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付属資料-1　エクアドル部門別国内総生産シェア

（単位：%、2000 年時点物価換算）

Ramas de actividad Años	1999	2000	2001	2002	2003	2004	2005
CIIU　CN			(p)	(p)	(p)	(prev)	(prev)
A. Agricultura, ganadería, caza y silvicultura	**9.1**	**9.2**	**8.8**	**9.1**	**9**	**8.4**	**8.3**
1. Cultivo de banano, café y cacao	2.9	2.8	2.4	2.7	2.7	2.5	2.4
2. Cultivo de cereales	0.8	0.9	0.9	0.9	0.8	0.8	0.8
3. Cultivo de flores	1.2	1.4	1.4	1.4	1.3	1.2	1.1
4. Otros cultivos	1.3	1.3	1.3	1.4	1.4	1.3	1.3
5. Cría de animales	1.9	1.7	1.7	1.7	1.8	1.7	1.7
6. Silvicultura y extracción de madera	1	1.1	1	1	1	1	0.9
B. Pesca	**1.9**	**1.4**	**1.4**	**1.4**	**1.5**	**1.4**	**1.4**
7. Cría de camarón	0.8	0.4	0.4	0.4	0.4	0.4	0.4
8. Pesca	1.1	1	1	1	1.1	1	0.9
C. Explotación de minas y canteras	**20.5**	**21.5**	**20.8**	**19.4**	**20.2**	**23.6**	**24.2**
9. Extracción de petróleo crudoy gas natural	20.1	21.1	20.4	19	19.7	23.2	23.8
10. Explotación de minas y canteras	0.4	0.4	0.4	0.4	0.4	0.4	0.4
D. Industrias manufactureras (excluye refinación de petróleo)	**15**	**13.6**	**13.3**	**13**	**13**	**12.6**	**12.6**
11. Producción, procesamiento y conservación de carne	1.2	1.2	1.1	1.1	1.2	1.1	1.1
12. Elaboración y conservación de camarón	3.1	1.3	1.4	1.4	1.3	1.3	1.3
13. Elaboración y conservación de pescado	1.1	1.1	1	1	1	0.9	0.9
14. Elaboración de aceites y grasas de origen vegetal y animal	0.3	0.3	0.3	0.3	0.4	0.4	0.4
15. Elaboración de productos lácteos	0.5	0.5	0.6	0.6	0.6	0.6	0.6
16. Elaboración de productos de molinería y panadería	0.4	0.5	0.5	0.5	0.5	0.5	0.5
17. Elaboración de azúcar	0.5	0.6	0.6	0.5	0.5	0.5	0.5
18. Elaboración de cacao, chocolate y productos de confitería	0.2	0.2	0.2	0.2	0.2	0.2	0.2

19. Elaboración de otros productos alimenticios	0.5	0.5	0.5	0.5	0.5	0.4	0.4
20. Elaboración de bebidas	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ramas de actividad ¥ Años	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
21. Elaboración de productos de tabaco	0.1	0.1	0	0	0	0	0
22. Fabricación de productos textiles, prendas de vestir	2.5	2.6	2.4	2.4	2.4	2.3	2.3
23. Producción de madera y fabricación de productos de madera	1.4	1.4	1.3	1.2	1.1	1.1	1.1
24. Fabricación de papel y productos de papel	0.6	0.6	0.6	0.5	0.5	0.5	0.5
26. Fabricación de sustancias y productos químicos	0.7	0.7	0.7	0.6	0.6	0.6	0.6
27. Fabricación de productos de caucho y plástico	0.4	0.4	0.4	0.3	0.3	0.3	0.3
28. Fabricación de otros productos minerales no metálicos	0.6	0.7	0.7	0.7	0.7	0.7	0.7
29. Fabricación de metales comunes y de productos elaborados	0.2	0.2	0.2	0.2	0.2	0.2	0.2
30. Fabricación de maquinaria y equipo	0.3	0.3	0.3	0.3	0.3	0.3	0.2
31. Fabricación de equipo de transporte	0.1	0.1	0.1	0.1	0.1	0.1	0.1
32. Industrias manufactureras n.c.p.	0	0	0	0	0	0	0
25. Fabricación de productos de la refinación de petróleo	**-6.8**	**-8.1**	**-7.5**	**-7.3**	**-7**	**-7.1**	**-7.2**
25. Fabricación de productos de la refinación de petróleo	-6.8	-8.1	-7.5	-7.3	-7	-7.1	-7.2
E. Suministro de electricidad y agua	**1.1**	**1.1**	**1.1**	**1**	**1**	**1**	**1**
33. Suministro de electricidad y agua	1.1	1.1	1.1	1	1	1	1
F. Construcción	**6.1**	**7.1**	**7**	**7.8**	**7.6**	**7.2**	**7.2**
34. Construcción	6.1	7.1	7	7.8	7.6	7.2	7.2
G. Comercio al por mayor y al por menor	**15.4**	**15.6**	**15.5**	**15.6**	**15.5**	**15**	**15**
35. Comercio al por mayor y al por menor	15.4	15.6	15.5	15.6	15.5	15	15
H. Hoteles y restaurantes	**1.2**	**1.2**	**1.2**	**1.1**	**1.2**	**1.1**	**1.1**
36. Hoteles y restaurantes	1.2	1.2	1.2	1.1	1.2	1.1	1.1

I. Trasporte, almacenamiento y comunicaciones	**10.3**	**10.8**	**10.4**	**10.2**	**10.1**	**9.8**	**9.9**
37. Transporte y almacenamiento	8.5	8.9	8.4	8.3	8.1	7.9	7.9
38. Correos y telecomunicaciones	1.8	1.9	2	1.9	2	1.9	1.9
j. Intermediación financiera	**1.9**	**1.9**	**2.5**	**2.6**	**2.8**	**2.8**	**2.7**
39. Intermediación financiera	1.7	1.7	2.3	2.5	2.6	2.6	2.6
Ramas de actividad ¥ Años	1999	2000	2001	2002	2003	2004	2005
40. Financiación de planes de seguros y de pensiones	0.2	0.2	0.2	0.2	0.2	0.2	0.2
K. Actividades inmobiliarias, empresariales y de alquiler	**6.3**	**6.3**	**6.5**	**6.3**	**6.1**	**5.8**	**5.7**
41. Alquiler de vivienda	3.4	3.4	3.4	3.3	3.2	3.1	3
42. Otras actividades empresariales	2.9	2.9	3.1	3	2.9	2.7	2.7
L. Administración pública y defensa; seguridad social	**4.9**	**5.2**	**5.1**	**5.1**	**4.9**	**4.6**	**4.4**
43. Administración pública y defensa; seguridad social	4.9	5.2	5.1	5.1	4.9	4.6	4.4
M. Enseñanza	**3.4**	**3.4**	**3.2**	**3.1**	**3**	**2.9**	**2.9**
44. Enseñanza	3.4	3.4	3.2	3.1	3	2.9	2.9
N. Servicios sociales y de salud	**1.6**	**1.6**	**1.6**	**1.5**	**1.5**	**1.4**	**1.4**
45. Servicios sociales y de salud	1.6	1.6	1.6	1.5	1.5	1.4	1.4
O. Otros servicios comunitarios, sociales y personales	**0.7**	**0.7**	**0.7**	**0.7**	**0.6**	**0.6**	**0.6**
46. Otros servicios comunitarios, sociales y personales	0.7	0.7	0.7	0.7	0.6	0.6	0.6
P. Hogares privados con servicio doméstico	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**
47. Hogares privados con servicio doméstico	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Serv. de intermediación financiera medidos indirectamente	-2.5	-2.4	-3.1	-3	-3	-2.9	-2.9
Otros elementos del PIB	10.1	10.1	11.3	12.1	11.8	11.6	11.6
PRODUCTO INTERNO BRUTO	100	100	100	100	100	100	100

出典：Banco Central del Ecuador. http://www.bce.fin.ec/frame.php?CNT=ARB0000124

CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY FOR AFFORESTATION AND REFORESTATION PROJECT ACTIVITIES: BASELINE (CDM-AR -NMB)

CONTENTS

SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

'Baseline methodology for afforestation or reforestation project activities that are additional due to financial barriers to their implementation.'

A.2. List of type(s) of A/R CDM project activity to which the methodology may apply:

14. Afforestation or reforestation project activities

A.3. Conditions under which the methodology is applicable to A/R CDM project activities:

This methodology may apply to projects with the following conditions:

1. Projects are eligible with regards to the definitions and modalities for A/R CDM projects as set out in Decision 19/CP.9;
2. Land tenure of the areas within the project boundary is clear and landowners are willing participants in the project activity;
3. Landowners do not depend on the areas subject to the project activities for maintaining on the short term their present levels of income or general well-being. Any income-generating activities that currently take place on the areas are easily transferable to other non-forested areas.
4. Areas subject to the project activities may not be illegally occupied and/or used by third parties. In the case of third parties legally occupying and/or using areas subject to the project activities the same conditions apply as set out under Point 3.

A.4. Carbon pools covered by the methodology:

All carbon pools: above ground biomass, below ground biomass, litter, dead wood and soil organic carbon.

A.5. What are the potential strengths and weaknesses of this proposed new methodology?

Strengths: Simple and widely applicable methodology; cost reduction; realistic simulation of investment decision; applicable to a wide range of afforestation and reforestation activities. Because this is a generic methodology, it gives projects the flexibility to choose quantification approaches according to data availability.

Weakness: Because this is a generic methodology, applicable to a wide range of situations, it is more dependent than usual on judgment of the DOE to ensure the complete, transparent and conservative application of the methodology.

SECTION B. Overall summary description:

This baseline methodology focuses on projects that are considering CO_2 removals and storage through afforestation or reforestation activities. Financial reasons or other barriers have traditionally prevented such activities. The methodology is applicable to project activities that are usually prevented to occur due to financial barriers.

The methodology is divided in two phases: determination of baseline scenario and project additionality, and ERs calculations, as follows:

Determination of baseline scenario and project additionality - The approach used for the determination of a baseline scenario is that it is a land use that represents an economically attractive course of action, taking into account barriers to investment.
The same approach is used to demonstrate that the project's activity (ies) is (are) not the baseline scenario. For this demonstration a modified EB additionality tool kit to be applied to A&R project activities is proposed here.

Calculation of emission reductions - After the baseline scenario and additionality determination, the emissions removals associated with the baseline and project scenarios and the net anthropogenic GHG removals by sinks are then calculated. The calculation procedures are described in sections E.4 to E.7.

SECTION C. Choice of and justification as to why one of the baseline approaches listed in paragraph 22 of CDM A/R modalities and procedures is considered to be the most appropriate:

C.1. General baseline approach for A/R project activities:

☐ Existing or historical, as applicable, changes in carbon stocks in the carbon pools within the project boundary;

☑ Changes in carbon stocks in the carbon pools within the project boundary from a land use that represents an economically attractive course of action, taking into account barriers to investment;

☐ Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts.

C.2. Justification of why the baseline approach for A/ R project activities chosen in C.1. above is considered the most appropriate:

Approach B is the most appropriate to define baseline and additionality of types of project activities that are usually prevented to occur due to financial barriers. After considering the national and sectoral policies in the definition of plausible scenarios, investor decisions are usually affected by their assessment of risks and investment returns. As risks related to new activities are difficult to measure, only qualitative assessments can be done. The investment return, on the other hand, is an easier option to simulate investor decisions in a quantitative assessment, resulting in a more precise evaluation of future scenarios.

Approach B allows for the integration of the A/R Additionality Toolkit (see Annex I – derived from the Additionality Tool for Emission Reduction Projects adopted by the Executive Board in its eleventh meeting – or an official EB adaptation for LULUCF as and when it becomes available) into this baseline methodology, which also adds to a more precise baseline analysis.

SECTION D. Explanation of how, by applying the baseline methodology, baselines are developed in a transparent and conservative manner:

The proposed baseline methodology is transparent and conservative because:

- It uses a conventional approach to determining if a proposed course of action is economically attractive.
- It can be applied in a transparent manner as it relies on conventional scientific and financial analysis that can be checked by an auditor to ensure completeness, correctness, plausibility and conservative assumptions (as defined below).
- It can be applied in a conservative manner provided the conditions for its use (see Section A.3) are followed.

Conservative assumptions - Data assumptions (i.e. not project-specific measurements) should be made in such a way that wherever options of choice exist for the application of data for any parameter of the approaches and formulae described in this methodology, those data should be assumed that result in the lower expected net anthropogenic greenhouse gas removals by sinks for the project.

SECTION E. Explanation and justification of the proposed new baseline methodology:

E.1. Explanation of how national and/or sectoral policies and circumstances could be taken into account by the application of the methodology:

National and sectoral policies and circumstances are taken into account through application of the A/R Additionality Toolkit (see Annex I – derived from the Additionality Tool for Emission Reduction Projects adopted by the Executive Board in its eleventh meeting – or an official EB adaptation for LULUCF as and when it becomes available) – see also Sections E.2 and E.3. Sub-step 1b of the A/R Additionality Toolkit includes an analysis to determine if baseline land use alternatives, including the proposed project activity(ies) are in compliance with all applicable legal and regulatory requirements, and whether or not there is general compliance in the country or region of the legal and regulatory requirements with regard to the proposed project activity(ies).

E.2. Explanation of how the methodology determines the baseline scenario (that is, how it indicates the scenario that reasonably represents the sum of the changes in carbon stocks in the carbon pools within the project boundary that would occur in the absence of the proposed A/R project activity):

The methodology combines the baseline determination and the additionality demonstration through application of the A/R Additionality Toolkit (see Annex I – derived from the Additionality Tool for Emission Reduction Projects adopted by the Executive Board in its eleventh meeting – or an official EB adaptation for LULUCF as and when it becomes available) – see also Sections E.1 and E.3.

The following steps should be followed for the determination of the baseline scenario:

Step 1. Stratify the project area into biophysically and socio-economically homogeneous areas

Step 2. Identify for each stratum the baseline land use alternatives, including the proposed project activity(ies). Where possible this should be supported with quantitative information.

Step 3. Conduct the five steps of the A/R Additionality Tool to determine whether the proposed project activity is additional. If so, proceed to Step 4.

Step 4. From the baseline land use alternatives identified in Step 2, determine the economically most attractive land use alternative, taking into account barriers to investment. This is the baseline land use, as resulting from the application of the baseline approach chosen in Section C.1.

Step 5. Quantify the sum of changes in carbon stocks in the carbon pools that would occur in the baseline land use, using the approaches and formula described in Section E.4.

E.3. Explanation of how, through the methodology, it can be demonstrated that a proposed A/R project activity is additional and therefore not the baseline scenario (section B.3 of the CDM-AR-PDD):

If from the application of the A/R Additionality Toolkit in Step 3 of the methodology as outlined in Section E.2 it is determined that the proposed project activities are not (the most) economically attractive land use alternatives, they are considered not to be the baseline scenario and therefore additional.

E.4. Explain and justify formulae/algorithms and/or models used to determine the baseline scenario. Variables, fixed parameters, values and different strata identified have to be reported (e.g. species, growth rates):

Project participants shall follow the following steps in order to calculate the baseline net GHG removals by sinks for the proposed A&R CDM project activity:

Step 1: Select the pools to be included in the calculation of the baseline net greenhouse gas removals by sinks, in accordance with Decision 19/CP.9 Paragraph 21.

Step 2: Stratify each area with a different defined baseline land use within the project boundary into strata where different behaviour of changes in carbon stocks is expected (e.g., based on different biophysical properties and/or management regimes).

Step 3: For each stratum, calculate the initial carbon stocks per hectare contained in all pools selected, and the subsequent yearly changes in these carbon stocks for each year in the project's crediting period. This is done using the approaches and formula described further below in this section.

Step 4: Add up for each year in the project's crediting period the carbon stocks per hectare in the carbon pools selected.

Step 5: Multiply for each stratum the total carbon content of pools per hectare in each year in the project's crediting period by the number of hectares of the stratum.

Step 6: Add up for each year in the project's crediting period the totals of all strata within the project boundary.

Step 7: Convert the total obtained in Step 6 from metric tonnes of C to metric tonnes of CO2 by multiplying by 3.67 (rounded up from 44/12).

Following is a description per carbon pool of the calculation approaches and formula to be used in Step 3.

General notes:

- Wherever possible, data assumptions should be based on project specific measurements, with the sampling methodologies and calculation assumptions given alongside.
- In the case where data cannot be provided by the project, they should be sourced from other scientific studies relevant to the project's region or country, or other literature data, and full references given. Non-project-specific data should be reasonably applicable to the project's situation and as applicable as possible.
- IPCC Good Practice Guidance for LULUCF procedures should be followed where possible.
- In this methodology, all uses of the word 'biomass' refer to dry-weight biomass.
- Baseline land uses may be dynamic, i.e. they may be expected to change in use and carbon stocks over time. For example, land use systems may include a fallow period in which carbon stocks increase temporarily. Projects should indicate for the baseline land use(s) determined under Step 4 in Section E.2 the likelihood that such dynamism would occur in the baseline scenario, including timings of management actions. This should be supported by verifiable data.

a) Aboveground Biomass Pool

Quantification of initial aboveground biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. The two main approaches are outlined here for tree biomass:

Tree biomass –

1. Direct use of allometric functions that calculate biomass from Diameter at Breast Height (DBH) and/or Height (H) and sometimes Wood Density (WD); or
2. Determination of Bole Biomass (BB) through bole Volume per hectare and WD, then determination of tree aboveground biomass through application of Crown Expansion Factor (CEF):

$$TAB = BB * CEF \quad \{1\}$$

Where:

TAB = Tree Aboveground Biomass
BB = Bole Biomass
CEF = Crown Expansion Factor

For non-tree vegetation biomass, the other component of aboveground biomass, direct application of biomass per hectare data from field measurements is usual.

Calculation of yearly changes in aboveground biomass content - Calculations of the changes in biomass content per hectare in the aboveground biomass pool during the crediting period are done by taking the initial biomass content per hectare ($BCAB_{t=0}$) and calculating the biomass content in the next year ($BCAB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCAB_{t=1} = BCAB_{t=0} + GROWTH_{AG} - LF - DWF - H_{ag} \quad \{2\}$$

Where:

$BCAB_{t=0}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 0
$BCAB_{t=1}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 1
$GROWTH_{AG}$ (t/ha/yr) = Accumulation of biomass in tree and non-tree vegetation through photosynthesis or planting
LF (t/ha/yr) = Litter Fall (fine parts of biomass died naturally)
DWF (t/ha/yr) = Dead Wood Fall (coarse parts of biomass died naturally)
H_{ag} (t/ha) = Harvestings (total aboveground biomass anthropogenically removed from the site or left to be incorporated in the Litter and/or Dead Wood pools)

The tree component of GROWTH is usually derived from data on increase in bole volume, DBH or tree height, with which biomass can be derived using the same approaches as outlined above. For the non-tree vegetation component direct biomass increase data are usually used.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCAB_{t=n} = BCAB_{t=n} * CBR_{AG} \qquad \{3\}$$

Where:
$CCAB_{t=n}$ = Carbon Content Aboveground Biomass Pool in year n
$BCAB_{t=n}$ = Biomass Content Aboveground Biomass Pool in year n
CBR_{AG} = Carbon to Biomass Ratio for aboveground biomass

b) Belowground Biomass Pool

Quantification of initial belowground biomass content – For the assessment of belowground biomass usually a Belowground to Aboveground Biomass Ratio (BABR) is applied. Initial belowground biomass content therefore follows from the quantification of aboveground biomass under a), using the formula:

$$BCBB_{t=n} = BCAB_{t=n} * BABR \qquad \{4\}$$

Where:
$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n
$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n
BABR = Belowground to Aboveground Biomass Ratio

The BABR can vary according to different species or vegetation types present in the stratum. Project-specific BABR(s) may be determined by the project, in which case belowground biomass should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. However, quantification of belowground biomass is cumbersome and expensive and projects may therefore use a published BABR applicable to the project.

Calculation of yearly changes in belowground biomass content - Calculations of the changes in biomass content per hectare in the belowground biomass pool during the crediting period are done by taking the initial biomass content ($BCBB_{t=0}$) and calculating the biomass content in the next year ($BCBB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCBB_{t=1} = BCBB_{t=0} + GROWTH_{BG} – CRM – FRT – H_{bg} \qquad \{5\}$$

Where:
$BCBB_{t=0}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 0
$BCBB_{t=1}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 1
$GROWTH_{BG}$ * (t/ha/yr) = Tree and non-tree vegetation growth through photosynthesis or planting
FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)
CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of dead biomass died naturally)
H_{bg} (t/ha/yr) = Harvestings (total root biomass anthropogenically killed)

* Usually calculated from aboveground growth by applying the same Belowground to Aboveground Biomass Ratio.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCBG_{t=n} = BCBG_{t=n} * CBR_{BG} \qquad \{6\}$$

Where:
$CCBG_{t=n}$ = Carbon Content Belowground Biomass Pool in year n
$BCBG_{t=n}$ = Biomass Content Belowground Biomass Pool in year n
CBR_{BG} = Carbon to Biomass Ratio for belowground biomass

c) Litter Pool

Quantification of initial litter biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in litter biomass content - Calculations of the changes in biomass content per hectare in the litter pool during the crediting period are done by taking the initial biomass content ($BCL_{t=0}$) and calculating the biomass content in the next year ($BCL_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCL_{t=1} = BCL_{t=0} + LF + FRM + H_{fine\text{-}in} – (BCL_{t=0} * Ldecomp) \qquad \{7\}$$

Where:
$BCL_{t=0}$ (t/ha) = Biomass Content Litter Pool in year 0
$BCL_{t=1}$ (t/ha) = Biomass Content Litter Pool in year 1
LF (t/ha/yr) = Litter Fall (fine parts of aboveground biomass died naturally)

FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)
$H_{fine-in}$ (t/ha) = The fine part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the dead wood pool after harvesting (see equation 8).
Ldecomp (%/yr) = Percentage of $BCL_{t=0}$ that decomposes

$$H_{fine-in} = (BCAB_{t=n} * PF_{AG}) + (BCBB_{t=n} * PF_{BG}) - H_{fine-out} \quad \{8\}$$

Where:
$H_{fine-in}$ (t/ha) = Fine part of the biomass left in the forest system (above and belowground)
$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n
PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine
$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n
PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine
$H_{fine-out}$ (t/ha) = Fine part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCL_{t=n} = BCL_{t=n} * CBR_L \quad \{9\}$$

Where:
$CCL_{t=n}$ = Carbon Content Litter Pool in year n
$BCL_{t=n}$ = Biomass Content Litter Pool in year n
CBR_L = Carbon to Biomass Ratio for litter

d) Dead Wood Pool

Quantification of initial dead wood biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in dead wood biomass content - Calculations of the changes in biomass content per hectare in the dead wood pool during the crediting period are done by taking the initial biomass content ($BCDW_{t=0}$) and calculating the biomass content in the next year ($BCDW_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCDW_{t=1} = BCDW_{t=0} + DWF + CRM + H_{coarse\text{-}in} – (BCDW_{t=0} * DWDecomp) \qquad \{10\}$$

Where:

$BCDW_{t=0}$ (t/ha) = Biomass Content Dead Wood Pool in year 0

$BCDW_{t=1}$ (t/ha) = Biomass Content Dead Wood Pool in year 1

DWF (t/ha/yr) = Dead Wood Fall (coarse parts of aboveground biomass died naturally)

CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of belowground biomass died naturally)

$H_{coarse\text{-}in}$ (t/ha) = The coarse part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the litter pool after harvesting (see equation 11).

