

PV Climate Module

PU001

Estimation of Baseline and Project GHG Removals by Carbon Pools in Plan Vivo Projects

Version 1.2

28 December 2025

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1 Summary

This module is part of the Plan Vivo Agriculture and Forestry Carbon Benefit Assessment Methodology (**PM001**). It is applicable to project interventions that result in net-removal of GHGs from the atmosphere, including afforestation and reforestation, forest restoration, agroforestry and farm forestry, changes to cultivation practices, and livestock management. It can be used to provide values for the following parameters:

Baseline removals in eligible carbon pools:

$BR_{WB,a,y}$	Net GHG removals in woody biomass under the baseline scenario for project area a up to year y (see Section 5.1.1)
$BR_{WB_LTA,a,y}$	Long-term average net GHG removals in woody biomass under the baseline scenario for project area a up to year y (t CO ₂ e; see Section 5.6)
$BR_{NB,a,y}$	Net GHG removals in non-woody biomass under the baseline scenario for project area a up to year y (t CO ₂ e; see Section 5.2.1)
$BR_{DW,a,y}$	Net GHG removals in dead wood under the baseline scenario for project area a up to year y (t CO ₂ e; see Section 5.3.1)
$BR_{LI,a,y}$	Net GHG removals in litter under the baseline scenario for project area a up to year y (t CO ₂ e; see Section 5.3.1)
$BR_{SO,a,y}$	Net GHG removals in soil organic carbon under the baseline scenario for project area a up to year y 5.3.1 (t CO ₂ e; see Section 5.4.1)
$BR_{WP,a,y}$	Net GHG removals in wood products under the baseline scenario for project area a up to year y (t CO ₂ e; see Section 5.5)

Project removals in eligible carbon pools:

$PR_{WB,a,y}$	Net GHG removals in woody biomass under the project scenario for project area a up to year y (t CO ₂ e; see Section 5.1.2)
$PR_{WB_LTA,a,y}$	Long-term average net GHG removals in woody biomass under the project scenario for project area a up to year y (t CO ₂ e; see Section 5.6)
$PR_{NB,a,y}$	Net GHG removals in non-woody biomass under the project scenario for project area a up to year y (t CO ₂ e; see Section 5.2.2)

$PR_{DW,a,y}$ Net GHG removals in dead wood under the project scenario for project area a up to year y (t CO₂e; see Section 5.3.2)

$PR_{LI,a,y}$ Net GHG removals in litter under the project scenario for project area a up to year y (t CO₂e; see Section 5.3.2)

$PR_{SO,a,y}$ Net GHG removals in soil organic carbon under the project scenario for project area a up to year y (t CO₂e; see Section 5.4.2)

$PR_{WP,a,y}$ Net GHG removals in wood products under the project scenario for project area a up to year y (t CO₂e; see Section 5.5)

Procedures for estimating baseline and project removals from the different carbon pools include direct measures, modelling and default factors.

2 Sources

This module includes procedures derived from the following CDM Methodologies and Tools:

AR-ACM0003 A/R Large-scale Consolidated Methodology: Afforestation and reforestation of lands except wetlands, Version 2.0

AR-AM0014 Afforestation and reforestation of degraded mangrove habitats, Version 3.0

AR-AMS003 Afforestation and reforestation project activities implemented on wetlands, Version 3.0

AR-TOOL12 Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R CDM project activities, Version 3.1

AR-TOOL14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities, Version 4.2

AR-TOOL16 Tool for estimation of change in soil organic carbon stocks due to the implementation of A/R CDM project activities, Version 1.1

This module applies the following Plan Vivo Tools:

PT001 Smallholder Agriculture Monitoring and Baseline Assessment (SHAMBA) Tool, Version 2.0

PT003 Guidance for the Use of Models Validated with Measurements in PV Climate Projects, Version 1.0

PT004 Identification of Degraded and Degrading Land in PV Climate Projects, Version 1.0

PT#WB Estimation of Change in Woody Biomass, Version 1.0

PT#NWB Estimation of Change in Non-Woody Biomass in Grasslands, Version 1.0

PT#DWL Estimation of Change in Dead Wood and Litter Carbon Stocks, Version 1.0

PT#SOC Estimation of Change in Soil Organic Carbon, Version 1.0

This module references the following IPCC Guidance:

IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Published by the Intergovernmental Panel on Climate Change. ISBN 978-4-88788-232-4.

3 Definitions

Definitions used in this module follow the latest version of the Plan Vivo Glossary, **PM001** and the following.

Organic soils

Soils are organic if they satisfy the requirements 1 and 2, or 1 and 3 below (FAO, 1998):

1. Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 percent or more organic carbon when mixed to a depth of 20 cm;
2. If the soil is never saturated with water for more than a few days, and contains more than 20 percent (by weight) organic carbon (about 35 percent organic matter);
3. If the soil is subject to water saturation episodes and has either:
 - a. At least 12 percent (by weight) organic carbon (about 20 percent organic matter) if it has no clay; or
 - b. At least 18 percent (by weight) organic carbon (about 30 percent organic matter) if it has 60 percent or more clay; or
 - c. An intermediate, proportional amount of organic carbon for intermediate amounts of clay.

4 Applicability Conditions

This module is applicable to Plan Vivo project interventions that result in net-removal of GHGs from the atmosphere. This includes any of the following intervention types:

- Agroforestry and farm forestry;
- Changes to cultivation practices;
- Changes to livestock management;
- Afforestation and reforestation; and
- Forest restoration.

This module can be used for:

- Estimation of net GHG removals by carbon pools in the baseline scenario,
- Estimation of expected net GHG removals by carbon pools in the project scenario, and
- Estimation of net GHG removals by carbon pools achieved in the project scenario

This module is applicable if all of the following conditions are met:

- a. Soil disturbance¹ attributable to the project activity does not cover more than 10 per cent of the area² in each of the following types of land, when these lands are included within the project boundary:
 - i. Land containing organic soils;
 - ii. Land which, in the baseline scenario, is subjected to land-use and management practices and receives inputs listed in Appendices 1 and 2;
 - iii. Wetlands.
- b. The project activity does not lead to alteration of hydrology of the project area or hydrologically connected wetland areas, unless this results from restoration of degraded wetlands by planting native species.

Projects applying this module shall also comply with the applicability conditions of any tools applied.

5 Procedures

5.1 Woody biomass

5.1.1 Baseline removals in woody biomass

¹ Soil disturbance refers to any activity that results in a decrease in soil organic carbon (SOC), for example ploughing, ripping, scarification, digging of pits and trenches, stump removal, etc.

² For example, digging pits of size 0.50 m × 0.50 m (length × width) at a spacing of 3 m × 3 m is equal to a coverage of 2.78 per cent; continuous ploughing of land is equal to a coverage of 100 per cent.

Baseline removals in woody biomass are calculated with Equation 1. If the baseline scenario includes harvesting of trees, approaches for defining long-term average baseline removals in tree biomass described in Section 5.6 must be followed.

Calculation of baseline removals in woody biomass

$$BR_{WB,a,y} = \sum_{t=1}^y \Delta C_{TREE_BSL,t} + \Delta C_{SHRUB_BSL,t}$$

Equation 1

Where:

$BR_{WB,a,y}$ Net GHG removals in woody biomass under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{TREE_BSL,t}$ Change in carbon stock in tree biomass under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{SHRUB_BSL,t}$ Change in carbon stock in shrub biomass under the baseline scenario within the project area in year t (t CO₂e)

Change in tree and shrub biomass under the baseline scenario ($\Delta C_{TREE_BSL,t}$ and $\Delta C_{SHRUB_BSL,t}$) can be estimated with any of the following approaches:

- i. Measurements in matched control areas, following the dynamic baseline procedures in Section 5.1.1.1;
- ii. Modelling of expected woody biomass growth and stand development, following the procedures in Section 5.1.1.2; or
- iii. Assuming no change in woody biomass carbon stocks if the conditions in Section 5.1.1.3 are met.

