumed to be water (Simpson & Sagoe, 1991)

44/12 is the ratio of the mass of carbon dioxide to the mass of carbon used to convert to CO2e units |

$$E_{L\,\Delta}^{[m]} = E_L^{[m]} - E_L^{[m-1]}$$

[F.42]

Variables	$E_L^{[m]}, E_L^{[m-1]}$
Section References	8.3
Comments	Total emissions from leakage for the current monitoring period. $E_{L\,\Delta}^{[m]}$ cannot be less than zero.

$$E_L^{[m]} = E_{L\,AS}^{[m]} + E_{L\,ME}^{[m]}$$

[F.43]

Variables	$E_{L\,AS}^{[m]}, E_{L\,ME}^{[m]}$
Section References	8.3
Comments	cumulative emissions from leakage

$$E_{L\,AS}^{[m]} = LEM\left(c_P^{[m]}, c_B^{[m]}, p_{L\,DEG}^{[m]}, t^{[m]}, x^{[m]}\right) \qquad \text{[F.44]}$$

Variables	$t^{[m]}, c_B^{[m]}, c_P^{[m]}, p_{L\,DEG}^{[m]}, x^{[m]}$
Section References	8.3.2
Comments	Cumulative emissions from activity-shifting leakage

$$LEM(c_P, c_B, p_{L\,DEG}, t, x) = p_{L\,DEG}^{[m]} A_{AS}(c_P - c_B) - \frac{A_{AS}(c_P - c_B)}{1 + e^{\ln\left(\frac{1}{p_{L\,DEG}^{[m=0]}} - 1\right) - \beta t - \theta(x_0 - x)^T}} \qquad \text{[F.45]}$$

Variables	$\beta, \theta, t, x, x_o, A_{PAA}, c_B^{[m]}, c_P^{[m]}, p_{L\,DEG}^{[m=0]}, p_{L\,DEG}^{[m]}, A_{AS}$
Section References	8.3.2.2
Comments	Leakage Emissions Model for activity shifting leakage

$$E_{L\,ME}^{[m]} = p_{L\,ME} E_{B\,AGMT}^{[m]} \qquad \text{[F.46]}$$

Variables	$p_{L\,ME}, E_{B\,AGMT}^{[m]}$
Section References	8.3.3
Comments	cumulative emissions from market-effects leakage

$$c_{L\,BM} = \sum_{p\in\mathcal{B}} c_{L\,p}$$ [F.47]

Variables	$c_{L\,p}$, $\mathcal{B}$
Section References	8.3.3.4
Comments	market-effects leakage factor

$$E_{\Delta\,GER}^{[m]} = E_{B\,\Delta}^{[m]} - E_{P\,\Delta}^{[m]} - E_{L\,\Delta}^{[m]} - E_{U}^{[m]}$$ [F.48]

Variables	$E_{B\,\Delta}^{[m]}$, $E_{P\,\Delta}^{[m]}$, $E_{L\,\Delta}^{[m]}$, $E_{U}^{[m]}$
Section References	8.4.1, 8.4.1.2, 8.4.2, 8.4.2.1
Comments	GERs for the current monitoring period

$$E_{GER}^{[m]} = \sum_{i\in\mathcal{M}} E_{\Delta\,GER}^{[i]}$$ [F.49]

Variables	$\mathcal{M}$, $E_{\Delta\,GER}^{[m]}$
Section References	8.4.2.1
Comments	Cumulative GERs to-date

$$E_{\Delta\,NER}^{[m]} = E_{\Delta\,GER}^{[m]} - E_{BA}^{[m]}$$ [F.50]

Variables	$E_{\Delta\,GER}^{[m]} E_U^{[m]}, E_{BA}^{[m]}$
Section References	8.4.3, 8.4.6
Comments	NERs for the current monitoring period

$$E_{NER}^{[m]} = \sum_{i\in\mathcal{M}} E_{\Delta\,NER}^{[i]}$$ [F.51]

Variables	$\mathcal{M}, E_{\Delta\,NER}^{[i]}$
Section References	8.4.6
Comments	Cumulative NERs to-date

$$E_U^{[m]} = E_{B\,\Delta}^{[m]} \left[\frac{1.64}{E_{B\,\Delta}^{[m]} + A_{PAA}c_P^{[m]} + A_{PX}c_B^{[m]}} \sqrt{\left(U_{EM}^{[M]}\right)^2 + \left(U_P^{[m]}\right)^2 + \left(U_B^{[m]}\right)^2} - 0.15 \right]$$ [F.52]

Variables	$A_{PAA}, c_P^{[m]}, c_B^{[m]}, E_{B\,\Delta}^{[m]}, U_{EM}^{[M]}, U_B^{[m]}, U_P^{[m]}, A_{PX}$
Section References	8.4.1.1
Comments	Confidence deduction based on uncertainty in emissions models, carbon stock estimates in the project accountting area and carbon stock estimates in the proxy area. $E_U^{[m]}$ shall be greater than zero; otherwise $E_U^{[m]} = 0$.

APPENDIX G: VALIDATION VARIABLES

Data / Parameter	Unit	Description	Source of Data	Used in Equations	Justification	Comment
α	unitless	Combined effects of β and θ at the start of the historic reference period	Reference area and historic reference period	[F.3], [F.5], [F.6], [F.8]	Time and place in which the logistic model is fit	
β	unitless	Effect of time on the cumulative proportion of deforestation over time	Reference area and historic reference period	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8], [F.45]	Time and place in which the logistic model is fit	
γ	days	Time shift from beginning of historic reference period to project start date	Historic reference period	[F.3], [F.6]	Time in which the logistic model is fit	
θ	unitless	Effect of certain covariates on the cumulative proportion of deforestation over time	Reference area and historic reference period	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8], [F.45]	Time and place in which the logistic model is fit	
λ_{SOC}	proportion (unitless)	Exponential soil carbon decay parameter	Default values, literature estimates or empirical estimation based on reference area sampling	[F.9], [F.32]	A conservative default or values derived from direct measurement by the project proponent or from the literature are acceptable	
$\hat{\sigma}_{EM}$	standard deviation (unitless)	The estimated standard deviation of the state observations used to fit the logistic function	Remote sensing image interpretation	[F.12], [F.14], [B.29]	-	
$\mathcal{B}$	set	The set of all selected carbon pools in biomass. Is a subset of $\mathcal{C}$	PDD	[F.17], [F.18], [F.23], [F.47]	-	
$\mathcal{C}$	set	The set of all selected carbon pools	Monitoring records		-	

Data / Parameter	Unit	Description	Source of Data	Used in Equations	Justification	Comment
$\mathcal{I}$	set	The set of all observations of deforestation. When superscripted with a monitoring period, the deforestation observations are taken for leakage analysis.	Remote sensing image interpretation or field observations in the leakage area.	[F.13]	-	
$\mathcal{M}$	set	The set of all monitoring periods	Monitoring records	[F.31], [F.32], [F.35], [F.49], [F.51]	-	
A_{PAA}	ha	Area of *project accounting area*	GIS analysis prior to sampling	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8], [F.40], [F.45], [F.52]	-	
A_{PX}	ha	Area of proxy area	GIS analysis prior to sampling	[F.52]	-	
A_{AS}	ha	Area of activity-shifting leakage area	GIS analysis prior to sampling	[F.45]		
$c_{L\,p}$	tCO2e/ha	Carbon stocks in project leakage	Leakage area sampling	[F.47]	Direct measurement	
m	tCO2e/yr	Average carbon in merchantable trees cut each year as a result of legally-sanctioned commercial logging	Timber harvest plans or measurement of carbon stocks in merchantable trees in the *project accounting area*	[F.2]	Should use the most accurate of the two data sources if both are available	
n_d		Number of spatial points in the reference area	Remote sensing image interpretation	[F.14]	-	
o_i	binary	State observation for the ith sample point in the reference area	Remote sensing image interpretation	[F.13]	-	
$p_{L\,ME}$	proportion (unitless)	Portion of leakage related to market effects	8.3.3	[F.46]	-	