DWDecomp (%/yr) = Percentage of $BCDW_{t=0}$ that decomposes

$$H_{coarse\text{-}in} = (BCAB_{t=n} * (1\text{-}PF_{AG})) + (BCBB_{t=n} * (1\text{-}PF_{BG})) – H_{coarse\text{-}out} \qquad \{11\}$$

Where:

$H_{coarse\text{-}in}$ (t/ha) = Coarse part of the biomass left in the forest system (above and belowground)

$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n

PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine

$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n

PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine

$H_{coarse\text{-}out}$ (t/ha) = Coarse part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCDW_{t=n} = BCDW_{t=n} * CBR_{DW} \qquad \{12\}$$

Where:
$CCDW_{t=n}$ = Carbon Content Dead Wood Pool in year n
$BCDW_{t=n}$ = Biomass Content Dead Wood Pool in year n
CBR_{DW} = Carbon to Biomass Ratio for dead wood

e) Soil Organic Carbon Pool

Quantification of initial soil organic carbon content – Initial carbon content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, IPCC (2003) provides a comprehensive overview of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in soil organic carbon content - Calculations of the changes in carbon stocks per hectare in the soil organic carbon pool during the crediting period are done by taking the initial carbon content ($CCS_{t=0}$) and calculating the carbon content in the next year ($CCS_{t=1}$) and subsequent years by adding yearly influxes of carbon and subtracting outfluxes of carbon from the pool.

$$CCS_{t=1} = CCS_{t=0} + CCL_{t=0} * Ldecomp * (1-Lresp) + (CCDW_{t=0} * DWdecomp * (1-DWresp) - Sresp - Serosion \quad \{13\}$$

Where:
$CCS_{t=0}$ (tC/ha) = Carbon Content Soil Pool in year 0
$CCS_{t=1}$ (tC/ha) = Carbon Content Soil Pool in year 1
$CCL_{t=0}$ (tC/ha) = Carbon Content Litter Pool in year 0
Ldecomp (%/yr) = Percentage of $CCL_{t=0}$ that decomposes
Lresp (%/yr) = Percentage of Ldecomp that is respired to the atmosphere
$CCDW_{t=0}$ (tC/ha) = Carbon Content Dead Wood Pool in year 0
DWdecomp (%/yr) = Percentage of $CCDW_{t=0}$ that decomposes
Dwresp = Percentage of DWDecomp that is respired to the atmosphere
Sresp = Percentage of $CCS_{t=0}$ that is respired to the atmosphere
Serosion = Percentage of $CCS_{t=0}$ that is lost from the system through erosion processes

E.5. Explain and justify formulae/algorithms and/or models used to determine the actual net GHG removals by sinks from the proposed A/R CDM project activity. Variables, fixed parameters, values and different strata identified have to be reported (e.g. fuel(s) used, fuel consumption rates):

For the calculation of the actual net GHG removals by sinks from the proposed A/R project activity, project participant shall follow the following steps:

Step 1. Apply the same formulae and procedures described in Steps 2-7 in Section E.4 for the calculation of the sum of the verifiable changes in carbon stocks in the carbon pools within the project boundary. In Step 2, stratify on the basis of project activities instead of baseline land use.

Step 2. Calculate on a year-by-year basis the increase in emissions of the greenhouse gases measured in CO2 equivalents by the sources within the project boundary that are increased as a result of the implementation of the project activity, attributable to the project activity. This is done using the approaches and formula described further below in this section.

Step 3. Subtract for the corresponding years the total obtained in Step 2 from the total obtained in Step 1.

$$ANR = VCP - IES \quad \{14\}$$

Where:

ANR (tCO_2e) = Actual Net GHG Removals by Sinks
VCP (tCO_2e) = Verifiable Changes in Carbon Stocks in the Carbon Pools
IES (tCO_2e) = Increase in Emissions of Greenhouse Gases by Sources

Following is a description of the calculation steps, approaches and formula to be used in Step 2.

Step 2a. Identification of sources - Identification of possible sources of increased GHG emissions resulting from the implementation of the project activity and the type of GHG emitted by these. Sources can be divided into the following categories:

1. Combustion of fossil fuels
2. Non-CO_2 GHG emissions from soils (e.g., application of fertilizers or growing of N-fixing trees)
3. Non-CO_2 GHG emissions from biomass burning (e.g., from site preparation)

Step 2b. Quantification of increased emissions by the sources identified under 2a. – For the calculation of emissions from identified sources pertaining to Category 1, the following formula shall be applied:

$$Emissions_{Cat1} = AFU * EC_{FU} * EF_{FU} \quad \{15\}$$

Where:

$Emissions_{Cat1}$ (tCO_2e) = Emissions from Category 1 Sources
AFU (unit) = Amount of Fuel Used
EC_{FU} (TJ/ unit) = Energy Content of Fuel Used
EF_{FU} (tCO2e/TJ) = Emission Factor of Fuel Used

For the calculation of emissions from identified sources pertaining to Categories 2 and 3 the default methods and data as given and referred to in Sections 3.2.1.4 and 4.3.3.6 of the IPCC Good Practice Guidance for LULUCF should be used.

Step 2c. Calculate total GHG emissions resulting from the implementation of the project activity, adding up the totals for emissions by sources from categories 1-3.

E.6. Explain how the baseline methodology addresses any potential leakage of the proposed A/R project activity:

This methodology addresses any potential leakage of the proposed A/R project activity through the estimation of increased emissions from the main potential source: combustion of fossil fuels from transportation outside the project boundary of products produced by the proposed A/R project. For this calculation a sound estimate needs to be made of the distance and frequency products will be transported and of the mode of transport used and related fossil fuel consumption. Following that, the approaches and formula as given in Section E.5 Step 2 for sources in Category 1 should be used.

E.7. Explain and justify formulae/algorithms and/or models used to determine the net anthropogenic GHG removals by sinks from the proposed A/R CDM project activity:

$$NAR = ANR - BNR - L \qquad \{16\}$$

Where:

NAR = Net Anthropogenic GHG Removals by Sinks

ANR = Actual Net GHG Removals by Sinks (from Section E.5)

BNR = Baseline Net GHG Removals by Sinks (from Section E.4)

L = Leakage (from Section E.6)

SECTION F. Data sources and assumptions:

F.1. Describe all parameters and assumptions (e.g. regarding biomass expansion factors and activity levels):

The assumptions that need to be made during the implementation of this baseline methodology are listed below. The DOE will need to check the appropriateness of these assumptions.

1. Determination of baseline land use alternatives:

- When putting together a list of plausible baseline land use alternatives for the project area it is assumed that only land uses are worth considering that already have been established for some time in the region where the project area is located.

2. Economic comparison of baseline land use alternatives:

- Information on acceptable benchmark IRRs or discount rates for comparable investments with a similar risk profile in the relevant sector and country. Data source: various business statistics, expert judgment.
- Other financial indicators will be mainly project-specific and based on a variety of assumptions made in the calculation of costs and revenues of the project.

3. Stratification of project area for determination of expected differences in behaviour of changes in carbon stocks:

- Assumptions on the impacts of various natural and/or anthropogenic factors on the behaviour of changes in carbon stocks as a basis for the stratification of the project area will need to be based on expert judgments, with a foundation in scientific and silvicultural experience.

4. Calculation of initial carbon stocks in pools and subsequent yearly changes:

- Assumptions are inherently made in the selection of data from literature or other non-project-specific sources towards the applicability and appropriateness of these data for the application of this baseline methodology by the project.
- Assumptions on the management of baseline land uses (e.g., fallow periods and harvesting regimes). These should be based on common practices in the project region.

5. Determination of emissions caused by the project (both in- and outside the project boundary):

- Assumptions on the amount of fossil fuel combusted as a result of the project.
- Assumptions on the amount of fertilizer to be applied by the project.
- Assumptions on the reduction of the water table as a result of wetland drainage by the project activities.
- For the calculation of increased N_2O emissions from the planting of N-fixing trees (mainly leguminous species) the IPCC Good Practice Guidance for LULUCF offers no default methodology due to data restrictions. This baseline methodology will therefore assume these emissions to be 0 until IPCC provides methodological guidance in the future.
- Assumptions on the amount of biomass burnt by the project.

F.2. List of data used and their sources:

This is a generic methodology applicable to a wide range of activities. The exact type and source of data needed will vary from project to project, but the table below specifies the type of data that will be required for the calculation of emissions for projects using this methodology.

Table 1: Data necessary to apply this methodology, including unit, when the data is used and data source.

ID n°	Data	Unit	When is used	Source
1	Spatial data (e.g., land use, vegetation, soil, geology, climate, topography)	-	Determination of plausible baseline land use alternatives; Analysis of common compliance practice of applicable laws and regulations; Common practice analysis; Stratification of project area for determination of expected differences in behaviour of changes in C stocks	Satellite images, aereal photographs, maps, literature.
2	Statistics on existing land uses (in the region of the project area	various	Determination of plausible baseline land use alternatives; Analysis of common compliance practice with applicable laws and regulations; Common practice analysis;	Literature, government authorities.
3	Applicable laws and regulations	-	Baseline and additionality definition	Government publications
4	Baseline financial indicators: costs, IRR or NPV	currency or %	Baseline and additionality definition	To be elaborated by the project proponent
5	Project financial indicators without CERs revenues	currency or %	Baseline and additionality definition	To be elaborated by the project proponent
6	Project financial indicators with CERs revenues	currency or %	Baseline and additionality definition	To be elaborated by the project proponent
7	Discount rates; benchmark IRRs	%	Baseline and additionality definition	Business and finance statistics
8	Diameter at breast height (DBH)	m	Determination of initial aboveground biomass	Project-specific data or from literature sources
9	Tree height (H)	m	Determination of initial aboveground biomass	Project-specific data or from literature sources
10	Bole height (H_B) for calculation of Bole Volume (V)	m/m^3	Determination of initial aboveground biomass	Project-specific data or from literature sources
11	Crown Expansion Factor (CEF)	-	Determination of initial aboveground biomass	Project-specific data or from literature sources
12	Wood density (WD)	g/cm^3	Determination of initial aboveground biomass	Project-specific data or from literature sources
13	Tree aboveground biomass	t/individual	Determination of aboveground biomass using CEF or allometric equations	Project-specific data or from literature sources
14	Non-tree aboveground biomass	t/ha	Determination of initial aboveground biomass	Project-specific data or from literature sources
15	Aboveground biomass accumulation ($GROWTH_{AG}$)	t/ha/yr	Determination of changes in aboveground biomass	Literature sources
16	Litter fall (LF)	t/ha/yr or %/yr	Determination of changes in aboveground biomass	Literature sources
17	Dead wood fall (DWF)	t/ha/yr or %/yr	Determination of changes in aboveground biomass	Literature sources
18	Aboveground biomass harvested (H_{ag})	t/ha	Determination of changes in aboveground biomass	Project assumption
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	%	Determination of carbon content of aboveground biomass	Project-specific data or from literature sources (e.g. IPCC)
20	Belowground to aboveground biomass ratio (BABR)	%	Determination of initial belowground biomass	Project-specific data or from literature sources
21	Belowground biomass accumulation ($GROWTH_{BG}$)	t/ha/yr	Determination of changes in belowground biomass	Literature sources

22	Fine root mortality (FRM)	t/ha/yr or %/yr	Determination of changes in belowground biomass	Literature sources
23	Coarse root mortality (CRM)	t/ha/yr or %/yr	Determination of changes in belowground biomass	Literature sources
24	Belowground biomass harvested (H_{bg})	t/ha/yr or %/yr	Determination of changes in belowground biomass	Project assumption
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	%	Determination of carbon content of belowground biomass	Project-specific data or from literature sources (e.g. IPCC)
26	Initial litter biomass ($BCL_{t=0}$)	t/ha	Determination of initial litter biomass	Project-specific data or from literature sources
27	Portion of aboveground biomass that is fine	%	Determination of changes in litter biomass	Project-specific data or from literature sources
28	Portion of belowground biomass that is fine	%	Determination of changes in litter biomass	Project-specific data or from literature sources
29	Fine part of harvested biomass taken out of system	t/ha or %	Determination of changes in litter biomass	Project assumption
30	Fine part of harvested biomass left in system (H_{fine})	t/ha or %	Determination of changes in litter biomass	Project assumption
31	Litter that decomposes in a given year (Ldecomp)	%/yr	Determination of changes in litter biomass	Literature sources
32	Carbon to biomass ratio for litter biomass (CBR_{L})	%	Determination of carbon content of litter biomass	Project-specific data or from literature sources (e.g. IPCC)
33	Initial dead wood biomass ($BCDW_{t=0}$)	t/ha	Determination of initial dead wood biomass	Project-specific data or from literature sources
34	Coarse part of harvested biomass taken out of system	t/ha or %	Determination of changes in dead wood biomass	Project assumption
35	Coarse part of harvested biomass left in system (H_{coarse})	t/ha	Determination of changes in dead wood biomass	Project assumption
36	Dead wood that decomposes in a given year (DWdecomp)	%/yr	Determination of changes in dead wood biomass	Literature sources
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	%	Determination of carbon content of dead wood biomass	Project-specific data or from literature sources (e.g. IPCC)
38	Initial soil carbon content ($CCS_{t=0}$)	t/ha	Determination of initial soil carbon content	Project-specific data or from literature sources
39	Percentage of decomposing litter respired to the atmosphere (Lresp)	%/yr	Determination of changes in soil carbon content	Literature sources
40	Percentage of decomposing dead wood respired to the atmosphere (DWresp)	%/yr	Determination of changes in soil carbon content	Literature sources
41	Percentage of soil carbon content respired to the atmosphere (Sresp)	%/yr	Determination of changes in soil carbon content	Literature sources
42	Percentage of soil carbon content lost through erosion (Serosion)	%/yr	Determination of changes in soil carbon content	Project-specific data or from literature sources
43	Amount of Fuel Used by project (AFU)	l or kg	Determination of emissions caused by project	Project assumption
44	Energy content of fuel used (EC_{FU})	TJ/l or TJ/kg	Determination of emissions caused by project	Literature sources (e.g. IPCC)
45	Emission Factor of Fuel Used (EF_{FU})	tCO2e/TJ	Determination of emissions caused by project	Literature sources (e.g. IPCC)
46	Data indicated in Sections 3.2.1.4 and 4.3.3.6 of IPCC (2003)	various	Determination of emissions caused by project of non-CO_2 GHG from soils and biomass burning	IPCC (2003)

In this methodology a number of publications are mentioned for which references are given here:

Brown S. (1997) – Estimating biomass and biomass change of tropical forests. A primer. FAO Forestry Paper 134. Rome.

IPCC (1996) – Guidelines for National GHG Inventories: Workbook and Reference Manual.

IPCC (2000) - Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

IPCC (2003) - Good Practice Guidance for LULUCF.

F.3. Vintage of data (e.g. relative to starting date of the proposed A/R CDM project activity):

The project should aim at using the most recent data sources available at the time of construction of the baseline.

F.4. Spatial resolution of data (e.g. local, regional, national):

ID n°	Data	Unit	Spatial resolution	Source
1	Spatial data (e.g., land use, vegetation, soil, geology, climate, topography)	-	Local, regional	Satellite images, aereal photographs, maps, literature.
2	Statistics on existing land uses (in the region of the project area	various	Local, regional	Literature, government authorities.
3	Applicable laws and regulations	-	National	Government publications
4	Baseline financial indicators: costs, IRR or NPV	currency or %	Regional, national	To be elaborated by the project proponent
5	Project financial indicators without CERs revenues	currency or %	Project specific	To be elaborated by the project proponent
6	Project financial indicators with CERs revenues	currency or %	Project specific	To be elaborated by the project proponent
7	Discount rates; benchmark IRRs	%	National, regional	Business and finance statistics
8	Diameter at breast height (DBH)	m	Project specific, regional, national	Project-specific data or from literature sources
9	Tree height (H)	m	Project specific, regional, national	Project-specific data or from literature sources
10	Bole height (H_B) for calculation of Bole Volume (V)	m/m^3	Project specific, regional, national	Project-specific data or from literature sources
11	Crown Expansion Factor (CEF)	-	Project specific, regional, national	Project-specific data or from literature sources
12	Wood density (WD)	g/cm^3	Project specific, regional, national	Project-specific data or from literature sources
13	Tree aboveground biomass	t/individual	Project specific, regional, national	Project-specific data or from literature sources
14	Non-tree aboveground biomass	t/ha	Project specific, regional, national	Project-specific data or from literature sources
15	Aboveground biomass accumulation ($GROWTH_{AG}$)	t/ha/yr	Regional, national, international (species specific)	Literature sources
16	Litter fall (LF)	t/ha/yr or %/yr	National, international	Literature sources
17	Dead wood fall (DWF)	t/ha/yr or %/yr	National, international	Literature sources
18	Aboveground biomass harvested (H_{ag})	t/ha	Project specific	Project assumption
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	%	Project specific, national, international	Project-specific data or from literature sources (e.g.

				IPCC)
20	Belowground to aboveground biomass ratio (BABR)	%	Project specific, national, international	Project-specific data or from literature sources
21	Belowground biomass accumulation ($GROWTH_{BG}$)	t/ha/yr	National, international	Literature sources
22	Fine root mortality (FRM)	t/ha/yr or %/yr	National, international	Literature sources
23	Coarse root mortality (CRM)	t/ha/yr or %/yr	National, international	Literature sources
24	Belowground biomass harvested (H_{bg})	t/ha/yr or %/yr	Project specific	Project assumption
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	%	Project specific, national, international	Project-specific data or from literature sources (e.g. IPCC)
26	Initial litter biomass ($BCL_{t=0}$)	t/ha	Project specific, regional, national	Project-specific data or from literature sources
27	Portion of aboveground biomass that is fine	%	Project specific, national, international	Project-specific data or from literature sources
28	Portion of belowground biomass that is fine	%	Project specific, national, international	Project-specific data or from literature sources
29	Fine part of harvested biomass taken out of system	t/ha or %	Project specific	Project assumption
30	Fine part of harvested biomass left in system (H_{fine})	t/ha or %	Project specific	Project assumption
31	Litter that decomposes in a given year (Ldecomp)	%/yr	National, international	Literature sources
32	Carbon to biomass ratio for litter biomass (CBR_{L})	%	Project specific, national, international	Project-specific data or from literature sources (e.g. IPCC)
33	Initial dead wood biomass ($BCDW_{t=0}$)	t/ha	Project specific, national, international	Project-specific data or from literature sources
34	Coarse part of harvested biomass taken out of system	t/ha or %	Project specific	Project assumption
35	Coarse part of harvested biomass left in system (H_{coarse})	t/ha	Project specific	Project assumption
36	Dead wood that decomposes in a given year (DWdecomp)	%/yr	National, international	Literature sources
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	%	Project specific, national, international	Project-specific data or from literature sources (e.g. IPCC)
38	Initial soil carbon content ($CCS_{t=0}$)	t/ha	Project specific, regional, national	Project-specific data or from literature sources
39	Percentage of decomposing litter respired to the atmosphere (Lresp)	%/yr	National, international	Literature sources
40	Percentage of decomposing dead wood respired to the atmosphere (DWresp)	%/yr	National, international	Literature sources
41	Percentage of soil carbon content respired to the atmosphere (Sresp)	%/yr	National, international	Literature sources
42	Percentage of soil carbon content lost through erosion (Serosion)	%/yr	Project specific, regional, national, international	Project-specific data or from literature sources
43	Amount of Fuel Used by project (AFU)	l or kg	Project specific	Project assumption
44	Energy content of fuel used (EC_{FU})	TJ/l or TJ/kg	National, international	Literature sources (e.g. IPCC)
45	Emission Factor of Fuel Used (EF_{FU})	tCO2e/TJ	National, international	Literature sources (e.g. IPCC)
46	Data indicated in Sections 3.2.1.4 and 4.3.3.6 of IPCC (2003)	various	various	IPCC (2003)

SECTION G. Assessment of uncertainties:

Sources of uncertainties regarding the results of the application of this baseline methodology in the PDD are:

- Choices made in the stratification of the project area (both for selection of baseline land use alternatives and different quantification of changes in carbon stocks) and in the selection of baseline land use alternatives;
- Appropriateness of assumptions made (see Section F.1);
- Accuracy of non-project-specific data used.

To limit these uncertainties, the following points should be considered:

- All choices and assumptions made must be justified by data and/or arguments;
- It should be assured that non-project-specific data are used from, where possible, the most:
  - respectable and reliable sources,
  - recent vintage,
  - appropriate spatial resolution
- All choices, assumptions and data must be checked by the DOE for their appropriateness.

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ANNEX I- MODIFIED ADDITIONALITY TOOLKIT

Sub-step 1a. Define alternatives to the project activity:

1. Identify realistic and credible land use alternatives available to the project participants, land owners or similar project developers, in the region in which the project activity will be implemented. These alternatives are to include:
. The proposed project activity not undertaken as a CDM project activity;
. All other plausible and credible land use alternatives to the project activity available in the region in which the project activity will be implemented;
. If applicable, continuation of the current situation (no project activity or land use chages undertaken).

Sub-step 1b. Enforcement of applicable laws and regulations:

2. The alternative(s) shall be in compliance with all applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. reforestation to mitigate or compensate local environmental impacts from project participants .[6] (This sub-step does not consider national and local policies that do not have legally-binding status.[7]).
3. If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current land use practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that noncompliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration;
4. If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with all regulations with which there is general compliance, then the proposed CDM project activity is not additional.[8]

 Proceed to Step 2 (Investment analysis) or Step 3 (Barrier analysis). (Project participants may also select to complete both steps 2 and 3.)

Step 2. Investment analysis

Determine whether the proposed project activity is the economically or financially less attractive than other land use alternatives without the revenue from the sale of certified emission reductions (CERs). To conduct the investment analysis, use the following sub-steps:

Sub-step 2a. Determine appropriate analysis method
1. Determine whether to apply simple cost analysis, investment comparison analysis or benchmark analysis (sub-step 2b). If the CDM project activity generates no financial or economic benefits other than CDM related income, then apply the simple cost analysis (Option I). Otherwise, use the investment comparison analysis (Option II) or the benchmark analysis (Option III).

Sub-step 2b. – Option I. Apply simple cost analysis
2. Document the costs associated with the CDM project activity and demonstrate that the activity produces no economic benefits other than CDM related income.

 If it is concluded that the proposed CDM project activity is not financially attractive then proceed to Step 4 (Common practice analysis).

Sub-step 2b. – Option II. Apply investment comparison analysis

3. Identify the financial indicator, such as IRR[9], NPV or cost benefit ratio, or unit cost of service most suitable for the project type and decision-making context.