5.1.1.1 Dynamic baseline procedures for woody biomass

With the dynamic baseline approach, changes to carbon stock in tree and shrub biomass under the baseline scenario are defined by measuring changes in control areas selected to represent the baseline scenario for individual project areas or groups of project areas in different strata. The process for identifying matched control areas is described in Appendix 3.

If a dynamic baseline is used, woody biomass must be measured in control areas throughout the crediting period following the procedures in Section 5.1.2.2. Ensuring that no visible markers of control plot location are left in place between survey events.

Change in carbon stock in woody biomass within the project area under the baseline scenario is calculated with Equation 2 and Equation 3.

$$\Delta C_{TREE_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{TREE_BSL,t2,i} - C_{TREE_BSL,t1,i})}{T}$$

Equation 2

$$\Delta C_{SHRUB_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{SHRUB_BSL,t2,i} - C_{SHRUB_BSL,t1,i})}{T}$$

Equation 3

Where:

$\Delta C_{TREE_BSL,t}$ Change in carbon stock in tree biomass under the baseline scenario within the project area in year t (t CO₂e; see Equation 2)

PA_i Extent of the project area assigned to baseline scenario stratum i (ha; see Appendix 3)

$C_{TREE_BSL,t2,i}$ Average carbon stock in tree biomass in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

$C_{TREE_BSL,t1,i}$ Average carbon stock in tree biomass in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

T Time between $t1$ and $t2$ (years)

M Number of baseline scenario strata (see Appendix 3)

$\Delta C_{SHRUB_BSL,t}$ Change in carbon stock in shrub biomass under the baseline scenario within the project area in year t (t CO₂e; see Equation 3)

$C_{SHRUB_BSL,t2,i}$ Average carbon stock in shrub biomass in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

$C_{SHRUB_{BSL,t,i}}$ Average carbon stock in shrub biomass in the control plots for baseline scenario stratum i in year t (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

5.1.1.2 Modelling expected woody growth

Expected changes in woody biomass in the project area(s) under a baseline scenario can be estimated using empirical or process-based models following the procedures in **PT003**. Tree and shrub growth models may be used in combination with data collected from the project areas describing existence of pre-project trees and shrubs, and any relevant management interventions (such as tree planting) under the baseline scenario. Growth models may be informed by local tree-growth data (e.g. age-diameter curves, yield tables, yield curves) while also considering relevant site factors (e.g. soil, terrain, slope, aspect, precipitation) and stand parameters. Expected changes in aboveground woody biomass are not subjected to uncertainty control, although projects should use the best available data and models that apply to the project site and the tree and/or shrub species.

Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{TREE_BSL,t}$ Change in carbon stock in tree biomass under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{SHRUB_BSL,t}$ Change in carbon stock in shrub biomass under the baseline scenario within the project area in year t (t CO₂e)

5.1.1.3 Conditions under which no change in woody biomass can be assumed in the baseline scenario

Changes in carbon stocks in woody biomass may be accounted as zero in the baseline scenario for project areas where one or more of the following conditions apply:

- a. Conditions in **PT004** are met;
- b. Observed reduction in topsoil depth (e.g. as shown by root exposure, presence of pedestals, exposed sub-soil horizons);
- c. Presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion;
- d. Presence of plant species locally known to be indicators of infertile land;
- e. Land comprises of bare sand dunes, or other bare lands;
- f. Land contains contaminated soils, mine spoils, or highly alkaline or saline soils;

- g. Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing-regrowing cycles) so that the aboveground woody biomass oscillates between a minimum and a maximum value in the baseline scenario;
- h. All of the following conditions are met:
 - i. Pre-project trees and shrubs in the project area are neither harvested, nor cleared, nor removed throughout the crediting period of the project intervention;
 - ii. The pre-project trees and shrubs do not suffer mortality because of competition from trees planted in the project, or damage because of implementation of the project intervention, at any time during the crediting period of the project intervention;
 - iii. The pre-project trees and shrubs are not inventoried along with the project trees in monitoring of carbon stocks but their continued existence, consistent with the baseline scenario, is monitored throughout the crediting period of the project intervention.

Evidence that each project area meets at least one of these conditions must be provided to assume no change in aboveground woody biomass in the baseline scenario.

5.1.2 Project removals in woody biomass

Expected and actual project removals in woody biomass are calculated with Equation 4. If the project scenario includes harvesting of trees, approaches for defining long-term average project removals in woody biomass described in Section 5.6 must be followed.

Calculation of project removals in woody biomass

$$PR_{WB,a,y} = \sum_{t=1}^y \Delta C_{TREE_PROJ,t} + \Delta C_{SHRUB_PROJ,t}$$

Equation 4

Where:

$PR_{WB,a,y}$ Net GHG removals in woody biomass under the project scenario for project area a up to year y (t CO₂e)

$\Delta C_{TREE_PROJ,t}$ Change in carbon stock in tree biomass under the project scenario within the project area in year t (t CO₂e; see Sections 5.1.2.1 and 5.1.2.2)

$\Delta C_{SHRUB_PROJ,t}$ Change in carbon stock in shrub biomass under the project scenario within the project area in year t (t CO₂e; see Sections 5.1.2.1 and 5.1.2.2)

5.1.2.1 Expected project removals in aboveground woody biomass

Expected project removals in tree and shrub biomass can be estimated with the following approach:

- i. Modelling of expected woody biomass growth, following the procedures in Section 5.1.1.2.

5.1.2.2 Actual project removals in woody biomass

Actual removals in woody biomass achieved by the project can be estimated with either of the following approaches:

- i. Measurements within the project area following the procedures in **PT#WB**, or
- ii. Modelling of tree growth and stand development, following the procedures Section 5.1.2.2.1.

5.1.2.2.1 Modelling change in woody biomass with predictions validated by measurements

Expected changes in woody biomass can be modelled following the procedures in Section 5.1.1.2.

Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{TREE_PROJ,t}$ Expected change in carbon stock in tree biomass under the project scenario within the project area in year t (t CO₂e)

$\Delta C_{SHRUB_PROJ,t}$ Expected change in carbon stock in shrub biomass under the project scenario within the project area in year t (t CO₂e)

Model outputs must then be validated with measurements within the project area, following the measurement procedures in **PT#WB** and model validation requirements in **PT003**. A model validation report must be submitted for each verification period

5.2 Non-woody biomass

5.2.1 Baseline removals in non-woody biomass

Baseline removals in non-woody biomass are calculated with Equation 5.

$$BR_{NB,a,y} = \sum_{t=1}^y \Delta C_{AGNWB_BSL,t} + \Delta C_{BGNWB_BSL,t}$$

Equation 5

Where:

$BR_{NB,a,y}$ Net GHG removals in non-woody biomass under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{AGNWB_BSL,t}$ Change in carbon stock in aboveground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{BGNWB_BSL,t}$ Change in carbon stock in belowground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

Change in aboveground and belowground non-woody biomass under the baseline scenario ($\Delta C_{AGNWB_BSL,t}$ and $\Delta C_{BGNWB_BSL,t}$) can be estimated with any of the following approaches:

- i. Measurements in matched control areas, following the dynamic baseline procedures in Section 5.2.1.1;
- ii. Modelling of expected vegetation growth, following the procedures in Section 5.2.1.2;
- iii. Assuming no change in non-woody biomass carbon stocks if the conditions in Section 5.2.1.3 are met; or
- iv. Applying conservative biomass accumulation estimates, as described in Section 5.2.1.3

5.2.1.1 Dynamic baseline procedures for non-woody biomass

With the dynamic baseline approach, changes in carbon stock in non-woody biomass under the baseline scenario are defined by measuring changes in control areas selected to represent the baseline scenario for specific project areas. The process for identifying matched control areas is described in Appendix 3.

