A/R methodological Tool

"Tool for estimation of Carbon Stocks, Removals and Emissions for the Dead Organic Matter Pools due to Implementation of a CDM A/R Project Activity"

(Version 01)

I. SCOPE, APPLICABILITY AND PARAMETERS

Scope

1. This tool can be used to estimate the carbon stocks, removals and emissions for the dead organic matter pools[1]—the dead-wood and litter pools—within the boundary of a CDM A/R project activity. The tool considers carbon stocks and changes in:

(a) Dead organic matter (DOM) existing within the project boundary at the time an A/R project commences—the "*existing DOM*";

(b) Dead organic matter that results from establishment of forest within the project boundary as part of A/R project activities—the "*project DOM*".

2. The tool provides:

(a) Guidance on conditions under which emissions and removals by the *existing DOM* pools need not be accounted (*Section II*);

(b) A simplified methodological approach for estimating DOM carbon stocks and changes, and any associated non-CO_2 emissions, based on conservative default data (*Section III*). An Annex gives guidelines and guidance on sources and selection of default data (*Annex 1, Section A.I*);

(c) Extended approach for field measurement of DOM carbon stocks,[2] that can be applied in circumstances not covered by the simplified methodological approach, or if project participants prefer a measurement-based approach (*Annex 1, Section A.II*).

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[1] Note that the dead organic matter pools do not include biomass that is live at the time the project commences, but is felled, burned or otherwise dies as part of site preparation activities. Emissions from such activities must be accounted separately, for example by using the approved A/R methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity*—available at <http://cdm.unfccc.int/Reference/tools>. Care must be taken to avoid double-counting as *project DOM* any residues ("slash") from such formerly live vegetation, if any such residues remain on site following site preparation.

[2] The mean rate of change in carbon stocks with time can be estimated using a standard stock-change approach: see, for example, Section 3.1.4, IPCC (2003).

Note: there is only one situation in which it is mandatory to use the field measurement-based approach: if the A/R project is established at a site where disturbance has significantly enhanced[3] *existing DOM* stocks, and fire is to be used to burn these stocks as part of site preparation. In this situation, use of default data is likely to underestimate the non-CO_2 emissions that will result from burning of the *existing DOM* stocks. Field-based measurement of *existing DOM* stocks is therefore required in this case.

Applicability

3. The tool is applicable for estimating the carbon stocks, removals and emissions for the DOM pools—including any associated increase in non-CO_2 emissions—within the boundary of a CDM A/R project. To ensure transparent accounting, the tool separately considers:

(a) **Change in *existing DOM* carbon stocks**—carbon stocks in the *existing DOM* pools present at project commencement may be increasing, static or decreasing depending on the state of existing live biomass stocks, antecedent disturbance and mortality conditions, fuelwood gathering and decomposition losses. Non-CO_2 emissions[4] may occur from burning of the *existing DOM* pools if fire is used as part of site preparation. Changes in the *existing DOM* pools are accounted as:

(i) Baseline removals—if carbon stocks of *existing DOM* are increasing[5] in the baseline scenario due to inputs from live woody vegetation existing in the project area at the time the project commences. Estimates of these removals are accounted in A/R methodologies as a component of *Baseline Net GHG Removals by Sinks*;

(ii) Project emissions—if carbon stocks of *existing DOM* decrease due to burning during site preparation carried out as part of the project activity. The only significant increase in emissions above those in the baseline scenario will be non-CO_2 (CH_4) emissions,[4] which are accounted in A/R methodologies as a component of *Actual Net GHG Removals by Sinks*.

(b) **Change in *project DOM* carbon stocks**—carbon stocks in the *project DOM* pools may increase over time due to natural mortality, and due to pruning, thinning and harvesting practices. Stocks may also increase substantially due to enhanced mortality from disturbance (including from outbreaks of pests or disease). By contrast, fire, either natural or anthropogenic, can result in a large decrease in the carbon stocks in the *project DOM* pools, as well as resulting in significant non-CO_2 emissions. Fuelwood gathering, and decomposition, will also reduce carbon stocks in the *project DOM* pools. Changes in the *project DOM* pools are accounted as:

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[3] The presence of any disturbance shall be recorded as part of the description of the proposed project activity, in the CDM-AR-PDD. If disturbance is present, archive photographic evidence of the state of the DOM pools in disturbed and adjacent undisturbed areas. Use visual assessment to determine whether dead-wood stocks in disturbed areas are significantly enhanced: that is, are at least 50% more than dead-wood stocks in adjacent undisturbed areas. The undisturbed areas used a s a reference should have a woody vegetation cover similar to that expected to have existed in the now disturbed areas, prior to the disturbance.

[4] Only non-CO_2 emissions need to be accounted, as decay of DOM stocks and consequent CO_2 emissions would have occurred in the absence of the project. Burning of the DOM pools will result in emissions of methane (CH_4) and nitrous oxide (N_2O)—although N_2O emissions are an insignificant proportion of total emissions from biomass burning and so need not be accounted.

[5] Declining stocks of *existing DOM* in the baseline scenario are conservatively neglected in this tool.

(i) Project carbon stock changes—changes in the carbon stocks of *project DOM* are calculated from estimates of the stocks made at two points in time, and accounted in A/R methodologies as a component of *Actual Net GHG Removals by Sinks;*

(ii) Project emissions—if decreases in the *project DOM* carbon stocks are due to fire, estimates of the non-CO_2 emissions that result from burning are accounted in A/R methodologies as a component of *Actual Net GHG Removals by Sinks*.

Applicability Conditions

4. If this tool is used as part of an A/R project methodology, the following applicability conditions shall be added to the methodology, as required, otherwise the tool is not applicable:[6]

(a) If the use of fire for site preparation is not specifically excluded, and the A/R methodology within which this tool is applied does not include accounting of leakage emissions due to the spread of fire beyond the project boundary, then add the following applicability condition:

(i) If fire is used during site preparation then fire control measures shall be taken to minimise the risk that leakage emissions may occur as a result of fire spreading outside the project boundary.

(b) Calculation of emissions can be simplified, and project emissions reduced, if areas with trees existing at the time the project commences are not cleared or damaged as part of site preparation. If changes in carbon stocks in the *existing DOM* pools in areas with existing trees are not to be accounted, then add the following applicability condition unless fire due to natural or anthropogenic causes is a common occurrence in the baseline scenario:

(i) Site preparation shall be restricted to clearance of areas without existing trees, with any biomass burning (if applicable) in adjacent areas during site preparation carried out in such a way as to avoid damage to vegetation in areas within the project boundary that have existing trees.

5. If either of the applicability conditions (a) or (b) is required, then project proponents must also provide suitable monitoring methodology to prove the applicability conditions are met.

6. For applicability condition (a), the following actions shall be considered adequate to minimise the risk of significant leakage emissions due to use of fire in site preparation—and as such, if leakage should occur it shall not be considered attributable to the project.

(a) Prepare, and archive in the CDM-AR-PDD, a site preparation plan that documents the risk of leakage due to fire. If the risk is considered significant then document procedures for fire control, and provide photographic evidence of the fire control measures installed;

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[6] The applicability conditions under items (a) and (b) below supercede the equivalent applicability conditions given in the methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity* (available at <http://cdm.unfccc.int/Reference/tools>). If both tools are used in a particular methodology, use (if required) only the applicability conditions listed above.

(b) Include in the CDM-AR-PDD expert testimony that the fire control measures planned are considered adequate to prevent the spread of fire to adjacent woody areas under wind conditions specified as suitable for site preparation. A summary of the qualifications or experience of the individual or organisation providing expert testimony on fire control, together with brief CVs of key experts as appropriate, should also be included;

(c) At the time of site preparation, obtain and archive as part of the CDM-AR-PDD a verifiable record (e.g., on-site weather/wind records) showing that wind conditions during burning were expected to be consistent with those specified as required to minimise the risk of leakage due to spread of fire.

7. For applicability condition (b), photographic evidence —acquired before and after site preparation—that demonstrates areas of trees remain undamaged by site preparation activities shall be considered adequate to prove the applicability condition has been met. All evidence shall be archived as part of the CDM-AR-PDD.