Sub-step 2b – Option III. Apply benchmark analysis

4. Identify the financial indicator, such as IRR[10], NPV or cost benefit ratio most suitable for the project type and decision context. Identify the relevant benchmark value, such as the required rate of return (RRR) on equity. The benchmark is to represent standard returns in the market, considering the specific risk of the project type, but not linked to the subjective profitability expectation or risk profile of a particular project developer. Benchmarks can be derived from:

. Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert;

. Estimates of the cost of financing and required return on capital (e.g. commercial lending rates and guarantees required for the country and the type of project activity concerned), based on bankers views and private equity investors/funds' required return on comparable projects;

. A company or land owner internal benchmark (weighted average capital cost of the company) if there is only one potential project developer (e.g. when the project activity upgrades an existing process). The project developers shall demonstrate that this benchmark has been consistently used in the past, i.e. that project activities under similar conditions developed by the same company or land owner used the same benchmark.

Sub-step 2c. Calculation and comparison of financial indicators (only applicable to options II andIII):

5. Calculate the suitable financial indicator for the proposed CDM project activity and, in the case of Option II above, for the other alternatives. Include all relevant costs (including, for example, the investment cost, the operations and maintenance costs), and revenues (excluding CER revenues, but including subsidies/fiscal incentives[11] where applicable), and, as appropriate, non-market cost and benefits in the case of public investors.

6. Present the investment analysis in a transparent manner and provide all the relevant assumptions in the CDM-PDD, so that a reader can reproduce the analysis and obtain the same results. Clearly present critical techno-economic parameters and assumptions (such as capital costs, fuel prices, lifetimes, and discount rate or cost of capital). Justify and/or cite assumptions in a manner that can be validated by the DOE. In calculating the financial indicator, the project's risks can be included through the cash flow pattern, subject to project-specific expectations and assumptions (e.g. insurance premiums can be used in the calculation to reflect specific risk equivalents).

7. Assumptions and input data for the investment analysis shall not differ across the project activity and its alternatives, unless differences can be well substantiated.

8. Present in the CDM-PDD submitted for validation a clear comparison of the financial indicator for the proposed A&R CDM activity and:

(a) The alternatives, if Option II (investment comparison analysis) is used. If one of the other alternatives has the best indicator (e.g. highest IRR), then the CDM project activity can not be considered as the most financially attractive;

(b) The financial benchmark, if Option III (benchmark analysis) is used. If the CDM project activity has a less favourable indicator (e.g. lower IRR) than the benchmark, then the CDM project activity cannot be considered as financially attractive.

Sub-step 2d. Sensitivity analysis (only applicable to options II and III):

9. Include a sensitivity analysis that shows whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions. The investment analysis provides a valid argument in favour of additionality only if it consistently supports (for a realistic range of assumptions) the conclusion that the project activity is unlikely to be the most financially attractive (as per step 2c para 8a) or is unlikely to be financially attractive (as per step 2c para 8b).

 If after the sensitivity analysis it is concluded that the proposed CDM project activity is unlikely to be the most financially attractive (as per step 2c para 8a) or is unlikely to be financially attractive (as per step 2c para 8b), then proceed to Step 3 (Barrier analysis) or Step 4 (Common practice analysis).

 Otherwise, unless barrier analysis below is undertaken and indicates that the proposed project activity faces barriers that do not prevent the baseline scenario(s) from occurring, the project activity is considered not additional.

Step 3. Barrier analysis

If this step is used, determine whether the proposed project activity faces barriers that:
(a) Prevent the implementation of this type of proposed project activity; and
(b) Do not prevent the implementation of at least one of the alternatives.
Use the following sub-steps:

Sub-step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity:
1. Establish that there are barriers that would prevent the implementation of the type of proposed project activity from being carried out if the project activity was not registered as a A&R CDM activity. Such barriers may include, among others:
Investment barriers, other than the economic/financial barriers in Step 2 above, *inter alia*:
- Debt funding is not available for this type of innovative project activities.
- No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.
Technological barriers, *inter alia*:
- Skilled and/or properly trained labour to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;
- Lack of infrastructure for implementation of the technology.

Barriers due to prevailing practice, *inter alia*:
- The project activity is the "first of its kind": No project activity of this type is currently operational in the host country or region.
The identified barriers are only sufficient grounds for demonstration of additionality if they would prevent potential project proponents from carrying out the proposed project activity if it was not expected to be registered as a A&R CDM activity.

2. Provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided may include:

(a) Relevant legislation, regulatory information or industry norms;
(b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc;
(c) Relevant statistical data from national or international statistics;
(d) Documentation of relevant market data (e.g. market prices, tariffs, rules);
(e) Written documentation from the company or institution developing or implementing the CDM project activity or the CDM project developer, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc;
(f) Documents prepared by the project developer, contractors or project partners in the context of the proposed project activity or similar previous project implementations;
(g) Written documentation of independent expert judgements from industry, educational institutions (e.g. universities, technical schools, training centres), industry associations and others.

Sub-step 3 b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity):

3. If the identified barriers also affect other alternatives, explain how they are affected less strongly than they affect the proposed CDM project activity. In other words, explain how the identified barriers are not preventing the implementation of at least one of the alternatives. Any alternative that would be prevented by the barriers identified in Sub-step 3a is not a viable alternative, and shall be eliminated from consideration. At least one viable alternative shall be identified.

 If both Sub-steps 3a – 3b are satisfied, proceed to Step 4 (Common practice analysis)

 If one of the Sub-steps 3a – 3b is not satisfied, the project activity is not additional.

Step 4. Common practice analysis

The above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3). Identify and discuss the existing common practice through the following sub-steps:

Sub-step 4a. Analyze other activities similar to the proposed project activity:

1. Provide an analysis of any other activities implemented previously or currently underway that are similar to the proposed project activity. Projects are considered similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide quantitative information where relevant.

Sub-step 4b. Discuss any similar options that are occurring:

2. If similar activities are widely observed and commonly carried out, it calls into question the claim that the proposed project activity is financially unattractive (as contended in Step 2) or faces barriers (as contended in Step 3). Therefore, if similar activities are identified above, then it is necessary to demonstrate why the existence of these activities does not contradict the claim that the proposed project activity is financially unattractive or subject to barriers. This can be done by comparing the proposed project activity to the other similar activities, and pointing out and explaining essential distinctions between them that explain why the similar activities enjoyed certain benefits that rendered it financially attractive (e.g., subsidies or other financial flows) or did not face the barriers to which the proposed project activity is subject.

3. Essential distinctions may include a serious change in circumstances under which the proposed CDM project activity will be implemented when compared to circumstances under which similar projects where carried out. For example, new barriers may have arisen, or promotional policies may have ended, leading to a situation in which the proposed CDM project activity would not be implemented without the incentive provided by the CDM. The change must be fundamental and verifiable.

 If Sub-steps 4a and 4b are satisfied, i.e. similar activities cannot be observed or similar activities are observed, but essential distinctions between the project activity and similar activities can reasonably be explained, please go to step 5 (Impact of CDM registration).

 If Sub-steps 4a and 4b are not satisfied, i.e. similar activities can be observed and essential distinctions between the project activity and similar activities cannot reasonably be explained, the proposed CDM project activity is not additional.

Step 5. Impact of CDM registration

Explain how the approval and registration of the project activity as a A&R CDM activity, and the attendant benefits and incentives derived from the project activity, will alleviate the economic and financial hurdles (Step 2) or other identified barriers (Step 3) and thus enable the project activity to be undertaken.
The benefits and incentives can be of various types, such as:
. Anthropogenic greenhouse gas emission reductions;
. The financial benefit of the revenue obtained by selling CERs,
. Attracting new players who are not exposed to the same barriers, or can accept a lower IRR (for instance because they have access to cheaper capital),
. Attracting new players who bring the capacity to implement a new technology, and
. Reducing inflation /exchange rate risk affecting expected revenues and attractiveness for investors.

 If Step 5 is satisfied, the proposed CDM project activity is not the baseline scenario.

 If Step 5 is not satisfied, the proposed CDM project activity is not additional.

Sub-step 1a. Define alternatives to the project activity:

1. Identify realistic and credible land use alternatives available to the project participants, land owners or similar project developers, in the region in which the project activity will be implemented. These alternatives are to include:

- The proposed project activity not undertaken as a CDM project activity;
- All other plausible and credible land use alternatives to the project activity available in the region in which the project activity will be implemented;
- If applicable, continuation of the current situation (no project activity or land use chages undertaken).

Sub-step 1b. Enforcement of applicable laws and regulations:

2. The alternative(s) shall be in compliance with all applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, e.g. reforestation to mitigate or compensate local environmental impacts from project participants .[6] (This sub-step does not consider national and local policies that do not have legally-binding status.[7]).

3. If an alternative does not comply with all applicable legislation and regulations, then show that, based on an examination of current land use practice in the country or region in which the law or regulation applies, those applicable legal or regulatory requirements are systematically not enforced and that noncompliance with those requirements is widespread in the country. If this cannot be shown, then eliminate the alternative from further consideration;

4. If the proposed project activity is the only alternative amongst the ones considered by the project participants that is in compliance with all regulations with which there is general compliance, then the proposed CDM project activity is not additional.[8]

 Proceed to Step 2 (Investment analysis) or Step 3 (Barrier analysis). (Project participants may also select to complete both steps 2 and 3.)

Step 2. Investment analysis

Determine whether the proposed project activity is the economically or financially less attractive than other land use alternatives without the revenue from the sale of certified emission reductions (CERs). To conduct the investment analysis, use the following sub-steps:

Sub-step 2a. Determine appropriate analysis method
1. Determine whether to apply simple cost analysis, investment comparison analysis or benchmark analysis (sub-step 2b). If the CDM project activity generates no financial or economic benefits other than CDM related income, then apply the simple cost analysis (Option I). Otherwise, use the investment comparison analysis (Option II) or the benchmark analysis (Option III).

Sub-step 2b. – Option I. Apply simple cost analysis
2. Document the costs associated with the CDM project activity and demonstrate that the activity produces no economic benefits other than CDM related income.

 If it is concluded that the proposed CDM project activity is not financially attractive then proceed to Step 4 (Common practice analysis).

Sub-step 2b. – Option II. Apply investment comparison analysis

3. Identify the financial indicator, such as IRR[9], NPV or cost benefit ratio, or unit cost of service most suitable for the project type and decision-making context.
Sub-step 2b – Option III. Apply benchmark analysis

4. Identify the financial indicator, such as IRR[10], NPV or cost benefit ratio most suitable for the project type and decision context. Identify the relevant benchmark value, such as the required rate of return (RRR) on equity. The benchmark is to represent standard returns in the market, considering the specific risk of the project type, but not linked to the subjective profitability expectation or risk profile of a particular project developer. Benchmarks can be derived from:

. Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert;

- Estimates of the cost of financing and required return on capital (e.g. commercial lending rates and guarantees required for the country and the type of project activity concerned), based on bankers views and private equity investors/funds' required return on comparable projects;
- A company or land owner internal benchmark (weighted average capital cost of the company) if there is only one potential project developer (e.g. when the project activity upgrades an existing process). The project developers shall demonstrate that this benchmark has been consistently used in the past, i.e. that project activities under similar conditions developed by the same company or land owner used the same benchmark.

Sub-step 2c. Calculation and comparison of financial indicators (only applicable to options II andIII):

5. Calculate the suitable financial indicator for the proposed CDM project activity and, in the case of Option II above, for the other alternatives. Include all relevant costs (including, for example, the investment cost, the operations and maintenance costs), and revenues (excluding CER revenues, but including subsidies/fiscal incentives[11] where applicable), and, as appropriate, non-market cost and benefits in the case of public investors.

6. Present the investment analysis in a transparent manner and provide all the relevant assumptions in the CDM-PDD, so that a reader can reproduce the analysis and obtain the same results. Clearly present critical techno-economic parameters and assumptions (such as capital costs, fuel prices, lifetimes, and discount rate or cost of capital). Justify and/or cite assumptions in a manner that can be validated by the DOE. In calculating the financial indicator, the project's risks can be included through the cash flow pattern, subject to project-specific expectations and assumptions (e.g. insurance premiums can be used in the calculation to reflect specific risk equivalents).

7. Assumptions and input data for the investment analysis shall not differ across the project activity and its alternatives, unless differences can be well substantiated.

8. Present in the CDM-PDD submitted for validation a clear comparison of the financial indicator for the proposed A&R CDM activity and:

(a) The alternatives, if Option II (investment comparison analysis) is used. If one of the other alternatives has the best indicator (e.g. highest IRR), then the CDM project activity can not be considered as the most financially attractive;

(b) The financial benchmark, if Option III (benchmark analysis) is used. If the CDM project activity has a less favourable indicator (e.g. lower IRR) than the benchmark, then the CDM project activity cannot be considered as financially attractive.

Sub-step 2d. Sensitivity analysis (only applicable to options II and III):

9. Include a sensitivity analysis that shows whether the conclusion regarding the financial attractiveness is robust to reasonable variations in the critical assumptions. The investment analysis provides a valid argument in favour of additionality only if it consistently supports (for a realistic range of assumptions) the conclusion that the project activity is unlikely to be the most financially attractive (as per step 2c para 8a) or is unlikely to be financially attractive (as per step 2c para 8b).

 If after the sensitivity analysis it is concluded that the proposed CDM project activity is unlikely to be the most financially attractive (as per step 2c para 8a) or is unlikely to be financially attractive (as per step 2c para 8b), then proceed to Step 3 (Barrier analysis) or Step 4 (Common practice analysis).

 Otherwise, unless barrier analysis below is undertaken and indicates that the proposed project activity faces barriers that do not prevent the baseline scenario(s) from occurring, the project activity is considered not additional.

Step 3. Barrier analysis

If this step is used, determine whether the proposed project activity faces barriers that:

(a) Prevent the implementation of this type of proposed project activity; and

(b) Do not prevent the implementation of at least one of the alternatives.
Use the following sub-steps:

Sub-step 3a. Identify barriers that would prevent the implementation of type of the proposed project activity:

1. Establish that there are barriers that would prevent the implementation of the type of proposed project activity from being carried out if the project activity was not registered as a A&R CDM activity. Such barriers may include, among others:
Investment barriers, other than the economic/financial barriers in Step 2 above, *inter alia*:

- Debt funding is not available for this type of innovative project activities.
- No access to international capital markets due to real or perceived risks associated with domestic or foreign direct investment in the country where the project activity is to be implemented.

Technological barriers, *inter alia*:

- Skilled and/or properly trained labour to operate and maintain the technology is not available and no education/training institution in the host country provides the needed skill, leading to equipment disrepair and malfunctioning;
- Lack of infrastructure for implementation of the technology.

Barriers due to prevailing practice, *inter alia*:

- The project activity is the “first of its kind”: No project activity of this type is currently operational in the host country or region.

The identified barriers are only sufficient grounds for demonstration of additionality if they would prevent potential project proponents from carrying out the proposed project activity if it was not expected to be registered as a A&R CDM activity.

2. Provide transparent and documented evidence, and offer conservative interpretations of this documented evidence, as to how it demonstrates the existence and significance of the identified barriers. Anecdotal evidence can be included, but alone is not sufficient proof of barriers. The type of evidence to be provided may include:

(a) Relevant legislation, regulatory information or industry norms;

(b) Relevant (sectoral) studies or surveys (e.g. market surveys, technology studies, etc) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc;

(c) Relevant statistical data from national or international statistics;

(d) Documentation of relevant market data (e.g. market prices, tariffs, rules);

(e) Written documentation from the company or institution developing or implementing the CDM project activity or the CDM project developer, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc;

(f) Documents prepared by the project developer, contractors or project partners in the context of the proposed project activity or similar previous project implementations;

(g) Written documentation of independent expert judgements from industry, educational institutions (e.g. universities, technical schools, training centres), industry associations and others.

Sub-step 3 b. Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity):

3. If the identified barriers also affect other alternatives, explain how they are affected less strongly than they affect the proposed CDM project activity. In other words, explain how the identified barriers are not preventing the implementation of at least one of the alternatives. Any alternative that would be prevented by the barriers identified in Sub-step 3a is not a viable alternative, and shall be eliminated from consideration. At least one viable alternative shall be identified.

 If both Sub-steps 3a – 3b are satisfied, proceed to Step 4 (Common practice analysis)

 If one of the Sub-steps 3a – 3b is not satisfied, the project activity is not additional.

Step 4. Common practice analysis

The above generic additionality tests shall be complemented with an analysis of the extent to which the proposed project type (e.g. technology or practice) has already diffused in the relevant sector and region. This test is a credibility check to complement the investment analysis (Step 2) or barrier analysis (Step 3). Identify and discuss the existing common practice through the following sub-steps:

Sub-step 4a. Analyze other activities similar to the proposed project activity:

1. Provide an analysis of any other activities implemented previously or currently underway that are similar to the proposed project activity. Projects are considered similar if they are in the same country/region and/or rely on a broadly similar technology, are of a similar scale, and take place in a comparable environment with respect to regulatory framework, investment climate, access to technology, access to financing, etc. Other CDM project activities are not to be included in this analysis. Provide quantitative information where relevant.

Sub-step 4b. Discuss any similar options that are occurring:

2. If similar activities are widely observed and commonly carried out, it calls into question the claim that the proposed project activity is financially unattractive (as contended in Step 2) or faces barriers (as contended in Step 3). Therefore, if similar activities are identified above, then it is necessary to demonstrate why the existence of these activities does not contradict the claim that the proposed project activity is financially unattractive or subject to barriers. This can be done by comparing the proposed project activity to the other similar activities, and pointing out and explaining essential distinctions between them that explain why the similar activities enjoyed certain benefits that rendered it financially attractive (e.g., subsidies or other financial flows) or did not face the barriers to which the proposed project activity is subject.

3. Essential distinctions may include a serious change in circumstances under which the proposed CDM project activity will be implemented when compared to circumstances under which similar projects where carried out. For example, new barriers may have arisen, or promotional policies may have ended, leading to a situation in which the proposed CDM project activity would not be implemented without the incentive provided by the CDM. The change must be fundamental and verifiable.

 If Sub-steps 4a and 4b are satisfied, i.e. similar activities cannot be observed or similar activities are observed, but essential distinctions between the project activity and similar activities can reasonably be explained, please go to step 5 (Impact of CDM registration).

 If Sub-steps 4a and 4b are not satisfied, i.e. similar activities can be observed and essential distinctions between the project activity and similar activities cannot reasonably be explained, the proposed CDM project activity is not additional.

Step 5. Impact of CDM registration

Explain how the approval and registration of the project activity as a A&R CDM activity, and the attendant benefits and incentives derived from the project activity, will alleviate the economic and financial hurdles (Step 2) or other identified barriers (Step 3) and thus enable the project activity to be undertaken.
The benefits and incentives can be of various types, such as:

- Anthropogenic greenhouse gas emission reductions;
- The financial benefit of the revenue obtained by selling CERs,
- Attracting new players who are not exposed to the same barriers, or can accept a lower IRR (for instance because they have access to cheaper capital),
- Attracting new players who bring the capacity to implement a new technology, and
- Reducing inflation /exchange rate risk affecting expected revenues and attractiveness for investors.

 If Step 5 is satisfied, the proposed CDM project activity is not the baseline scenario.

 If Step 5 is not satisfied, the proposed CDM project activity is not additional.

CLEAN DEVELOPMENT MECHANISM
PROPOSED NEW METHODOLOGY FOR AFFORESTATION AND REFORESTATION PROJECT ACTIVITIES: MONITORING (CDM-AR-NMM)

CONTENTS

SECTION A. Identification of methodology

A.1. Title of the proposed methodology:

'Monitoring methodology for afforestation or reforestation project activities'

A.2. List of type(s) of A/R CDM project activity to which the methodology may apply:

14. Afforestation or reforestation project activities

A.3. Conditions under which the methodology is applicable to A/R CDM project activities:

This methodology may apply to projects with the following conditions:

1. Projects are eligible with regards to the definitions and modalities for A/R CDM projects as set out in Decision 19/CP.9;
2. Land tenure of the areas within the project boundary is clear and landowners are willing participants in the project activity;
3. Landowners do not depend on the areas subject to the project activities for maintaining on the short term their present levels of income or general well-being. Any income-generating activities that currently take place on the areas are easily transferable to other non-forested areas.
4. Areas subject to the project activities may not be illegally occupied and/or used by third parties. In the case of third parties legally occupying and/or using areas subject to the project activities the same conditions apply as set out under Point 3.

A.4 Carbon pools covered by the methodology:

All carbon pools: above ground biomass, below ground biomass, litter, dead wood and soil organic carbon.

A.5. What are the potential strengths and weaknesses of this proposed new methodology?

Strengths: Simple and widely applicable methodology; cost reduction; applicable to a wide range of afforestation and reforestation activities. Because this is a generic methodology, it gives projects the flexibility to choose quantification approaches according to data availability.

Weakness: Because this is a generic methodology, applicable to a wide range of situations, it is more dependent than usual on judgment of the DOE to ensure the complete, transparent and conservative application of the methodology.

SECTION B. Proposed new monitoring methodology

B.1. Overall summary description of the methodology:

This Monitoring Methodology aims to be generic and generally applicable to afforestation or reforestation projects. In general, it recommends that projects should adhere to the relevant guidance in Section 4.3.3 of the IPCC Good Practice Guidance for LULUCF (2003).

For the monitoring of the actual net GHG removals by sinks, carbon pools are measured in representative sample plots within each identified stratum[1] within the project boundary. This will be done for the first time after a period to be determined by the project proponents and thereafter in 5-yearly intervals. The results from the sample plots are then extrapolated to the entire area of the stratum. Before each verification, an assessment will be carried out to analyse whether any plantations have significantly under-performed relative to the results from the sample plots, e.g. as a result of fire, plague or a deviation of prescribed management practices. The IPCC Good Practice Guidance for LULUCF (2003) describes various methods to conduct such an assessment. A choice will need to be made and justified by the project management whether or not an identified under-performance in a specific area has already been captured by the results of the established sample plots. If not, the affected area should be treated as a separate stratum and additional sample plots should be established to quantify the carbon stocks in the pools within this stratum.

For the monitoring of increased GHG emissions by the sources within the project boundary resulting from fossil fuel combustion, fuel consumption shall be recorded as and when it occurs or fuel expenses shall be recorded as and when the project or contractors incur them, and the corresponding fuel consumption shall be calculated using the fuel price at the time.

Monitoring of increased GHG emissions by the sources within the project boundary shall be done on the basis of records on the mode of transport used for transportation and estimates of average distance transported and average fuel efficiency per mode of transport.

Project proponents applying this monitoring methodology shall assure quality by employing or contracting trained professionals on the monitoring of biomass and carbon data in forest systems. In addition, projects should follow procedural guidance on the collection of reliable field measurements, the

[1] Strata are identified according to differences in baseline, management and/or biophysical properties.

verification of collected field data, the verification of field data entry and analysis and data management and storage, as outlined in Section 4.3.4 of the GPG Good Practice Guidance for LULUCF (2003).