Non-woody biomass must be measured in control areas throughout the crediting period following the procedures in Section 5.2.2.2 and, for land covers other than grasslands, replacing the parameters $\Delta C_{AGNWB_PROJ,t}$ and $\Delta C_{BGNWB_PROJ,t}$ with $\Delta C_{AGNWB_BLS,t}$ and $\Delta C_{BGNWB_BLS,t}$ respectively.

For grasslands, change in carbon stock in non-woody biomass under the baseline scenario can be modelled following the procedures in Section 5.2.2.2 and replacing the parameters $\Delta C_{AGNWB_PROJ,t}$ and $\Delta C_{BGNWB_PROJ,t}$ with $\Delta C_{AGNWB_BLS,t}$ and $\Delta C_{BGNWB_BLS,t}$ respectively; or with in-situ measurements following the procedures **PT#NWB** and applying Equation 6 and Equation 7.

$$\Delta C_{AGNWB_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{AGNWB_BSL,t2,i} - C_{AGNWB_BSL,t1,i})}{T}$$

Equation 6

$$\Delta C_{BGNWB_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{BGNWB_BSL,t2,i} - C_{BGNWB_BSL,t1,i})}{T}$$

Equation 7

Where:

$\Delta C_{AGNWB_BSL,t}$ Change in carbon stock in aboveground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e; see Equation 6)

PA_i Extent of the project area assigned to baseline scenario stratum i (ha; see Appendix 3)

$C_{AGNWB_BSL,t2,i}$ Average carbon stock in aboveground non-woody biomass in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; measured following the procedures in **PT#NWB**)

$C_{AGNWB_BSL,t1,i}$ Average carbon stock in aboveground non-woody biomass in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e/ha; measured following the procedures in **PT#NWB**)

T Time between $t1$ and $t2$ (years)

M Number of baseline scenario strata (see Appendix 3)

$\Delta C_{BGNWB_BSL,t}$ Change in carbon stock in belowground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e; Equation 5)

$C_{BGNWB_BSL,t2,i}$ Average carbon stock in belowground non-woody biomass in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; measured following the procedures in **PT#NWB**)

$C_{BGNWB_BSL,t1,i}$ Average carbon stock in belowground non-woody biomass in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e/ha; measured following the procedures in **PT#NWB**)

If in-situ measurements in control plots are used, no visible markers of control plot location should be left in place between survey events.

5.2.1.2 Modelling expected growth of non-woody vegetation

Expected changes in non-woody biomass in the project area(s) can be estimated using empirical or process-based models following the procedures in **PT003**. Models describing growth of non-woody vegetation may be used in combination with data collected from the project areas describing extent of vegetation cover, and any relevant management interventions (such as grazing) under the baseline scenario. Expected changes in non-woody biomass are not subjected to uncertainty control, although projects should use the best available data and models that apply to the project site and the non-woody vegetation type.

Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{AGNWB_BSL,t}$ Change in carbon stock in aboveground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{BGNWB_BSL,t}$ Change in carbon stock in belowground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

5.2.1.3 Conditions under which no change in non-woody biomass can be assumed in the baseline scenario

Changes in carbon stocks in non-woody biomass may be accounted as zero in the baseline scenario for project areas where one or more of the following conditions apply:

- a) Conditions in **PT004** are met³;
- b) Observed reduction in topsoil depth (e.g. as shown by root exposure, presence of pedestals, exposed sub-soil horizons);
- c) Presence of gully, sheet or rill erosion; or landslides, or other forms of mass movement erosion;
- d) Presence of plant species locally known to be indicators of infertile land;
- e) Land comprises of bare sand dunes, or other bare lands;
- f) Land contains contaminated soils, mine spoils, or highly alkaline or saline soils;
- g) Land is subjected to periodic cycles (e.g. slash-and-burn, or clearing-regrowing cycles) so that the aboveground woody biomass oscillates between a minimum and a maximum value in the baseline scenario;

³ In grasslands this could use a projection of historical degradation in the project area/matched control areas using tools such as the Land and Carbon lab grassland extent maps (<https://landcarbonlab.org/data/global-grassland-and-livestock-monitoring/>) showing grassland cover change, coupled with IPCC default biomass stocks for grasslands under land use change (Grasslands. Chapter 6, table 6.4. 2006 IPCC Guidelines for GHG inventories)

- h) Evidence that each project area meets at least one of these conditions must be provided to assume no change in non-woody biomass in the baseline scenario.

5.2.1.4 Conservative estimates of non-woody biomass accumulation

Expected changes in non-woody biomass in the project area(s) under the baseline scenario can be estimated default values for non-woody biomass accumulation that:

- a) Are clearly conservative; and
- b) Are published in IPCC guidance or a peer reviewed source; and
- c) Are relevant for the biophysical conditions of the project area (i.e. if the project is located in the tropics, then default values developed for tropical areas should be used, not temperate).

Default values must include one or more of the following parameters:

$\Delta C_{AGNWB_BSL,t}$ Change in carbon stock in aboveground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{BGNWB_BSL,t}$ Change in carbon stock in belowground non-woody biomass under the baseline scenario within the project area in year t (t CO₂e)

5.2.2 Project removals in non-woody biomass

Expected and actual project removals in non-woody biomass are calculated with Equation 8.

Calculation of project removals in non-woody biomass

$$PR_{NB,a,y} = \sum_{t=1}^y \Delta C_{AGNWB_PROJ,t} + \Delta C_{BGNWB_PROJ,t}$$

Equation 8

Where:

$PR_{NB,a,y}$ Net GHG removals in non-woody biomass under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{AGNWB_PROJ,t}$ Change in carbon stock in aboveground non-woody biomass under the project scenario within the project area in year t (t CO₂e; see Sections 5.2.2.1 and 5.2.2.2)

$\Delta C_{BGNWB_PROJ,t}$ Change in carbon stock in belowground non-woody biomass under the project scenario within the project area in year t (t CO₂e; see Sections 5.2.2.1 and 5.2.2.2)

5.2.2.1 Expected project removals in non-woody biomass

Expected project removals in aboveground and belowground non-woody biomass can be estimated with either of the following approaches:

- i. Modelling of vegetation growth, following the procedures in Section 5.2.1.2; or
- ii. Applying conservative non-woody biomass accumulation estimates as described in Section 5.2.1.3.

Model outputs or default values must include or be used to calculate the following parameters:

$\Delta C_{AGNWB_PROJ,t}$ Change in carbon stock in aboveground non-woody biomass under the project scenario within the project area in year t (t CO₂e)

$\Delta C_{BGNWB_PROJ,t}$ Change in carbon stock in belowground non-woody biomass under the project scenario within the project area in year t (t CO₂e)

5.2.2.2 Actual project removals in non-woody biomass

Actual removals in non-woody biomass achieved by the project can be estimated with either of the following approaches:

- i. In-situ measurements within the project area following the procedures in Section 5.2.2.2.1, or
- ii. Modelling of vegetation growth with results validated with in-situ measurements, following the procedures in following the procedures in Section 5.2.2.2.2

5.2.2.2.1 In-situ measurement of non-woody biomass

For grasslands, actual changes in non-woody biomass in the project area can be measured throughout the crediting period following the procedures in **PT#NWB**.