Assumptions

8. The simplifying assumptions made in developing this tool are given below.

(a) Carbon stocks in the DOM pools due to non-woody vegetation are negligible, and may be neglected during accounting;

(b) A constant rate of decay, and accumulation, is assumed for the DOM pools—consistent with IPCC default approaches;

(c) If the DOM pools are subject to fire, then the entire litter pool is burned;

(d) If the *existing DOM* stocks are not burned during site preparation, non-CO_2 emissions from burning of these stocks remaining at any future time are negligible compared with emissions from burning of *project DOM* stocks at that time;

(e) No leakage emissions occur as a result of DOM being removed from the project area and burned: that is, it is assumed the DOM substitutes for fuelwood that would otherwise have been sourced from elsewhere.

Parameters

This tool provides procedures to determine the following parameters:

Parameter	SI Unit	Description
$C_{DOM,\,t}$	$t\ C$	Carbon stocks in the *existing DOM,* or *project DOM*, pools (as applicable), for each vegetation class (i.e. trees or shrubs) in a stratum of area A_s, at time *t*
$\Delta C_{DOM,\,t}$	$t\ C\ yr^{-1}$	Average annual change in carbon stocks in the *existing DOM,* or *project DOM,* pools (as applicable), for each vegetation class (i.e. trees or shrubs) in a stratum of area A_s, at time *t*
$E_{DOM,\,burn,\,t}$	$t\ CO_2\text{-}e$	Increase in non-CO_2 emissions due to burning of DOM stocks, for each vegetation class (i.e. trees or shrubs) in a stratum of area A_s, at time *t*

Conventions Used in this Tool

9. In applying this methodological tool, estimates of DOM carbon stocks based on default parameters[7] (*Section III*) are made separately for the tree and shrub vegetation classes (and neglected for the herbaceous vegetation class). This is because these two woody vegetation classes will usually have similar within-class—but very different between-class—values of mean carbon stocks in the DOM pools. Separating the estimates of DOM carbon stocks by vegetation class is therefore expected to make estimation both simpler and more transparent.

10. Although distinguishing between herbaceous vegetation and woody perennial shrubs presents few problems, there is no universal definition that uniquely distinguishes shrubs from smaller trees. If both smaller trees and shrubs are part of vegetation within the project boundary, then a practical working definition to distinguish these vegetation classes under field conditions shall be developed, and recorded in the CDM-AR-PDD as part of forest inventory standard operating procedures. Any such definition should be consistent with common practice in the region or country in which the project exists, and shall be applied uniformly to both existing vegetation, and vegetation established as part of A/R project implementation.

II. GUIDANCE ON CONDITIONS UNDER WHICH EMISSIONS FROM OR REMOVALS BY THE EXISTING DOM POOLS NEED NOT BE ACCOUNTED

11. Emissions from clearance, harvesting and/or burning of *existing DOM* during site preparation need not be accounted if any of the conditions (a) to (c) below are met:[8]

(a) It can be demonstrated that harvesting of DOM is a common practice in the baseline scenario for the area of land to which this tool is applied;

(b) It can be demonstrated that fire due to natural or anthropogenic causes is a common occurrence in the baseline scenario for the area of land to which this tool is applied;

(c) The baseline scenario is *degrading land* involving a decline in woody vegetation cover over time in the project area, and fire is not used as part of site preparation.

12. Demonstrating that harvesting of DOM is a common practice in the baseline scenario for the project area can be performed by:

(a) *Either*—providing photographic or other evidence that shows an absence of DOM stocks, or alternatively shows that activities involving harvesting of DOM are routinely practised (e.g., fuelwood gathering), within the planned project area;

(b) *Or*—providing evidence from published studies or official reports, or by survey of local landowners and communities, that demonstrates harvesting of DOM is routinely practised as part of the baseline land use for land areas including the planned project area.[9]

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[7] However, if DOM stocks are determined by field measurement, and strata comprise mixed vegetation classes, it is not necessary—and often not possible—to separate DOM stocks by vegetation class.

[8] Emissions may be neglected at the project, parcel, or individual stratum level, as applicable, depending on the extent of the area likely to be affected.

[9] If studies are not available that include all or part of the planned project area, evidence obtained from studies on land areas with characteristics similar to the proposed project area may be used. Such studies must have been performed for lands with similar existing vegetation, climate, and socio-economic conditions (including similar human and/or domestic animal population densities). The lands must also be subject to the same legal, policy and regulatory frameworks as the proposed project area.

13. Demonstrating that fire due to natural or anthropogenic causes is a common occurrence can be performed by:

(a) *Either*—providing verifiable evidence that demonstrates "slash-and-burn" land clearance activities are commonly practiced in the region on land areas similar to those proposed for the project activity,[9] and that vegetation within the project boundary is:

(i) *Either:* already typical of that commonly cleared by "slash-and-burn" land clearance activities;

(ii) *Or:* in the absence of the project would, within 10 years of the proposed start of the project, be expected to become typical of vegetation commonly cleared by "slash-and-burn" land clearance activities.

(b) *Or*—providing verifiable evidence that demonstrates:

(i) Fire due to causes other than "slash-and-burn" land clearance activities has resulted in burning of all areas with woody species within the project boundary at least once within the 10 years prior to project commencement; and

(ii) Climatic, vegetative cover, land use, socio-economic, legal, policy, and regulatory circumstances under which fire occurred in the past are expected in the absence of the project either to remain unchanged in the future, or to change in such a way as to make fire more likely than in the past.

14. Evidence to demonstrate that the baseline scenario is *degrading land* with a declining woody cover can be taken from information assembled to determine the baseline scenario, and/or to determine whether removals by trees within the project boundary at the time the project commences must be accounted. Alternatively, analysis of historical photographs or official archived records/maps, or interviews with local officials or landowners with knowledge of the land-use history of the area, may be used to determine if woody cover was declining in the absence of the project. All evidence obtained should be archived as part of the CDM-AR-PDD.

III. A SIMPLIFIED APPROACH TO ACCOUNTING OF DOM CARBON STOCKS, REMOVALS AND EMISSIONS BASED ON DEFAULT DATA

III.1. Equations for Accounting of Carbon Stocks, Emissions and Removals

III.1.1. Simplified accounting of carbon stocks and removals using default data

15. The carbon stocks, and removals, in the DOM pools of each stratum, for each vegetation class at time *t*, are given by:

$$C_{DOM,t} = C_{DOM,Litter,t} + C_{DOM,DW,t} \qquad \textbf{(1)}$$

and:

$$\Delta C_{DOM,t} = \Delta C_{DOM,Litter,t} + \Delta C_{DOM,DW,t} \qquad \textbf{(2)}$$

where:

$C_{DOM,t}$	Carbon stocks in the DOM pools at time *t*; *t C*
$C_{DOM,Litter,t}$	Carbon stocks in the litter pool at time *t*; *t C*
$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*
$\Delta C_{DOM,t}$	Average annual change in carbon stocks in the DOM pools at time *t*; *t C*
$\Delta C_{DOM,Litter,t}$	Average annual change in carbon stocks in the litter pool, at time *t*; $t\ C\ yr^{-1}$
$\Delta C_{DOM,DW,t}$	Average annual change in carbon stocks in the dead-wood pool, at time *t*; $t\ C\ yr^{-1}$

16. In the absence of fire or significant harvesting of DOM, estimates of carbon stocks, and removals, in the litter and dead-wood pools can be based on default values of steady-state carbon stocks in these pools, together with information on woody vegetation age (t_{age}). The estimates are made under the IPCC default approximation that net accumulation in DOM carbon stocks can be represented as a linear increase with time, which continues until steady-state values are reached—with the time to reach steady-state termed the transition period, T_p. Under these conditions, carbon stocks and removals can be simply calculated, for each vegetation class in a stratum of area A_s, and for $t_{age} \leq T_p$, as:[10]

$$C_{DOM,Litter,t} = A_S\ C_{DOM,Litter,steady\text{-}state}\ t_{age} / T_p \quad (3)$$

$$C_{DOM,DW,t} = A_S\ C_{DOM,DW,steady\text{-}state}\ t_{age} / T_p \quad (4)$$

$$\Delta C_{DOM,Litter,t} = A_S\ C_{DOM,Litter,steady-state} / T_p \quad (5)$$

$$\Delta C_{DOM,DW,t} = A_S\ C_{DOM,DW,steady-state} / T_p \quad (6)$$

where:

$C_{DOM,Litter,t}$	Carbon stocks in the litter pool at time *t*; *t C*
A_S	Area of stratum; *ha*
$C_{DOM,Litter,steady\text{-}state}$	Carbon stocks at steady-state in the litter pool; $t\ C\ ha^{-1}$
t_{age}	Age of existing live vegetation; *yr*
T_p	Transition period—time for DOM pools to reach steady-state; *yr*
$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*
$C_{DOM,DW,steady\text{-}state}$	Carbon stocks at steady-state in the dead-wood pool; $t\ C\ ha^{-1}$

[10] If $t_{age} > T_p$, carbon stocks are equal to their steady-state values, and removals are zero.