Data / Parameter	Unit	Description	Source of Data	Used in Equations	Justification	Comment
q	days	Lag between start of degradation and deforestation	Expert knowledge, results from the PRA or reports from peer-reviewed literature	[F.3], [F.4], [F.5], [F.45]	Commonly accepted methods in the social sciences, choice determined and justified by project proponent	
$r_{CF\,b}$	unitless	Carbon fraction of biomass for burned wood b	Literature estimates or direct measurement	[F.41]	-	
r_{RS}	unitless	Expansion factor for above-ground biomass to below-ground biomass (root/shoot ratio)	Reviewed literature, allometry, or IPCC default values	[F.29]	-	
r_U	unitless	Onset proportion of deforestation immediately adjacent to project area	GIS analysis and image interpretation	[F.4]	Positions the baseline emissions models relative to the instantaneous rate of deforestation	
t	days	Time since project start date	Monitoring records	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8],[F.10], [F.45]	-	
t_i	days	The point in time of the observation made at point i	Remote sensing image interpretation	[F.11], [A.6]	-	
t_{PA}	days	Time prior to the project start date when the primary agent began commercial logging in the *project accounting area*	Harvest plans prepared for the *project accounting area*, or by public record	[F.1], [F.2], [F.3], [F.6]	Should use the most accurate of the two data sources if both are available	
t_m	days	Length of project or logging in baseline scenario	PD	[F.1]		
t_{PL}	days	Length of project crediting period	PD			

Data / Parameter	Unit	Description	Source of Data	Used in Equations	Justification	Comment
t_{PAI}	days	Number of days after the project start date for the start of a project activity instance in a grouped project	PD	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8]		
t_{SA}	days	Arrival time of secondary agents after start of commercial logging	Participatory rural appraisal, or expert knowledge	[F.2]	Should use the most accurate of the two data sources if both are available	
w_i	unitless	weight applied to the ith sample point in the reference area	Remote sensing image interpretation	[A.6], [F.13]		
x	unitless	Covariate values	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8], [F.45]	Should use the most accurate of the data sources if both are available	
x_i	geographic coordinates	Latitude of the ith sample point	Remote sensing image interpretation	[F.11], [A.6]	-	
x_o	unitless	Covariate values as of the project start date	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery	[F.4], [F.5], [F.6], [F.7], [F.8], [F.45]	Should use the most accurate of the data sources if both are available	

Data / Parameter	Unit	Description	Source of Data	Used in Equations	Justification	Comment
x_{PAI}	unitless	Covariate values as of a project activity instance start date	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery		Should use the most accurate of the data sources if both are available	
x_{SA}	unitless	Covariate values as of the arrival of the secondary agents	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery	[F.2]	Should use the most accurate of the data sources if both are available	
y_i	geographic coordinates	Longitude of the ith sample point	Remote sensing image interpretation	[F.11], [A.6]	-	