For other land cover types, actual changes in non-woody biomass in the project area can be estimated with Equation 9 and Equation 10.

Calculation of annual removals in non-woody biomass

$$\Delta C_{AGNWB_PROJ,t} = \frac{A_{HERB,t2} \cdot AGB_{HERB,t2} - A_{HERB,t1} \cdot AGB_{HERB,t1}}{T}$$

Equation 9

$$\Delta C_{BGNWB_PROJ,t} = \frac{A_{HERB,t2} \cdot BGB_{HERB,t2} - A_{HERB,t1} \cdot BGB_{HERB,t1}}{T}$$

Equation 10

Where:

$\Delta C_{AGNWB_PROJ,t}$ Change in carbon stock in aboveground non-woody biomass under the project scenario within the project area in year t (t CO₂e; see Equation 9)

$A_{HERB,t2}$ Area of herbaceous vegetation in project area a in year $t2$ (ha)

$AGB_{HERB,t2}$ Above-ground biomass of herbaceous vegetation in year $t2$ (t CO₂e/ha)

$A_{HERB,t1}$ Area of herbaceous vegetation in project area a in year $t1$ (ha)

$AGB_{HERB,t1}$ Above-ground biomass of herbaceous vegetation in year $t1$ (t CO₂e/ha)

T Time between $t1$ and $t2$ (years)

$\Delta C_{BGNWB_PROJ,t}$ Change in carbon stock in belowground non-woody biomass under the project scenario within the project area in year t (t CO₂e; see Equation 10)

$BGB_{HERB,t2}$ Belowground biomass of herbaceous vegetation in year $t2$ (t CO₂e/ha)

$BGB_{HERB,t1}$ Belowground biomass of herbaceous vegetation in year $t1$ (t CO₂e/ha)

5.2.2.2.2 Modelling change in non-woody biomass with predictions validated by measurements

Expected changes in non-woody biomass can be modelled following the procedures in Section 5.2.1.2. Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{AGNWB_PROJ,t}$ Expected change in carbon stock in aboveground non-woody biomass under the project scenario within the project area in year t (t CO₂e)

$\Delta C_{BGNWB_PROJ,t}$ Expected change in carbon stock in belowground non-woody biomass under the project scenario within the project area in year t (t CO₂e)

Model outputs must then be validated with measurements within the project area, following the requirements in Section 5.2.2.2.1 and **PT003**. A model validation report must be submitted for each verification period.

5.3 Dead wood and litter

5.3.1 Baseline removals in dead wood and litter

Baseline removals in dead wood and litter are calculated with Equation 11 and Equation 12.

Calculation of baseline removals in dead wood

$$BR_{DW,a,y} = \sum_{t=1}^y \Delta C_{DW_BSL,t}$$

Equation 11

Where:

$BR_{DW,a,y}$ Net GHG removals in dead wood under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{DW_BSL,t}$ Change in carbon stock in dead wood under the baseline scenario within the project area in year t (t CO₂e)

Calculation of baseline removals in litter

$$BR_{LI,a,y} = \sum_{t=1}^y \Delta C_{LI_BSL,t}$$

Equation 12

Where:

$BR_{LI,a,y}$ Net GHG removals in litter under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{LI_BSL,t}$ Change in carbon stock in litter under the baseline scenario within the project area in year t (t CO₂e)

Change in carbon stocks in dead wood ($\Delta C_{DW_BSL,t}$) and litter ($\Delta C_{LI_BSL,t}$) can be estimated with any of the following approaches:

- i. Measurements in matched control areas, following the dynamic baseline procedures in Section 5.3.1.1;
- ii. Modelling of carbon removals from dead wood and litter, following the procedures in Section 5.3.1.2;
- iii. Applying a conservative estimate of change in carbon stocks in dead wood/litter, as described in **PT#DWL** Sections 5.1.2 and 5.2.3.

5.3.1.1 Dynamic baseline procedures for dead wood and litter

With the dynamic baseline approach, changes to carbon stock in dead wood and litter under the baseline scenario are defined by measuring changes in control areas selected to represent the

baseline scenario for specific project areas. The process for identifying matched control areas is described in Appendix 3.

Dead wood and litter must be measured in control areas throughout the crediting period following the procedures in Section 5.3.2.2, ensuring that no visible markers of control plot location are left in place between survey events.

Change in carbon stock in dead wood and litter within the project area under the baseline scenario is calculated with and Equation 13 and Equation 14.

$$\Delta C_{DW_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{DW_BSL,t2,i} - C_{DW_BSL,t2-t1,i})}{T}$$

Equation 13

$$\Delta C_{LI_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{LI_BSL,t2,i} - C_{LI_BSL,t2-t1,i})}{T}$$

Equation 14

Where:

$\Delta C_{DW_BSL,t}$ Change in carbon stock in dead wood under the baseline scenario within the project area in year t (t CO₂e; see Equation 13)

PA_i Extent of the project area assigned to baseline scenario stratum i (ha; see Appendix 3)

$C_{DW_BSL,t2,i}$ Average carbon stock in dead wood in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.3.2.2)

$C_{DW_BSL,t1,i}$ Average carbon stock in dead wood in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.3.2.2)

T Time between $t1$ and $t2$ (years)

M Number of baseline scenario strata (see Appendix 3)

$\Delta C_{LI_BSL,t}$ Change in carbon stock in litter under the baseline scenario within the project area in year t (t CO₂e; see Equation 3)

$C_{LI_BSL,t2,i}$ Average carbon stock in litter in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

$C_{LI_BSL,t1,i}$ Average carbon stock in shrub biomass in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e; either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2)

5.3.1.2 Modelling expected change in dead wood and litter

Expected changes in dead wood and litter in the project area(s) can be estimated using empirical or process-based models following the procedures in **PT003**. Models may be used in combination with data collected from the project areas describing existence of pre-project trees and shrubs, and any relevant management interventions (such as tree planting) under the baseline scenario. Expected changes in dead wood and litter are not subjected to uncertainty control, although projects should use the best available data and models that apply to the project site and the tree and/or shrub species present.

Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{DW_BSL,t}$ Change in carbon stock in dead wood under the baseline scenario within the project area in year t (t CO₂e)

$\Delta C_{LI_BSL,t}$ Change in carbon stock in litter under the baseline scenario within the project area in year t (t CO₂e)

5.3.2 Project removals in dead wood and litter

Expected and actual project removals in dead wood and litter are calculated with Equation 15 and Equation 16.

Calculation of project removals in dead wood

$$PR_{DW,a,y} = \sum_{t=1}^y \Delta C_{DW_PROJ,t}$$

Equation 15

Where:

$PR_{DW,a,y}$ Net GHG removals in dead wood under the project scenario for project area a up to year y (t CO₂e)

$\Delta C_{DW_PROJ,t}$ Change in carbon stock in dead wood under the project scenario within the project area in year t (t CO₂e; see Sections 5.3.2.1 and 5.3.2.2)

Calculation of project removals in litter

$$PR_{LI,a,y} = \sum_{t=1}^y \Delta C_{LI_PROJ,t}$$

Equation 16

Where:

$PR_{LI,a,y}$ Net GHG removals in litter under the project scenario for project area a up to year y (t CO₂e)

$\Delta C_{LI_PROJ,t}$ Change in carbon stock in litter under the project scenario within the project area in year t (t CO₂e; see Sections 5.3.2.1 and 5.3.2.2)

5.3.2.1 Expected project removals in dead wood and litter

Expected project removals in dead wood and litter can be estimated with either of the following approaches:

- i. Modelling of carbon fluxes, following the procedures in Section 5.3.1.2; or
- ii. Applying a conservative estimate of change in carbon stocks in dead wood/litter, as described in **PT#DWL** Sections 5.1.2 and 5.2.2