B.2. Monitoring of the baseline net GHG removals by sinks and the actual net GHG removals by sinks:

This Monitoring Methodology aims to be generic and generally applicable to afforestation or reforestation projects. In general, it recommends that projects should adhere to the relevant guidance in Section 4.3.3 of the IPCC Good Practice Guidance for LULUCF (2003).

B.2.1 Actual net GHG removals by sinks data:

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B.2.1.1. Data to be collected or used in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary from the proposed A/R CDM project activity, and how this data will be archived:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1	Spatial data	Satellite images, aereal photographs, maps, GPS data	-	M and C	Before the first verification or as new strata are identified (see Section B.2.2.1)	100 %	Electronic	Data used to stratify the project and to quantify the number of hectares in each stratum.
8	Diameter at breast height (DBH)	Field measurements	m	M	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
9	Tree height (H)	Field measurements	m	M or E	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
10	Bole height (H_B) for calculation of Bole Volume (V)	Field measurements	m/m^3	C	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
11	Crown Expansion Factor (CEF)	Field measurements	-	C	Before each verification	-	Electronic and paper	See Section B.2.4 for the formula to calculate the CEF. Of a limited number of trees of each species crowns or parts of crowns will be destructively harvested to determine crown biomass.

12	Wood density (WD)	Field measurements or from literature sources	g/cm^3	C	Before the first verification or as new species appear naturally within the plots.	A significant number of samples per tree species	Electronic and paper	Samples for the determination of WD will be taken from surrounding areas where mature trees are found of the species planted or naturally regenerated in the sample plots. The WD to be used in the formulae will be the average of the 5 samples.
13	Tree aboveground biomass	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis. See also Section B.2.4.
14	Non-tree aboveground biomass	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
18	Aboveground biomass harvested (H_{ag})	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	Needed for calculation of Data ID nos. 24, 30 and 35.
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. May be broken down into different components of the pool (e.g. stem wood, leaves, etc.). IPCC (1996) recommends a default CBR of 0.5.
20	Belowground to aboveground biomass ratio (BABR)	Field measurements or literature sources	%	C	Before each verification	100% of sampling plots*	Electronic and paper	For calculation of belowground biomass. See Annex I for a general overview of methods for data collection and analysis.
24	Belowground biomass harvested (H_{bg})	Field measurements	t/ha/yr or %/yr	C	Before each verification	100% of sampling plots*	Electronic and paper	Calculated, using the BABR, from the aboveground biomass harvested.
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. May be broken down into different components of the pool (e.g. coarse and fine roots). IPCC (1996) recommends a default CBR of 0.5.
26	Litter biomass ($BCL_{t=n}$)	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
27	Portion of aboveground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Needed to calculate Data ID no. 30

28	Portion of belowground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Needed to calculate Data ID no. 30
29	Fine part of harvested biomass taken out of system	Field measurements	t/ha or %	M	Before each verification	100% of sampling plots*	Electronic and paper	Needed to calculate Data ID no. 30
30	Fine part of harvested biomass left in system (H_{fine})	Field measurements	t/ha or %	C	Before each verification	100% of sampling plots*	Electronic and paper	
32	Carbon to biomass ratio for litter biomass (CBR_L)	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. IPCC (1996) recommends a default CBR of 0.5.
33	Dead wood biomass ($BCDW_{t=n}$)	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
34	Coarse part of harvested biomass taken out of system	Field measurements	t/ha or %	M	Before each verification	100% of sampling plots*	Electronic and paper	Needed to calculate Data ID no. 35
35	Coarse part of harvested biomass left in system (H_{coarse})	Field measurements	t/ha or %	M or E	Before each verification	100% of sampling plots*	Electronic and paper	
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. IPCC (1996) recommends a default CBR of 0.5.
38	Soil carbon content ($CCS_{t=0}$)	Field measurements	t/ha	M	Before each verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
a	Data on planting schedules and management of plantations	Management decisions taken by the central project management or individual project participants	-	Time, place and % biomass removed	As management occurs	100%	Electronic and paper	Which areas were subjected to which planting schedule and management regime, including timings.

b	Data on negative deviation of areas from sampling plot measurement results	Field observations or field measurements	% or t/ha	E or M	Before each verification	100%	Electronic and paper	E.g. lower than expected biomass in certain parts of the project area affected by fire, plague or drought.
c	Data on environmental impacts of the project (if required in accordance with Paragraph 12c of Decision 19/CP.9)	Field observations or field measurements	various	E, C or M	As deemed appropriate	As deemed appropriate	Electronic and paper	E.g., data on biodiversity or hydrology in the project area, or on indirect impacts such as reduced sedimentation downstream.
d	Data on socio-economic impacts of the project (if required in accordance with Paragraph 12c of Decision 19/CP.9)	Project observations or interviews.	various	E or C	As deemed appropriate	As deemed appropriate	Electronic and paper	E.g., data on income levels of impacted people or employment records.
e	Information to demonstrate that any exclusion of carbon pools in accordance with Paragraph 21 of Decision 19/CP.9 does not increase the net anthropogenic greenhouse gas removals by sinks.	Field measurements	As appropriate	M and/or C	Before each verification	Only an indicative amount of data	Electronic and paper	
f	Changes in circumstances within the project boundary that affect legal title to the land or rights of access to the carbon pools.	Legal documents	-	Observed	Before each verification	100%	Electronic and paper	

* Sampling plots representative for the entire project area will be established to measure carbon stocks in the pools in accordance with standard sampling procedures as given in a large number of forest mensuration and sampling text books. Annex I gives a general overview of methods of data collection.

B.2.1.2. Data to be collected or used in order to monitor the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary, and how this data will be archived:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
38	Amount of Fuel Used by project (AFU)	Project-specific data	l or kg	e	As and when fuel use occurs	100%	Electronic and paper	Data will be collected from incurred fuel costs by the project and any contractors.
39	Energy content of fuel used (EC_{FU})	Literature sources (e.g. IPCC)	TJ/l or TJ/kg	m	Updated before each verification	-	Electronic and paper	
40	Emission Factor of Fuel Used (EF_{FU})	Literature sources (e.g. IPCC)	tCO2e/TJ	m	Updated before each verification	-	Electronic and paper	
41	Data indicated in Sections 3.2.1.4 and 4.3.3.6 of IPCC (2003)	IPCC (2003)	various	-	Annually	various	Electronic and paper	Only to be monitored if relevant.

B.2.2. Description of formulae and/or models used to monitor the estimation of the actual net GHG removals by sinks:

B.2.2.1. Description of formulae and/or models used to monitor the estimation of the verifiable changes in carbon stock in the carbon pools within the project boundary (for each carbon pool in units of CO_2 equivalent):

Calculation of carbon stocks in the carbon pools within sample plots

Formulae for the estimation of aboveground biomass are given in Section B.2.4. Biomass content of the pools per hectare should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. Data are generated for representative sample plots of either permanent or temporary nature. Sample plots should adequately cover all strata identified in Step 2 of Section E.4 of the Baseline Methodology.

Biomass content of the all pools except soil is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCP_{t=n} = BCP_{t=n} * CP_{AG}$$

Where:

$CCP_{t=n}$ = Carbon Content Pool in year n

$BCP_{t=n}$ = Biomass Content Pool in year n

CBR_P = Carbon to Biomass Ratio for Pool

Carbon content of the soil pool is measured directly from field samples.

For each stratum, the average for each pool’s carbon content will be calculated from the individual results of the sample plots within the stratum and converted to a per-hectare result.

Calculation of carbon stocks in the carbon pools within the project boundary

For each stratum, the average per-hectare results from the sample plots will be multiplied by the number of hectares within the stratum

Correction for underperformance relative to sample plot-based data

Before each verification, an assessment will be carried out to analyse whether any plantations have significantly under-performed relative to the results from the sample plots, e.g. as a result of fire, plague or a deviation of prescribed management practices. The IPCC Good Practice Guidance for LULUCF (2003) describes various methods to conduct such an assessment. A choice will need to be made and justified by the project management whether or not an identified under-performance in a specific area has already been captured by the results of the established sample plots. If not, the affected area should be treated as a separate stratum and additional sample plots should be established to quantify the carbon stocks in the pools within this stratum.

B.2.2.2. Description of formulae and/or models used to monitor the estimation of the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary (for each source and gas, in units of CO_2 equivalent):

Calculations of the increase in emissions of the greenhouse gases measured in CO2 equivalents by the sources within the project boundary that are increased as a result of the implementation of the project activity should be done using the following approaches:

Step 1. Identification of sources - Identification of possible sources of increased GHG emissions resulting from the implementation of the project activity and the type of GHG emitted by these. Sources can be divided into the following categories:

1. Combustion of fossil fuels
2. Non-CO_2 GHG emissions from soils (e.g., application of fertilizers or growing of N-fixing trees)
3. Non-CO_2 GHG emissions from biomass burning (e.g., from site preparation)

Step 2. Quantification of increased emissions by the sources identified under Step 1. – For the calculation of emissions from identified sources pertaining to Category 1, the following formula shall be applied:

$$Emissions_{Cat1} = AFU * EC_{FU} * EF_{FU}$$

Where:

$Emissions_{Cat1}$ (tCO_2e) = Emissions from Category 1 Sources
AFU (unit) = Amount of Fuel Used
EC_{FU} (TJ/ unit) = Energy Content of Fuel Used
EF_{FU} (tCO2e/TJ) = Emission Factor of Fuel Used

For the calculation of emissions from identified sources pertaining to Categories 2 and 3 the default methods and data as given and referred to in Sections 3.2.1.4 and 4.3.3.6 of the IPCC Good Practice Guidance for LULUCF should be used. However, for the calculation of increased N_2O emissions from the planting of N-fixing trees (mainly leguminous species) the IPCC Good Practice Guidance for LULUCF offers no default methodology due to data restrictions. This monitoring methodology will therefore assume these emissions to be 0 until IPCC provides methodological guidance in the future.

Step 3. Calculate total GHG emissions resulting from the implementation of the project activity, adding up the totals for emissions by sources from categories 1-3.

B.2.3. As appropriate, relevant data necessary for determining the baseline net GHG removals by sinks and how such data will be collected and archived:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1	Spatial data	Satellite images, aereal photographs, maps, GPS data	-	M and C	Before the first verification	100 %	Electronic	Data used to stratify the project and to quantify the number of hectares in each stratum.
8	Diameter at breast height (DBH)	Field measurements	m	M	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
9	Tree height (H)	Field measurements	m	M or E	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
10	Bole height (H_B) for calculation of Bole Volume (V)	Field measurements	m/m^3	C	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
11	Crown Expansion Factor (CEF)	Field measurements	-	C	Before the first verification	-	Electronic and paper	See Section B.2.4 for the formula to calculate the CEF. Of a limited number of trees of each species crowns or parts of crowns will be destructively harvested to determine crown biomass.

12	Wood density (WD)	Field measurements or from literature sources	g/cm^3	C	Before the first verification	A significant number of samples per tree species	Electronic and paper	Samples for the determination of WD will be taken from surrounding areas where mature trees are found of the species planted or naturally regenerated in the sample plots. The WD to be used in the formulae will be the average of the 5 samples.
13	Tree aboveground biomass	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis. See also Section B.2.4.
14	Non-tree aboveground biomass	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
15	Aboveground biomass accumulation ($GROWTH_{AG}$)	Project assumption, field measurements or literature data	t/ha/yr	C	Before the first verification	100%	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
16	Litter fall (LF)	Project assumption, field measurements or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
17	Dead wood fall (DWF)	Project assumption, field measurements or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
18	Aboveground biomass harvested (H_{ag})	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	Needed for calculation of Data ID nos. 24, 30 and 35.
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. May be broken down into different components of the pool (e.g. stem wood, leaves, etc.). IPCC (1996) recommends a default CBR of 0.5.
20	Belowground to	Field measurements	%	C	Before the first	100% of sampling plots*	Electronic and paper	For calculation of belowground biomass. See Annex I for a general overview of

	aboveground biomass ratio (BABR)	or literature sources			verification			methods for data collection and analysis.
21	Belowground biomass accumulation ($GROWTH_{BG}$)	Project assumption or literature data	t/ha/yr	C	Before the first verification	100%	Electronic and paper	Often assumed similar to aboveground biomass accumulation
22	Fine root mortality (FRM)	Project assumption or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	
23	Coarse root mortality (CRM)	Project assumption or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	
24	Belowground biomass harvested (H_{bg})	Field measurements	t/ha/yr or %/yr	C	Before the first verification	100% of sampling plots*	Electronic and paper	Calculated, using the BABR, from the aboveground biomass harvested.
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. May be broken down into different components of the pool (e.g. coarse and fine roots). IPCC (1996) recommends a default CBR of 0.5.
26	Litter biomass ($BCL_{t=n}$)	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
27	Portion of aboveground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Needed to calculate Data ID no. 30
28	Portion of belowground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Needed to calculate Data ID no. 30
29	Fine part of harvested biomass taken out of system	Field measurements	t/ha or %	M	Before the first verification	100% of sampling plots*	Electronic and paper	Needed to calculate Data ID no. 30
30	Fine part of harvested biomass left in system (H_{fine})	Field measurements	t/ha or %	C	Before the first verification	100% of sampling plots*	Electronic and paper	

31	Litter that decomposes in a given year (Ldecomp)	Project assumption or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	
32	Carbon to biomass ratio for litter biomass (CBR_L)	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. IPCC (1996) recommends a default CBR of 0.5.
33	Dead wood biomass ($BCDW_{t=n}$)	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
34	Coarse part of harvested biomass taken out of system	Field measurements	t/ha or %	M	Before the first verification	100% of sampling plots*	Electronic and paper	Needed to calculate Data ID no. 35
35	Coarse part of harvested biomass left in system (H_{coarse})	Field measurements	t/ha or %	M or E	Before the first verification	100% of sampling plots*	Electronic and paper	
36	Dead wood that decomposes in a given year (DWdecomp)	Project assumption or literature data	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	Project-specific data or from literature sources (e.g. IPCC)	%	M	Before the first verification	-	Electronic and paper	Established in laboratory. IPCC (1996) recommends a default CBR of 0.5.
38	Soil carbon content ($CCS_{t=0}$)	Field measurements	t/ha	M	Before the first verification	100% of sampling plots*	Electronic and paper	See Annex I for a general overview of methods for data collection and analysis.
39	Percentage of decomposing litter respired to the atmosphere (Lresp)	Project assumption or literature data	%/yr	E	Before the first verification	100%	Electronic and paper	
40	Percentage of decomposing dead wood	Project assumption or literature data	%/yr	E	Before the first verification	100%	Electronic and paper	

	respired to the atmosphere (DWresp)							
41	Percentage of soil carbon content respired to the atmosphere (Sresp)	Project assumption or literature data	%/yr	E	Before the first verification	100%	Electronic and paper	
42	Percentage of soil carbon content lost through erosion (Serosion)	Project assumption	%/yr	E	Before the first verification	100%	Electronic and paper	

B.2.4. Description of formulae and/or models used to monitor the estimation of the baseline net GHG removals by sinks (for each carbon pool, in units of CO_2 equivalent):

General notes:

- Wherever possible, data assumptions should be based on project specific measurements, with the sampling methodologies and calculation assumptions given alongside.
- In the case where data cannot be provided by the project, they should be sourced from other scientific studies relevant to the project's region or country, or other literature data, and full references given. Non-project-specific data should be reasonably applicable to the project's situation and as applicable as possible.
- IPCC Good Practice Guidance for LULUCF procedures should be followed where possible.
- In this methodology, all uses of the word 'biomass' refer to dry-weight biomass.
- Baseline land uses may be dynamic, i.e. they may be expected to change in use and carbon stocks over time. For example, land use systems may include a fallow period in which carbon stocks increase temporarily. Projects should indicate for the baseline land use(s) determined under Step 4 in Section E.2 the likelihood that such dynamism would occur in the baseline scenario, including timings of management actions. This should be supported by verifiable data.

a) Aboveground Biomass Pool

Quantification of initial aboveground biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. The two main approaches are outlined here for tree biomass:

Tree biomass –

1. Direct use of allometric functions that calculate biomass from Diameter at Breast Height (DBH) and/or Height (H) and sometimes Wood Density (WD); or
2. Determination of Bole Biomass (BB) through bole Volume per hectare and WD, then determination of tree aboveground biomass through application of Crown Expansion Factor (CEF):

$$TAB = BB * CEF \quad \{1\}$$

Where:

TAB = Tree Aboveground Biomass
BB = Bole Biomass
CEF = Crown Expansion Factor

For non-tree vegetation biomass, the other component of aboveground biomass, direct application of biomass per hectare data from field measurements is usual.

Calculation of yearly changes in aboveground biomass content - Calculations of the changes in biomass content per hectare in the aboveground biomass pool during the crediting period are done by taking the initial biomass content per hectare ($BCAB_{t=0}$) and calculating the biomass content in the next year ($BCAB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCAB_{t=1} = BCAB_{t=0} + GROWTH_{AG} - LF - DWF - H_{ag} \qquad \{2\}$$

Where:
$BCAB_{t=0}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 0
$BCAB_{t=1}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 1
$GROWTH_{AG}$ (t/ha/yr) = Accumulation of biomass in tree and non-tree vegetation through photosynthesis or planting
LF (t/ha/yr) = Litter Fall (fine parts of biomass died naturally)
DWF (t/ha/yr) = Dead Wood Fall (coarse parts of biomass died naturally)
H_{ag} (t/ha) = Harvestings (total aboveground biomass anthropogenically removed from the site or left to be incorporated in the Litter and/or Dead Wood pools)

The tree component of GROWTH is usually derived from data on increase in bole volume, DBH or tree height, with which biomass can be derived using the same approaches as outlined above. For the non-tree vegetation component direct biomass increase data are usually used.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCAB_{t=n} = BCAB_{t=n} * CBR_{AG} \qquad \{3\}$$

Where:
$CCAB_{t=n}$ = Carbon Content Aboveground Biomass Pool in year n
$BCAB_{t=n}$ = Biomass Content Aboveground Biomass Pool in year n
CBR_{AG} = Carbon to Biomass Ratio for aboveground biomass

b) Belowground Biomass Pool

Quantification of initial belowground biomass content – For the assessment of belowground biomass usually a Belowground to Aboveground Biomass Ratio (BABR) is applied. Initial belowground biomass content therefore follows from the quantification of aboveground biomass under a), using the formula:

$$BCBB_{t=n} = BCAB_{t=n} * BABR \qquad \{4\}$$

Where:

$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n

$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n

BABR = Belowground to Aboveground Biomass Ratio

The BABR can vary according to different species or vegetation types present in the stratum. Project-specific BABR(s) may be determined by the project, in which case belowground biomass should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. However, quantification of belowground biomass is cumbersome and expensive and projects may therefore use a published BABR applicable to the project.

Calculation of yearly changes in belowground biomass content - Calculations of the changes in biomass content per hectare in the belowground biomass pool during the crediting period are done by taking the initial biomass content ($BCBB_{t=0}$) and calculating the biomass content in the next year ($BCBB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCBB_{t=1} = BCBB_{t=0} + GROWTH_{BG} – CRM – FRT – H_{bg} \qquad \{5\}$$

Where:

$BCBB_{t=0}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 0

$BCBB_{t=1}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 1

$GROWTH_{BG}$ * (t/ha/yr) = Tree and non-tree vegetation growth through photosynthesis or planting

FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)

CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of dead biomass died naturally)

H_{bg} (t/ha/yr) = Harvestings (total root biomass anthropogenically killed)

* Usually calculated from aboveground growth by applying the same Belowground to Aboveground Biomass Ratio.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCBG_{t=n} = BCBG_{t=n} * CBR_{BG} \qquad \{6\}$$

Where:

$CCBG_{t=n}$ = Carbon Content Belowground Biomass Pool in year n

$BCBG_{t=n}$ = Biomass Content Belowground Biomass Pool in year n

CBR_{BG} = Carbon to Biomass Ratio for belowground biomass

c) Litter Pool

Quantification of initial litter biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in litter biomass content - Calculations of the changes in biomass content per hectare in the litter pool during the crediting period are done by taking the initial biomass content ($BCL_{t=0}$) and calculating the biomass content in the next year ($BCL_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCL_{t=1} = BCL_{t=0} + LF + FRM + H_{fine\text{-}in} - (BCL_{t=0} * Ldecomp) \qquad \{7\}$$

Where:

$BCL_{t=0}$ (t/ha) = Biomass Content Litter Pool in year 0

$BCL_{t=1}$ (t/ha) = Biomass Content Litter Pool in year 1

LF (t/ha/yr) = Litter Fall (fine parts of aboveground biomass died naturally)

FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)

$H_{fine\text{-}in}$ (t/ha) = The fine part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the dead wood pool after harvesting (see equation 8).

Ldecomp (%/yr) = Percentage of $BCL_{t=0}$ that decomposes

$$H_{fine\text{-}in} = (BCAB_{t=n} * PF_{AG}) + (BCBB_{t=n} * PF_{BG}) - H_{fine\text{-}out} \qquad \{8\}$$

Where:
$H_{fine-in}$ (t/ha) = Fine part of the biomass left in the forest system (above and belowground)
$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n
PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine
$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n
PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine
$H_{fine-out}$ (t/ha) = Fine part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCL_{t=n} = BCL_{t=n} * CBR_L \qquad \{9\}$$

Where:
$CCL_{t=n}$ = Carbon Content Litter Pool in year n
$BCL_{t=n}$ = Biomass Content Litter Pool in year n
CBR_L = Carbon to Biomass Ratio for litter

d) Dead Wood Pool

Quantification of initial dead wood biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in dead wood biomass content - Calculations of the changes in biomass content per hectare in the dead wood pool during the crediting period are done by taking the initial biomass content ($BCDW_{t=0}$) and calculating the biomass content in the next year ($BCDW_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCDW_{t=1} = BCDW_{t=0} + DWF + CRM + H_{coarse-in} - (BCDW_{t=0} * DWDecomp) \qquad \{10\}$$

Where:

$BCDW_{t=0}$ (t/ha) = Biomass Content Dead Wood Pool in year 0

$BCDW_{t=1}$ (t/ha) = Biomass Content Dead Wood Pool in year 1

DWF (t/ha/yr) = Dead Wood Fall (coarse parts of aboveground biomass died naturally)

CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of belowground biomass died naturally)

$H_{coarse\text{-}in}$ (t/ha) = The coarse part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the litter pool after harvesting (see equation 11).