$\Delta C_{DOM,Litte,r,t}$	Average annual change in carbon stocks in the litter pool, at time *t*; *t C yr*$^{-1}$
$\Delta C_{DOM,DW,t}$	Average annual change in carbon stocks in the dead-wood pool, at time *t*; *t C yr*$^{-1}$

III.1.2. Calculation of non-CO_2 emissions from burning of DOM

17. If carbon stocks in the DOM pools at time *t* are burned, the resultant non-CO_2 emissions can be estimated as the fraction of DOM burned times the CH_4 emission ratio for biomass burning—adjusted to CO_2 equivalents. In this tool it is assumed all DOM in the litter pool is burned, so that for each stratum and vegetation class the emissions are given by:

$$E_{DOM,Burn,t} = \left[C_{DOM,Litter,t} + C_{DOM,DW,t}\left(1 - f_{BL,DOM,DW}\right)\right] ER_{CH4} \; {}^{16}\!/_{12} \; GWP_{CH4} \qquad (7)$$

where:

$E_{DOM,Burn,t}$	Increase in non-CO_2 greenhouse gas emissions as a result of burning DOM stocks, at time *t*; *t CO_2-e*
$C_{DOM,Litter,t}$	Carbon stocks in the litter pool at time *t*; *t C*
$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*
$f_{BL,DOM,DW}$	Average fraction of dead-wood left to decay after burning of DOM stocks, default value 0.4; dimensionless
ER_{CH4}	Emission ratio for CH_4 (IPCC default: 0.012); *kg C as CH_4 (kg C burned)*$^{-1}$
GWP_{CH4}	Global warming potential for CH_4 (IPCC default: 21 for the first commitment period); *t CO_2-e (t CH_4)*$^{-1}$
${}^{16}\!/_{12}$	Conversion factor: ratio of molecular weights of CH_4 and C; *mol mol*$^{-1}$

18. Guidelines on the choice of $f_{BL,DOM,DW}$ are provided in *Annex 1*, *Section A.I.1*. The default value of 0.4 given above is an average for standing live woody biomass, and may be used if no better data are available.

III.2. Simplified Accounting of Emissions and Removals for *Existing DOM*

19. Estimates of emissions and removals are required for the *existing DOM* pools in the following circumstances:

(a) **Non-CO_2 emissions from the DOM pools**—if site preparation is to involve use of fire, there will be an increase in emissions due to burning of the *existing DOM* litter and dead wood pools. Only the increase in non-CO_2 emissions need be accounted, as the CO_2 emissions associated with burning at time *t* would have occurred in the absence of the project as the DOM decayed. The increase in non-CO_2 emissions from burning of *existing DOM* is accounted, for each vegetation class in each stratum, by:

(i) Estimating the age of existing woody vegetation at time t, t_{age};

(ii) Selecting a value of TP appropriate for project climatic conditions and the type of existing vegetation;

(iii) Obtaining default values for steady-state litter and dead-wood stocks;

(iv) Calculating $C_{DOM,Litter,t}$ and $C_{DOM,DW,t}$ using equations (**3**) and (**4**);

(v) Calculating non-CO2 emissions using equation (**7**), based on the calculated values of $C_{DOM,Litter,t}$ and $C_{DOM,DW,t}$;

(vi) The resultant non-CO2 emissions at time t, $E_{DOM,Burn,t}$, are accounted as a component of Baseline Net GHG Removals by Sinks.

(b) **Average carbon removals by the DOM pools**—if the age of live woody biomass existing within the project boundary at the time the project commences is less than the transition period T_P, then the average annual carbon removals by the *existing DOM* pools can be accounted, for each vegetation class in each stratum at time *t*, by:

(i) Obtaining the same information as required by steps (a) to (c) immediately above, in relation to estimating non-CO2 emissions from burning of DOM;

(ii) Calculating average annual removals by the litter and dead-wood pools, $\Delta C_{DOM,Litte,r,t}$ and $\Delta C_{DOM,DW,t}$ respectively, using equations (**5**) and (**6**), and the total removals using equation (**2**);

(iii) The resultant average annual carbon stock removals in existing DOM, $\Delta C_{DOM,t}$ are accounted as a component of *Actual Net GHG Removals by Sinks*.

20. Practical implementation of the methodology given in items (a) and (b) above requires data for t_{age}, and default values for T_P, steady-state litter carbon stocks, and steady-state dead wood carbon stocks—by vegetation class. The following guidelines should be used to obtain these data and default values:

(a) The age of existing live woody vegetation can be determined by:

(i) Preferably—growth-ring counting of a sample of at least 10 trees and/or shrubs that are felled by cutting at the base during site preparation. Use the median age of sampled trees/shrubs as the value for the parameter t_{age};

(ii) Or alternatively—analysis of historical photographs or official archived records/maps, or from interviews with local officials or landowners with knowledge of the land-use history of the area. If age is only be able to be determined approximately, it is conservative to select the likely maximum, and minimum, ages when estimating DOM stocks, and removals, respectively.

(b) Guidance on choice of a value for the transition period T_P is given in *Annex 1, Section A.I.2*. Data should preferably be chosen according to the broad climate zone and forest type within the appropriate for the project area;

(c) Guidelines on sources of default values for steady-state litter and dead-wood stocks are given in *Annex 1*, *Section A.I.3*—which includes references to sources of IPCC default data that may be used for these parameters if no better data are available. Note that default data from regional or national inventory, or given in peer-reviewed studies or IPCC literature, usually relate to fully-stocked stands, whereas estimation of *existing DOM* stocks and removals is relevant to the baseline scenario where woody vegetation will cover only a small fraction of the project area. To account for this, default values for steady-state litter and dead-wood stocks from fully-stocked stands will need to be reduced, by multiplying by a factor equal to the average fractional crown cover of existing woody vegetation in each vegetation class, for each stratum. The crown cover can be estimated by visual assessment;

(d) If default data on DOM biomass stocks, rather than carbon stocks, are available, convert the biomass to carbon using a carbon fraction of 0.50 $t\ C\ (t\ d.m)^{-1}$ for dead-wood, and 0.37 $t\ C\ (t\ d.m)^{-1}$ for litter (*Section 3.2.1.2.1.1*, IPCC 2003; *Section 2.3.2.1*, IPCC 2006).