5.3.2.2 Actual project removals in dead wood and litter

Actual project removals in dead wood and litter achieved by the project can be estimated with either of the following approaches:

- i. In-situ measurements in the project area, following the procedures in **PT#DWL** Sections 5.1.1 and 5.2.1; or
- ii. Modelling of carbon fluxes in dead wood and litter following the procedures in Section 5.3.2.2.1

5.3.2.2.1 Modelling change in dead wood and litter with predictions validated by measurements

Expected changes in dead wood and litter can be modelled following the procedures in Section 5.3.1.2. Model outputs must include or be used to calculate one or more of the following parameters:

$\Delta C_{DW_PROJ,t}$ Expected change in carbon stock in dead wood under the project scenario within the project area in year t (t CO₂e)

$\Delta C_{LI_PROJ,t}$ Expected change in carbon stock in litter under the project scenario within the project area in year t (t CO₂e)

Model outputs must then be validated with in-situ measurements within the project area, following the measurement procedures in **PT#DWL** Sections 5.1.1 and 5.2.1 and model validation requirements in **PT003**. A model validation report must be submitted for each verification period

5.4 Soil organic carbon

5.4.1 Baseline removals in soil organic carbon

Baseline removals in soil organic carbon are calculated with Equation 17.

Calculation of baseline removals in soil organic carbon

$$BR_{SO,a,y} = \sum_{t=1}^y \Delta C_{SOC_BSL,t}$$

Equation 17

Where:

$BR_{SO,a,y}$ Net GHG removals in soil organic carbon under the baseline scenario for project area a up to year y (t CO₂e)

$\Delta C_{SOC_BSL,t}$ Change in carbon stock in soil organic carbon under the baseline scenario within the project area in year t (t CO₂e)

Change in soil organic carbon stock under the baseline scenario ($\Delta C_{SOC_BSL,t}$) can be estimated with any of the following approaches:

- i. In-situ measurements in matched control areas, following the dynamic baseline procedures in Section 5.4.1.1;
- ii. Process-based modelling using models parameterised with environmental and activity data that represents the baseline scenario for the project area(s), following the procedures in **PT001** or **PT#SOC**,
- iii. Assuming no change in in soil organic carbon under the baseline scenario if it can be demonstrated using **PT004** that land in the project area is degraded and degrading; or

- iv. Applying a conservative soil organic carbon accumulation estimate, derived following the procedures in **PT#SOC**.

If using the procedures in **PT001** (Option ii), change in soil organic carbon stock under the baseline scenario ($\Delta C_{SOC_BSL,t}$) is calculated with Equation 18.

Calculation of change in soil organic carbon stock under the baseline scenario using PT001

$$\Delta C_{SOC_BSL,t} = -1 \cdot BE_{SO_t} \cdot A$$

Equation 18

Where:

$\Delta C_{SOC_BSL,t}$ Change in carbon stock in soil organic carbon under the baseline scenario within the project area in year t (t CO₂e)

BE_{SO_t} Baseline scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO₂e/ha; from **PT001**)

A Extent of the project area (ha; from **PT001**)

5.4.1.1 Dynamic baseline procedures for soil organic carbon

With the dynamic baseline approach, changes in soil organic carbon under the baseline scenario are defined by measuring changes in control areas selected to represent the baseline scenario for specific project areas. The process for identifying matched control areas is described in Appendix 3.

Soil organic carbon must be measured in control areas throughout the crediting period following the procedures in **PT#SOC**, ensuring that no visible markers of control plot location are left in place between survey events.

Change in carbon stock in soil organic carbon under the baseline scenario within the project area is calculated with Equation 19.

$$\Delta C_{SOC_BSL,t} = \frac{\sum_{i=1}^M PA_i \times (C_{SOC_BSL,t2,i} - C_{SOC_BSL,t1,i})}{T}$$

Equation 19

Where:

$\Delta C_{SOC_BSL,t}$ Change in carbon stock in soil organic carbon under the baseline scenario within the project area in year t (t CO₂e; see Equation 19)

PA_i Extent of the project area assigned to baseline scenario stratum i (ha; see Appendix 3)

$C_{SOC_{BSL,t2,i}}$ Average carbon stock in soil organic carbon in the control plots for baseline scenario stratum i in year $t2$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in **PT#SOC**)

$C_{SOC_{BSL,t1,i}}$ Average carbon stock in soil organic carbon in the control plots for baseline scenario stratum i in year $t1$ (t CO₂e/ha; either measured or modelled with model predictions validated by measurements following the procedures in **PT#SOC**)

T Time between $t1$ and $t2$ (years)

M Number of baseline scenario strata (see Appendix 3)

5.4.2 Project removals in soil organic carbon

Expected and actual project removals in soil organic carbon are calculated with Equation 20

Calculation of project removals in soil organic carbon

$$PR_{SO,a,y} = \sum_{t=1}^y \Delta C_{SOC_PROJ,t}$$

Equation 20

Where:

$PR_{SO,a,y}$ Net GHG removals in soil organic carbon under the project scenario for project area a up to year y (t CO₂e)

$\Delta C_{SOC_PROJ,t}$ Change in carbon stock in soil organic carbon under the project scenario within the project area in year t (t CO₂e; see Sections 5.4.2.1 and 5.4.2.2)

5.4.2.1 Expected project removals in soil organic carbon

Expected project removals in soil organic carbon can be estimated with any of the following approaches:

- i. Process-based modelling using models parameterised with environmental and activity data that represents the project scenario(s), following the procedures in **PT#SOC** or **PT001**, or
- ii. Applying conservative soil organic carbon accumulation estimate, derived following the procedures in **PT#SOC**.

Model outputs or default values must include or be used to calculate the following parameter:

$\Delta C_{SOC_PROJ,t}$ Change in carbon stock in soil organic carbon under the project scenario within the project area in year t (t CO₂e)

If using the procedures in **PT001** (Option i), change in carbon stock in soil organic carbon under the project scenario is calculated with Equation 21.

Calculation of change in soil organic carbon stock under the project scenario using PT001

$$\Delta C_{SOC_PROJ,t} = -1 \cdot PE_{SO_t} \cdot A$$

Equation 21

Where:

$\Delta C_{SOC_PROJ,t}$ Expected change in carbon stock in soil organic carbon under the project scenario within the project area in year t (t CO₂e)

PE_{SO_t} Project scenario emissions from change in soil organic carbon stocks in year t of the verification period (tCO₂e/ha; from **PT001**)

A The extent of the project area (ha; from **PT001**)

5.4.2.2 Actual project removals in soil organic carbon

Actual project removals in soil organic carbon can be estimated with either of the following approaches:

- i. In-situ measurements in project areas, following the procedures in **PT#SOC**; or
- ii. Process-based modelling using models parameterized with environmental and activity data that represents the project scenario(s) with results validated with in-situ measurements, following the procedures in **PT#SOC**.

5.5 Wood products

Baseline and project removals in wood products can be estimated with the following approach:

- i. Modelling following procedures in a tool approved by Plan Vivo.

5.6 Harvesting

To avoid the potential for reversal of carbon benefits as a result of tree harvesting, if the baseline or project scenario includes harvesting of trees, estimation of removals in woody biomass are

based on the long-term average carbon stock. Procedures for calculation of long-term average carbon stock depend on whether harvesting is part of an even-aged management or partial felling system.

5.6.1 Even-aged management

If the baseline or project scenario includes harvesting with even-aged management (e.g. shelterwood, seed tree or clear cutting) long-term average removals in woody biomass are calculated as the average removals over a period of at least one full rotation that includes the final harvest, as shown in Equation 22 and Equation 23.