APPENDIX H: MONITORING VARIABLES

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$\mathcal{W}^{[m]}$	set	The set of all burned wood	Monitoring records	N/A	[F.41]	Every monitoring period	Review of monitoring records	
$A_{P\,1}^{[m=0]}$	ha	Area of project accounting area stratum 1 prior to first verification event	GIS analysis prior to sampling	GIS analysis of best available data B.1.1	[F.24]	First monitoring period	Cross-check of GIS analysis	
$A_{P\,2}^{[m=0]}$	ha	Area of project accounting area stratum 2 prior to first verification event	GIS analysis prior to sampling	GIS analysis of best available data B.1.1	[F.24]	First monitoring period	Cross-check of GIS analysis	
$A_{P\,n}^{[m=0]}$	ha	Area of project accounting area stratum n prior to first verification event	GIS analysis prior to sampling	GIS analysis of best available data B.1.1	[F.24]	First monitoring period	Cross-check of GIS analysis	
$B_{b}^{[m]}$	tonnes	Biomass in burned wood b	Measurements of biomass	Scale	[F.41]	Every monitoring period	Review of monitoring records	
$c_{B}^{[m]}$	tCO2e/ha	Baseline carbon stocks at the end of the current monitoring period	Proxy area sampling	B.2,6.4	[F.2], [F.3], [F.4], [F.5], [F.6], [F.7], [F.8], [F.44], [F.45], [F.52]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$C_{B\,BGB}^{[m]}$	tCO2e	Carbon not decayed in BGB at the end of the current monitoring period	Proxy area sampling	8.1.7	[F.16]	Every monitoring period	Review of monitoring records	
$C_{B\,DW}^{[m]}$	tCO2e	Carbon not decayed in DW at the end of the current monitoring period	Proxy area sampling	8.1.6	[F.16]	Every monitoring period	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$C_{B\,SOC}^{[m]}$	tCO2e	Carbon not decayed in SOC at the end of the current monitoring period	Proxy area sampling	8.1.8	[F.16]	Every monitoring period	Review of monitoring records	
$C_{B\,WP}^{[m]}$	tCO2e	Carbon not decayed in WP at the end of the current monitoring period	Proxy area sampling	C	[F.16]	Every monitoring period	Review of monitoring records	
$c_{B\,AGMT}^{[m]}$	tCO2e/ha	Baseline carbon stocks in above-ground merchantable trees at the end of the current monitoring period	Proxy area sampling	B.2.1	[F.36], [F.37], [F.38], [F.39]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$C_{B\,BGMT}^{[m]}$	tCO2e/ha	Baseline carbon stocks in below-ground merchantable trees at the end of the current monitoring period	Proxy area sampling	B.2.1	[F.36], [F.37], [F.38], [F.39]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$C_{P\,AGMT}^{[m=0]}$	tCO2e	Project carbon stocks in above-ground merchantable trees at project start	Project accounting area sampling	B.2.1	[F.1]	First monitoring period	Review of monitoring records	
$C_{P\,BGMT}^{[m=0]}$	tCO2e	Project carbon stocks in below-ground merchantable trees at project start	Project accounting area sampling	B.2.3	[F.1]	First monitoring period	Review of monitoring records	
$c_{B\,b}^{[m]}$	tCO2e/ha	Baseline scenario average carbon stock in selected carbon pools	Proxy area sampling	B.1.5	[F.18] [F.24]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$c_{B\,BM}^{[m]}$	tCO2e/ha	Baseline carbon stocks in biomass at the end of the current monitoring period	Proxy area sampling	B.2	[F.19], [F.20], [F.21], [F.24]	Every time measured (≤ 5 yrs)	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$c_{B\,SOC}^{[m]}$	tCO2e/ha	Baseline soil carbon stocks at the end of the current monitoring period	Proxy area sampling	B.2.6	[F.25], [F.27], [F.28]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$c_P^{[m]}$	tCO2e/ha	Project carbon stocks at the end of the current monitoring period	Project accounting area sampling	B.2	[F.40], [F.44], [F.45], [F.52]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$c_P^{[m-1]}$	tCO2e/ha	Project carbon stocks at the beginning of the current monitoring period	Project accounting area sampling	B.2	[F.40]	Prior monitoring period	Already reviewed	
$c_P^{[m=0]}$	tCO2e/ha	Project carbon stocks prior to first verification event	Project accounting area sampling	B.2	[F.7]	First monitoing period	Review of monitoring records	
$c_{P\,1\,BM}^{[m=0]}$	tCO2e/ha	Project carbon stocks in biomass in stratum 1 prior to first verification event	Project accounting area sampling	B.2	[F.24]	First monitoing period	Review of monitoring records	
$c_{P\,2\,BM}^{[m=0]}$	tCO2e/ha	Project carbon stocks in biomass in stratum 2 prior to first verification event	Project accounting area sampling	B.2	[F.24]	First monitoing period	Review of monitoring records	
$c_{P\,3\,BM}^{[m=0]}$	tCO2e/ha	Project carbon stocks in biomass in stratum 3 prior to first verification event	Project accounting area sampling	B.2	[F.24]	First monitoing period	Review of monitoring records	
$c_{P\,n\,BM}^{[m=0]}$	tCO2e/ha	Project carbon stocks in biomass in stratum n prior to first verification event	Project accounting area sampling	B.2	[F.24]	First monitoing period	Review of monitoring records	
$c_{P\,AGMT}^{[m=0]}$	tCO2e/ha	Project carbon stocks in above-ground merchantable trees prior to first verification event	Project accounting area sampling	B.2.1	[F.36], [F.37], [F.38], [F.39]	First monitoing period	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$c_{P\,BM}^{[m=0]}$	tCO2e	Project carbon stocks in biomass prior to first verification event	Project accounting area sampling	B.2	[F.19], [F.20], [F.21]	First monitoing period	Review of monitoring records	
$c_{P\,b}^{[m]}$	tCO2e/ha	Average carbon in biomass in the project accounting area	Project accounting area sampling	B.2	[F.17]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$c_{P\,s\,b}^{[m]}$	tCO2e/ha	Average carbon in biomass for each project accounting area stratum s	Project accounting area sampling	B.2	[F.23]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$c_{P\,SOC}^{[m=0]}$	tCO2e/ha	Project soil carbon stocks prior to first verification event	Project accounting area sampling	B.2.6	[F.25], [F.27], [F.28]	First monitoring period	Review of monitoring records	
$C_{P\,\varDelta\,WP}^{[m]}$	tCO2e	Project carbon stocks in wood products at the end of the current monitoring period	Project accounting area sampling	C	[F.40]	Every monitoring period	Review of monitoring records	
$E_{\varDelta\,GER}^{[m]}$	tCO2e	GERs for the current monitoring period	Area measurements	8.4.1	[F.50], [F.52]	Every monitoring period	Review of GER calculations	
$E_{\varDelta\,GER}^{[i]}$	tCO2e	GERs for monitoring period i	Area measurements	8.4.1	[F.49]	Prior monitoring period	Review of GER calculations	
$E_{\varDelta\,NER}^{[i]}$	tCO2e	NERs for monitoring period i	Area measurements	8.4.3	[F.51]	Prior monitoring period	Review of NER calculations	
$E_{B}^{[m]}$	tCO2e	Cumulative baseline emissions at the end of the current monitoring period	Proxy area measurements	8.1	[F.15]	Every monitoring period	Review of monitoring records	
$E_{B}^{[m-1]}$	tCO2e	Cumulative baseline emissions at the beginning of the current monitoring period	Proxy area measurements	8.1	[F.15]	Prior monitoring period	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$E_{B\,\Delta}^{[m]}$	tCO2e	Change in baseline emissions	Proxy area measurements	8.1	[F.10], [F.14], [F.48], [F.52]	Every monitoring period	Review of monitoring records	
$E_{B\,\Delta\,BGB}^{[i]}$	tCO2e	Change in baseline emissions from below-ground biomass during monitoring period i	Monitoring the proxy area	B.2.3	[F.31]	Prior monitoring period	Review of monitoring records	
$E_{B\,\Delta\,DW}^{[i]}$	tCO2e	Baseline emissions from dead wood in monitoring period i	Measurements in the proxy area	B.2.4 and B.2.5	[F.35]	Prior monitoring period	Review of monitoring records	
$E_{B\,\Delta\,SOC}^{[m]}$	tCO2e	Baseline change in emissions from soil carbon	Measurements in the proxy area	8.1.3, 8.1.4, 8.1.5, B.2.6	[F.15],[F.32]	Every monitoring period	Review of monitoring records	
$E_{B\,\Delta\,SOC}^{[i]}$	tCO2e	Baseline emissions from soil carbon in monitoring period i	Measurements in the proxy area	8.1.3, 8.1.4, 8.1.5, B.2.6	[F.32]	Prior monitoring period	Review of monitoring records	
$E_{B\,AGMT}^{[m]}$	tCO2e	Cumulative baseline emissions from above-ground commercial trees at the end of the current monitoring period	Measurements in the proxy area	8.1.9, 8.1.10, 8.1.11	[F.33], [F.46]	Every monitoring period	Review of monitoring records	
$E_{B\,BGB}^{[m]}$	tCO2e	Cumulative baseline emissions from below-ground biomass at the end of the current monitoring period	Measurements in the proxy area	8.1.7	[F.30]	Every monitoring period	Review of monitoring records	
$E_{B\,BGB}^{[m-1]}$	tCO2e	Cumulative baseline emissions from below-ground biomass at the beginning of the current monitoring period	Measurements in the proxy area	8.1.7	[F.30]	Prior monitoring period	N/A	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$E_{B\ BM}^{[m]}$	tCO2e	Cumulative baseline emissions from biomass at the end of the current monitoring period	Measurements in the proxy area	8.1.1, 8.1.2.1	[F.16], [F.29]	Every monitoring period	Review of monitoring records	
$E_{B\ DW}^{[m]}$	tCO2e	Cumulative baseline emissions from dead wood at the end of the current monitoring period	Measurements in the proxy area	8.1.6	[F.34]	Every monitoring period	Review of monitoring records	
$E_{B\ DW}^{[m-1]}$	tCO2e	Cumulative baseline emissions from dead wood at the beginning of the current monitoring period	Measurements in the proxy area	8.1.6	[F.34]	Prior monitoring period	N/A	
$E_{B\ SOC}^{[m]}$	tCO2e	Cumulative baseline emissions from soil carbon at the end of the current monitoring period	Measurements in the proxy area	8.1.3, 8.1.4, 8.1.5	[F.16], [F.26]	Every monitoring period	Review of monitoring records	
$E_{B\ SOC}^{[m-1]}$	tCO2e	Cumulative baseline emissions from soil carbon at the beginning of the current monitoring period	Measurements in the proxy area	8.1.3, 8.1.4, 8.1.5	[F.26]	Prior monitoring period	N/A	
$E_{BA}^{[m]}$	tCO2e	Cumulative emissions allocated to the buffer account at the end of the current monitoring period	N/A	8.4.3.1	[F.50]	Every monitoring period	Review of monitoring records	
$E_{L}^{[m]}$	tCO2e	Cumulative emissions from leakage at the end of the current monitoring period	Measurements in the leakage area(s)	8.3	[F.42]	Every monitoring period	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$E_L^{[m-1]}$	tCO2e	Cumulative emissions from leakage at the beginning of the current monitoring period	Measurements in the leakage area(s)	8.3	[F.42]	Prior monitoring period	N/A	
$E_{L\,\Delta}^{[m]}$	tCO2e	Change in emissions due to leakage	N/A	8.3	[F.48]	Every monitoring period	Review of monitoring records	
$E_{L\,AS}^{[m]}$	tCO2e	Cumulative emissions from activity-shifting leakage at the end of the current monitoring period	Measurements in the activity-shifting leakage area	8.3	[F.43]	Every monitoring period	Review of monitoring records	
$E_{L\,ME}^{[m]}$	tCO2e	Cumulative emissions from market effects leakage at the end of the current monitoring period	Measurements in the market-effects leakage area	8.3	[F.43]	Every monitoring period	Review of monitoring records	
$E_{P\,\Delta}^{[m]}$	tCO2e	Change in project emissions	Monitoring records for Forest Fire, Burning, logging, wood products, and natural disturbance events	8.2	[F.48]	Every monitoring period	Review of monitoring records	
$E_{P\,\Delta BRN}^{[m]}$	tCO2e	Cumulative project emissions due to burning at the end of the current monitoring period	Monitoring plots in the project	8.2.2	[F.40]	Every monitoring period	Review of monitoring records	
$E_U^{[m]}$	tCO2e	Cumulative confidence deduction at the end of the current monitoring period	N/A	8.4.1.1	[F.50]	Every monitoring period	Review of monitoring records	
$p_{L\,DEG}^{[m]}$	proportion (unitless)	Portion of leakage due to degradation at the end of the current monitoring period	Monitoring in the leakage area	8.3.2.3	[F.44], [F.45]	Every time measured (≤ 5 yrs)	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$p_{L\,DEG}^{[m=0]}$	proportion (unitless)	Portion of leakage due to degradation prior to first verification event	Monitoring in the leakage area	8.3.2.3	[F.45]	First monitoring period	Project verification	
$p_{SL}^{[m]}$	proportion (unitless)	Proportion of AGMT that is not merchantable and goes into slash estimated from inventory	Estimated from inventory	8.1.11	[F.33]	Every time measured (≤ 5 yrs)	Review of monitoring records	
$t^{[i-1]}$	days	Time from project start date to beginning of monitoring period i	Monitoring records	N/A	[F.31], [F.32]	Prior monitoring period	N/A	
$t^{[m]}$	days	Time from project start date to end of current monitoring period	Monitoring records	N/A	[F.19], [F.20], [F.24], [F.21], [F.25], [F.27], [F.28], [F.31], [F.32], [F.35], [F.36], [F.37], [F.38], [F.39], [F.44]	Every monitoring period	Review of monitoring records	
$t^{[m-1]}$	days	Time from project start date to beginning of current monitoring period	Monitoring records	N/A	[F.10], [F.35]	Prior monitoring period	N/A	
$U_B^{[m]}$	tCO2e	Total uncertainty in proxy area carbon stock estimate	N/A	N/A	[F.52]	Every monitoring period	Review of monitoring records	
$U_{EM}^{[M]}$	tCO2e	Total uncertainty in Baseline Emissions Models	N/A	N/A	[F.52]	Every monitoring period	Review of monitoring records	
$U_P^{[m]}$	tCO2e	Total uncertainty in project accounting area carbon stock estimate	N/A	N/A	[F.52]	Every monitoring period	Review of monitoring records	