DWDecomp (%/yr) = Percentage of $BCDW_{t=0}$ that decomposes

$$H_{coarse\text{-}in} = (BCAB_{t=n} * (1\text{-}PF_{AG})) + (BCBB_{t=n} * (1\text{-}PF_{BG})) - H_{coarse\text{-}out} \qquad \{11\}$$

Where:

$H_{coarse\text{-}in}$ (t/ha) = Coarse part of the biomass left in the forest system (above and belowground)

$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n

PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine

$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n

PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine

$H_{coarse\text{-}out}$ (t/ha) = Coarse part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCDW_{t=n} = BCDW_{t=n} * CBR_{DW} \qquad \{12\}$$

Where:

$CCDW_{t=n}$ = Carbon Content Dead Wood Pool in year n

$BCDW_{t=n}$ = Biomass Content Dead Wood Pool in year n

CBR_{DW} = Carbon to Biomass Ratio for dead wood

e) Soil Organic Carbon Pool

Quantification of initial soil organic carbon content – Initial carbon content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, IPCC (2003) provides a comprehensive overview of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in soil organic carbon content - Calculations of the changes in carbon stocks per hectare in the soil organic carbon pool during the crediting period are done by taking the initial carbon content ($CCS_{t=0}$) and calculating the carbon content in the next year ($CCS_{t=1}$) and subsequent years by adding yearly influxes of carbon and subtracting outfluxes of carbon from the pool.

$$CCS_{t=1} = CCS_{t=0} + CCL_{t=0}*Ldecomp*(1-Lresp) + (CCDW_{t=0}*DWdecomp*(1-DWresp) – Sresp –Serosion \quad \{13\}$$

Where:

$CCS_{t=0}$ (tC/ha)	= Carbon Content Soil Pool in year 0
$CCS_{t=1}$ (tC/ha)	= Carbon Content Soil Pool in year 1
$CCL_{t=0}$ (tC/ha)	= Carbon Content Litter Pool in year 0
Ldecomp (%/yr)	= Percentage of $CCL_{t=0}$ that decomposes
Lresp (%/yr)	= Percentage of Ldecomp that is respired to the atmosphere
$CCDW_{t=0}$ (tC/ha)	= Carbon Content Dead Wood Pool in year 0
DWdecomp (%/yr)	= Percentage of $CCDW_{t=0}$ that decomposes
Dwresp	= Percentage of DWDecomp that is respired to the atmosphere
Sresp	= Percentage of $CCS_{t=0}$ that is respired to the atmosphere
Serosion	= Percentage of $CCS_{t=0}$ that is lost from the system through erosion processes

B.3. Treatment of leakage in the monitoring plan:

B.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage of the proposed A/R CDM project activity:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
38	Amount of Fuel (AFU)	Project-specific data and regional statistics	l or kg	e	Annually[+]	100%	Electronic and paper	On the basis of records on the mode of transport used for transportation and estimates of average distance transported and average fuel efficiency per mode of transport.
39	Energy content of fuel used (EC_{FU})	Literature sources (e.g. IPCC)	TJ/l or TJ/kg	m	Updated before each verification	-	Electronic and paper	
40	Emission Factor of Fuel Used (EF_{FU})	Literature sources (e.g. IPCC)	tCO2e/TJ	m	Updated before each verification	-	Electronic and paper	

[+] Monitoring of records and estimation of leakage is best done annually. However, for the calculation of the Net Anthropogenic GHG Removals by Sinks (Section B.4) the annual estimation results for all years since the previous verification need to be added up

B.3.2. Description of formulae and/or models used to estimate leakage (for each GHG, source, carbon pool, in units of CO_2 equivalent):

As given in Section B.2.2.2 for Category 1 sources.

B.4. Description of formulae and/or models used to estimate net anthropogenic GHG removals by sinks for the proposed A/R CDM project activity (for each GHG, carbon pool, in units of CO_2 equivalent):

NAR = ANR –BNR – L

Where:

NAR	= Net Anthropogenic GHG Removals by Sinks
ANR	= Actual Net GHG Removals by Sinks (from Section B.2.2)
BNR	= Baseline Net GHG Removals by Sinks (from Section B.2.4)
L	= Leakage (from Section E.6)

B.5. Default values used in elaborating the new methodology:

This is a generic methodology and the use of any particular default values has been avoided to offer maximum flexibility to project proponents in applying this methodology. The only default value that is mentioned is IPCC's recommendation to use 0.5 as a Carbon to Biomass Ratio (IPCC, 1996).

B.6. Please indicate how quality control (QC) and quality assurance (QA) procedures are applied to the monitoring process:

Project proponents applying this monitoring methodology shall assure quality by employing or contracting trained professionals on the monitoring of biomass and carbon data in forest systems. For further quality assurance as well as for quality control it is recommended that projects use independent third-party experts to conduct the field monitoring and data processing.

In addition, projects should follow procedural guidance on the collection of reliable field measurements, the verification of collected field data, the verification of field data entry and analysis and data management and storage, as outlined in Section 4.3.4 of the GPG Good Practice Guidance for LULUCF (2003).

B.7. Has the methodology been applied successfully for other purposes and, if so, in which circumstances?

The core monitoring activities as presented in this methodology are based on common practice in silvicultural monitoring and scientific data collection.

ANNEX 1 – Carbon and biomass data collection and analysis

This section provides a general overview of methods of data collection for carbon offset projects. It is not meant to be an extensive instructions guide. For detailed information on carbon inventory methods, please refer to A Guide to Monitoring Carbon Sequestration in Forestry and Agroforestry Projects (Winrock 1996), the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1996), the IPCC Good Practice Guidance for LULUCF (IPCC 2003) or standard forest mensuration and sampling texts.

Biomass and Necromass

The most common approach to monitoring the carbon sequestration benefits associated with a forestry project is through permanent sampling plots, in which biomass (and possibly necromass) are measured at regular intervals. Specific methodologies exist for measuring the distinct pools and flows but the general approach of permanently identifying plots, trees, or sites and re-measuring specific variables associated with these plots, trees, or sites will often be appropriate. The advantage of permanent plots over random samples is that the relevant variables (e.g., diameter, biomass, soil organic matter content), and changes in these variables between time *i* and time *i+1*, can be estimated with more precision.

Standard protocols used for the establishment of forest growth and yield plots are applicable to monitoring carbon in trees. Plots should be distributed so as to incorporate the range of variability that exists within the site, and to be representative of the larger area to which the estimates will be applied. A stratified random design is recommended, where the strata are defined by topographical positions, site conditions, or when little information exists for a site or when the area is fairly homogenous, the strata may be evenly spaced transects that are distributed across the area. The number of plots established within each stratum should be proportional to the size of the stratum relative to the whole. Minimum distance between plots should be sufficient to insure that the plots are independent. As a general rule of thumb for natural forests, twice the canopy height is often a sufficient distance to consider plots independent.

Plot size can be fixed or variable, but should be based on the size of the units being measured, the variability within the units, both in size and distribution, and the logistics of collecting data within the plots with a minimum of error. Plot size should be large enough to avoid having many plots with zero individuals and to avoid having plots with so many individuals that it becomes difficult to keep track of them (e.g., >30 trees). Generally, a nested design is useful, where a large plot is demarcated in which the large trees are measured and smaller subdivisions within the large plot are demarcated for smaller size classes. This design is appropriate for plantations where, following establishment, the trees are fairly small (dbh <5 cm) and dense, and a small plot is appropriate (e.g., 100 m^2) but as the trees grow, a larger plot will be required to capture the variation within the stand and to maintain an adequate number of trees in the each plot. Nested designs are also appropriate for natural forest with uneven size class distributions. Often a fixed area plot of 40 x 20 m, with nested subplots of 20 x 20m, 10 x 10 m, and 5 x 5m will be suitable, though 0.25 ha (50 x 50 m) plots are probably more commonly used.] For forests with very large trees that are scattered randomly at low densities in a stand, it may be prudent to increase plot size to 80 x 20 for trees >=60 cm dbh. Plots can be either circular or rectangular, and during establishment care should be taken to correct plot lengths and widths for slope. Verification process should include checking borderline trees and accuracy of plot area.

In each plot, trees above a minimum dbh are tagged and identified. At intervals of 5 years, the diameter at breast height (1.3 m, hereafter dbh) is measured, as is height, tree deaths are recorded and any trees that have grown above the minimum are tagged and recorded. This standard methodology provides an estimate of growth (i.e., diameter and volume increment), mortality, and recruitment. For sites with lianas, stems can be tagged and diameters measured within the same plots as the trees.

Plot data on stand structure (number of individuals per ha by diameter class) can be used to calculate stem volume or biomass using a variety of methods which vary in terms of cost, precision, and training required. Destructive harvesting for direct measurements of biomass are likely to be appropriate for mixed species shrub and herbaceous vegetation, understorey or early successional vegetation. For vegetation that is dominated by trees, the use of allometric equations applied to stand data from permanent plots is recommended.

Allometric equations are regression equations that relate biomass or stem volume to one or more independent variables, usually diameter at breast height (dbh) and height (to first branch). The equations are developed from destructive sampling of 100-1000 trees and are a standard component in the development of stand volume tables used for predicting yield. Relationships between stem volume and dbh (or diameter and height) are species- and region-specific but generic equations for tropical trees by climatic region have been produced (Brown 1997) and provide average figures for species and sites that are not well known. Tables of defaults for the various carbon pools and flows are given in Book 3. For species with established stem volume equations, conversion from stem volume to biomass can be achieved by the application of a Biomass Expansion Factor (Brown 1997; IPCC 2003).

Below-ground biomass, as with aboveground biomass, can be measured directly by coring of fine roots and pit sampling and excavations of coarse roots, or indirectly with allometric equations or conversion factors that estimate below-ground biomass from aboveground biomass. Pit sampling is type of destructive sampling where all of the woody roots above a minimum diameter (e.g., 5 mm) are collected from a set volume of soil (e.g., 50 x 50 x 50 cm pit), dry mass determined, and then calculated per ha basis. But does not allow sampling directly beneath the stumps and so represents an underestimate of woody root biomass. Excavations of trees can be done to develop equations relating dbh to butt root mass, few exist for tropical tree species.

For the purposes of monitoring carbon offset projects in natural forest, direct sampling of coarse roots may not be cost-effective as variability in root biomass is likely to be high, sampling is time-consuming and labor intensive, and belowground biomass is unlikely to be a major contributor to the carbon benefit. For sites and forest types where the relationship between above- and below-ground biomass has been estimated from empirical data, the use of this simple factor adjustment to convert aboveground biomass to total biomass will be reasonable approach.

To measure litter and dead wood (together often referred to as necromass) and monitor changes in these pools, it is useful to divide the necromass pool into components based on decomposition rates (or diameter classes) to facilitate the estimation of changes in pools over time. Aboveground necromass divisions are generally divided by size but these divisions are correlated with persistence. For those projects where necromass is considered significant, separate monitoring procedures will be appropriate for coarse woody debris, standing dead trees and fine litter.

The distribution of coarse woody debris has been found to be highly clumped and correlated with slope, consequently, a stratified random design, with strata defined by position on slope, may be a suitable design. Methods for quantifying mass of coarse woody debris(>15 cm in its largest dimension) involve either direct sampling of mass in randomly located plots or indirect sampling by determining volume and density. Woody debris can also be estimated using a planar intersect technique (Brown & Roussopoulous 1974 in Uhl & Kauffman 1990). Coarse woody debris in plantations can be readily monitored in the permanent sampling plots for living trees, as mortality in these plots represents the primary input. The relative importance of branchfall will depend on the species and stand age.

Often CWD is classified by grades of decay that coincide with mean wood density values (e.g., Sollins 1982); mass estimation is then based on sampling for volume of CWD by grade of decay. Standing dead trees can be included in the permanent sampling plots for living trees or in the necromass plots. A common approach to estimating mass is to determine volume (volume = 0.5*basal area*height) and multiply by the density of the appropriate grade of decay.

Fine litter, including leaves, twigs, and wood fragments (<5 cm in its largest dimension) can be collected from small (e.g. 1 m^2) randomly located plots, for dry weight determination (oven dried at 70 degrees to constant mass). Small woody litter (5-15 cm in its largest dimension) is quantified in a manner similar to fine litter, however plots are generally bigger (e.g., 10 m^2).

Soil Carbon

Soils are often large storage pools for carbon, both organic and inorganic. It is possible to effectively determine the soil carbon content by taking composite samples from multiple plots. Soil can contain two types of carbon: organic and inorganic (carbonates). Not all soils contain inorganic carbon and most changes in soil carbon due to project activities are assumed to be in organic matter, and not in inorganic carbonate.

Soil samples should be taken when the permanent plots are established in the forest. They should be taken from the 0-30 cm horizon using either a soil corer or hand-dug pits. All vegetation and litter should be cleared from the soil surface and after sampling coarse fragments should be removed using a 2 mm screen. If the site has been burned it is important to remove any charcoal from the sample because of its high carbon content.

The size of the sample will depend on the needs of the laboratory and this should be discussed thoroughly before collection. The most commonly used lab method for the quantification of soil carbon is “loss on ignition” (Anderson and Ingram 1989), although this is not so effective on clay soils. Other good methods are burning and converting the carbon to $C0_2$ or the Walkley-Black method. The bulk density of soils is required to convert total or organic carbon concentrations (expressed as a percentage of the sample) into total quantities. Bulk density is considered to have relatively low spatial variability with coefficients of variability of less than 10%. For a uniform soil type, four samples should be sufficient to estimate bulk density to within 10% of the true value 95% of the time. It is then possible to calculate the tonnes of soil carbon per hectare for the 0-30 cm soil depth.

Sampling Intensity and Precision of Estimates

A universally accepted level of precision for estimates of carbon benefits does not currently exist. As a general rule, the cost of a monitoring program is negatively related to the precision of the estimate of the carbon benefit. In certain cases, it may not be cost effective to monitor certain pools or flows with a high level of precision; a cheaper solution to increasing the level of accuracy of measurements may be to adjust the carbon claims by discounting the standard error of measurements.

In developing an internal monitoring program for an individual project, it is unlikely that a common level of precision will be desired for each of the significant pools and flows. For example, there is little cause to be very precise in a small flow if the large flow can't be estimated with similar level of precision. Sample size determination, based on a desired precision in the estimate, is described in standard statistical method books such as Zar (1984).

In estimating any particular component (pool or flow), the precision of the estimate is expressed with a confidence interval (i.e., the sample mean plus or minus half the width of the interval; at a defined level of confidence, typically 90-99%, the true mean of the population would fall within the interval). The number of samples needed to calculate a confidence interval of a specific width depends on the width desired (precision), the variability in the population being sampled, and the confidence level specified (1-alpha).

Once an estimate of the sample variance is obtained, either from previous or preliminary measurements, data from comparable sites, or published literature, the required sample size can be calculated as

$$n = \frac{s^2 t^2_{\text{alpha (2), (n-1)}}}{d^2}$$

where d is the half-width of the desired confidence interval, s^2 is the sample variance, estimated with n-1 degrees of freedom, 1-alpha is the confidence level for the confidence interval, a t is the tabular value for two-tailed Student t statistic with n-1 degrees of freedom. The solution is obtained in an iterative process that begins by guessing a sample size, solving the equation, and then raising or lowering the guess until your guess is similar to the solution of the equation. Methods for calculating sample sizes that consider cost can be found in Wenger (1984).

When estimates of each of the components have been obtained, it may be necessary 1) to combine the components to estimate the overall project carbon balance, and 2) to determine the difference between the project and baseline case for each component. Summing of means is straightforward but to calculate an overall confidence interval for the variance for a sum of means or differences between means, sample variances for each of the components are not necessarily summed or subtracted. A weighted estimate can be calculated that weighs the variance that each component contributes by the relative importance of the component mean to the sum of means.

ANNEX 2 - References

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付属資料-５： プロジェクトによる人為的実質 GHG 吸収量の算定にかかる詳細データ/パラメーター等

プロジェクトによる人為的実質 GHG 吸収量を算定するにあたっての留意事項:

- 本事業による CO_2 排出量は、事業開始後の最初の 5 年間で年間 100 トンと推定される。これは過大な推定であり、プロジェクト活動による純吸収もより控えめに予測されている。

- 燃料消費についても詳細な推定をしているが、クレジット期間の 5 年目以降はそれ程大きな排出は起こらないと予測される。最初の 5 年間で、化石燃料の燃焼による CO_2 排出は、主に植林活動及び事業地の管理活動から発生するものである。ディーゼルの年間消費量は推定 2 万リットルで、1 リットルにつき約 2.7 kg の CO_2 排出が計算され、年間で 54 トンの CO_2 排出となる。

- 植林する各苗につき NPK 化学肥料（窒素 18%）50 グラムを投与する。植林する苗の数は 1 年目が 5 万本、2 年目及び 3 年目は各年 10 万本であるため、合計 2250 kg の窒素が植林地に投与されることになる。IPCC が設定している合成化学肥料の排出係数（0.0125kg-N_2O/kg-N）及び N_2O の温暖化係数（310）を用いると、この NPK 化学肥料投与による CO_2 排出量は推定 8.7 tCO_2e.となる。

プロジェクト活動（混合種による再植林）の GHG 吸収量推計に用いる樹種・植林地区ごとのパラメーター等

Model input	Parameters used	Notes and references
PROJECT SPECIFICATIONS		
Title	Maquipucuna CI	
Project sub-unit 1: Mixed forest planted on pastures in Maquipucuna		
Unit title	Mixed forest planted on pastures in Maquipucuna	
Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Pasture	
Harvesting	(none)	
Site code	FORESTPAST	
Baseline	Pastures	
Project sub-unit 2: Mixed forest planted on abandoned pastures in Maquipucuna		
Unit title	Mixed forest planted on abandoned pastures in Maquipucuna	

Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Shrubland	
Harvesting	(none)	
Site code	FORESTSHRUB	
Baseline	Abandoned pastures	
Project sub-unit 3: Mixed forest planted on sugarcane plantations in Maquipucuna		
Unit title	Mixed forest planted on sugarcane plantations in Maquipucuna	
Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Sugarcane	
Harvesting	Sugarcane: year 0, 100% as Sugar.	
Site code	FORESTCANE	
Baseline	Sugarcane	
BASELINE SPECIFICATIONS		
Baseline unit 1: Pastures		
Species mixture	(No tree species)	
Other plant species	Pasture	
Harvesting	(none)	
Site code	PAST	
Baseline unit 2: Abandoned pastures		
Species mixture	(No tree species)	
Other plant species	Shrubland	
Harvesting	(none)	
Site code	PASTSHR	
Baseline unit 3: Sugarcane		
Species mixture	(No tree species)	
Other plant species	Sugarcane	
Harvesting	(none)	
Site code	SUGAR	
TREE SPECIES PARAMETERS		
Coefficients for Cordia		
Species	Laurel (Cordia alliodora)	
Growth data (Volume)	Growth data approximated in model by Vtot= 1586.0 x exp(-4.920/Age$^{0.3736}$)	*From figure in Alder (1998)*
Wood density	0.5	*Average derived from Liegel & Stead (1990), Brown (1997) and ter Steege and Hammond (2001)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*

Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	80-100	*Liegel & Stead (1990)*
Maximum vegetation height	30	*Liegel & Stead (1990)*
Shade persistence factor	0.2	*Liegel & Stead (1990) comment that Laurel is an "intolerant pioneer species, demanding lots of light for best growth".*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Alnus		
Species	Aliso (Alnus acuminata)	
Growth data (Volume)	140.0 m3/ha at 8years 199.3 m3/ha at 30years 237.3 m3/ha at 45years	*Fehse et al. (1999)* *Fehse et al. (1999)* *Fehse et al. (1999)* *Growth data approximated in model by* $Vtot= 305.0 \times exp(-3.040/Age^{0.6278})$
Wood density	0.4	*Average derived from Fehse et al. (1999)*
Crown expansion factor	1.433	*Fehse et al. (1999)*
Root:shoot ratio	0.12	*Brown (1997) for tropical lowland forests*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	60-80	*ESL&CI assumption*
Maximum vegetation height	25	*Fehse et al. (1999)*
Shade persistence factor	0.3	*ESL&CI assumption - Alnus is pioneer species*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Cedro odo		
Species	Cedrela odorata	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*Aguirre (no date)* *EARTH (no date)* *Growth data approximated in model by* $Vtot= 263.0 \times exp(-12.278/Age^{1.2194})$

Wood density	0.4	*Cintron (no date)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997) for tropical lowland forests*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	80-100	*ESL&CI assumption*
Maximum vegetation height	35	*USDA Forest Service (no date)*
Shade persistence factor	0.7	*ESL&CI assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Inga sp.		
Species	Inga sp.	
Growth data (MAI)	Assumed same as Cordia alliodora	*Growth data approximated in model by* $Vtot = 1586.0 \times \exp(-4.920/Age^{0.3736})$
Wood density	0.49	*Brown (1997)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	60-80	*ESL&CI assumption*
Maximum vegetation height	30	*Lawrence (1993)*
Shade persistence factor	0.2	*Lawrence (1993): "forest gap regenerator"*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Juglans		
Species	Juglans neotropica	

Growth data (Volume)	No growth data available for this species. Assumed same as Tabebuia rosea since this is slow growing climax species, giving the most conservative estimate. Data from Roncancio (2001) for a 3x3 monospecific plantation	*Growth data approximated in model by* $Vtot= 307.0 \times exp(-358.135/Age^{1.5414})$
Wood density	0.66	*Estrada (1997)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	80-100	*ESL&CI assumption*
Maximum vegetation height	30	*ESL&CI assumption*
Shade persistence factor	1	*ESL&CI assumption - this is a climax species*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Nectandra		
Species	Nectandra acutifolia	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*No growth data for this species. Assumed same as Cedrela odorata, giving the most conservative estimate* *Growth data approximated in model by* $Vtot= 263.0 \times exp(-12.278/Age^{1.2194})$
Wood density	0.42	*Martinez Amores (1989)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	80-100	*ESL&CI assumption*

Maximum vegetation height	30	*ESL&CI assumption*
Shade persistence factor	0.8	*ESL&CI assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Otoba		
Species	Otoba gordonifolia	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*No growth data for this species. Assumed same as Cedrela odorata, giving the most conservative estimate* *Growth data approximated in model by* *Vtot= 263.0 x exp(-12.278/Age$^{1.2194}$)*
Wood density	0.41	*Martinez Amores (1989)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL&CI assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL&CI assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL&CI assumption*
Life expectancy	80-100	*ESL&CI assumption*
Maximum vegetation height	35	*ESL&CI assumption*
Shade persistence factor	0.8	*ESL&CI assumption*
OTHER VEGETATION SPECIES PARAMETERS		
Coefficients for Pasture		
Short species name	Pasture	*Mainly Setaria sp.*
Initial biomass, t/ha	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that living biomass constitutes 50% of biomass*
Maximum biomass, t/ha	11.2	*ESL&CI assumption, pasture is assumed to have reached maximum biomass*
Maximum productivity, t/ha/yr	0.01	*ESL&CI assumption - used to model steady state*
Maximum vegetation height	1	*EcoPar field data (2005)*
Root:shoot ratio	1	*Jackson et al. (1996)*
Coarse:fine ratio	0.98	*ESL&CI assumption*
Shade persistence factor	0.05	*ESL&CI assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Shrubland		

Short species name	Shrubland	*Abandoned pastures, dominated by Setaria sp. pasture, Piper shrub (Piperaceae) and Baccharis shrub (Asteraceae).*
Initial biomass, t/ha	14.7	*From field data by EcoPar (2005)*
Maximum biomass, t/ha	21.7	*ESL&CI assumption - the shrubland is assumed to accumulate 3.5 t/ha over 15 years (difference between pasture and shrubland)*
Maximum productivity, t/ha/yr	0.233	*ESL&CI assumption - 3.5/15*
Maximum vegetation height	3	*EcoPar field data (2005)*
Root:shoot ratio	1	*Jackson et al. (1996)*
Coarse:fine ratio	0.85	*ESL&CI assumption*
Shade persistence factor	0.1	*ESL&CI assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Sugarcane		
Short species name	Sugarcane	*Sugarcane*
Initial biomass, t/ha	25	*From field data by EcoPar (2005) on 7-month old sugarcane*
Maximum biomass, t/ha	25	*ESL&CI assumption*
Maximum productivity, t/ha/yr	0.01	*ESL&CI assumption - used to model steady state*
Maximum vegetation height	3	*EcoPar field data (2005)*
Root:shoot ratio	0.4	*ESL&CI assumption*
Coarse:fine ratio	0.98	*ESL&CI assumption*
Shade persistence factor	0.1	*ESL&CI assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
NECROMASS & SOIL PARAMETERS		
Coefficients for site code : FORESTPAST		
Initial fine necromass (t/ha)	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that dead biomass constitutes 50% of biomass*
Initial coarse necromass (t/ha)	0	*ESL&CI assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL&CI assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL&CI assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL&CI assumption*

Coefficients for site code : FORESTSHRUB		
Initial fine necromass (t/ha)	21.2	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*All necromass measured by EcoPar (2005) is included in fine necromass*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL&CI assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL&CI assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL&CI assumption*
Coefficients for site code : FORESTCANE		
Initial fine necromass (t/ha)	23.7	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*ESL&CI assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL&CI assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL&CI assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL&CI assumption*
Coefficients for site code : PAST		
Initial fine necromass (t/ha)	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that dead biomass constitutes 50% of biomass*
Initial coarse necromass (t/ha)	0	*ESL&CI assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*

Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
Coefficients for site code : PASTSHR		
Initial fine necromass (t/ha)	21.2	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*All necromass measured by EcoPar (2005) is included in fine necromass*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*
Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
Coefficients for site code : SUGAR		
Initial fine necromass (t/ha)	23.7	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*ESL&CI assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*
Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
PRODUCT PARAMETERS		
Sugar	Product half-life: 0.1 yrs	*ESL&CI assumption*

Note: ESL = EcoSecurities Ltd.