III.3. Simplified Accounting of Carbon Stocks, Emissions and Removals for *Project DOM*

21. The dynamics of carbon stocks in the *project DOM* pools can be relatively complex, and depend on the frequency, and type; of such activities as pruning, thinning and harvesting of live biomass, harvesting of DOM for fuel-wood, and disturbance (including fire). Although a comprehensive approach to accounting of carbon stocks in the *project DOM* pools using carbon gain-loss approaches is possible, such approaches tend to be quite demanding in terms of data requirements. However, a simplified approach to accounting *project DOM* can be developed under the following approximations—that although conservative will for many CDM A/R projects be acceptably accurate:[11]

(a) Forests are usually managed to minimise natural mortality and so achieve maximum wood yield. Conservatively neglecting inputs of above-ground biomass to the project DOM dead-wood pool from natural mortality of trees is therefore expected to have little impact on claimable tCERs or lCERs;

(b) For most areas in which CDM A/R projects are established, there is a high demand for wood products. All stem-wood and larger branches that result from forest pruning, thinning or harvesting operations are therefore likely to be removed from the project area. Conservatively neglecting potential above-ground biomass inputs to the project DOM dead-wood pool is therefore expected to have little impact on claimable tCERs or lCERs;

(c) If site preparation for the second (or any later) rotation planting within the project area involves fire, all biomass in the project DOM litter pool shall be conservatively considered to be burned, and project DOM stocks set equal to zero;

[11] If the following approximations and assertions are not acceptable, measure DOM stocks using the guidance and guidelines provided in *Annex 1, Section A.II.*

(d) Just after the time of thinning or harvest, the only significant project DOM dead-wood component will be the residual stump and coarse roots, which decay over a period equal to TDecay—provided the woody vegetation thinned or harvested is not a coppicing species, in which case project DOM stocks and removals shall be considered equal to zero. The initial project DOM dead-wood carbon stock can be conservatively estimated using a root:shoot ratio, together with data on the amount of above-ground live woody carbon stock removed during thinning or harvesting12—which will be available from project management records or sales data.

22. Under the above approximations, and the applicability conditions of this tool, *project DOM* is thus conservatively accounted, for a stratum of area A_s and for $t_{age} \leq T_{Decay}$, as:

(a) **Emissions from the litter pool**—if site preparation for the second or subsequent rotations involves use of fire, carbon stocks in and removals by the *project DOM* pool will become zero at the time of burning, and there will be an increase in non-CO_2 emissions that must be accounted as part of project emissions. Under the project conditions given above in this section, there are no above-ground dead-wood stocks to be burned. Also, an assumption made in developing this tool is that any remaining *existing DOM* litter stocks are negligible in comparison with *project DOM* litter stocks by the end of the first rotation of planted forest.[13] For this situation, the increase in non-CO_2 emissions from burning of *project DOM* litter stocks is therefore accounted, for each stratum and vegetation class, by:

(i) Setting the parameter t_{age} equal to the shorter of:

- The time elapsed since fire, other than as part of site preparation, last occurred within the stratum; or
- The time elapsed since trees were planted within the stratum, less twice the time the stratum has been temporarily unstocked between rotations.

(ii) Selecting a value of the transition period, TP, appropriate for project climatic conditions and the type of forest planted;

(iii) Obtaining default values for steady-state litter carbon stocks;

(iv) Calculating $C_{DOM,Litter,t}$ at time t using equation (**3**), with the value of t_{age} determined above;

(v) Calculating non-CO_2 emissions at time t using equation (**7**), based on the calculated value of $C_{DOM,Litter,t}$—with $C_{DOM,DW,t}$ set equal to zero;

(vi) Accounting the resultant non-CO_2 emissions, $E_{DOM,Burn,t}$, as a component of project Actual Net GHG Removals by Sinks.

[12] It is possible that the volume, rather than the biomass carbon stock, of harvested above-ground live woody vegetation is recorded at the time of thinning or harvesting. Guidelines on conversion of volume to above-ground biomass are given in *Annex 1, Section III.4* of the methodological tool: *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity*, (available at <http://cdm.unfccc.int/ Reference/tools>).

[13] That is, *existing DOM* litter stocks, if not already burned during site preparation, will usually have decayed to negligible levels in comparison with *project DOM* litter stocks, by the end of the first rotation of planted forest.

(b) **Carbon stocks in the litter pool**—carbon stocks in the *project DOM* litter pool are accounted, for each stratum and vegetation class, by:

(i) Performing the same steps in the first four bullets points as in item (a) immediately above, to estimate the litter carbon stocks at time t, $C_{DOM,Litter,t}$;

(ii) The change in carbon stocks in the project DOM litter pool with time is accounted as part of project Actual Net GHG Removals by Sinks.

(c) **Carbon stocks in the dead-wood pool**—under the project conditions given above in this section, the only significant *project DOM* dead-wood component will be the residual stumps and coarse roots left after thinning or harvesting, which are assumed to decay over a period equal to T_{Decay}. The initial dead-wood stock is conservatively estimated using a root:shoot ratio, from available data on the above-ground carbon stock removed from the project area during thinning or harvesting. For simplicity in the equations that follow, we refer to any forest management operation that involves felling of trees and/or shrubs as a "harvest event". The carbon stocks in the *project DOM* dead-wood pool at time *t*, as a result of a harvest event at time t_h, are estimated, for each stratum and vegetation class, by (for $\Delta t \leq T_{decay}$):[14]

$$C_{DOM,DW,t} = C_{AGB,harvest,t_h} \; R \; \left(1 - \Delta t / T_{decay}\right) \tag{8}$$

where:

$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*
$C_{AGB,harvest,t_h}$	Carbon stock in above-ground biomass felled during the harvest event at time t_h; *t C*
R	Root:shoot ratio for estimating below-ground carbon stocks from above-ground carbon (or biomass) stocks—default value for harvested trees or shrubs of 0.26 or 0.4, respectively; $t\ C\ (t\ C)^{-1}$
Δt	Interval between times *t* and t_h; *yr*
T_{decay}	Decay period—time over which dead-wood decays completely; *yr*

23. The change in carbon stocks in the *project DOM* dead-wood pool with time is accounted as part of project *Actual Net GHG Removals by Sinks*.

When estimating *project DOM* dead-wood stocks using equation (**8**):

(a) For simplicity, it is recommended that project participants treat each harvest event separately, and for each event use equation (**8**) to calculate the contribution of that particular harvest event to the *project DOM* dead-wood pool at time *t*. The total *project DOM* carbon stocks at time *t* are obtained by summing over all harvest events that have occurred up to time *t* for that stratum. Project participants must archive, as part of project management records, information on the amount of above-ground carbon stock removed by, and the year of, each harvest event in each stratum for which below-ground dead-wood stocks are to be accounted;

[14] If $\Delta t > T_{decay}$, $C_{DOM,DW,t}$ is zero.

(b) The default value for the decay period, T_{decay} , must be numerically equal to the value of the transition time, T_P, selected for the *project DOM* litter pool—see the guidelines given in *Annex 1*, *Section A.1.2*;

(c) If values for $C_{AGB,\,harvest,\,t_h}$ are not available by vegetation class, an approximate assessment of the proportion of above-ground tree and shrub biomass felled should be made based on visual assessment of project circumstances, supported by photographic evidence of forest understorey conditions—accuracy is not critical;Guidance on choice of root:shoot ratios is given in *Annex 1*, *Section A.II.3*, of the methodological tool: "Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity" (available at <http://cdm.unfccc.int/ Reference/tools>). If no better data are available, the default values given—which are derived from IPCC literature—may be used.

References

IPCC 2003. *Good Practice Guidance for Land Use, Land-use Change and Forestry*. Available from the IPCC Secretariat (www.ipcc.ch), or may be downloaded from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

IPCC 2006. *Guidelines for National Greenhouse Gas Inventory. Volume 4; Agriculture, Forestry and Other Land*. Available from the IPCC Secretariat (www.ipcc.ch), or downloadable from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

ANNEX 1

MEASUREMENT METHODOLOGY, AND DEFAULT DATA, FOR ESTIMATION OF CARBON STOCKS IN THE DOM POOLS

This Annex provides guidelines and guidance on the following topics:

(a) Guidelines and guidance on selecting IPCC and other default data for estimating carbon stocks in the DOM pools (*Section A.I*);

(b) Guidelines on estimating carbon stocks in the DOM pools by field measurement (*Section A.II*). These guidelines can be used to determine DOM carbon stocks when suitable default data are not available, or when project participants prefer to use measured data rather than basing estimates on default data.