Calculation baseline removals in woody biomass with even-aged management

$$BR_{WB_LTA,a,y} = \frac{\sum_{t=1}^z BR_{WB,a,t}}{z}$$

Equation 22

Where:

$BR_{WB_LTA,a,y}$ Long-term average net GHG removals in aboveground woody biomass under the baseline scenario for project area a up to year y (t CO₂e)

$BR_{WB,a,t}$ Net GHG removals in aboveground woody biomass under the baseline scenario for project area a in year t (t CO₂e; see Section 5.1.1)

z Number of years in one or more full rotations (years)

Calculation of project removals in woody biomass with even-aged management

$$PR_{WB_LTA,a,y} = \frac{\sum_{t=1}^z PR_{WB,a,t}}{z}$$

Equation 23

Where:

$PR_{WB_LTA,a,y}$ Long-term average GHG removals in aboveground woody biomass under the project scenario for project area a up to year y (t CO₂e)

$PR_{WB,a,t}$ Net GHG removals in aboveground woody biomass under the project scenario for project area a in year t (t CO₂e; see Section 5.1.2)

z Number of years in one or more full rotations (years)

5.6.2 Partial felling

If the baseline or project scenario includes thinning or partial felling (e.g. single tree or group selection), long-term average net-removals in woody biomass are estimated as the minimum post-harvest removals in tree biomass, as shown in Equation 24 and Equation 25.

Calculation of baseline removals in woody biomass with partial felling

$$BR_{WB_LTA,a,y} = BR_{WB,a,x}$$

Equation 24

Where:

$BR_{WB_LTA,a,y}$ Maximum net GHG removals in aboveground woody biomass under the baseline scenario for project area a up to year y (t CO₂e)

$BR_{WB,a,x}$ Net GHG removals in aboveground woody biomass under the baseline scenario for project area a up to year x , where year x is the year between the time of the first harvest and 50-years after the start of the baseline period that has the lowest cumulative net GHG removals in woody biomass (t CO₂e; see Section 5.1.1).

Calculation of project removals in woody biomass with partial felling

$$PR_{WB_LTA,a,y} = PR_{WB,a,x}$$

Equation 25

Where:

$PR_{WB_LTA,a,y}$ Maximum net GHG removals in aboveground woody biomass under the project scenario for project area a up to year y (t CO₂e)

$PR_{WB,a,x}$ Net GHG removals in aboveground woody biomass under the project scenario for project area a up to year x , where year x is the year between the time of the first harvest and 50-years after the initiation of the project intervention that has the lowest cumulative net GHG removals in aboveground woody biomass (t CO₂e; see Section 5.1.2).

6 Parameter

Data/Parameter	$\Delta C_{TREE_BSL,t}$
Units	t CO ₂ e
Description	Change in carbon stock in tree biomass under the baseline scenario within the project area in year t
Equations	Equation 1

Source	See Section 5.1.1.
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.1.1.
Purpose of Data	Calculation of baseline removals in woody biomass
Comments	NA

Data/Parameter	$\Delta C_{SHRUB_BSL,t}$
Units	t CO ₂ e
Description	Change in carbon stock in shrub biomass under the baseline scenario within the project area in year t
Equations	Equation 1
Source	See Section 5.1.1.
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.1.1.
Purpose of Data	Calculation of baseline removals in woody biomass
Comments	NA

Data/Parameter	PA_i
Units	ha
Description	Extent of the project area assigned to baseline scenario stratum i
Equations	Equation 2; Equation 3; Equation 6; Equation 7; Equation 13; Equation 14; Equation 19
Source	Derived from maps of project area boundaries. See Appendix 3.

Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Accurate maps of project area boundaries are required.
Purpose of Data	Estimation of baseline emissions from woody and non-woody biomass, dead wood and litter, and soil organic carbon
Comments	NA

Data/Parameter	$C_{TREE_{BSL,t1,i}}$; $C_{TREE_{BSL,t2,i}}$
Units	t CO ₂ e/ha
Description	Average carbon stock in tree biomass in the control plots for baseline scenario stratum <i>i</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 2
Source	Either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.1.2.2
Purpose of Data	Estimation of baseline emissions from tree biomass.
Comments	NA

Data/Parameter	$C_{SHRUB_{BSL,t1,i}}$; $C_{SHRUB_{BSL,t2,i}}$
Units	t CO ₂ e/ha
Description	Average carbon stock in shrub biomass in the control plots for baseline scenario stratum <i>i</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 3

Source	Either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.1.2.2
Purpose of Data	Estimation of baseline emissions from shrub biomass.
Comments	NA

Data/Parameter	$\Delta C_{TREE_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in tree biomass under the project scenario within the project area in year t
Equations	Equation 4
Source	See Sections 5.1.2.1 and 5.1.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Sections 5.1.2.1 and 5.1.2.2
Purpose of Data	Estimation of project removals in woody biomass
Comments	NA

Data/Parameter	$\Delta C_{SHRUB_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in shrub biomass under the project scenario within the project area in year t
Equations	Equation 4
Source	See Sections 5.1.2.1 and 5.1.2.2

Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Sections 5.1.2.1 and 5.1.2.2
Purpose of Data	Estimation of project removals in woody biomass.
Comments	NA

Data/Parameter	$\Delta C_{AGNWB_BSL,t}; \Delta C_{BGNWB_BSL,t}$
Units	t CO ₂ e
Description	Change in carbon stock in aboveground and belowground non-woody biomass under the baseline scenario within the project area in year t
Equations	Equation 5
Source	See Section 5.2.1
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.2.1
Purpose of Data	Estimation of baseline removals in non-woody biomass
Comments	NA

Data/Parameter	$C_{AGNWB_BSL,t1,i}; C_{AGNWB_BSL,t2,i}$
Units	t CO ₂ e/ha
Description	Average carbon stock in aboveground non-woody biomass in the control plots for baseline scenario stratum i in year $t1$ and $t2$
Equations	Equation 6
Source	See PT#NWB
Value	NA

Justification of choice of data or description of measurement methods and procedures applied	See PT#NWB
Purpose of Data	Estimation of baseline removals in aboveground non-woody biomass
Comments	NA

Data/Parameter	$C_{BGNWB_{BSL,t1,i}}; C_{BGNWB_{BSL,t2,i}}$
Units	t CO ₂ e/ha
Description	Average carbon stock in belowground non-woody biomass in the control plots for baseline scenario stratum <i>i</i> in year <i>t1</i> and <i>t2</i>
Equations	Equation 7
Source	See PT#NWB
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See PT#NWB
Purpose of Data	Estimation of baseline removals in belowground non-woody biomass
Comments	NA

Data/Parameter	$\Delta C_{AGNWB_PROJ,t}; \Delta C_{BGNWB_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in aboveground and belowground non-woody biomass under the project scenario within the project area in year <i>t</i>
Equations	Equation 8
Source	See sections 5.2.2.1 and 5.2.2.2
Value	NA

Justification of choice of data or description of measurement methods and procedures applied	See sections 5.2.2.1 and 5.2.2.2
Purpose of Data	Estimation of baseline removals in non-woody biomass
Comments	NA

Data/Parameter	$A_{HERB,t1}; A_{HERB,t2}$
Units	ha
Description	Area of herbaceous vegetation in project area <i>a</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 9; Equation 10
Source	Measured, modelled or estimated for each project area
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Direct measurements or estimates of percentage cover in sample plots or from remote sensing data (see PT003 and PT004)
Purpose of Data	Calculation of removals in non-woody biomass
Comments	NA