Data / Parameter	Unit	Description	Source of Data	Measurement Method	Used in Equations	Frequency of Monitoring/ Recording	QA/QC	Comment
$x^{[m]}$	varies	Covariate values	Participatory Rural Appraisal, analysis of public records, and/or expert interpretation of inventory data or remotely sensed imagery	N/A	[F.19], [F.20], [F.21], [F.24], [F.25], [F.27], [F.28], [F.36], [F.37], [F.38], [F.39], [F.44]	Every time measured (≤ 5 yrs)	Review of monitoring records	

APPENDIX I: PROJECT DOCUMENT REQUIREMENTS BY BASELINE TYPE

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.1	Applicability Conditions	For each applicability condition, a statement of whether it applies to the project. If the applicability condition does not apply to the project, justification for this conclusion.	x	x	x	x	x
PDR.2	Applicability Conditions	Where applicability conditions apply, credible evidence in the forms of analysis, documentation or third-party reports to satisfy the condition.	x	x	x	x	x
PDR.3	Applicability Conditions	Definition of forest used by project proponent and its source	x	x	x	x	x
PDR.4	Spatial Project Boundaries	A digital (GIS-based) map of the project area with at least the above minimum requirements for delineation of the geographic boundaries.	x	x	x	x	x
PDR.5	Spatial Project Boundaries	Credible documentation demonstrating control of the project area, or documentation that the provisos listed in the case of less than 80% project control at the time of validation delineated in this methodology are met.	x	x	x	x	x
PDR.6	Temporal Project Boundaries	The project start date.	x	x	x	x	x
PDR.7	Temporal Project Boundaries	The *project crediting period start date* and length.	x	x	x	x	x
PDR.8	Temporal Project Boundaries	The dates for mandatory *baseline reevaluation* after the project start date.	x	x	x	x	x
PDR.9	Temporal Project Boundaries	A timeline including the first anticipated monitoring period showing when project activities will be implemented.	x	x	x	x	x
PDR.10	Temporal Project Boundaries	A timeline for anticipated subsequent monitoring periods.	x	x	x	x	x
PDR.11	Carbon Pools	A list of the greenhouse gases considered.	x	x	x	x	x
PDR.12	Carbon Pools	A list of the selected carbon pools.	x	x	x	x	x
PDR.13	Carbon Pools	The definition and evidence to support the definition of a merchantable tree if the baseline scenario or project activities include logging.	x	x	x	x	x
PDR.14	Grouped Projects	A list and descriptions of all instances in the group.	x	x	x	x	x
PDR.15	Grouped Projects	A map of the locations or boundaries of all instances in the group indicating that all instances are in the same region.	x	x	x	x	x
PDR.16	Grouped Projects	A map of the common reference area, proxy area, activity-shifting leakage area and market-effects leakage area.	x	x	x	x	x
PDR.17	Agents and Drivers of Deforestation	A list of the evident agents and drivers of deforestation, including quantitative descriptions of agent mobilities.	x	x	x	x	x
PDR.18	Agents and Drivers of Deforestation	A narrative describing the agents and drivers of *deforestation*	x	x	x	x	x
PDR.19	Agents and Drivers of Deforestation	Descriptions of agents and drivers including any useful statistics and their sources.	x	x	x	x	x
PDR.20	Agents and Drivers of Deforestation	A list of external drivers (covariates) of deforestation used in the model, if any (e.g. median household income, road density, rainfall).	x	x	x	x	x

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.21	Accounting Areas	A digital (GIS-based) map of the accounting areas, including aerial or satellite imagery showing that they are completely forested as of the project start date and 10 years prior to the project start date.	x	x	x	x	x
PDR.22	Accounting Areas	Justification and area of the selected accounting areas.	x	x	x	x	x
PDR.23	Identifying the Baseline Type	If Type P1 or Type P2 are selected, justification for meeting the definition of APD in the current VCS-approved AFOLU Requirements.	x	x			
PDR.24	Identifying the Baseline Type	If Type P1 is selected, evidence of legally-sanctioned commercial harvest in the *baseline scenario*.	x				
PDR.25	Identifying the Baseline Type	If Type U1 is selected, a spatial analysis of the project area showing that at least 25% of the perimeter is within 120 meters of *deforestation* that occurred within 10 years prior to the *project start date* and showing that the reference area is adjacent to at least 25% of the project area.			x		
PDR.26	Identifying the Baseline Type	If Type U2 is selected, a spatial analysis of the project area showing that at least 25% of the perimeter is within 120 meters of deforestation that occurred within 10 years prior to the project start date.				X	
PDR.27	Identifying the Baseline Type	If Types U1, U2 or U3 is selected, a spatial analysis of the project area showing that it is within 120 meters of deforestation that occurred within 10 years prior to the project start date.			x	x	x
PDR.28	Delineation of the Proxy Areas	A map of the delineated boundaries.	x	x	x	x	x
PDR.29	Delineation of the Proxy Areas	Maps of the landscape configuration, including: a) topography (elevation, slope, aspect); b) recent land use and land cover (either a thematic map created by the project proponent or publicly available map); c) Access points; d) Soil class maps (if available); e) Locations of important markets; f) Locations of important resources like waterways or roads; and g) Land ownership/tenure boundaries.	x	x	x	x	x
PDR.30	Delineation of the Proxy Areas	A narrative describing the rationale for selection of proxy area boundaries.	x	x	x	x	x
PDR.31	Delineation of the Proxy Areas	Results of a spatial analysis to demonstrate the proxy area is not forested, on average, as of the project start date.	x	x	x	x	x
PDR.32	Delineation of the Reference Area for Planned Types	A map of the delineated boundaries, demonstrating that the reference area was held by the identified baseline agent or agents and does not include the project area.	x	x			
PDR.33	Delineation of the Reference Area for Planned Types	Results of a spatial analysis to demonstrate the reference area had as much *forest* as the *project accounting area* at some point in time during the historic reference period.	x	x			
PDR.34	Delineation of the Reference Area for Planned Types	Evidence that the forest management practices of the baseline agent in the reference area are similar to those that would have been applied to the accounting area or areas in the baseline.	x	x			