A.I. GUIDELINES AND GUIDANCE ON SELECTING DEFAULT DATA FOR ESTIMATING CARBON STOCKS IN THE DOM POOLS

A.I.1. Default Data for the Fraction of Dead-wood Left After Burning

1. Evaluation of non-CO_2 emissions using methodology provided in this tool requires an estimate of the fraction of dead-wood left to decay after burning. A value for this parameter may be obtained from:

(a) Preferably—local, regional or national forest inventory, official reports, or peer-reviewed studies on plantations of the same species in the same broad climate zone as the project. If data for the same species do not exist, preferably use data from the same *genus*, or otherwise from the same *family*;

(b) Or alternatively—if no better data are available, a default value of 0.4 may be used.[15]

A.I.2. Default Data for the Transition and Decay Periods

2. Default data for the transition period, T_p can be obtained from regional or national inventory, official reports, or peer-reviewed studies on plantations of the same species in the same broad climate zone as the project. If data for the same species do not exist, preferably use data from the same *genus*, or otherwise from the same *family*.

3. If no better data are available, IPCC default data for T_p may be used. The most appropriate data are those given by broad climate zone and forest family in *Table 3.2.1* of the *GPG-LULUCF* (IPCC 2003). An IPCC default value for T_p of 20 years may also be used, if the data in *Table 3.2.1.* are not considered valid for project circumstances.

4. For consistency and symmetry, the numerical value of T_p selected for estimating *existing DOM* stocks must be the same as that for the parameter T_{decay} used for estimating *project DOM* Stocks.

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[15] The value given is that for live tree wood, derived from data in IPCC publications (for details, see *Annex 1, Section A.I.4*, of the methodological tool: *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity*; (available at <http://cdm.unfccc.int/ Reference/tools>).

A.I.3. Default Data for Estimating DOM Carbon Stocks due to Existing Vegetation

A.I.3.1. Default data for existing trees

5. Default data for steady-state carbon stocks in the litter and dead-wood pools of natural forests, and for the transition period, T_p (the time for DOM stocks to reach steady-state) can be obtained from regional or national inventory, official reports, or peer-reviewed studies on stands of the same species in the same broad climate zone as the project. If data for the same species do not exist, preferably use data from the same *genus*, or otherwise from the same *family*. If no better data are available, IPCC default data for steady-state DOM stocks may be used—see *Tables 3.2.1* and *3.2.2,*[16] *GPG-LULUCF* (IPCC 2003).

Note that:

(a) Default data on litter and dead-wood stocks from regional or national inventory, or given in peer-reviewed studies or IPCC literature, usually relate to fully-stocked stands, whereas estimation of *existing DOM* stocks and removals is relevant to the baseline scenario where trees will cover only a small fraction of the stratum. To account for this, default values for $C_{DOM, Litter, steady\text{-}state}$ and $C_{DOM, DW, steady\text{-}state}$ from fully-stocked stands will need to be reduced by multiplying by a factor equal to the average fractional crown cover of baseline tree vegetation in each stratum;

(b) Estimation of *existing DOM* carbon stocks for use with this tool requires an estimate of the age of live trees existing at the time the project commences. This can be obtained by growth-ring counting at the base of a sample of at least 10 trees that might be felled by cutting at the base during site preparation (alternatively an increment borer may be used), and calculating the median age. Alternatively, the approximate age may be determined satisfactorily from historical photographs, official archived records or maps, or from interviews with local officials or landowners.

A.I.3.2. Default data for existing shrubs

6. There are no data in IPCC publications that can be used for values of shrubland steady-state DOM stocks, so any such data must come from either local, regional or national inventory; or from official recorded or peer-reviewed studies. Alternatively, values can be estimated from measurements of DOM stocks[17] (for methodology, see *Annex 1*, *Section I*). Such measurements should be performed in areas of closed-canopy ("fully stocked") shrubland that are to be cleared as part of site preparation,[18] so that the average age of the shrubland (t_{age}) may also be determined—from growth-ring counting of a sample of at least 10 shrubs felled by cutting at the base, and calculating the median age. The values of steady-state DOM stocks for shrubland can then be estimated as:

If $t_{age} \geq T_p$ then:

$$C_{DOM, Litter, steady\text{-}state} = C_{DOM, Litter, t} \qquad \textbf{(A1)}$$

[16] Use of median values of dead-wood carbon stocks in mature forests is considered an acceptable approximation for steady-state values, when estimating stocks of, or removals by, *existing DOM*.

[17] If shrubland DOM stocks are small, direct measurement may not be a cost-effective option. In this case, it is suggested that *existing DOM* stocks in shrubland at steady-state be conservatively set equal to zero.

[18] If areas of closed canopy shrubland do not exist, convert the values of $C_{DOM, DW, t}$ and $C_{DOM, Litter, t}$ that are measured in more open canopies to closed-canopy equivalents by dividing the average DOM stock ($t\ C\ ha^{-1}$) per plot by the average fractional shrubland crown cover per plot.

$$C_{DOM,DW,steady\text{-}state} = C_{DOM,DW,t} \tag{A2}$$

otherwise:

$$C_{DOM,Litter,steady\text{-}state} = C_{DOM,Litter,t} \; T_P / t_{age} \tag{A3}$$

$$C_{DOM,DW,steady\text{-}state} = C_{DOM,DW,t} \; T_P / t_{age} \tag{A4}$$

where:

$C_{DOM,Litter,t}$	Carbon stocks in the litter pool at time *t*; *t C*
$C_{DOM,Litter,steady\text{-}state}$	Carbon stocks at steady-state in the litter pool; $t\ C\ ha^{-1}$
$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*
$C_{DOM,DW,steady\text{-}state}$	Carbon stocks at steady-state in the dead-wood pool; $t\ C\ ha^{-1}$
t_{age}	Age of existing live vegetation; *yr*
T_p	Transition period—time for DOM pools to reach steady-state; *yr*

A.II. GUIDELINES ON ESTIMATING DOM CARBON STOCKS BY FIELD MEASUREMENT

7. This section provides guidelines on the estimation of DOM carbon stocks based on measurement of biomass in the litter and dead-wood pools, together with assessment of the density of decayed dead-wood. In the approach that follows, it is assumed that:

(a) Sample plots for measurement of *project DOM* stocks are located in areas that do not have any remnants from the *existing DOM* stocks present at project commencement;

(b) The average decay class of below-ground dead-wood is the same as the average for above-ground dead-wood.

A.II.1. General Guidelines on Field Measurement of DOM Biomass and Carbon Stocks

8. For field measurements of biomass and carbon in the DOM pools, the recommended sample unit is a permanent sample plot.[19] Temporary sample plots may also be used if measurements are only to be carried out at one time. If there are components of the DOM pools that are minor, which will often be the case for at least the litter pool, measurements should be completed at sub-plots within a sample plot. The sub-plots may be of the nested fixed-radius type, or comprise randomly located areas of fixed dimensions.

[19] Whenever dividing the weight of biomass measured in a sample plot to obtain biomass stocks per unit area, it is the area of the sample plot projected into a horizontal plane that must be used in the denominator.

9. If field-based measurement of DOM is to be used as the primary source of data, the number of sample plots should be estimated using the latest version of the tool for the "*Calculation of the number of sample plots for measurements within A/R CDM project activities*", approved by the CDM Executive Board.[20] Targeting a minimum precision of ±20% of the mean above-ground dead-wood stocks at a 90% confidence level is considered adequate when estimating dead-wood stocks using sampling schemes, as DOM stocks are usually a small proportion of live biomass. However, there is one circumstance in which a higher precision should be targeted: when disturbance, and/or harvesting/thinning of forest established by the project have resulted in large inputs to the DOM pools, and the majority of that DOM will either remain on-site or be burned on-site. In such a case, inventory of the dead-wood pool should target the precision normally expected for live biomass (i.e. an estimate of stocks in each stratum to a precision level of ±10% of the mean at a 95% confidence level). To assess whether the target precision is reached for the dead-wood pool, an initial set of measurements can be made for 10 sample plots per stratum (which may be the entire project area if relatively uniform conditions exist). More plots can be added if the achieved precision does not approach the targeted precision.