CI= Conservation International

付属資料－６：　CCB 基準 2.0 版

Climate, Community and Biodiversity

Project Design Standards

Draft 2.0

January 12, 2005

*コミュニティ、自然保全、生物多様性配慮方プロジェクト計画の評価基準（**CCB** 基準、**2.0** 版英文）
***この基準は現在も開発段階にある。今回の事業評価には、本 2.0** 版を使用した

Project Checklist

General / Cross Cutting — *3 possible points*

Y			**Gen1. Baseline at the Project Site**	Required
Y			**Gen2. General Project Description**	Required
Y			**Gen3. Legal Approval**	Required
Y	?	N	**Gen4. Land Tenure**	1 point
Y	?	N	**Gen5. Adaptive Management**	1 point
Y	?	N	**Gen6. Integrated Project Design**	1 point

Climate — *3 possible points*

Y			**Clim1. Carbon Additionality**	Required
Y			**Clim2. Quantifying Carbon**	Required
Y	?	N	**Clim3. Leakage Assessment**	Required
Y	?	N	**Clim4. Permanence**	1 point
Y	?	N	**Clim5. Adapting to Climate Change**	1 Point
Y	?	N	**Clim6. Monitoring & Verification**	1 Point

Community — *4 possible points*

Y			**Comm1. Defining & Engaging Community Stakeholders**	Required
Y			**Comm2. Worker Safety**	Required
Y	?	N	**Comm3. Transparency**	1 Point

Y	?	N	**Comm4. Employing Stakeholders in Project Management**	1 Point
Y	?	N	**Comm5. Capacity Building**	1 Point
Y	?	N	**Comm6. Stakeholder Grievances**	1 Point

Biodiversity ***4 possible points***

Y			**Biod1. Conservation Plan**	Required
Y			**Biod2. Not Harming Threatened Species**	Required
Y			**Biod3. Genetically Modified Organisms (GMOs)**	Required
Y	?	N	**Biod4. Native versus Non-Native Species**	1 Point
Y	?	N	**Biod5. Helping Threatened, Rare & Endemic Species**	1 Point
Y	?	N	**Biod6. Water Resources**	1 Point
Y	?	N	**Biod7. Project Location**	1 Point

Project Totals ***14 possible points***

☐ ☐ ☐

☐ **CERTIFIED** 7-8 points total, 1 point minimum in each section and all requirements

☐ **BRONZE** 9-10 points total, 1 point minimum in each section and all requirements

☐ **SILVER** 11-12 points total, 2 points minimum in each section and all requirements

☐ **GOLD** 13-14 points total, 3 points minimum in each section and all requirements

Gen	Clim	Comm	Biod
Gen1.		**Required**	

Baseline at the Project Site

Concept

A baseline explains the current status of key variables about an area before a project commences. It also makes projections about what would likely occur in the absence of the project.

Requirements

Project proponents must complete a baseline assessment, at minimum, containing the following information:

General information

1) Describe the location of the project including basic physical parameters (i.e., relevant information on soil, geology, climate, etc.).
2) Describe the types and condition of vegetation found within the project site and in adjacent areas (e.g., forest and grassland native species types, plantation forest species, size classes of various forest types, etc.).
3) Describe the most likely land use scenario in the absence of the project.
4) Indicate whether the scenario assumes that existing laws or regulations would have required that project activities be undertaken anyway.[1]
5) Describe how the precision of baseline estimates will be evaluated over time.

Climate information

6) Describe and quantify the current carbon stocks and fluxes at the project site. Indicate whether the fluxes are in the form of carbon dioxide (CO_2) or methane (CH_4). Where possible, express probable changes in GHG stocks/fluxes in terms of carbon per hectare per year.
7) Describe and quantify projected carbon fluxes in the absence of the project that would occur under land use scenarios described in the general baseline.
8) Describe and quantify any non-carbon GHG fluxes (e.g., N_2O) that are relevant at the project site. If no information is known, indicate so.
9) Wherever possible, provide information about the certainty of the carbon and GHG estimates.

Community information

10) Provide a brief overview of communities located in and around the project and relevant socio-economic information. If relevant, discuss whether community access to resources will be impacted by the project.
11) Describe current land use and land tenure in the project site and surrounding areas.

Biodiversity information

12) Provide an overview of pertinent biodiversity attributes in the absence of the project.
13) Provide information on the threats to biodiversity and water resources in the project area.
14) Provide supporting documentation and reference material relevant to establishing the biodiversity baseline.

~ continued next page ~

[1] This is important for justifying whether project activities are “additional” and can rightly take credit for impacts.

Certification

Evaluator certifies that the baseline and supporting documentation has been reviewed and satisfies the above requirements.

Potential Tools & Strategies

- While still in development, the Clean Development mechanism (CDM) will soon have approved methodologies for land use baselines. If a project uses CDM-approved methodologies, or intends to submit to the consideration of the EB a new methodology, this should constitute an acceptable baseline.

- Other approaches may include default baseline factors for the region, other emission projections, statistical or other land-use models and *(
- the discussion for including more information here is on going (CA Climate Action Registry, IPCC, etc).

- Rapid Assessment methodologies.

Gen	Clim	Comm	Biod
Gen2.		**Required**	

General Project Description

Concept

Project must be described in sufficient detail so that it can be adequately evaluated by outside parties.

Requirements

1) Provide a brief overview of the scope of the project and a summary of the major climate, community and biodiversity goals.

2) Discuss the expected outcomes of the project, including how local incomes and livelihoods will be affected.

3) Identify potential negative impacts on climate, community and biodiversity.

4) Describe each of the major project activities and their relevance to the overall project.

5) Provide a regional map identifying the project location and showing where the major project activities will occur.

Certification

Evaluator certifies that the documentation describing the project has been reviewed and satisfies the above requirements.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Gen3.		**Required**	

Legal Approval

Concept

Project proposal must be based on a solid legal framework (e.g., appropriate contracts are in place or planned) and the project satisfies applicable planning and regulatory requirements.

Requirements

1) No laws have been broken or ignored

2) The project has, or expects to secure, approval from the appropriate authorities.

Certification

Evaluator certifies that the project has, or expects to secure, approval from the appropriate authorities, and that the project conforms to legal and regulatory requirements in the country and region where it will occur.

Potential Tools & Strategies

During the project design phase, project proponent should communicate early on with relevant local, regional and national authorities, providing adequate time to earn the necessary approvals. In addition, the project design should be flexible enough to accommodate potential modifications required to secure regulatory approval.

Gen	Clim	Comm	Biod
Gen4.		**1 Point**	

Land Tenure

Concept

There are no significant land tenure issues being disputed in the project area or immediate surroundings, or the project is fundamentally helping to resolve these tenure issues.

Requirements

1) The project will not encroach uninvited on private property, community property, or government property.

2a) The project does not require the relocation of people.

OR

2b) Any necessary relocation is 100% voluntary and fundamentally helps resolve land tenure problems in the area

3) If relevant, describe potential in-migration of people from surrounding areas and explain how the project will respond.

Certification

Evaluator certifies that the project fully satisfies these three land tenure requirements.

Potential Tools & Strategies

Gen	Clim	Comm	Biod
Gen5.		**1 Point**	

Adaptive Management

Concept

Adaptive management enables a project to evolve to meet changing or unanticipated needs, and can help ensure that the project realizes its broad goals over the long term. *(Definition of adaptive management to be included)

Requirements

1) Planned management and operations of the project encompass adaptive management principles.

2) Where relevant, stakeholders are educated about project developments and participate in on-going evaluation and management of the project.

3) The project design is sufficiently flexible to accommodate potential changes and has a defined process in place for reformulating project goals and activities.

Certification

Evaluator certifies that the project fully satisfies these three adaptive management requirements.

Potential Tools & Strategies

Gen	Clim	Comm	Biod
Gen6.		**1 Point**	

Integrated Project Design

Concept

Integrated projects utilize a variety of activities in a holistic manner to achieve broad project goals. A diversity of project activities may help reduce leakage (see section Clim3) and contribute to permanence of project goals (see section Clim4). For instance, a project that protects existing forests, plants new trees, and manages a fuel-wood and timber plantation may be more likely to reduce deforestation pressure on surrounding lands.

Requirements

1a) The project incorporates at least two different project activities that each account for at least 20% of the project's total GHG benefits or 20% of the project area.

OR

1b) The project incorporates at least three different project activities that each account for at least 10% of the project's total GHG benefits or 10% of the project area.

Certification

Evaluator certifies that the project fully satisfies one of these two requirements in a manner that improves the overall project design.

Potential Tools & Strategies

Diversified project activities may include: primary or secondary forest conservation; reforestation or re-vegetation; agro-forestry plantations; densification; enrichment planting; introduction of new cultivation practices; introduction of new timber harvesting and/or processing practices (e.g., reduced impact logging); reduced tillage on cropland; improved livestock management; soil conservation; bio-energy production, etc.

Gen	Clim	Comm	Biod
Clim1.		**Required**	

Carbon Additionality

Concept

Additionality refers to the additional tons of carbon that are either sequestered or conserved as a direct result of the project activities. Additional carbon is the net difference in atmospheric GHGs between without-project carbon estimates (Gen1) and with-project carbon estimates provided in the project information section (Gen2).

Requirements

To be additional, project proponents must demonstrate that the project directly contributes to a change in GHG fluxes. The project passes an additionality test, by satisfying the following three conditions:

1a) The project activities are clearly not required by law

OR

1b) The project proponents make a compelling case demonstrating that the pertinent laws were not being enforced and that project implementation will lead to more sustainable land use practices in the area.

AND

2) The project proponent provides a credible and well-documented economic analysis showing that without carbon financing the project would be less profitable than other competing land-uses.

AND

3) Estimates of negative leakage (Clim3) have been subtracted from the project's estimated carbon benefits.

Certification

Evaluator certifies that the project fully satisfies the above three carbon additionality requirements.

Potential Tools & Strategies

CDM website with additionality tools…

Various economic and financial tools can be used, including: the pay-back period with and without carbon financing; economic analyses showing without carbon financing that the project would be less profitable than other competing land-uses; analyses showing that the project would not be realized because of barriers such as lack of financial capital, prevailing practices, lack of capacity or knowledge, and institutional or market barriers. *(discussion on-going for description here) Project proponents can describe if there are similar projects in the area. If yes, are the projects financed privately or publicly? Is climate change financing used to make the comparable projects viable?

Gen	Clim	Comm	Biod
Clim2.		**Required**	

Quantifying Carbon

Concept

Carbon fluxes that are generated as a result of the project activities must be accurately quantified using best practices.

Requirements

Complete a carbon calculation worksheet using best practice methodologies, such as outlined in the IPCC Good Practice Guidance.

Certification

Evaluator certifies that the project's anticipated carbon benefits are credibly quantified using best practice methodologies.

Potential Tools & Strategies

IPCC GPG.
IPCC LULUCF 2000.
WRI/WBCSD GHG Protocol
California Climate Action Registry Forestry Protocols for measuring carbon fluxes.
CDM and JI Validation & Verification Manual developed by the International Emissions Trading Association (IETA) and the World Bank Carbon Finance Group:
http://www.ieta.org/ieta/www/pages/index.php?IdSiteTree=1146

Gen	Clim	Comm	Biod
Clim3.		**Required**	

Leakage Assessment

Concept

Leakage is a climate change term that refers to unintended greenhouse gas fluxes outside the project boundary as a result of project activities.

Requirements

1) Project proponents must provide a complete leakage assessment. This assessment should address potential leakage scenarios, explain the main factors that will drive such leakage, and explore mitigating project actions.

2) The project proponent must subtract any likely displaced emissions or decreased sequestration (leakage) from the project's projected carbon benefits.

3) If leakage is 20% or more of the projects' total carbon benefits, the project proponent must provide a credible plan for monitoring leakage once the project commences.

Certification

Evaluator certifies that the project fully satisfies the above three leakage assessment requirements.

Potential Tools & Strategies

- Control plots can be used to compare changes within a project area to areas outside of a project area.
- Leakage contracts can be used.
- If the project has plans to foster positive leakage, explain how.
- Having multi-faceted (integrated) projects can help counter leakage (section Gen7).
- *More

Gen	Clim	Comm	Biod
Clim4.		1 Point	

Permanence

Concept

Project designers must strive to ensure that the carbon benefits generated by the project persist over time, even in the case of unforeseen circumstances. Potential threats include: fire, pests, droughts, landslides, human encroachment and deforestation.

Requirements

1) Identify possible risks to the longevity of carbon benefits.

2) Based on identified threats, list specific measures that will be undertaken to counter the risks. For instance, if plant disease outbreaks could occur in the area, describe actions taken that can mitigate this risk, such as selective and diverse-species planting, thinning methods, or pest monitoring.

Certification

Evaluator certifies that the project satisfies the above two requirements and that the project's stated carbon benefits are likely to last at least 30 years.

Potential Tools & Strategies

- Insurance (this may or may not be an option for some projects)
- Conservation easements or other legal land management tools
- To mitigate fire risk, project designers should: assess the risk and likely sources of fire; collect information about prevailing winds; and establish sufficient fire protection measures, such as utilizing fire/wind breaks and low fuel zones.
- Hedging project outcomes. For example, if a project is in an area that occasionally burns, project activities can be dispersed so that a single fire will not be catastrophic to the entire project.
- Designing the project for the sustainability of certain activities after funding or project intervention finishes

Gen	Clim	Comm	Biod
Clim5.		**1 Point**	

Adapting to Climate Change

Concept

Projects that have been designed to anticipate and adapt to probable climate change impacts are likely to fare better over the long-term.

Requirements

1) Projects proponents must identify and justify (with available research studies) likely regional climate change impacts for the area.

2) Projects must demonstrate that the project has been designed to anticipate such potential impacts and will take measures to lessen negative impacts of climate change on the project site.

Certification

Evaluator certifies that the project fully satisfies the above two requirements for adapting to climate change.

Potential Tools & Strategies

- Although the magnitude of the impacts of climate change remains speculative, there are several scientific tools that predict regional impacts from likely future climate change. E.g…
- Regional climate projection tools may be available for some areas.
- By using mitigating topographic features
- *More to be included

Gen	Clim	Comm	Biod
Clim6.		**1 Point**	

Monitoring & Verification

Concept

Robust monitoring & verification procedures and practices are necessary to check whether the projected carbon benefits actually materialize,

Requirements

Project proponents must develop a preliminary plan to monitor changes in carbon stocks and fluxes that result project activities. Since funding is often limited during the project design stage, all aspects of the monitoring plan may not be completed at this stage. For aspects of the monitoring plan that have not yet been completed, project proponents should provide evidence of how they plan to proceed once the project is operational. Project proponents must clearly explain how carbon and/or greenhouse gases will be expressed (units).

Specifically, the monitoring plan must identify:

1) How the project area will be stratified;
2) Which carbon pools will be measured;
3) How the number of plots will be determined based on the variance and relative area of each stratum;
4) Which methods will be used for measuring the carbon pools; and
5) The frequency of sampling activities.

Certification

Evaluator certifies that an adequate monitoring plan for the project is in place that satisfies the above requirements.

Potential Tools & Strategies

- Standard techniques for field measurements of vegetation and soil should be used based on accepted protocols.
- Examples include IPCC Special Report on LULUCF (2000) and the GPG for LULUCF
- Consider external validation and verification of carbon benefits by independent third-party certifier.
- *(More)

Gen	Clim	Comm	Biod
Comm1.		**Required**	

Defining & Engaging Community Stakeholders

Concept

In some projects, there may be no or very few interested outside parties. Other projects may involve multiple stakeholders, each group potentially desiring different project outcomes. Projects should have a clear process for identifying relevant stakeholders and engaging them meaningfully in the design of the project.

Requirements

1) Project proponents must document how local stakeholders have been defined.

2) Land tenure in the project's area of influence must be clear and secure, and all land-owner participation must be voluntary.

If the project occurs in a place lacking significant outside stakeholders, then the following requirements can be skipped.

3) Project proponents must describe the ethnic and socio-economic make-up of relevant groups and identify potential issues and strategies for engaging each group.

4) The project must engage a diversity of stakeholders, including a representative cross-section of geographic and socio-economic sub-groups within the project vicinity. Special attention should be paid to underrepresented groups.

5) Stakeholders in the project's area of influence must be given an opportunity, before the project design is finalized, to raise concerns about potential negative impacts, express desired outcomes and provide general input on the project design.

6) Project developers must document all stakeholder dialogues and indicate the changes made to the project proposal based on such input.

7) Project proponents must clearly explain how the design is based on a consensus of interests or a compromise among different interests. There should also be a plan for handling unresolved conflicts.

Certification

Evaluator certifies that the project proponent has adequately defined potential project stakeholders and their interests, and (except for those projects lacking significant outside stakeholders) that all the above requirements have been satisfied.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Comm2.		**Required**	

Worker Safety

Concept

Worker safety should be considered at the design stage of the project.

Requirements

1) Project proponents have comprehensively assessed and addressed all situations or occupations that could pose a substantial risk to worker safety.

2) In instances where worker safety cannot be guaranteed (for instance if community members will be employed in logging or other dangerous jobs), project proponents must show how the risks will be minimized using best work practices.

3) A plan must be in place for project managers to inform workers of the risks associated with each job and to explain how to minimize such risks.

Certification

Evaluator certifies that these three worker safety requirements have been satisfied.

Potential Tools & Strategies

*under discussion

Gen	Clim	Comm	Biod
Comm3.			**1 Point**

Transparency

Concept

Projects that operate in a transparent manner enable local stakeholders and outside parties to properly evaluate and contribute more fully to the project.

Requirements

1) All project documentation (not including sensitive information) must be publicly accessible at, or near, the project site.

2) Project proponents must inform local stakeholders how they can access the project documentation.

3) Where appropriate, key project documents should be made available in the local language(s).

Certification

Evaluator certifies that the project is operating in a transparent manner and satisfies the above requirements.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Comm4.		1 Point	

Employing Stakeholders in Project Management

Concept

Stakeholders' involvement in projects will be strongest when they have a direct role in management. While some projects employ people and others use volunteers, projects that specifically allocate management capacities for local stakeholders are likely to be more sensitive and responsive to community concerns.

Requirements

1) Project requires that local stakeholders will fill some management positions.

2) Project proponents explain how stakeholders will be selected for management positions (either a rotating position or one based on skills). Where relevant, projects should indicate how traditionally underrepresented groups in the community will be given priority when filling management roles.

Certification

Evaluator certifies that the project satisfies the above requirements for employing stakeholders in project management.

Potential Tools & Strategies

* Under discussion

Gen	Clim	Comm	Biod
Comm5.		**1 Point**	

Capacity Building

Concept

Projects that include a significant capacity-building component are more likely to sustain the positive outcomes generated by the project and have them replicated elsewhere.

Requirements

1) The project must include a plan to provide orientation and training for the project's employees, volunteers and relevant community members with an eye to building skills and knowledge that will be useful beyond the project's implementation.

2) Project proponents must have a plan for fostering the replication of project activities and positive outcomes beyond the project boundary. To this end, at least three separate project outreach and information sharing activities must be undertaken. For example: undertaking and disseminating research that has wide-reaching applications; holding training workshops for community members from other locales; promoting "farmer to farmer" knowledge-transfer activities; and working with interested academic, corporate, governmental and non-governmental organizations to replicate all or some of the project activities.

Certification

Evaluator certifies that the project has a written plan for capacity building that satisfies the above two requirements.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Comm6.		1 Point	

Stakeholder Grievances

Concept

Having a clearly defined stakeholder grievance and resolution process, enables projects to identify and address potential community concerns before they evolve into major conflicts.

Requirements

1) The project design includes a process for hearing, responding to and resolving community grievances within a reasonable time period.

2) This grievance process is publicized to local stakeholders.

3) Project management must attempt to resolve all reasonable grievances raised and provide a written response to the grieving party within 30 days

4) All grievances and project responses will be documented and made available to all interested parties.

Certification

Evaluator certifies that the project satisfies the above four requirements concerning stakeholder grievances.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Biod1.		Required	

Conservation Plan

Concept

A conservation plan identifies specific actions to enhance biodiversity at and around the project site. Threats to biological systems identified in the baseline scenario (section Gen1) should be mitigated by specific project actions in the conservation plan. Other actions that the project will undertake to support biodiversity should be explained. The project should make significant contributions to the conservation or restoration of biodiversity.

Requirements

1) The conservation plan must address all the major threats to biodiversity within the project area. For example, if hunting is a dominant threat to biodiversity in the project area, describe the plan to reduce hunting to a sustainable level. If deforestation is a major threat, the project should include specific actions that will be taken to counter deforestation.

2) The conservation plan should outline impacts that the project may have on species inhabiting surrounding areas. If any project activities may lead to detrimental biodiversity outcomes beyond the project site, specific mitigating actions should be detailed.

3) The project must provide a credible description of the project's biodiversity conservation goals (e.g., enhance and restore ecological systems) and, where possible, outline the indicators and strategies that will be used to meet these goals.