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.35	Delineation of the Reference Area for Unplanned Types	A description of the rationale for selection of reference area boundaries.	x	x			
PDR.36	Delineation of the Reference Area for Unplanned Types	A map of the delineated boundaries, demonstrating that the reference area is held by the identified baseline agent or agents and does not include the project area.			x	x	x
PDR.37	Delineation of the Reference Area for Unplanned Types	Maps of the landscape configuration, including: a) topography (elevation, slope, aspect); b) recent land use and land cover (either a thematic map created by the project proponent or publicly available map); c) Access points; d) Soil class maps (if available); e) Locations of important markets; f) Locations of important resources like waterways or roads; and g) Land ownership/tenure boundaries.			x	x	x
PDR.38	Delineation of the Reference Area for Unplanned Types	A description of the rationale for selection of reference area boundaries.			x	x	x
PDR.39	Delineation of the Reference Area for Unplanned Types	Results of a spatial analysis to demonstrate the reference area had as much *forest* as the *project accounting area* at some point in time during the historic reference period.			x	x	x
PDR.40	Defining the Reference Period for Planned Types	Established reference period boundaries.	x	x			
PDR.41	Defining the Reference Period for Planned Types	The date when the agent acquired control of the reference area or when the land management practices employed in the reference area changed.	x	x			
PDR.42	Defining the Reference Period for Unplanned Types	Established reference period boundaries.			x	x	x
PDR.43	Defining the Reference Period for Unplanned Types	A list of available historic imagery for the reference area.			x	x	x
PDR.44	Defining the Reference Period for Unplanned Types	A timeline of important events as they relate to the agents and drivers of *deforestation*.			x	x	x
PDR.45	Defining the Reference Period for Unplanned Types	Narrative rationale for the selection of the reference period.			x	x	x
PDR.46	Historic Imagery to Parameterize α, β and θ	A map of the reference area showing the area of "double-coverage".	x	x	x	x	x
PDR.47	Historic Imagery to Parameterize α, β and θ	Quantification of "double coverage"(greater than 90%).	x	x	x	x	x
PDR.48	Historic Imagery to Parameterize α, β and θ	A line plot of the historic image dates to confirm stationarity.	x	x	x	x	x

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.49	Historic Imagery to Parameterize α, β and θ	Evidence that all image pixels are not more than 30m x 30m.	x	x	x	x	x
PDR.50	Historic Imagery to Parameterize α, β and θ	Empirical evidence that imagery is registered to within 10% RMSE, on average.	x	x	x	x	x
PDR.51	Sampling Deforestation to Parameterize α, β and θ	The sample size.	x	x	x	x	x
PDR.52	Sampling Deforestation to Parameterize α, β and θ	A map of the reference area showing the sample point locations.	x	x	x	x	x
PDR.53	Parameterizing α, β and θ	The covariates that were considered and their data sources.	x	x	x	x	x
PDR.54	Parameterizing α, β and θ	The parameters in θ that were evaluated during model selection.	x	x	x	x	x
PDR.55	Parameterizing α, β and θ	The parameters in $\hat{\theta}$ of the selected model.	x	x	x	x	x
PDR.56	Parameterizing α, β and θ	The rationale used for selecting $\hat{\theta}$ including comparisons of AIC.	x	x	x	x	x
PDR.57	Minimizing Uncertainty in Parameters $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\theta}$	A protocol for interpreting forest state from imagery.	x	x	x	x	x
PDR.58	Minimizing Uncertainty in Parameters $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\theta}$	The results of an independent check of the interpretation.	x	x	x	x	x
PDR.59	Minimizing Uncertainty in Parameters $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\theta}$	Evidence of systematic errors, if any, from the independent check of the interpretation were corrected.	x	x	x	x	x
PDR.60	Parameterizing t_{SA}	The parameter t_{SA} as the number of days after the primary agent begins commercial logging until when the secondary agent of deforestation is likely to begin degrading the project accounting area.	x				
PDR.61	Parameterizing t_{SA}	A description of how $\hat{t}_{SA}$ t_{SA} was obtained	x				
PDR.62	Parameterizing t_{SA}	Harvest plans for the *project accounting area* under the *baseline scenario*, results from the PRA or analysis of the reference area to determine the parameter.	x				
PDR.63	Parameterizing t_{SA}	The parameter $\hat{t}_{PA}$ t_{PA} as the number of days relative to the project start date when the primary agent began or would have begun legally-sanctioned commercial logging in the *project accounting area*.	x				
PDR.64	Parameterizing t_{SA}	A description of how $\hat{t}_{PA}$ was obtained	x				
PDR.65	Parameterizing t_{SA}	Harvest plans for the *project accounting area* under the *baseline scenario* or public records to support the determination of the parameter.	x				
PDR.66	Determining x_0	A table of *covariate* values as of the project start dates and a description of how the values were determined including any interpolation or extrapolation methods.	x	x	x	x	x

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.67	Parameterizing m	The parameter $\hat{m}$ as the average carbon in merchantable trees cut each day as a result of legally-sanctioned commercial logging.	x				
PDR.68	Parameterizing m	Documentation of how m was determined. This may include an analysis of carbon stocks in merchantable trees in the *project accounting area*, timber harvest plans for the *project accounting area* or reference to a publication containing the maximum allowable cut applicable to the *project accounting area*. The parameter shall be greater than zero.	x				
PDR.69	Determining γ	The project shift parameter γ as the number of days between the beginning of the historical reference period and the project start date.	x	x			
PDR.70	Parameterizing q	The parameter q as the number of days between the onset of *degradation* and the beginning of *deforestation*.	x	x	x	x	x
PDR.71	Parameterizing q	If the default of zero is not selected for q, then a justification for the determination of q	x	x	x	x	x
PDR.72	Parameterizing r_U	The parameter $\hat{r}_U$ as the ratio of deforested perimeter to total threatened perimeter, or the ratio of deforested area to total project accounting area(s), as of the project start date.				x	x
PDR.73	Parameterizing r_U	Description of how $\hat{r}_U$ was obtained.				x	x
PDR.74	Parameterizing r_U	Results of GIS analysis to determine or measure $\hat{r}_U$ in the project area including the dates of images used to identify deforestation.				x	x
PDR.75	Empirically Estimating λ_{soc}	Description of how samples from the reference area were selected including stratification, if any.	x	x	x	x	x
PDR.76	Empirically Estimating λ_{soc}	A map of sample locations in the reference area.	x	x	x	x	x
PDR.77	Empirically Estimating λ_{soc}	A table showing the conversion time for each area (farm or otherwise) from which samples were taken.	x	x	x	x	x
PDR.78	Empirically Estimating λ_{soc}	Description of and statistics for the method applied to estimate λ_{soc}.	x	x	x	x	x
PDR.79	Empirically Estimating λ_{soc}	Graph of projected decay model over project lifetime.	x	x	x	x	x
PDR.80	Literature Estimates for λ_{soc}	Inclusion of decay model on which parameter is based.	x	x	x	x	x
PDR.81	Literature Estimates for λ_{soc}	Explicit description of referenced literature, including project location, sampling methodology, included species, sample size, and decay parameter upon which decay is based.	x	x	x	x	x
PDR.82	Literature Estimates for λ_{soc}	Graph of projected decay model over project lifetime.	x	x	x	x	x
PDR.83	Literature Estimates for λ_{soc}	If decay model is based on any other element besides carbon, defense of ability to predict carbon decay shall be provided.	x	x	x	x	x
PDR.84	Describing the Baseline Scenarios for Selected Carbon Pools	A qualitative description of the baseline scenario for each selected carbon pool.	x	x	x	x	x