10. For litter stocks, taking at least 4 litter samples per sample plot is considered adequate unless stocks are very variable—and in which case taking 8 samples per sample plot is recommended.

A.II.2. Estimation of Carbon Stocks in the Litter Pool

11. The biomass stocks in the litter pool can be measured by simple harvesting techniques. Guidance on the procedure can be found in *Chapter 4.3.3.5.3* of the *Good Practice Guidance for Land Use, Land-use Change and Forestry* (*GPG-LULUCF*; IPCC 2003), which should be consulted as necessary. The procedure can be completed by:

(a) Randomly locating four[21] small sub-plots (either circular or square) of area about 0.1–0.25 m^2 within each inventory sample plot. A small frame equal in area to a sub-plot is often used to aid this task;

(b) If a sub-plot is on a slope, adjust the slope area to obtain the equivalent horizontally-projected area of the sub-plot for use in equations below;

(c) Remove all litter, including the partially decomposed organic layers (usually termed the LF and LFH layers) that are beneath the fine twigs and intact leaf litter, and above the mineral soil;

(d) Combine all sub-samples from a given sample plot, oven-dry at 70ºC, and determine the dry mass.

Litter carbon stocks for a sample plot are then calculated as:

$$C_{DOM,Litter,plot} = \left(B_{Litter,dry,s-p} \Big/ \sum_{j=1}^{n_{s-p}} A_{s-p,j} \right) CF_{Litter}\ 10 \qquad \textbf{(A5)}$$

[20] Available at <http://cdm.unfccc.int/Reference/tools>

[21] Use more sub-plots if the litter layer is very variable in composition or depth: use of 8 sub-plots is suggested in this case.

where:

$C_{DOM,Litter,plot}$	Carbon stocks in the litter pool of a sample plot; $t\ C\ ha^{-1}$
$B_{Litter,dry,s-p}$	Dry mass of litter pooled for all sub-plots in a sample plot; *kg d.m*
$A_{s-p,j}$	Horizontally-projected area of sub-plot *j*; m^2
n_{s-p}	Number of sub-plots in a sample plot; dimensionless
j	Index of the number of sub-plots in a sample plot; dimensionless
CF_{Litter}	Carbon fraction of litter, IPCC default 0.37; $t\ C\ (t\ d.m)^{-1}$
10	Conversion factor: $kg\ m^{-2}$ to $t\ ha^{-1}$

12. If the combined samples in each sample plot are too large to dry easily, ensure the combined sample is well-mixed and then determine its total (wet) weight immediately before taking at least 4 sub-samples to determine the average dry-to-wet weight ratio for litter in each sample plot. Litter carbon stocks for a sample plot are then calculated as:

$$C_{DOM,Litter,plot} = \left(B_{Litter,s-p}\ R_{d/w,s-p} \Big/ \sum_{j=1}^{n_{s-p}} A_{s-p,j} \right) CF_{Litter}\ 10 \qquad \textbf{(A6)}$$

where:

$C_{DOM,Litter,plot}$	Carbon stocks in the litter pool of a sample plot; $t\ C\ ha^{-1}$
$B_{Litter,s-p}$	Mass (wet) of litter pooled for all sub-plots in a sample plot; *kg*
$R_{d/w,s-p}$	Average dry-to-wet weight ratio of litter for the sub-samples; $g\ g^{-1}$
$A_{s-p,j}$	Area of a sub-plot *j*; m^2
n_{s-p}	Number of sub-plots in a sample plot; dimensionless
j	Index of the number of sub-plots in a sample plot; dimensionless
CF_{Litter}	Carbon fraction of the litter pool, IPCC default 0.37; $t\ C\ (t\ d.m)^{-1}$
10	Conversion factor: $kg\ m^{-2}$ to $t\ ha^{-1}$

13. Finally, average the litter carbon stocks in the sample plots in each stratum to get the average stocks in $t\ C\ ha^{-1}$ for the stratum (which may be the entire project area), and multiply the result by the stratum area to obtain the total litter carbon stocks in the stratum at time *t*, $C_{DOM,\ Litter,\ t}$.

A.II.3. Estimation of Carbon Stocks in the Dead-wood Pool

14. Dead-wood may consist of above-ground biomass that is still standing or is lying on the ground, and may also include dead below-ground biomass. Different sampling and estimation procedures are used for the different biomass components:

(a) Standing dead-wood: estimate volume or mass using the same techniques as for live biomass, and then adjust for any loss of branches and for reductions in wood density due to decay;

(b) Lying dead-wood: estimate by the line transect method, or by plot-based sampling. Both approaches use of a decay-class-adjusted wood density;

(c) Below-ground dead-wood: this is estimated from total above-ground dead-wood mass, using a biomass expansion factor (under the assumption that the average above- and below-ground decay classes are the same). Any above-ground dead-wood that becomes buried over time is conservatively neglected.

15. If any methodology that follows provides an estimate of woody biomass stock, and an explicit conversion to carbon stock is not included, calculate the carbon stock by multiplying biomass by the IPCC default carbon fraction for wood: 0.5 *t C (t d.m)*$^{-1}$.

A.II. 3.1. Assessing the dead-wood decay class and wood density

16. The decay class of each item of above-ground dead wood must be assessed, and the mean wood density estimated for each decay class, before the mass of dead-wood can be determined.[22]

The decay class and associated wood density can be determined by:

(a) Categorising an item of dead-wood as belonging to one of three decay classes—sound, intermediate, or rotten—using the "machete test": when striking dead wood (not bark) lightly with a "machete", if the blade bounces off the decay class is "sound", if it enters slightly is it "intermediate", and if it enters deeply or causes the wood to fall apart it is "rotten";

(b) Estimating the average wood density for the sound, intermediate and rotten decay classes from the (wet) volume and dry weight of wood samples taken in the field. At least 10 samples should be taken for each decay class;

(c) If the standing or lying dead-wood has lost only leaves and twigs, the density of the dead-wood can be assumed equal to the density of live wood, if live wood density data are available—otherwise include samples of such wood as part of estimating the density of the "sound" decay class. IPCC default data for live wood density of tree species can be found in *Table 3A.9* of the *GPG-LULUCF* (IPCC 2003). For shrub species, live wood density must be obtained from national inventory or peer-reviewed studies, or may need to be measured. If species-specific live wood density is not available, data for the same *genus*, or if necessary for the same *family*, may be used.

Note also that:

(a) Volumes of above-ground dead-wood may also need to be reduced to account for any decay which has left stems that are hollow;

(b) If the tree or shrub types to be sampled vary widely in terms of wood density, differentiation of collected dead wood samples by *genus* or *family* may be required;

(c) If well-calibrated models are available that describe the decrease in wood density due to decay over time, these may be used instead of field measurement—provided the time since tree or shrub death is known approximately (within three years). This approach is thus usually only useful for estimating *project DOM* stocks.

[22] The approach presented here is adapted from the IPCC default methodology for determining dead-wood stocks, given in *Section 4.3.3.5.4* of the *GPG-LULUCF* (IPCC 2003).

A.II.3.2. Biomass in standing dead-wood

17. The biomass of standing dead-wood can be estimated by either an allometric equations or biomass expansion factors (BEFs) approach, using the same sample plots as for estimation of live biomass. Use of allometric equations is generally considered a more direct approach, and is preferred if suitable equations are available (*GPG-LULUCF*, IPCC 2003).

18. Guidelines on estimating tree (or shrub) biomass using either an allometric equations or BEF approach in plot-based sampling schemes are given in *Annex 1* of the methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity* (available at <http://cdm.unfccc.int/ Reference/tools>). When applying those guidelines to estimation of standing dead-wood, the following applies:

(a) If the allometric or BEF approach includes wood density as a variable, use either live wood density or the wood density value for the appropriate decay class, depending on the state of decay;

(b) If the allometric or BEF approach results in direct calculation of mass without an explicit wood density parameter, and the wood has been classified as being in one of the three decay classes, multiply the calculated mass by the ratio of the average dry wood density in the assigned decay class to the dry live wood density. IPCC default data for live wood density of tree species can be found in *Table 3A.9* of the *GPG-LULUCF* (IPCC 2003). For shrub species, live wood density must be obtained from national inventory or peer-reviewed studies, or may need to be measured. If species-specific live wood density is not available, data for the same *genus*, or if necessary for the same *family*, may be used;

(c) Multiply the above-ground biomass estimated for standing dead trees (or shrubs) using allometric or BEF methods developed for live biomass by the following factors, depending on the appearance of standing dead trees (or shrubs):

(i) Some foliage and all twigs still intact: 1.00;

(ii) Foliage and small twigs no longer present: 0.95;

(iii) Small branches no longer present: 0.90;

(iv) Large branches no longer present: 0.80.