Data/Parameter	$AGB_{HERB,t1}; AGB_{HERB,t2}; BGB_{HERB,t1}; BGB_{HERB,t2}$
Units	t CO ₂ e/ha
Description	Aboveground and belowground biomass of herbaceous vegetation in years <i>t1</i> and <i>t2</i>
Equations	Equation 9; Equation 10
Source	Measured or estimated for each type of herbaceous vegetation, present; or from a credible peer-reviewed published source specific to the project region.
Value	NA
Justification of choice of data or description of	Measurement from sample plots using destructive harvesting approach, or use of literature values.

measurement methods and procedures applied	
Purpose of Data	Calculation of removals in non-woody biomass
Comments	NA

Data/Parameter	$\Delta C_{DW_BSL,t}$
Units	t CO ₂ e
Description	Change in carbon stock in dead wood under the baseline scenario within the project area in year t
Equations	Equation 11
Source	See Section 5.3.1
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.1
Purpose of Data	Calculation of baseline removals in dead wood
Comments	NA

Data/Parameter	$\Delta C_{LI_BSL,t}$
Units	t CO ₂ e
Description	Change in carbon stock in litter under the baseline scenario within the project area in year t
Equations	Equation 12
Source	See Section 5.3.1
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.3.1
Purpose of Data	Calculation of baseline removals in litter

Comments	NA
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Data/Parameter	$C_{DW_{BSL,t1,i}}; C_{DW_{BSL,t2,i}}$
Units	t CO ₂ e/ha
Description	Average carbon stock in dead wood in the control plots for baseline scenario stratum <i>i</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 13
Source	Either measured or modelled with model predictions validated by measurements following the procedures in Section 5.3.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Estimation of baseline removals in dead wood
Comments	NA

Data/Parameter	$C_{LI_{BSL,t1,i}}; C_{LI_{BSL,t2,i}}$
Units	
Description	Average carbon stock in shrub biomass in the control plots for baseline scenario stratum <i>i</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 14
Source	Either measured or modelled with model predictions validated by measurements following the procedures in Section 5.1.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Estimation of baseline removals in litter

Comments	NA
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Data/Parameter	$\Delta C_{DW_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in dead wood under the project scenario within the project area in year <i>t</i>
Equations	Equation 15
Source	See Sections 5.3.2.1 and 5.3.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Sections 5.3.2.1 and 5.3.2.2
Purpose of Data	Calculation of project removals in dead wood
Comments	NA

Data/Parameter	$\Delta C_{LI_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in litter under the project scenario within the project area in year <i>t</i>
Equations	Equation 16
Source	See Sections 5.3.2.1 and 5.3.2.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Sections 5.3.2.1 and 5.3.2.2
Purpose of Data	Calculation of project removals in litter
Comments	NA

Data/Parameter	$\Delta C_{SOC_BSL,t}$
-----------------------	-------------------------

Units	t CO ₂ e
Description	Change in carbon stock in soil organic carbon under the baseline scenario within the project area in year <i>t</i>
Equations	Equation 17
Source	See Section 5.4.1
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.4.1
Purpose of Data	Estimation of baseline removals in soil organic carbon
Comments	NA

Data/Parameter	BE_{SO_t}
Units	tCO ₂ e/ha
Description	Baseline scenario emissions from change in soil organic carbon stocks in year <i>t</i> of the verification period
Equations	Equation 18
Source	PT001
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See PT001
Purpose of Data	Calculation of baseline removals in soil organic carbon
Comments	NA

Data/Parameter	<i>A</i>
Units	ha
Description	Extent of the project area
Equations	Equation 18, Equation 21

Source	PT001
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See PT001
Purpose of Data	Calculation of baseline removals in soil organic carbon
Comments	NA

Data/Parameter	$C_{SOC_{BSL,t1,i}}; C_{SOC_{BSL,t2,i}}$
Units	t CO ₂ e/ha
Description	Average carbon stock in soil organic carbon in the control plots for baseline scenario stratum <i>i</i> in years <i>t1</i> and <i>t2</i>
Equations	Equation 19
Source	Either measured or modelled with model predictions validated by measurements following the procedures in PT#SOC
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See PT#SOC
Purpose of Data	Estimation of baseline removals in soil organic carbon
Comments	NA

Data/Parameter	$\Delta C_{SOC_PROJ,t}$
Units	t CO ₂ e
Description	Change in carbon stock in soil organic carbon under the project scenario within the project area in year <i>t</i>
Equations	Equation 20
Source	See Sections 5.4.2.1 and 5.4.2.2

Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Sections 5.4.2.1 and 5.4.2.2
Purpose of Data	Estimation of project removals in soil organic carbon
Comments	NA

Data/Parameter	PE_{SO_t}
Units	tCO ₂ e/ha
Description	Project scenario emissions from change in soil organic carbon stocks in year t of the verification period
Equations	Equation 21
Source	PT001
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See PT001
Purpose of Data	Calculation of project removals in soil organic carbon
Comments	NA

Data/Parameter	$BR_{WB,a,t}$
Units	t CO ₂ e
Description	Net GHG removals in aboveground woody biomass under the baseline scenario for project area a in year t
Equations	Equation 22
Source	See Section 5.1.1
Value	NA
Justification of choice of data or description of	See Section 5.1.1

measurement methods and procedures applied	
Purpose of Data	Calculation of long-term average removals in woody biomass under the baseline scenario
Comments	NA

Data/Parameter	z
Units	years
Description	Number of years in one or more full rotations
Equations	Equation 22, Equation 23
Source	Description of baseline scenario
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	NA
Purpose of Data	Calculation of long-term average removals in baseline and project scenarios
Comments	NA

Data/Parameter	$PR_{WB,a,t}$
Units	t CO ₂ e
Description	Net GHG removals in aboveground woody biomass under the project scenario for project area a in year t
Equations	Equation 23
Source	See Section 5.1.2
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.1.2

Purpose of Data	Calculation of long-term average project removals in woody biomass
Comments	NA

Data/Parameter	$BR_{WB,a,x}$
Units	t CO ₂ e
Description	Net GHG removals in aboveground woody biomass under the baseline scenario for project area a up to year x , where year x is the year between the time of the first harvest and 50-years after the start of the baseline period that has the lowest cumulative net GHG removals in woody biomass
Equations	Equation 24
Source	See Section 5.1.1
Value	NA
Justification of choice of data or description of measurement methods and procedures applied	Avoids over-estimating baseline removals
Purpose of Data	Calculation of baseline removals in woody biomass
Comments	NA

Data/Parameter	$PR_{WB,a,x}$
Units	t CO ₂ e
Description	Net GHG removals in aboveground woody biomass under the project scenario for project area a up to year x , where year x is the year between the time of the first harvest and 50-years after the initiation of the project intervention that has the lowest cumulative net GHG removals in aboveground woody biomass
Equations	Equation 25
Source	See Section 5.1.2
Value	NA

Justification of choice of data or description of measurement methods and procedures applied	Avoids over-estimating project removals
Purpose of Data	Calculation of project removals
Comments	NA

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PT#WB Estimation of Change in Woody Biomass, Version 1.0

PT#NWB Estimation of Change in Non-Woody Biomass in Grasslands, Version 1.0

PT#DWL Estimation of Change in Dead Wood and Litter Carbon Stocks, Version 1.0

PT#SOC Estimation of Change in Soil Organic Carbon, Version 1.0

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Appendices

Appendix 1 Cropland in which soil disturbance is restricted

Cropland which is subjected, in the baseline, to the land-use, land management practices, and inputs listed in the following table attracts the restriction on the extent of soil disturbance as described in paragraph 3(b) (ii) of this methodology.