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.85	Baseline Reevaluation	All required documentation as specified in section 6 for the project prior to the *baseline reevaluation*.	x	x	x	x	x
PDR.86	Baseline Reevaluation	All required documentation as specified in section 6 for the project after the *baseline reevaluation* including the reevaluation period.	x	x	x	x	x
PDR.87	Baseline Reevaluation	A narrative of the reevaluation including any obstacles and how they were overcome.	x	x	x	x	x
PDR.88	Reevaluation of the Reference Area and Period	A map of the new reference area.	x	x	x	x	x
PDR.89	Re-parameterization of α, β and θ	Summary of new data observed in the new reference area.	x	x	x	x	x
PDR.90	Re-parameterization of α, β and θ	The re-parameterized values $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\theta}$.	x	x	x	x	x
PDR.91	Demonstration of Project Additionality	A list of alternative land use scenarios to the project.	x	x	x	x	x
PDR.92	Demonstration of Project Additionality	Justification for the selected *baseline scenario*. This justification can include expert knowledge, results from the participatory rural appraisal and ex-ante estimates of avoided *emissions* (see sections 6.1 and 8.4.5).	x	x	x	x	x
PDR.93	Demonstration of Project Additionality	An investment or barriers analysis proving that the project is not the most economical option OR PDR.94	x	x	x	x	x
PDR.94	Demonstration of Project Additionality	A common practice analysis including a list of project activities and the drivers of *deforestation* that they address OR PDR.93	x	x	x	x	x
PDR.95	Demonstration of Project Additionality	Evident compliance with the minimum requirements of the aforementioned VCS tool. This evidence may be the same as the evidence provided to meet reporting requirements listed in section 4.	x	x	x	x	x
PDR.96	Leakage Mitigation Strategies	A list of project activities designed to mitigate *leakage*.	x	x	x	x	x
PDR.97	Delineation of the Activity-Shifting Leakage Area	A map of the delineated boundaries.	x	x	x	x	x
PDR.98	Delineation of the Activity-Shifting Leakage Area	Maps of the landscape configuration, including: a) topography (elevation, slope, aspect); b) recent land use and land cover (either a thematic map created by the project proponent or publicly available map); c) Access points; d) Soil class maps (if available); e) Locations of important markets; f) Locations of important resources like waterways or roads; and g) Land ownership/tenure boundaries.	x	x	x	x	x
PDR.99	Delineation of the Activity-Shifting Leakage Area	A narrative describing the rationale for selection of *activity-shifting leakage area* boundaries. If the activity-shifting leakage area is smaller than the project accounting area or cannot be defined, justification for the size of the area.	x	x	x	x	x
PDR.100	Delineation of the Activity-Shifting Leakage Area	Results of a spatial analysis to demonstrate the *activity-shifting leakage area* is entirely forested as of the project start date.	x	x	x	x	x
PDR.101	Delineation of the Activity-Shifting Leakage Area	Results of a spatial analysis to demonstrate the *activity-shifting leakage area* is no larger than the *project accounting area*.	x	x	x	x	x

PDR #	Category	Requirement	P1	P2	U1	U2	U3
PDR.102	Determining the Market-Effects Discount Factor	The selected discount factor $p_{L\,ME}$.	x	x	x	x	x
PDR.103	Determining the Market-Effects Discount Factor	Calculations of $c_{L\,AGMT}$ in the *market-effects leakage area*, including references to literature if cited.	x	x	x	x	x
PDR.104	Determining the Market-Effects Discount Factor	If the lowest discount factor (0.1) is selected from Table 6 or is not determined using a market-effects leakage area, the project description shall include the following: Justification for the selection of the discount factor.	x	x	x	x	x
PDR.105	Delineation of the Market-Effects Leakage Area	A map of the delineated boundaries.	x	x	x	x	x
PDR.106	Delineation of the Market-Effects Leakage Area	Maps of the landscape configuration, including: a) topography (elevation, slope, aspect); b) recent land use and land cover (either a thematic map created by the project proponent or publicly available map); c) Access points; d) Soil class maps (if available); e) Locations of important markets; f) Locations of important resources like waterways or roads; and g) Land ownership/tenure boundaries.	x	x	x	x	x
PDR.107	Delineation of the Market-Effects Leakage Area	A narrative describing the rationale for selection of *market-effects leakage area* boundaries.	x	x	x	x	x
PDR.108	Delineation of the Market-Effects Leakage Area	Results of a spatial analysis to demonstrate the *market-effects leakage area* is entirely forested as of the project start date.	x	x	x	x	x
PDR.109	Delineation of the Market-Effects Leakage Area	Results of a spatial analysis to demonstrate the *market-effects leakage area* is as large or larger than the *project accounting area*.	x	x	x	x	x
PDR.110	*Ex-Ante* Estimation of NERs	The projected avoided *baseline emissions*, project *emissions* and *leakage* for each monitoring period over the lifetime of the project.	x	x	x	x	x
PDR.111	*Ex-Ante* Estimation of NERs	A narrative description of sources used to estimate the *leakage* rate and demonstration that the estimated rate is conservative.	x	x	x	x	x
PDR.112	*Ex-Ante* Estimation of NERs	If included in project activities, a description of procedures used to estimate the rate of biomass burning, charcoal production or logging and demonstration that these estimates are conservative.	x	x	x	x	x
PDR.113	Data and Parameters Available at Validation	The value for each variable in Appendix G.	x	x	x	x	x
PDR.114	Description of the Monitoring Plan	Summary of sampling procedures, with a copy of a sampling protocol, with a copy of a sampling protocol used to carry out measurements.	x	x	x	x	x
PDR.115	Description of the Monitoring Plan	Summary of sampling procedures for the proxy areas, with a copy of a sampling protocol used to carry out measurements.	x	x	x	x	x
PDR.116	Description of the Monitoring Plan	Summary of sampling procedures for the activity-shifting leakage areas, with a copy of a sampling protocol used to carry out measurements.	x	x	x	x	x