(d) If only stems or part-stems are present, biomass estimates can be made by:

(i) Calculating the above-ground volume of each stem, as the mean stem cross-sectional area multiplied by (remaining) stem height;

(ii) Multiplying the volume by the average wood density appropriate for the decay state of the dead-wood, to estimate the mass of standing above-ground dead wood.

A.II.3.3. Lying dead wood

19. The biomass of lying dead-wood may be calculated in one of two ways, depending on its amount and distribution:

(a) If the amount of dead-wood biomass is small,[23] and dead-wood remains where it falls, the *line-intersect* method may be used (see *Section 4.3.3.5.3, GPG-LULUCF*; IPCC 2003);

(b) In all other cases, use measurements of the volume of all dead wood within inventory sample plots.

20. The line transect method is implemented by first laying out two lines of length L/2 at right-angles, and centred on each sample plot. The diameter and decay class of each item of dead-wood that the lines intersect are recorded, and the dead-wood stocks associated with each sample plot calculated from:

$$C_{DOM,DW,plot} = \pi^2 \left(\sum_{i=1}^{n} d_i^{\,2}\, \rho_{class,i} \right) CF_{Wood} \Big/ (8L) \qquad \textbf{(A7)}$$

where:

$C_{DOM,DW,plot}$	Carbon stocks in the dead-wood pool for a sample plot; $t\ C\ ha^{-1}$
π	Constant; *pi*, 3.142
I	Index of the number of pieces of dead wood measured; dimensionless
d_i	Diameter of the dead-wood piece *i*; *cm*
$\rho_{class,i}$	Average wood density for the decay class of the dead wood piece *i*; $(t\ d.m)\ m^{-3}$
CF_{Wood}	Carbon fraction of wood, IPCC default 0.50; $t\ C\ (t\ d.m)^{-1}$
L	Total length of the transect(s), recommended default 100 m; *m*

21. In all other cases, $B_{DOM,\ DW,\ plot}$ should be estimated from a complete inventory of dead-wood within a sample plot. This requires that the volume of each piece of dead-wood be determined from measurements of the mean diameter, and length, of that part of each piece that is within the sample plot boundary. The decay class of each piece of dead-wood must also be determined. The carbon stocks in the sample plot are then calculated from:

$$C_{\mathrm{DOM,\,DW,\,plot}} = \pi \left(\sum_{\mathrm{i}=1}^{n} d_i^{\,2}\, l_{\mathrm{i}}\, \rho_{\mathrm{class,\,i}} \right) CF_{Wood} \Big/ \left(4\ A_{plot} \right) \qquad \textbf{(A8)}$$

where:

$C_{DOM,DW,plot}$	Carbon stocks in the dead-wood pool for a sample plot; $t\ C\ ha^{-1}$
π	Constant; *pi*, 3.142
i	Index of the number of pieces of dead wood measured
d_i	Diameter of the dead wood piece *i*; *cm*

[23] Visually estimated as being less than 15% of above-ground live biomass.

l_i	Length of dead wood piece *i* within the sample plot boundary; *m*
$\rho_{class,i}$	Average wood density for the decay class of the dead wood piece *i*; $(t\ d.m)\ m^{-3}$
CF_{Wood}	Carbon fraction of wood, IPCC default 0.50; $t\ C\ (t\ d.m)^{-1}$
A_{plot}	Horizontally-projected area of a sample plot; m^{-2}
4	Conversion factor: ratio of cross-sectional area calculated using diameter to that using radius; dimensionless

22. Finally, average the dead-wood carbon stocks in the dead-wood pool of the sample plots in each stratum (which may be the entire project area) to get the average stocks in $t\ C\ ha^{-1}$ for the stratum, and multiply the result by the stratum area to obtain the dead-wood carbon stocks in the stratum at time *t*, $C_{DOM,\ DW,\ t}$.

A.II.3.4. Below-ground dead-wood

23. The biomass of below-ground dead-wood is estimated from the above-ground dead-wood stocks, using a root:shoot ratio for live biomass. Guidelines on selection of root:shoot ratios are given in *Annex 1* of the methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity* (available at <http://cdm.unfccc.int/ Reference/tools>). An IPCC default value of 0.26 may be used for trees, or a value of 0.4 for shrubs, if no better data are available.

24. Note that if coppicing is part of project activities, it shall be conservatively assumed that no below-ground live biomass dies as a result of harvesting of above-ground live biomass.

References

IPCC 2003. *Good Practice Guidance for Land Use, Land-use Change and Forestry*. This is available from the IPCC Secretariat (www.ipcc.ch), or may be downloaded from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

IPCC 2006. *Guidelines for National Greenhouse Gas Inventory. Volume 4; Agriculture, Forestry and Other Land*. Available from the IPCC Secretariat (www.ipcc.ch), or downloadable from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

ANNEX 2

PARAMETERS NOT MONITORED; AND PARAMETERS TO BE MONITORED OR ESTIMATED

Default Data or Parameters (not Estimated or Measured)

Data ID	Data or Parameter Description	Value	Source of Data	References and Comments
T1.1– 1	CF_{Litter} — Carbon fraction of the litter pool	0.37 $t\ C\ (t\ d.m.)^{-1}$	IPCC default value	*GPG-LULUCF* [1], Chapter 3, Section 3.2.1.2.1.1, (IPCC 2003); or *AFOLU Guidelines*[2], Volume 4, Chapter 2, Section 2.3.2.1 (IPCC 2006)
T1.1–2	$C_{DOM, DW, steady\text{-}state}$ — Carbon stocks at steady-state in the dead-wood pool	Selected by vegetation class and climate; $t\ C\ ha^{-1}$	IPCC, or other, default values	IPCC values for forest: see *GPG-LULUCF* [1], Chapter 3, Table 3.2.2 (IPCC 2003). For shrubs, use default values from regional or national inventory, or peer-reviewed publications, if available
T1.1–3	$C_{DOM, Litter, steady\text{-}state}$ — Carbon stocks at steady-state in the litter pool	Selected by vegetation class and climate; $t\ C\ ha^{-1}$	IPCC, or other, default values	IPCC values for forest: see *GPG-LULUCF* [1], Chapter 3, Table 3.2.1 (IPCC 2003). For shrubs, use default values from regional or national inventory, or peer-reviewed publications, if available
T1.1–5	CF_{Wood} — Carbon fraction of wood, IPCC default	0.50; $t\ C\ (t\ d.m)^{-1}$	IPCC default value	*GPG-LULUCF* [1], Chapter 3, Section 3.2.1.1.1.1, (IPCC 2003); or *AFOLU Guidelines*[2], Volume 4, Chapter 6, Section 6.3.1.4 (IPCC 2006).
T1.1–6	ER_{CH4} — Emission ratio for CH_4	0.012 $kg\ C\ as\ CH_4\ (kg\ C\ burned)^{-1}$	IPCC default value	*GPG-LULUCF* [1], Table 3A.1.15, Annex 3A.1(IPCC 2003)

Data ID	Data or Parameter		Source of Data	References and Comments
	Description	Value		
T1.1–7	$f_{BL,DOM,DW}$ — Average fraction of dead-wood left to decay after burning of DOM stocks	0.4	Default value	For derivation see *Annex 1* of the methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity* (available at <http://cdm.unfccc.int/ Reference/tools>). The default value may be used if no better data are available.
T1.1–8	GWP_{CH4} — Global warming potential for CH_4	21 $t\ CO_2\text{-}e\ (t\ CH_4)^{-1}$	IPCC default value, for CP1 only	*Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1996).
T1.1–9	π — Constant	3.142		
T1.1–10	T_{decay} — Decay period—time over which dead-wood stocks decay completely	Selected by forest type and climate (numerically equal to T_P); *yr*	IPCC, or other, default values	IPCC values: see *GPG-LULUCF* [1], Chapter 3, Table 3.2.1 (IPCC 2003). The value of T_{Decay} must for reasons of consistency be equal to the value selected for the transition period, T_P.
T1.1–11	T_p — Transition period: time for DOM pools to reach steady-state	Selected by forest type and climate; *yr*	IPCC, or other, default values	IPCC values: see *GPG-LULUCF* [1], Chapter 3, Table 3.2.1 (IPCC 2003).