Certification

Evaluator certifies that the project's conservation plan has been reviewed and satisfies the above three requirements.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Biod2.		**Required**	

Not Harming Threatened Species

Concept

CITES[2] species are species considered globally vulnerable to extinction in the next X years. Projects should have no negative effects on CITES species or species deemed threatened at the national or regional level.

Requirements

1) Project proponents must identify all CITES and threatened species that inhabit the project site and immediate vicinity and document how the project activities will not be detrimental in any way to these species

.

Certification

Evaluator certifies that the project will not cause a deterioration of the conservation status of any CITES species or threatened species in the project area or immediate vicinity.

Potential Tools & Strategies

IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK

[2] Define CITES here…

Gen	Clim	Comm	Biod
Biod3.		**Required**	

Genetically Modified Organisms (GMOs)

Concept

Genetically modified organisms are unproven technologies that may have the potential to generate negative impacts on a significant scale. Therefore, projects may not use GMOs.

Requirements

The project proponent must identify all species to be employed by the project and guarantee that no GMOs will been used.

Certification

Evaluator certifies that the project does not use any genetically modified organisms.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Biod4.		1 Point	

Native versus Non-Native Species

Concept

Projects can produce a variety of biodiversity benefits: conserving native species habitats; restoring degraded areas; reducing pressure on ecologically-sensitive areas; and restoring ecosystem processes. In most cases, (when and where appropriate) native species will have a higher biodiversity benefit than non-native species. In other cases, non-native species can be more effective than native species at rehabilitating degraded areas or providing fast growing biomass, timber, fruits and other valuable products.

Requirements

1) If the project uses species not native to the site, project proponents must describe any potential adverse impacts on the area's environment. This evaluation must address potentially significant impacts and address at a minimum, the following issues: 1) impacts on native species; 2) invasiveness; 3) disease introduction or facilitation; 4) hydrological and other impacts. If these impacts have a substantial bearing on the biodiversity or environmental outcomes of the project, the project proponents must justify the necessity of using non-native species over native species and demonstrate how these impacts will be mitigated.

Certification

Evaluator certifies that any use of non-native species by the project satisfies the above requirement.

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Potential Tools & Strategies

*Under discussion

If planting non-native species, consider only using those with which local people have had extensive experience (e.g., those introduced generations ago to the region). This can reduce the likelihood that negative outcomes could unexpectedly arise.

Gen	Clim	Comm	Biod
Biod5.		**1 Point**	

Helping Threatened, Rare & Endemic Species

Concept

Projects that restore or conserve habitats for threatened species create a biodiversity benefit.

Requirements

1) Project proponents must describe how the project will directly benefit threatened, rare or endemic species located within the project area.

2) Project proponents must document how project activities will help to restore or conserve habitats for threatened, rare or endemic species. The project proponent must describe how the habitat needs of such species will be addressed (e.g., protected zones, retention of important species/structural features, connectivity, harvest timing, etc.).

Certification

Evaluator certifies that the project satisfies the above requirement for helping threatened, rare or endemic species in the project area.

Potential Tools & Strategies

IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK

Gen	Clim	Comm	Biod
Biod6.		**1 Point**	

Water Resources

Concept

The quality and quantity of water resources should at a minimum be maintained by a project. When possible, projects should strive to enhance water resource quality and quantity.

Requirements

1) The project proponents must document how any threats to water resources identified in the baseline (Gen1), will be addressed by specific project activities.

2) The project proponents must credibly demonstrate that the project will contribute to improving water resource quality or quantity.

Certification

Evaluator certifies that the project satisfies both the above water resource requirements.

Potential Tools & Strategies

*Under discussion

Gen	Clim	Comm	Biod
Biod7.		1 Point	

Project Location

Concept

Biodiversity and threats to biodiversity are not evenly distributed. Consequently, project location significantly influences the potential for biodiversity benefits of a project. Projects in areas identified as conservation priorities have greater potential to contribute to overall biodiversity outcomes.

Requirements

1) The project is based in a biological priority area identified by a global or regional priority setting or is in an area identified in a gap analysis[3].

Certification

Evaluator certifies that the project is located in an area identified as a global priority, a national priority or a gap analysis.

Potential Tools & Strategies

- Is the project in a global conservation priority area: WWF, CI, Birdlife, *(list to be included)
- Is the project in an area identified by national or regional analyses of biodiversity or conservation importance? If so, describe.
- Is the project in an area identified by gap-analyses or similar exercises as critical for biological conservation or restoration?

[3] Define Gap Analysis here…

CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM FOR AFFORESTATION AND REFORESTATION PROJECT ACTIVITIES (CDM-AR-PDD)

CONTENTS

Annexes

SECTION A. General description of the proposed A/R CDM project activity:

A.1. Title of the proposed A/R CDM project activity:

Coastal Ecuador Reforestation and Conservation Carbon Project

A.2. Description of the proposed A/R CDM project activity:

Reforestation will take place on 468 ha of pasture lands owned by the Maquipucuna Foundation in the western foothills of the Ecuadorian Andes (1000-1500 m.a.s.l.). The project site lies at the intersection of the Andes and Chocó bioregions and is extraordinarily rich in biodiversity.

Upto 15 native species will be used to establish a mixed-species plantations outside of the Maquipucuna Reserve, a privately owned conservation area encompassing cloud forest ranging from 1000 to over 2800 meters. All areas to be reforested are outside the formally declared *bosque protector* (protective forest)which contains primary or secondary forest. Over the long term the structural and microclimatic conditions created by the forest plantation will serve to re-establish a broad suite of native plant and animal species through dispersal from neighbouring primary and secondary forests.

The project has a conservation focus and aims to maintain these forest plantation areas for the long term, with no harvesting of wood products foreseen.

The project will provide long-term benefits for climate, biodiversity and watershed protection in an area identified both nationally and internationally as a top conservation and sustainable development priority.

A.3. Project participants:

- Conservation International
- Maquipucuna Foundation
- Jatun Sacha Foundation

A.4. Technical description of the A/R CDM project activity:

A.4.1. Location of the proposed A/R CDM project activity:

>>

A.4.1.1. Host Party(ies):

Ecuador

A.4.1.2. Region/State/Province etc.:

Pichincha Province

A.4.1.3. City/Town/Community etc:

Parroquia (Parish) of Nanegal, Quito Metropolitan District

A.4.1.4. Detail of geographical location and project boundary, including information allowing the unique identification(s) of the proposed A/R CDM project activity:

The project is located in Northwestern Ecuador as indicated in the Figure 1 Overview Map:

Figure 1: Overview Map of Project Location in Ecuador

Areas to be reforested are found within the following coordinates:

- 78º39´54.8¨ W 0º10´51.6¨ N
- 78º36´2.9´´ W 0º10´51.6´´ N
- 78º39´54.8¨ W 0º 6´37.3´´N
- 78º36´2.9´´ W 0º 6´37.3´´N

Figure 2 indicates the specific areas to be reforested within the project site.

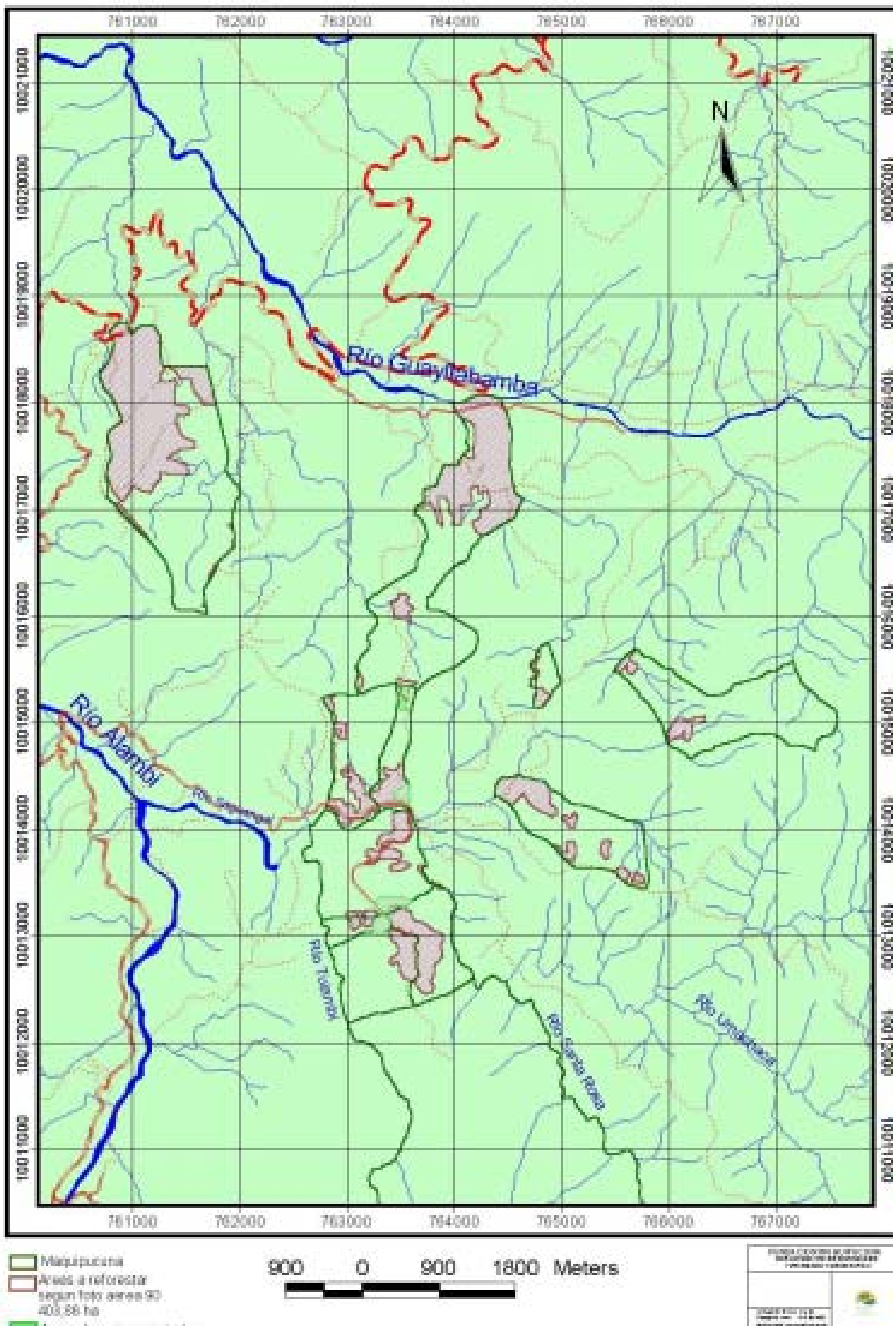

Figure 2: Location of Project Reforestation Areas

A.4.1.5. A description of the present environmental conditions of the area, including a description of climate, hydrology, soils, ecosystems, and the possible presence of rare or endangered species and their habitats:

Climate

Temperatures are stable year-round, with an annual mean temperature of 21.5^{0}C.

Rainfall is markedly seasonal, with precipitation concentrated in the months of January to May, and averaging 3200 mm/year for the project site. A dry period occurs between July and September, and during part of the month of December.

Reforestation will take place within the Premontane Moist Forest life zone, according to the Holdridge system.

Geology and Soils

Soils in the region are mainly inceptisols (USDA Taxonomy) derived from andesitic volcanic ash. Areas for reforestation are a complex mosaic formed by alluvial deposition and volcanic parent material. Soils are predominantly deep and well-drained, with relatively high organic matter content in the upper horizons and low to moderate in lower layers.

In the Maquipucuna Reserve the upper 75 – 100 cm of soil are formed from volcanic ash deposited 2500 years ago by the volcano Pululahua (Papale and Rossi, 1993). Soil pH averages 10.9 in the top meter , indicating the presence of allophane minerals (Perrot, 1966), while surface soil reaction is strongly acidic (Rhoades, 1997).

Biodiversity

The project area has been recognized in several national and international assessments as a top priority for biodiversity conservation:

- The project activity lies at the interface of two of Conservation International's global "hotspots" for biodiversity conservation: the Tropical Andes and the Chocó-Darién-Western Ecuador Hotspots.
- BirdLife International identified the area as one of its Important Bird Areas, based on avian diversity and endemism.
- Dinerstein et al (1995) identified the montane forests of the northwestern Andes (Ecuador and Colombia) as "Vulnerable, Globally Outstanding, and Highest Priority at Regional Scale."
- Ecuador's Ministry of Environment, in its most recent strategy and policy framework document highlighted this area of northwest Ecuador as one of the top five conservation priorities in the nation.

Fifty-five mammal species are confirmed for the Maquipucuna area, of which 3 are classified as near-threatened, 3 as vulnerable and 1 as endangered, according to the Ecuadorian Red List for Mammals. An additional 22 species of mammals are highly likely to inhabit the area as well, given collections in nearby areas and information regarding habitat and distribution.

The Maquipucuna Reserve has over 1700 species of vascular plants, including 154 families and 614 genera, including 230 species of pteridophytes and over 200 species of orchids. Two endemic species have been described, with more still to be published. (Webster and Rhode, 2001).

The region also has 347 bird species, 20% of Ecuador's bird fauna[1]. Of the species, 4 are endangered species, 16 are vulnerable species, 9 near threatened species to local level (Granizo et al. 2002).

Threats to biodiversity in the area include:

- Deforestation associated with the expansion of agriculture.
- Illegal hunting, especially of the endangered Andean spectacled bear (*Tremarctos ornatus*), but also of large rodents (*Agouti paca, Dasyprocta punctata*), collared peccary (*Pecari tajacu*), howler monkeys (*Alouatta palliata*), mountain lion (*Puma concolor*) and birds (guans, toucans).
- Logging, especially high-grading of valuable hardwoods.

Hydrology

The project activity lies within the upper watershed of the Guayllabamba River watershed.

The main rivers draining the area include the Umachaca, Santa Rosa, Tulambi, Pichán and Afilana rivers, which together drain into the Alambi river, which in turn feeds the Guayllabamba.

A preliminary study of the effects of land use on aquatic ecosystem health was done using small headwater streams within the Maquipucuna Reserve. The study found highest diversity in larger streams with larger stable substrate. Very few species were found at sites with high silt composition (abandoned pastures). It also found pastures streams to be more narrow than forested streams consistent with other studies regarding effects of riparian vegetation on stream width. Total suspended solids and turbidity showed higher turbidity in the abandoned pasture streams where fine sand, silt and clay were the major components of the substrate. High nitrate was found in grazed and abandoned pastures relative to secondary and primary forest streams. Alkalinity in the streams at Maquipucuna reflect relatively high concentrations of $CaCO^3$, most likely influenced by the new volcanic soils. Higher diversity of benthic macroinvertebrates was found in grazed pasture and large secondary forest streams based on both Shannon's Index and Fisher's Alpha. Calamoceratid and Hydropsycid caddisflies dominated the primary

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[1] Studies were conducted by James Andrews, J. M. Carrión, D. Gardner, L. Kiff, M. Marín, Francisco Sornoza, Niels Krabbe, Paul Greenfield, F. Sarmiento, Niall O´Dea, and Francisco Prieto

forest streams. Relatively high numbers of Simulids (Diptera) were found in both secondary forest and abandoned pastures sites, suggesting the possible influence of land use change on pest organisms-possibly affecting human health (Thom, 2000)

Current land use
Areas to be reforested were previously deforested and pastures established prior to 1990.

Approximately 72% of the area is pasture with virtually no tree cover, dominated by a tussock grass (*Setaria sphacelata*), known locally as "pasto miel." This introduced East African grass is aggressive and leads to a state of arrested succession. A portion (approximately 24%) of the area is a mix of grassland with a low (2-4 m) stratum of shrubby pioneer species, predominantly *Piper hispidum* and *Baccharis sp*. Analysis shows that pastures abandoned for over 15 years have still not regenerated to forest due to the aggressive growth of *S. sphacelata*. The remaining portion of the area is currently in sugar cane (<3% of total reforestation area).

A.4.2. Species and varieties selected:

Reforestation will be carried out with a mix of native species:

- *Cordia alliodora*
- *Alnus acuminata*
- *Nectandra acutifolia*
- *Juglans neotropica*
- *Cedrela odorata*
- *Cedrela montana*
- *Inga* spp. (*I. densiflora, I. nobilis, I. punctata*)
- *Otoba gordoniifolia*

Additional native species to improve plantation diversity and similarity to natural forests will be integrated as seed availability permits.

A.4.3. Specification of the greenhouse gases (GHG) whose emissions will be part of the proposed A/R CDM project activity:

CO_2

A.4.4. Carbon pools selected:

- Aboveground biomass
- Belowground biomass
- Litter
- Dead wood
- Soil organic carbon

A.4.5. Compliance with the definition for afforestation or reforestation:

Ecuador has not yet formally selected and reported to the Executive Board its parameters for forest definition. However, the Designated National Authority for Ecuador has indicated to project developers that they have selected the following parameters:

- A minimum tree crown cover of 30 per cent;
- A minimum land area of 1 hectare; and
- A minimum tree height value of 5 meters

Land is currently non-forested: Areas to be reforested are all > 1 ha, with crown cover of <30% and tree heights under 5 meters.

Of the 468 hectares to be reforested, 343 hectares are covered almost solely with pasture grasses (primarily *Setaria sphacelata),* 12 hectares are covered in sugar cane crops, and the remaining 113 hectares are a mix of grasses with shrubby vegetation dominated by *Piper hispidum* up to 3-5 meters in height.

Reforestation will be based on direct human-induced conversion: Reforestation will be based on manual planting of seedlings and organic enrichment of the soil. Once forest structure and overstory has been established, creating adequate microclimate conditions, seed dispersal and colonization from adjacent native forest will enrich forest regeneration. This would not take place in the absence of these human activities given the aggressive nature of dominant pasture grasses.

Lands did not contain forest on 31 December 1989: Areas to be reforested were deforested prior to 31 December 1989, based on review of aerial photographs and information from landowners and neighbouring communities.

A.4.6. A description of legal title to the land, current land tenure and land use and rights of access to the sequestered carbon:

Lands to be reforested by the project are all in properties owned by the Maquipucuna Foundation, a legally registered foundation by the Government of Ecuador.

Reforestation plots are distributed amongst eight separate properties, all duly titled to the Maquipucuna Foundation. Under Ecuadorian law, the plantations established, as well as all their products, are the property of the landowner. Although there is no legal regime explicitly regulating rights of access to sequestered carbon, carbon rights should also accrue to the Maquipucuna Foundation.

A.4.7. Type(s) of A/R CDM project activity:

Reforestation.

A.4.8. Technology to be employed by the proposed A/R CDM project activity:

Seed collection: Seeds will be secured from trees in the project area, both within the Maquipucuna Reserve and with the collaboration of members of the neighbouring communities.

Nurseries: Seeds will be propagated and plants established in four separate nurseries within the project area. Plants will be grown under shade cloth for 6-18 months in polyethylene nursery bags filled with soil mix, reaching a height of 50-80 cm.

Site preparation: Sites will be previously grazed to reduce initial competition from grasses. Herbicide (glyphosate) will be applied at project sites to reduce initial competition from aggressive grasses. Following this, holes will be dug manually.

Planting: Trees will be transplanted in a 4 m x 5 m spacing, during the first half of the rainy season (January-March). Plants will be transported by truck in accessible areas, or by mule/horse in areas without road access.

Replanting: Trees that do not survive the first year will be replanted in the following rainy season.

Maintenance: Maintenance for the first six years after planting will entail clearing planting lines and/or spot clearing with machetes and/or brush cutters to keep the trees free from competition, primarily from grasses. In the first two years of the project, three clearings will occur throughout the year. In years 3 and 4, two clearings per planting cycle will occur, while in Years 5 and 6, clearing will be done once per year.

A.4.9. Approach for addressing non-permanence:

Issuance of lCERs

A.4.10. Duration of the proposed A/R CDM project activity / Crediting period:

30 years

A.4.10.1. Starting date of the proposed A/R CDM project activity and of the (first) crediting period, including a justification:

The CDM activity will begin in March 2006 with approval from all investors. The first crediting period will be March 2008 (Year 2 of the project).

A.4.10.2. Expected operational lifetime of the proposed A/R CDM project activity:

30 Years

A.4.10.3. Choice of crediting period and related information:

Fixed Crediting Period

A.4.10.3.1. Renewable crediting period, if selected:

A.4.10.3.1.1. Starting date of the first crediting period:

A.4.10.3.1.2. Length of the first crediting period:

A.4.10.3.2 Fixed crediting period, if selected:

>> 30 Years

A.4.10.3.2 .1. Starting date:

March 2008

A.4.10.3.2.2. Length:

30 years

A.4.11. Brief explanation of how the net anthropogenic GHG removals by sinks are achieved by the proposed A/R CDM project activity, including why these would not occur in the absence of the proposed A/R CDM project activity, taking into account national and/or sectoral policies and circumstances:

Over the crediting period, due to the project's reforestation activity, the total carbon stocks in the pools will increase in comparison with the pools as they are now, which are assumed to be maintained in the baseline scenario. The baseline scenario is predicted to be similar to the existing situation: 343 hectares in pasture actively used for grazing, 113 hectares of abandoned pastures in a state of arrested succession due to ecological constraints, and 12 hectares in sugar cane.

Economic barriers are the primary constraint to reforestation activities at the project site. Reforestation is relatively expensive and the conservation focus of this project activity implies that there will be no revenue generated from forest product harvest. Baseline land uses provide positive returns, making reforestation a financially unattractive and in fact infeasible alternative without the CDM. (For further information, see Additionality Tool analysis in Sec B.2. Step 3)

A.4.11.1. Estimated amount of net anthropogenic GHG removals by sinks over the chosen crediting period:

167,106 tCO_2

A.4.12. Public funding of the proposed A/R CDM project activity:

None.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the proposed A/R CDM project activity:

The title of the baseline methodology applied to the proposed A/R CDM project activity is 'Baseline methodology for afforestation or reforestation project activities that are additional due to financial barriers to their implementation'. It has been developed by this project. It is currently waiting to be submitted to the Methodologies Panel and has thus, not yet been approved.

B.1.1. Justification of the choice of the methodology and its applicability to the proposed A/R CDM project activity:

Though designed to be a generic baseline methodology applicable to many other projects, the methodology was developed by this project with a view on applying it in its baseline study.

B.2. Description of how the methodology is applied to the proposed A/R CDM project activity:

The steps as described in Section E.2 of the Baseline Methodology are applied as follows:

Step 1. Stratify the project area into biophysically and socio-economically homogeneous areas
The project area is considered to consist of only a single stratum that is biophysically and socio-economically homogeneous.

Step 2. Identify for each stratum, the baseline land use alternatives, including the proposed project activity
The project area has a unique character compared to other areas in the region, due to the objectives its owner has with regards to its use. All lands within the project boundary are owned by the Maquipucuna Foundation, which has as a statutory objective, the conservation of natural forests in Ecuador and in particular of the forests on the Andean slopes in the Chocó-Andean biological corridor. Maquipucuna's objectives for the use of the land are thus not commercial or for self-subsistence, contrary to the objectives of the owners of most other landowners in the region.