APPENDIX J: MONITORING REPORT REQUIREMENTS BY BASELINE TYPE

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.1	Spatial Project Boundaries	A digital (GIS-based) map of the project area with at least the above minimum requirements for delineation of the geographic boundaries.	x	x	x	x	x
MR.2	Temporal Project Boundaries	The project start date.	x	x	x	x	x
MR.3	Temporal Project Boundaries	The *project crediting period start date*, end date and length.	x	x	x	x	x
MR.4	Grouped Projects	A list and descriptions of all instances in the group.	x	x	x	x	x
MR.5	Grouped Projects	A map of the locations or boundaries of all instances in the group indicating that all instances are in the same region.	x	x	x	x	x
MR.6	Accounting Areas	A digital (GIS-based) map of the accounting areas with at least the above minimum requirements for delineation of the geographic boundaries.	x	x	x	x	x
MR.7	Determining Time until Project Activity Instance Start Date	For each project activity instance in the group, its project activity instance start date.	x	x	x	x	x
MR.8	Determining Time until Project Activity Instance Start Date	For each project accounting area, the value of $\hat{t}_{PAI}$.	x	x	x	x	x
MR.9	Determining Covariate Data as of the Project Activity Instance Start Date	A table of covariate values as of the project activity instance start dates and a description of how the values were determined including any interpolation or extrapolation methods.	x	x	x	x	x
MR.10	Baseline Emissions	Calculations of current *baseline emissions* $E_{B\,\Delta}^{[m]}$ as of the current monitoring period.	x	x	x	x	x
MR.11	Baseline Emissions	Calculations of *baseline emissions* $E_{B\,\Delta}^{[m-1]}$ from prior monitoring periods.	x	x	x	x	x
MR.12	Baseline Emissions	Calculations of cumulative *baseline emissions* for each selected pool ($E_{B\,BM}^{[m]}$ and $E_{B\,SOC}^{[m]}$) and undecayed carbon ($C_{B\,BGB}^{[m]}$, $C_{B\,DW}^{[m]}$, $C_{B\,SOC}^{[m]}$ and $C_{B\,WP}^{[m]}$), as of the current monitoring period.	x	x	x	x	x
MR.13	Baseline Emissions from Biomass for Types P1, P2, U1, U2 and U3	Calculations of cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ for the current monitoring period.	x	x	x	x	
MR.14	Baseline Emissions from Biomass for Types P1, P2, U1, U2 and U3	Calculations of cumulative baseline emissions from biomass $E_{B\,BM}^{[m]}$ for all prior monitoring periods.	x	x	x	x	
MR.15	Applying the Spatial Algorithm	The order of strata from lowest carbon stocks to highest carbon stocks based on the average across all pools.					x
MR.16	Applying the Spatial Algorithm	Calculations for each step which are carried through from monitoring period to monitoring period.					x
MR.17	Applying the Spatial Algorithm	Calculations of cumulative *baseline emissions* from biomass $E_{B\,BM}^{[m]}$ for prior monitoring periods.					x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.18	Baseline Emissions from SOC for Types P1 and P2	An estimate of current *baseline emissions* from SOC $E^{[m]}_{\text{B} \Delta SOC}$ as of the current monitoring period.	x	x			
MR.19	Baseline Emissions from SOC for Types P1 and P2	An estimate of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for the current monitoring period.	x	x			
MR.20	Baseline Emissions from SOC for Types P1 and P2	Calculations of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for all prior monitoring periods.	x	x			
MR.21	Baseline Emissions from SOC for Type U1	An estimate of current *baseline emissions* from SOC $E^{[m]}_{\text{B} \Delta SOC}$ as of the current monitoring period.			x		
MR.22	Baseline Emissions from SOC for Type U1	An estimate of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for the current monitoring period.			x		
MR.23	Baseline Emissions from SOC for Type U1	Calculations of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for all prior monitoring periods.			x		
MR.24	Baseline Emissions from SOC for Types U2 and U3	An estimate of current *baseline emissions* from SOC $E^{[m]}_{\text{B} \Delta SOC}$ as of the current monitoring period.				x	x
MR.25	Baseline Emissions from SOC for Types U2 and U3	An estimate of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for the current monitoring period.				x	x
MR.26	Baseline Emissions from SOC for Types U2 and U3	Calculations of cumulative *baseline emissions* from SOC $E^{[m]}_{B\ SOC}$ for all prior monitoring periods.				x	x
MR.27	Carbon Not Decayed in DW	An estimate of carbon stored in non-decayed DW $C^{[m]}_{\text{B}\ DW}$ for the current monitoring period.	x	x	x	x	x
MR.28	Carbon Not Decayed in DW	An estimate of cumulative *baseline emissions* from DW $E^{[m]}_{B\ DW}$ for the current monitoring period.	x	x	x	x	x
MR.29	Carbon Not Decayed in DW	An estimate of cumulative *baseline emissions* from AGMT $E^{[m]}_{B\ AGMT}$ for the current monitoring period.	x	x	x	x	x
MR.30	Carbon Not Decayed in DW	Calculations of cumulative *baseline emissions* from DW $E^{[m]}_{B\ DW}$ for all prior monitoring periods.	x	x	x	x	x
MR.31	Carbon Not Decayed in DW	Calculations of cumulative *baseline emissions* from AGMT $E^{[m]}_{B\ AGMT}$ for all prior monitoring periods.	x	x	x	x	x
MR.32	Carbon Not Decayed in BGB	An estimate of carbon stored in non-decayed BGB $C^{[m]}_{\text{B}\ BGB}$ for the current monitoring period.	x	x	x	x	x
MR.33	Carbon Not Decayed in BGB	An estimate of cumulative *baseline emissions* from BGB $E^{[m]}_{B\ BGB}$ for the current monitoring period.	x	x	x	x	x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.34	Carbon Not Decayed in BGB	Calculations of cumulative *baseline emissions* from BGB $E_{B\,BGB}^{[m]}$ for all prior monitoring periods.	x	x	x	x	x
MR.35	Carbon Not Decayed in SOC	An estimate of carbon stored in non-decayed SOC $C_{B\,SOC}^{[m]}$ for the current monitoring period.	x	x	x	x	x
MR.36	Carbon Stored in Wood Products	Carbon stored in *long-lived wood products* $C_{B\,WP}^{[m]}$ after 100 years.	x	x	x	x	x
MR.37	Carbon Stored in Wood Products	Calculations to determine $C_{B\,WP}^{[m]}$.	x	x	x	x	x
MR.38	Emissions Events in Project Area	A map of the boundaries of any significant disturbance in the project accounting areas during the monitoring period.	x	x	x	x	x
MR.39	Emissions Events in Project Area	Evidence that plots were installed into these disturbed areas and were measured per section 9.	x	x	x	x	x
MR.40	Emissions from Burning from Project Activities	A table of events when woody biomass was burned during the monitoring period, showing the weight of woody biomass in tonnes and the date consumed.	x	x	x	x	x
MR.41	Carbon Stored in Wood Products from Project Activities	Carbon stored in *long-lived wood products* $C_{P\,\Delta WP}^{[m]}$ after 100 years.	x	x	x	x	x
MR.42	Carbon Stored in Wood Products from Project Activities	Scale reports or records of carbon in *log production* by wood product type $C_{P\,ty}^{[m]}$.	x	x	x	x	x
MR.43	Carbon Stored in Wood Products from Project Activities	Calculations to determine $C_{P\,\Delta WP}^{[m]}$.	x	x	x	x	x
MR.44	Leakage Mitigation Strategies	A description of project activities that have been implemented since the project start date and the estimated effects of these activities on *leakage* mitigation.	x	x	x	x	x
MR.45	Estimating Emissions from Activity-Shifting Leakage	Calculated cumulative *emissions* from activity-shifting *leakage* for the current monitoring period $E_{L\,AS}^{[m]}$ and supporting calculations.	x	x	x	x	x
MR.46	Estimating Emissions from Activity-Shifting Leakage	Calculated cumulative *emissions* from activity-shifting *leakage* for the prior monitoring periods $E_{L\,AS}^{[m]}$.	x	x	x	x	x
MR.47	Change to the Activity-Shifting Leakage Area	A description and justification of the change to the activity-shifting leakage area.	x	x	x	x	x
MR.48	Change to the Activity-Shifting Leakage Area	A map of the delineated boundaries.	x	x	x	x	x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.49	Change to the Activity-Shifting Leakage Area	Maps of the landscape configuration, including: a. Topography (elevation, slope, aspect); b. Recent land use and land cover (either a thematic map created by the project proponent or publicly available map); c. Access points; d. Soil class maps (if available); e. Locations of important markets; f. Locations of important resources like waterways or roads; and g. Land ownership/tenure boundaries.	x	x	x	x	x
MR.50	Change to the Activity-Shifting Leakage Area	A narrative describing the rationale for selection of activity-shifting leakage area boundaries. If the activity-shifting leakage area is smaller than the project accounting area or cannot be defined, justification for the size of the area.	x	x	x	x	x
MR.51	Change to the Activity-Shifting Leakage Area	Results of a spatial analysis to demonstrate the activity-shifting leakage area is entirely forested as of the project start date.	x	x	x	x	x
MR.52	Change to the Activity-Shifting Leakage Area	Results of a spatial analysis to demonstrate the activity-shifting leakage area is no larger than the project accounting area.	x	x	x	x	x
MR.53	Estimating $p_{L\,DEG}$	The estimated value $\hat{p}_{L\,DEG}^{[m]}$ for the current monitoring period and supporting calculations.	x	x	x	x	x
MR.54	Estimating $p_{L\,DEG}$	The calculated value $\hat{p}_{L\,DEG}^{[m=0]}$ calculated for the first monitoring period.	x	x	x	x	x
MR.55	Determining Emissions from Market-Effects Leakage	Estimated cumulative *emissions* from market-effects *leakage* for the current monitoring period $E_{L\,ME}^{[m]}$ and supporting calculations.	x	x	x	x	x
MR.56	Determining Emissions from Market-Effects Leakage	Calculated cumulative *emissions* from market-effects *leakage* for the prior monitoring periods $E_{L\,ME}^{[m]}$.	x	x	x	x	x
MR.57	Ensuring Constancy of Baseline Operator Management	Provide evidence in the form of GIS imagery, PRA evidence, or the baseline operator's management plan that management plans or land-use designations have not changed in the baseline operator's other lands.	x	x			
MR.58	Quantification of GERs	Quantified GERs for the current monitoring period including references to calculations.	x	x	x	x	x
MR.59	Quantification of GERs	Quantified GERs for the prior monitoring period.	x	x	x	x	x
MR.60	Quantification of GERs	A graph of GERs by monitoring period for all monitoring periods to date.	x	x	x	x	x
MR.61	Confidence Deduction	The confidence deduction $E_U^{[m]}$ and estimated standard errors used to determine the confidence deduction.	x	x	x	x	x
MR.62	Confidence Deduction	Reference to calculations used to determine the confidence deduction.	x	x	x	x	x
MR.63	Quantification of NERs Using a Linear Model	The linear model used to generate GERs for the current monitoring period.	x	x	x	x	x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.64	Quantification of NERs Using a Linear Model	A graph of GERs from the linear model by monitoring period for all monitoring periods to date that used a linear model.	x	x	x	x	x
MR.65	Reversal Event	A description of the reversal including which pools contributed to the reversal and reasons for its occurrence.	x	x	x	x	x
MR.66	Reversal Event as a Result of Baseline Reevaluation	A description of the reversal including a summary of new data obtained in the reference area.	x	x	x	x	x
MR.67	Quantification of NERs for a PAA	Quantified NERs for the current monitoring period including references to calculations.	x	x	x	x	x
MR.68	Quantification of NERs for a PAA	Quantified NERs for the prior monitoring period.	x	x	x	x	x
MR.69	Quantification of NERs for a PAA	A graph of NERs by monitoring period for all monitoring periods to date.	x	x	x	x	x
MR.70	Buffer Account	Reference to the VCS requirements used to determine the buffer account allocation.	x	x	x	x	x
MR.71	Buffer Account	Reference to calculations used to determine the buffer account allocation.	x	x	x	x	x
MR.72	Quantification of NERs across PAAs	Quantified NERs for the current monitoring period including references to calculations.	x	x	x	x	x
MR.73	Quantification of NERs across PAAs	Quantified NERs for the prior monitoring period.	x	x	x	x	x
MR.74	Quantification of NERs across PAAs	A graph of NERs by monitoring period for all monitoring periods to date.	x	x	x	x	x
MR.75	Vintages	Quantified NERs by vintage year for the current monitoring period including references to calculations.	x	x	x	x	x
MR.76	Evaluating Project Performance	Comparison of NERs presented for verification relative to NERs from *ex-ante* estimates.	x	x	x	x	x
MR.77	Evaluating Project Performance	Description of the cause and effect of deviations from *ex-ante* estimates.	x	x	x	x	x
MR.78	Data and Parameters Monitored	List of parameters from Appendix H, their values and the time last measured.	x	x	x	x	x
MR.79	Data and Parameters Monitored	Quality assurance and quality control measures employed for each.	x	x	x	x	x
MR.80	Data and Parameters Monitored	Description of the accuracy of each.	x	x	x	x	x
MR.81	Description of the Monitoring Plan	Documentation of training for field crews.	x	x	x	x	x
MR.82	Description of the Monitoring Plan	If included in project activities, a description of procedures used to estimate the rate of biomass burning and charcoal production and demonstration that these estimates are conservative.	x	x	x	x	x
MR.83	Description of the Monitoring Plan	Documentation of data quality assessment such as a check cruise and plots of the data such as diameter distributions by strata or plot.	x	x	x	x	x
MR.84	Description of the Monitoring Plan	Maps of a stratification (if any) and references to plot allocation.	x	x	x	x	x
MR.85	Description of the Monitoring Plan	List of plot GPS coordinates.	x	x	x	x	x
MR.86	Description of the Monitoring Plan	Description of plot size and layout (such as the use of nests and their sizes) for each carbon pool.	x	x	x	x	x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.87	Description of the Monitoring Plan	If applicable, a detailed description of the process used to develop allometric equations, to include: a) Sample size b) Distribution (e.g. diameter) of the sample c) Model fitting procedure d) Model selection	x	x	x	x	x
MR.88	Description of the Monitoring Plan	The estimated carbon stock, standard error of the total for each stock, and the sample size for each stratum in the area selected.	x	x	x	x	x
MR.89	Description of the Monitoring Plan	Log export monitoring records and standard operating procedure in the project area, if there is commercial harvest in the project scenario.	x	x	x	x	x
MR.90	Description of the Monitoring Plan	Deviations from the measurement methods set out in Appendix B or the monitoring plan, per current VCS requirement.	x	x	x	x	x
MR.91	Description of the Monitoring Plan	The frequency of monitoring for each plot for all plots – all plots should be measured for the first verification. All leakage plots should be measured every verification, and all proxy and project accounting area plots at least every 5-10 years, or after a significant event that changes stocks.	x	x	x	x	x
MR.92	Sources of Allometry	A list of all selected allometric equations used to estimate biomass for trees and non-trees.	x	x	x	x	x
MR.93	Sources of Allometry	For each selected allometric equation, a list of species to which it is being applied and the proportion of the total carbon stocks predicted by the equation.	x	x	x	x	x
MR.94	Sources of Allometry	For each selected allometric equation, indication of when it was first employed to estimate carbon stocks in the project area (monitoring period number and year of monitoring event).	x	x	x	x	x
MR.95	Sources of Allometry	For each selected allometric equation, indication of whether was validated per sections 9.3.1.1 or 9.3.1.2.	x	x	x	x	x
MR.96	Sources of Allometry	Documentation of the source of each selected allometric equation and justification for their applicability to the project area considering climatic, edaphic, geographical and taxonomic similarities between the project location and the location in which the equation was derived.	x	x	x	x	x
MR.97	Validating Previously Developed Allometry	A list of allometric equations validated by destructive sampling.	x	x	x	x	x
MR.98	Validating Previously Developed Allometry	For each, the number of trees (or non-trees) destructively sampled and the location where the measurement were made relative to the project area.	x	x	x	x	x
MR.99	Validating Previously Developed Allometry	A field protocol used to measure destructively sampled trees (or non-trees).	x	x	x	x	x
MR.100	Validating Previously Developed Allometry	Justification that the field protocol for the destructive measurement method is conservatively estimates biomass.	x	x	x	x	X
MR.101	Validating Previously Developed Allometry	For each allometric equation in the list, a figure showing all the descriptive measurements of biomass compared to predicted values from its selected allometric equation.	x	x	x	x	x
MR.102	Validating Newly Developed Allometry	A list of allometric equations cross validated.	x	x	x	x	x