[1] Good Practice Guidance for Land Use, Land-use Change and Forestry. IPCC 2003. Available from the IPCC Secretariat (www.ipcc.ch), or downloadable from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp.

[2] Guidelines for National Greenhouse Gas Inventory. Volume 4, Agriculture, Forestry and Other Land. IPCC 2006. Available from the IPCC Secretariat (www.ipcc.ch), or downloadable from the National Greenhouse Gas Inventory Programme at http://www.ipcc-nggip.iges.or.jp

Data or Parameters to be Estimated or Measured

Data ID	Data or Parameter: Symbol	Description	Determined at	Source of Estimated or Measured Data	Estimation or Measurement Procedures, and Comments
T1.2– 1	A_S	Area of stratum; *ha*	Planning and monitoring of project activities	Maps, orthorectified images, field-based GPS measurements	Horizontal projected area required
T1.2– 2	A_{plot}	Horizontally-projected area of a sample plot; m^2	Field sampling of DOM stocks	Plot-based inventory of DOM stocks	Horizontal projected area required
T1.2–3	$A_{s-p,j}$	Horizontally-projected area of sub-plot *j*; m^2	Field sampling of DOM stocks	Plot-based inventory of DOM stocks	Horizontal projected area required
T1.2-4	$B_{Litter,dry,s-p}$	Dry mass of litter pooled for all sub-plots in a sample plot; *kg d.m*	Field sampling of DOM stocks	Plot-based inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-5	$B_{Litter,s-p}$	Mass (wet) of litter pooled for all sub-plots in a sample plot; *kg*	Field sampling of DOM stocks	Plot-based biomass inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-6	$C_{AGB,harvest,\ t_h}$	Carbon stock in above-ground biomass felled during the harvest event at time t_h; *t C*	Time of thinning or harvesting	Plot-based biomass inventory of live above-ground biomass stocks, or otherwise determined from project management records	

Data ID	Data or Parameter: Symbol	Description	Determined at	Source of Estimated or Measured Data	Estimation or Measurement Procedures, and Comments
T1.2-7	$C_{DOM,DW,plot}$	Carbon stocks in the dead-wood pool for a sample plot; $t\ C\ ha^{-1}$	Field sampling of DOM stocks	Line transect method, or plot-based biomass inventory, of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-8	$C_{DOM,DW,steady\text{-}state}$	Carbon stocks at steady-state in the dead-wood pool; $t\ C\ ha^{-1}$	Field sampling of shrubland DOM stocks	Plot-based biomass inventory of shrubland DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-9	$C_{DOM,DW,t}$	Carbon stocks in the dead-wood pool at time *t*; *t C*	Field sampling of biomass stocks (in live and/or dead pools)	Direct measurement by line-transect method, or by plot-based biomass inventory, of DOM stocks. Alternatively, estimated from a combination of default data and data from inventory of live biomass.	See Note 1, at the end of the Table See also *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-10	$C_{DOM,Litter,plot}$	Carbon stock in the litter pool of a sample plot; $t\ C\ ha^{-1}$	Field sampling of DOM stocks	Plot-based biomass inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools

Data ID	Data or Parameter: Symbol	Description	Determined at	Source of Estimated or Measured Data	Estimation or Measurement Procedures, and Comments
T1.2-11	$C_{DOM, Litter, steady\text{-}state}$	Carbon stocks at steady-state in the litter pool; $t\ C\ ha^{-1}$	Field sampling of shrubland DOM stocks	Plot-based biomass inventory of shrubland DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-12	$C_{DOM, Litter, t}$	Carbon stocks in the litter pool at time *t*; *t C*	Field sampling of biomass stocks	Direct measurement by line-transect method, or by plot-based biomass inventory, of DOM stocks. Alternatively, estimated from a combination of default data and data from inventory of live biomass.	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-13	d_i	Diameter of the dead wood piece *i*; *cm*	Field sampling of DOM	Line transect method, or plot-based biomass inventory, of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass and determination of carbon stocks in the DOM pools
T1.2-14	i	Index of the number of pieces of dead wood measured; dimensionless	Field sampling of DOM	Line transect method, or plot-based biomass inventory, of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass and determination of carbon stocks in the DOM pools
T1.2-15	j	Index of the number of sub-plots in a sample plot; dimensionless	Field sampling of DOM	Plot-based inventory of litter DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of litter carbon stocks in the DOM pools

Data ID	Data or Parameter Symbol	Description	Determined at	Source of Estimated or Measured Data	Estimation or Measurement Procedures, and Comments
T1.2-16	L	Total length of the transect(s), recommended default 100 m; *m*	Field sampling of DOM	Line transect method of inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass and determination of carbon stocks in the DOM pools
T1.2-17	l_i	Length of the dead wood piece *i* that is within the sample plot boundary; *m*	Field sampling of DOM	Plot-based biomass inventory, of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass and determination of carbon stocks in the DOM pools
T1.2-18	n_{s-p}	Number of sub-plots in a sample plot; dimensionless	Field sampling of DOM	Plot-based biomass inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools
T1.2-19	$\rho_{class,i}$	Average wood density for the decay class of the dead wood piece *i*; $(t\ d.m)\ m^{-3}$	Field sampling of DOM	Plot-based biomass inventory of DOM stocks	See *Annex 1, Section A.II* for guidelines and guidance on: measurement of biomass, and determination of carbon stocks, in the DOM pools

Data ID	Data or Parameter: Symbol	Description	Determined at	Source of Estimated or Measured Data	Estimation or Measurement Procedures, and Comments
T1.2-20	R	Root:shoot ratio for estimating below-ground carbon stocks from above-ground carbon (or biomass) stocks—default value for harvested trees or shrubs of 0.26 or 0.4, respectively[24]; or 0 if stands are coppiced; $t\ C\ (t\ C)^{-1}$	Field sampling of live biomass, if measured.	Direct measurement by destructive harvest of individual tree/shrub above- and below-ground live biomass	See Note 1, at the end of the Table
T1.2-21	$R_{d/w,\ s-p}$	Average dry-to-wet weight ratio of litter for the sub-samples; $g\ g^{-1}$	Field sampling of DOM	Laboratory analysis of destructively harvested biomass in the DOM pools	Oven-drying of samples at 70°C is recommended
T1.2-22	Δt	Interval between times t_1 and t_2; *yr*	Inventory of biomass or carbon stocks	Planning and monitoring of project activities	
T1.2-23	t_{age}	Age of live vegetation; *yr*	Field sampling of live biomass, if measured.	Direct measurement by destructive harvest of individual trees/shrubs. Alternatively, determined from historical maps, official records, aerial photographs, satellite imagery, or interviews with local landowners	See Note 1, at the end of the Table

[24] Derivation of default values for root:shoot ratios is discussed in *Annex 1*, *Section A.I.3*, of the methodological tool: *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity*, (available at <http://cdm.unfccc.int/ Reference/tools>).

Note:

1. Guidelines on estimating above- and below-ground live biomass using allometric or BEF methods, or destructive harvesting, in plot-based sampling schemes are given in *Annex 1, Section A.II* of the methodological tool for *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity* (available at <http://cdm.unfccc.int/ Reference/tools>).

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History of the document

Version	Date	Nature of revision
01	EB 41, Annex 14 02 August 2008	Initial adoption.