Cropland in which soil disturbance is restricted⁴

Region	Land use	Management	Inputs
Boreal	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure
			High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure
			High with manure
Temperate, cold, dry	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	Medium
			High without manure
			High with manure
Temperate, cold, moist	Long-term cultivated cropland	Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure

⁴ Adapted from “2006 IPCC Guidelines for National Greenhouse Gas Inventories”. See table 5.5 on page 5.17 for a more complete description of the terms used in the table.

Region	Land use	Management	Inputs
		No-till	High without manure
			High with manure
Temperate, warm, dry	Long-term cultivated cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	Medium
			High without manure
Temperate, warm, moist	Long-term cultivated cropland	Reduced tillage	High with manure
		No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High with manure
		No-till	High without manure
			High with manure
Tropical, dry	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	Medium
			High without manure
			High with manure
	No-till	All	
Tropical, moist	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure
			High with manure
		No-till	High without manure
	High with manure		
Tropical, montane	Long-term cultivated cropland	No-till	High with manure
	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure

Region	Land use	Management	Inputs
			High with manure
		No-till	Medium
			High without manure
			High with manure
Tropical, wet	Short-term or set aside cropland	Full tillage	High with manure
		Reduced tillage	High without manure
			High with manure
		No-till	High without manure
			High with manure

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Appendix 2 Grassland in which soil disturbance is restricted

Grassland which is subjected, in the baseline, to the land management practices and inputs listed in the following table attracts the restriction on the extent of soil disturbance as described in paragraph 3(b) (ii) of the methodology.

Grassland in which soil disturbance is restricted⁵

Temperature / Moisture Regime	Management	Inputs
Boreal	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, cold, dry	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, cold, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, warm, dry	Improved	All
	Non-degraded	All
	Moderately degraded	High
Temperate, warm, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, dry	Improved	All
	Non-degraded	All
Tropical, moist	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, montane	Improved	All
	Non-degraded	All
	Moderately degraded	High
Tropical, wet	Improved	All

⁵ Adapted from “2006 IPCC Guidelines for National Greenhouse Gas Inventories”. See table 6.2 on page 6.16 for a more complete description of the terms used in the table.

	Non-degraded	High
	Moderately degraded	High

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Appendix 3 Dynamic baseline control plot matching

A dynamic baseline approach may be suitable if there are areas that represent the baseline scenario for all project areas and that can serve as reference points to monitor and measure carbon stock changes in the baseline scenario. It is expected that the project will not expand to these control areas, and that they can be monitored throughout the crediting period with in-situ measurements. Each project area must be assigned to a baseline scenario stratum, control areas with similar conditions to the baseline scenario stratum are then monitored throughout the crediting period so that carbon benefits can be calculated as the difference between changes in carbon pools in the project areas and matched control areas.

Projects using dynamic baseline procedures must use the approaches in this Appendix to:

- i. define baseline scenario strata for the project area(s);
- ii. identify control plots matched to each baseline scenario stratum;
- iii. demonstrate similarity of control plots to the baseline scenario stratum they are matched with; and
- iv. calculate the extent of the project area in each baseline scenario stratum.

Details of these steps are provided below.

i) Defining baseline scenario strata for the project area(s)

Baseline scenario strata must represent the most likely land use in the absence of the project (i.e. the baseline scenario) defined following an approved methodology, and other key criteria related to the carbon pools measured by the project.

To define baseline scenario strata, the following steps must be followed:

1. Identify the number of baseline scenarios across all project areas.
2. Identify parameters that describe carbon stocks at the start of the project for the measured carbon pools in the project context. This may be a direct measure (e.g. of above-ground biomass to estimate woody biomass) or a proxy that is demonstrated to be closely correlated to carbon stocks. At least one carbon stock parameter or proxy must be identified for each measured carbon pool. A single proxy may apply to multiple carbon pools. All carbon stock parameters must be continuous variables.
3. Identify the key environmental variables that drive carbon stock change for the measured carbon pools in the project context. These may include variables related to climate, soil

texture or topography, for example clay content, slope, aspect, elevation, precipitation, proximity of seed sources. At least two environmental factors must be identified for each measured carbon pool. The relevance of the selected environmental variables to the measured carbon pool(s) must be demonstrated, for example with reference to peer-reviewed literature sources. The same environmental variables can apply to multiple carbon pools. All environmental variables must be continuous variables.

4. Collect data or analyse existing data sets to assign a value for each carbon stock parameter and environmental variable identified in Steps 2 and 3, for all project areas in the project.
5. Assign each project area to a baseline scenario stratum according to its identified pre-project land use, carbon stock parameters and environmental variable values.

The total number of carbon stock parameters and environmental variables selected should be eight or less.

ii) Identifying potential control plots

For each baseline scenario stratum, at least 30 control plots that meet the following criteria must be identified:

1. **Location:** Control plots must be within 100 km of the project area(s) they are matched with; and must be within the same jurisdictional boundary as the project area. Jurisdictional boundaries are either national boundaries, or if there is a government defined sub-national jurisdictional boundary defined for REDD+ reporting, the sub-national jurisdictional boundary must be used.
2. **Land tenure:** Control areas must have the same land tenure classification as the project area(s) they are matched with. As a minimum land tenure classification should distinguish between public, private and community ownership, and where possible more precise classifications should be used.
3. **Land use:** Control plots must have the same baseline scenario as the baseline scenario stratum they are matched with. This must be demonstrated by applying the approach for determining the baseline scenario of project areas in **PM001**.
4. **Access:** It must be possible to monitor all carbon pools assessed using dynamic baseline procedures in control plots using the same approaches used to measure actual project removals in the project areas throughout the crediting period.

5. **Outside existing carbon projects:** Control plots must not be within existing projects registered under a carbon offset programme with activities that could affect the carbon pools accounted for by the project.

iii) Covariate matching of control plots

Once potential control plots have been identified, projects must collect data or analyse existing data sets to assign a value for each carbon stock parameter and environmental variable identified in Steps 2 and 3 for defining the baseline. Similarity between control plots, and project areas in the baseline scenario stratum they are matched with must be demonstrated by showing that the standardised difference of means (SDM) between the control plots and project areas for each baseline scenario stratum is less than or equal to 0.25 for each carbon stock parameter and environmental variable used to define the baseline scenario stratum.

SDM is calculated for each carbon stock parameter and environmental variable with Equation 1.

$$SDM = \frac{|\bar{v}_{wp,u} - \bar{v}_{bsl,u}|}{\sqrt{\frac{\sigma_{wp,u}^2 + \sigma_{bsl,u}^2}{2}}}$$

Equation 1

Where:

- SDM* Standardized difference of means
- $\bar{v}_{wp,u}$ Mean value of covariate u in the population of project plots
- $\bar{v}_{bsl,u}$ Mean value of weighted sums of covariate u in the population of matched sets of control plots
- $\sigma_{wp,u}^2$ Sample variance of covariate u in the population of project plots
- $\sigma_{bsl,u}^2$ Weighted sample variance of covariate u in the population of control plots

If the SDM is greater than 0.25 for any of the covariates, control plots should be replaced and/or project areas should be reassigned to different baseline scenario strata and SDM should be recalculated. This should be repeated until 30 control plots that meet the applicability criteria and covariate matching criteria have been identified for each baseline scenario stratum.

iv) Calculating extent of project area and control area in each baseline scenario stratum

Once project areas have been assigned to baseline scenario strata and control plots have been identified the following parameter should be calculated.

$$PA_i = \sum_{j=1}^n A_{PA_i,j}$$

Equation 2

Where:

PA_i (ha)	Extent of the total project area assigned to baseline scenario stratum i
$A_{PA_i,j}$	Extent of project area j in baseline scenario stratum i (ha)

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