MR #	Category	Requirement	P1	P2	U1	U2	U3
MR.103	Validating Newly Developed Allometry	For each, the number of trees (or non-trees) destructively sampled to build the equation and the location where the measurement were made relative to the project area.	x	x	x	x	x
MR.104	Validating Newly Developed Allometry	A field protocol used to measure trees (or non-trees) when developing the equation.	x	x	x	x	x
MR.105	Validating Newly Developed Allometry	Justification that the field protocol for the measurement method to build the equation conservatively estimates biomass.	x	x	x	x	x
MR.106	Validating Newly Developed Allometry	For each allometric equation in the list, the value of $\bar{E}$.	x	x	x	x	x

DOCUMENT HISTORY

Version	Date	Comment
v1.0	11 Feb 2011	Initial version released
v1.1	10 Nov 2011	Clarifications were made to the soil carbon loss model in section 6.5. Specifically, updates (all effective on issue date) were made to: 1. Clarify the lambda value in section 6.5.2 2. Clarify the procedures for soil sampling in section 6.5.3.
v2.0	26 Oct 2012	Revisions were made to the methodology to accommodate a variety of baseline deforestation scenarios. The methodology now quantifies GHG removals from avoiding planned deforestation and unplanned deforestation in both the mosaic and frontier configurations. End land use carbon stocks are based on a proxy area. The decay of carbon from the belowground biomass, dead wood, and harvested wood products pools have been updated to decay over time and may not be assumed to be immediately released.
v2.1	13 Dec 2012	A correction was made to the methodology to insert Equation [F.9] to Appendix F which was also referenced in section 6.18, because the equation was inadvertently omitted.