When the Maquipucuna Foundation acquired the project area some 15 years ago two land uses were practiced on it: 15 ha (3%) were used for growing sugarcane and 467 ha (97%) was used for extensive cattle ranching. Immediately some 126 ha (approx. 27% of the pastures) were taken out of productive ranching and left to regenerate. Of these, 13 ha regenerated well and these areas are now not considered to be within the project boundary. On the remaining 113 ha, no significant forest regeneration or biomass accumulation has taken place since then. This is mainly due to a particular ecological characteristic of the dominant pasture that inhibits forest succession:

> "It is widely held that tropical pastures will quickly revert to forest if fire and grazing are removed and if forest sources of seed are nearby. We found that a common pasture used in the Andean slopelands, known as *pasto miel* (*Setaria sp*.), does not revert to forest even when grazing is absent for as much as 15 years and forest surrounds the pasture. We discovered that

> this grass supports huge populations of bacteria on labile sugars exuded from the grass roots. The bacteria immobilized nitrogen and normally this nitrogen would be unavailable to plants. However, large populations of predatory nematodes feed on this bacteria within the root zone and release ammonia nitrogen as waste which is quickly assimilated by the grass. Between the grass clumps, bacteria immobilize nitrogen but nematodes are scarce. Thus a kind of nitrogen account is maintained within the root zone of the grass but a nitrogen deficit occurs between the grass clumps. This nitrogen deficit strongly inhibits forest succession." (Campbell, 1997).

These findings are confirmed by Rhoades and Coleman (1999). In addition, Sarmiento (1997) concluded that the arrested succession towards lower montane forest was partly a result of *Setaria*'s bioarchitecture and planting patterns strongly inhibiting seed germination of successional species.

In the 15 years since Maquipucuna gained title to the project area, the following developments took place: the 15 ha of sugarcane were reduced to 12 ha; the 113 ha of pasture taken out of production converted into a sort of 'shrubland' dominated by *pasto miel* and a species called *Cordoncillo* (a Piperaceae); the remaining 343 ha of pasture were maintained as pastures by renting them out to caretakers of the Maquipucuna reserve (i.e. employees of the Foundation) and their families to graze their family's cattle on.

In the project region (i.e. outside the project activity and outside the land owned by Maquipucuna), land use dynamics have mainly consisted of a back and forth between sugarcane and cattle ranching, depending on which was more economically attractive at the time. The main factors determining this dynamism are the price of sugarcane products (sugar and alcohol) and, above all, the price of meat (Rebeca Justicia, *personal comment*).

The three candidate baseline land uses are thus, apart from the project activity -- sugarcane, pastures and abandoned pastures. Even though the region surrounding the project activity has witnessed a certain degree of dynamism in the past, there seems to be no reason to assume that the baseline in the lands held by Maquipucuna would show any such dynamics over the 30-year crediting period. This assumption is based on the relatively static situation observed on these lands over the last 15 years.

<u>Step 3</u>. Conduct the five steps of the A/R Additionality Tool to determine whether the proposed project activity is additional.

AT-step 1. Enforcement of applicable laws and regulations:

There is no Ecuadorian law or regulation enforcing any non-forest land use on any parts of the project area.

The current Forestry Law of 1981 states in Articles 10 and 18-20 that all areas classified as with *aptitud forestal* or 'forestry aptitude' must be reforested, lest they be expropriated by the state. However, no cases are known of any reforestation having taken place because of these Articles or of them ever having been enforced. In fact, there has not been, to the knowledge of the project proponents, an official government classification of forestry aptitude of any lands in Ecuador. But even when assuming that all areas within the project boundary would be classified as with forestry aptitude if a government classification would exist, this is a clear case where it can be shown that a law is systematically not enforced and that noncompliance with those requirements is widespread in the country.

AT-Step 2. Investment analysis

AT-Step 2a. Determine appropriate analysis method:

As the project activity is reforestation without any generation of financial or economic benefits other than CDM related income, the simple cost analysis (Option I) should be applied

.

AT-Step 2b. – Option I. Apply simple cost analysis:

The project activity is reforestation with the aim of reestablishing a natural forest over time, where natural processes have total freedom and no anthropogenic interventions will be made. The project activity will not generate any financial or economic benefits other than CDM related income and costs US$1,478 per ha to establish and maintain over the first four years (data by Maquipucuna and Jatun Sacha.

AT-Step 4. Common practice analysis

AT-Step 4a. Analyze other activities similar to the proposed project activity:

Interviews were carried out with Ing. Camilo González of the Dirección Forestal (Forestry Directorate) of the Ministerio de Agricultura y Ganadería (Ministry of Agriculture and Livestock) in Quito and with Ing. Rodrigo Aguilar, Director of the Regional Forestry Office of Ambato. Also interviewed was Dr. Michael McColm, Executive Director of the Jatun Sacha Foundation, a leading conservation NGO within Ecuador.

At the Ministry in Quito, Ing. González reported no knowledge of other conservation reforestation activities without harvesting objectives in Ecuador. However, Ing. Aguilar reported he knew of one other such project: 4500 ha to be reforested for conservation purposes by a company called MG.LAND owned by Mr. Isac Alvarez in three high-altitude regions of Ecuador (Ilinizas, Boliche and Cotopaxi). 300 ha seem to have been established to date. This is not a CDM project.

From this information it can be analyzed that reforestation for conservation purposes is not a common practice in Ecuador. There seems to be only one other such project. This is not located anywhere close to the project in Maquipucuna or in a similar climatic zone, and it is clearly an exceptional and isolated case.

The Jatun Sacha Foundation established a carbon sequestration project in the coastal forest of Ecuador, within their Bilsa Biological Station with investment from The Climate Trust. This project will offset 120,000 tons of CO_2 over 100 years and will meet requirements for power plants regulated by the State of Oregon within the United States. The project involves the enrichment of secondary forests and not reforestation on pasturelands. It is not a CDM project.

Step 4. From the baseline land use alternatives identified in Step 2, determine the economically most attractive land use alternative, taking into account barriers to investment.
An overview and comparison of economic parameters for the three identified candidate baseline land uses is given in Table 1. However, considering the specific objectives of the Maquipucuna Foundation, which are to restore and conserve natural forests without any economic gain, this baseline land use determination will necessarily have to focus on the barriers to investment.

Table 1. Comparison of economic parameters for the three candidate baseline land uses.

Candidate Baseline Land Use	*Investment required for establishment ($/ha)**	*Recurrence of investment**	*Time before first revenues (months)**	*Net revenues ($/ha/yr)**	*Management/workload required**
Sugarcane	2,500	Every 20 years	18	442	High
Pastures	300	Once-off	5	280**	Low
Abandoned pastures	0	Once-off	N/A	0	None
Conservation reforestation	1,478	Once-off	N/A	0	High in first 6 years, none thereafter

* Data from Maquipucuna Foundation records.
** Assuming 2 heads of cattle per ha.

From the statutes and activities of the Maquipucuna Foundation it is clear that since MF gained title to the project area it has not wished to invest in any other activity but conservation reforestation. Yet without external funding this has not been possible, due to an internal lack of financial resources and the impossibility of securing commercial finance due to the absence of any financial returns on the investment. Abandoning part of the pastureland to allow forest regeneration was an attempt to reach its objectives without the need for investment, but this failed due to inhibited regeneration for reasons explained above. The economic activities that were maintained in part of the areas under pasture and sugarcane were necessary to cover the costs of having caretakers and guards for the forested core area of the Maquipucuna Reserve. These costs will now be internalised in the overall costs of the CDM project and financed though the sale of CERs, thus taking away another barrier to the establishment of conservation reforestation.

The principal barrier to the expansion of sugarcane into pastures and abandoned pastures, or of pastures into sugarcane and abandoned pasture areas in the baseline scenario is the Maquipucuna Foundation's clear unwillingness to make any investments into these changes.

The principle barrier to the conversion of sugarcane and pasture areas to abandoned pastures is the need for the Maquipucuna Foundation to maintain these activities to finance the guards and caretakers of the forest reserve.

In conclusion, it follows from this barrier analysis that the baseline scenario is the continuation of the status quo of current land uses over the 30-year crediting period, as it also has been for the past 15 years: 12 ha of sugarcane, 356 ha of pastures and 113 ha of abandoned pastures.

Step 5. Quantify the sum of changes in carbon stocks within the carbon pools that would occur in the baseline, land use, and emissions by sources (project scenario only).

Sub-step 1: Select the pools to be included in the calculation of the baseline net greenhouse gas removals by sinks, in accordance with Decision 19/CP.9 Paragraph 21.

All pools are selected by the project.

Sub-step 2: Stratify each area with a different defined baseline land use within the project boundary into strata where different behaviour of changes in carbon stocks is expected.
At the start of the crediting period, i.e. when plantations are established, the entire project area of 468 ha consists of nine strata, based on baseline land use and year of planting, as presented in Table 2.

Project activity	***Baseline land use***	***Year of planting***
Planting of species mix	Pasture	Year 1
		Year 2
		Year 3
	Abandoned pasture	Year 1
		Year 2
		Year 3
	Sugarcane	Year 1
		Year 2
		Year 3

Sub-steps 3-7:
For the quantification of the initial carbon stocks in the carbon pools at the beginning of the crediting period and the subsequent yearly changes in these stocks over the crediting period the ECO_2Forestry™ Model, software specifically designed for this purpose and proprietary to EcoSecurities Ltd., was used. Detailed information on the model, the modeling results and the modeling data and assumptions can be found in Annex 3. The summarized modeling results for the baseline scenario are presented in Section D.2 of this PDD. The summarized modeling results for the project scenario are presented in Section D.1.

It should be noted that leakage in the project scenario was not deemed necessary to be quantified. Any emissions from fuel consumption outside the project boundary are internalized in the total fuel use (see also the Monitoring Plan in Section C). Any leakage of the activity shifting type is not expected to occur due to the compensation of current income from sugarcane and cattle grazing activities needed to finance the guards and caretakers of the forest reserve by CER revenues.

B.3. Description of how the actual net GHG removals by sinks are increased above those that would have occurred in the absence of the registered A/R CDM project activity:

Over the 30-year crediting period, due to the project's reforestation activity, the total carbon stocks in the pools will increase in comparison with the pools as they are now, which are assumed to be maintained in the baseline scenario. The increased emissions by sources as a result of the implementation of the project are not expected to change this overall outcome significantly.

B.4. Detailed baseline information, including the date of completion of the baseline study and the name of person(s)/entity(ies) determining the baseline:

The baseline analysis was carried out by Mr. Jan Fehse of EcoSecurities Ltd. in January 2005. See Annex 3 for detailed baseline information.

SECTION C. Application of a monitoring methodology and of a monitoring plan

C.1. Title and reference of approved monitoring methodology applied to the project activity:

The monitoring methodology applied here is titled 'Monitoring methodology for afforestation or reforestation project activities'. It has been developed by this project. It is currently waiting to be submitted to the Methodologies Panel and has thus not yet been approved.

C.2. Justification of the choice of the methodology and its applicability to the proposed A/R CDM project activity:

The methodology applied here is a generic methodology that can be applied to most afforestation or reforestation project activities. It is also applicable to the monitoring of this project.

C.3. Monitoring of the baseline net GHG removals by sinks and the actual net GHG removals by sinks:

C.3.1. Actual net GHG removals by sinks data:

* Permanent sampling plots (PSPs) representative for the entire project area will be established to measure carbon stocks in aboveground tree biomass and soil in accordance with standard sampling procedures as given in the IPCC Good Practice Guidance for LULUCF (2003) and in a large number of forest mensuration and sampling text books. Plots will be established using a stratified random design. Temporary plots for measuring aboveground non-tree biomass, litter and dead wood will be established in or close to PSPs. The exact number and location of sampling plots will be determined by Corporación EcoPar in the first year of field monitoring, taking into account the variability of terrain and the locations of areas under different planting schedules.

C.3.1.1. Data to be collected or used in order to monitor the verifiable changes in carbon stock in the carbon pools within the project boundary from the proposed A/R CDM project activity, and how this data will be archived:

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1	Spatial data	Aereal photographs, maps, GPS data	-	M and C	Before the first verification or as new strata are identified (see Section B.2.2.1)	100 %	Electronic	Data used to stratify the project area and to quantify the number of hectares in each stratum.
8	Diameter at breast height (DBH)	Field measurements	cm	M	Before each verification	100% of sampling plots*	Electronic and paper	In 20 x 20 m plots, the project will calculate Tree aboveground biomass (ID no. 13) of each tree using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11). DBH is only measured when trees are > 5 cm.
9	Tree height (H)	Field measurements	m	M or E	Before each verification	100% of sampling plots*	Electronic and paper	Indicator for ID no. b (see below).

10	Bole height (H_B) for calculation of Bole Volume (V)	Field measurements	m/m^3	C	Before each verification	100% of sampling plots*	Electronic and paper	The project will calculate Tree aboveground biomass (ID no. 13) using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11)
11	Crown Expansion Factor (CEF)	Field measurements	-	C	Before each verification	-	Electronic and paper	Of a limited number of trees of each species crowns or parts of crowns will be destructively harvested to determine crown biomass.
12	Wood density (WD)	Field measurements or from literature sources	g/cm^3	C	Before the first verification or as new species appear naturally within the plots.	A significant number of samples per tree species	Electronic and paper	Samples for the determination of WD will be taken from surrounding areas where mature trees are found of the species planted or naturally regenerated in the sample plots. The WD to be used in the formulae will be the average of the 5 samples.
13	Tree aboveground biomass	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	The project will calculate Tree aboveground biomass (ID no. 13) using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11)
14	Non-tree aboveground biomass	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	For all understorey vegetation and trees with DBH < 5 cm. Destructive harvesting of 2 x 2 m nested sample plots to establish dry weight.
18	Aboveground biomass harvested (H_{ag})	Field measurements	t/ha	E	Before each verification	100% of sampling plots*	Electronic and paper	No harvestings are planned. Should any illegal harvesting occur, the aboveground biomass harvested will be estimated by measuring of diameter of tree stumps and comparing with biomass of trees with similar diameter from plot data. Needed for calculation of Data ID nos. 24, 30 and 35.
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	IPCC (1996)	%	M	Before the first verification	-	Electronic and paper	The project will apply the IPCC (1996) recommended default CBR of 0.5.
20	Belowground to aboveground biomass ratio (BABR)	Field measurements or literature sources	%	C	Before each verification	A limited number of samples	Electronic and paper	For calculation of belowground biomass. Of a limited number (5-10) of tree individuals of the species to be planted the entire root system will be dug up according to acknowledged scientific practice, in order to establish dry weight.
24	Belowground biomass harvested (H_{bg})	Field measurements	t/ha/yr or %/yr	E	Before each verification	100% of sampling plots*	Electronic and paper	Calculated, using the BABR, from the aboveground biomass harvested.
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	IPCC (1996)	%	M	Before the first verification	-	Electronic and paper	The project will apply the IPCC (1996) recommended default CBR of 0.5.

26	Litter biomass ($BCL_{t=n}$)	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	Destructive harvesting of 2 x 2 m nested sample plots to establish dry weight.
27	Portion of aboveground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Established from the data taken to determine Crown Expansion Factor (ID no. 11). Harvested crowns will be separated into coarse parts (branches) and fine parts (twigs and leaves). Needed to calculate Data ID no. 30.
28	Portion of belowground biomass that is fine	Field measurements or literature sources	%	C	Before the first verification	-	Electronic and paper	Established from the data taken to determine BABR (ID no. 20). Harvested root systems will be separated into coarse roots and fine roots. Needed to calculate Data ID no. 30.
29	Fine part of harvested biomass taken out of system	Field measurements	t/ha or %	E	Before each verification	100% of sampling plots*	Electronic and paper	See comment ID no. 18. Needed to calculate Data ID no. 30
30	Fine part of harvested biomass left in system (H_{fine})	Field measurements	t/ha or %	E	Before each verification	100% of sampling plots*	Electronic and paper	See comment ID no. 18.
32	Carbon to biomass ratio for litter biomass (CBR_L)	IPCC (1996)	%	M	Before the first verification	-	Electronic and paper	The project will apply the IPCC (1996) recommended default CBR of 0.5.
33	Dead wood biomass ($BCDW_{t=n}$)	Field measurements	t/ha	C	Before each verification	100% of sampling plots*	Electronic and paper	Destructive harvesting of 2 x 2 m nested sample plots to establish dry weight.
34	Coarse part of harvested biomass taken out of system	Field measurements	t/ha or %	E	Before each verification	100% of sampling plots*	Electronic and paper	See comment ID no. 18. Needed to calculate Data ID no. 35
35	Coarse part of harvested biomass left in system (H_{coarse})	Field measurements	t/ha or %	E	Before each verification	100% of sampling plots*	Electronic and paper	See comment ID no. 18.
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	IPCC (1996)	%	M	Before the first verification	-	Electronic and paper	The project will apply the IPCC (1996) recommended default CBR of 0.5.
38	Soil carbon content ($CCS_{t=0}$)	Field measurements	t/ha	M	Before each verification	100% of sampling plots*	Electronic and paper	Two mixed samples, each consisting of 5 sub-samples, are taken from each plot. One sample is taken from the top 5 cm of mineral soil using a ring with know volume to establish bulk density. The other is analysed for carbon content in the laboratory of the Ministry of Agriculture.

a	Data on planting schedules and management of plantations	Management decisions taken by the central project management	-	Time, place and % biomass removed	As management occurs	100%	Electronic and paper	Which areas were subjected to which planting schedule and management regime, including timings. The project will keep detailed records.
b	Data on negative deviation of areas from sampling plot measurement results	Field observations and field measurements	% or t/ha	E or M	Before each verification	100%	Electronic and paper	E.g. lower than expected biomass in certain parts of the project area affected by fire, plague or drought. Indicators to be used are: overall visual state, phytosanitary state, tree heigh and diameter
c	Data on environmental impacts of the project (if required in accordance with Paragraph 12c of Decision 19/CP.9)	Field observations or field measurements	Biodiversity data in various formats	observed	As deemed appropriate	As deemed appropriate	Electronic and paper	Since no significant negative impacts are expected, the project is not required to carry out any monitoring on these impacts. However, Fundación Maquipucuna has a scientific station in its reserve, where biologists frequently conduct research. It is likely and in its own interest that biological inventories will be carried out within the plantations during the project crediting period
d	Data on socio-economic impacts of the project (if required in accordance with Paragraph 12c of Decision 19/CP.9)	Project records	Employment and income data	M	As deemed appropriate	As deemed appropriate	Electronic and paper	Since no significant negative impacts are expected, the project is not required to carry out any monitoring on these impacts. However, it is in the interest of the project to keep employment and income records of its employees and contracted workers.
f	Changes in circumstances within the project boundary that affect legal title to the land or rights of access to the carbon pools.	Legal documents	-	Observed	Before each verification	100%	Electronic and paper	Legal land titles will be administered by law firm hired by project participants and verified by the land registry office (Government of Ecuador)

C.3.1.2. Data to be collected or used in order to monitor the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary, and how this data will be archived:								
ID number	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c) or estimated (e)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived? (electronic/ paper)**	**Comment**
38	Amount of Fuel Used by project (AFU)	Project-specific data	l or kg	e	As and when fuel use occurs	100%	Electronic and paper	Data will be collected from incurred fuel costs by the project and any contractors.
39	Energy content of fuel used (EC_{FU})	Literature sources (e.g. IPCC)	TJ/l or TJ/kg	m	Updated before each verification	-	Electronic and paper	
40	Emission Factor of Fuel Used (EF_{FU})	Literature sources (e.g. IPCC)	tCO2e/TJ	m	Updated before each verification	-	Electronic and paper	
41	Amount of fertilizer applied	IPCC (2003)	kg/ha	m	Annually	100%	Electronic and paper	
42	Nitrogen content of fertilizer	Project-specific data	%	m	Annually	100%	Electronic and paper	
43	Emission Factor N_2O	IPCC (1996)	kg N_2O / kg N	m	Before first verification	100%	Electronic and paper	IPCC (1996) gives a default Emission Factor of 0.0125

C.3.1.3. Description of formulae and/or models used to monitor the estimation of the actual net GHG removals by sinks:

C.3.1.3.1. Description of formulae and/or models used to monitor the estimation of the verifiable changes in carbon stock in the carbon pools within the project boundary (for each carbon pool in units of CO_2 equivalent):

Calculation of carbon stocks in the carbon pools within sample plots

The project will calculate Tree aboveground biomass as follows:

TAB = BB * CEF {1}

Where:

TAB = Tree Aboveground Biomass
BB = Bole Biomass
CEF = Crown Expansion Factor

The project will not measure the gains and losses of carbon from and between the pools, it will only measure and quantify existing carbon stocks prior to each verification

Biomass content of the pools per hectare will be quantified according to an established and published methodological approach. Field techniques for data generation are indicated in the table in Section C.3.1.1.

Biomass content of the all pools except soil is converted to carbon content through multiplying by a Carbon to Biomass Ratio of 0.5 (IPCC 1996 recommended default).

$$CCP_{t=n} = BCP_{t=n} * CP_{AG} \quad \{2\}$$

Where:

$CCP_{t=n}$ = Carbon Content Pool in year n
$BCP_{t=n}$ = Biomass Content Pool in year n
CBR = 0.5

Carbon content of the soil pool is measured directly from field samples.

For each stratum, the average for each pool’s carbon content will be calculated from the individual results of the sample plots within the stratum and converted to a per-hectare result.

Calculation of carbon stocks in the carbon pools within the project boundary

For each stratum, the average per-hectare results from the sample plots will be multiplied by the number of hectares within the stratum

Correction for underperformance relative to sample plot-based data

Before each verification, an assessment will be carried out to analyse whether any plantations have significantly under-performed relative to the results from the sample plots, e.g. as a result of fire, plague or a deviation of prescribed management practices. The indicators that will be used for this assessment are: overall visual state, phytosanitary state, tree height and diameter. A choice will need to be made and justified by the project management whether or not an identified under-performance in a specific area has already been captured by the results of the established sample plots. If not, the affected area should be treated as a separate stratum and additional sample plots should be established to quantify the carbon stocks in the pools within this stratum.

C.3.1.3.2. Description of formulae and/or models used to monitor the estimation of the GHG emissions by the sources, measured in units of CO_2 equivalent, that are increased as a result of the implementation of the proposed A/R CDM project activity within the project boundary (for each source and gas, in units of CO_2 equivalent):

Calculations of the increase in emissions of the greenhouse gases measured in CO2 equivalents by the sources within the project boundary that are increased as a result of the implementation of the project activity will be done in the following manner:

Step 1. Identification of sources - Identification of possible sources of increased GHG emissions resulting from the implementation of the project activity and the type of GHG emitted by these. Sources can be divided into the following categories:

1. Combustion of fossil fuels – Possible sources could be: use of vehicles during planting, replanting and other maintenance activities and monitoring.
2. Non-CO_2 GHG emissions from soils (e.g., application of fertilizers or growing of N-fixing trees) – A limited amount of synthetic fertilizers will be applied. No wetland areas will be drained. Approx. 15% of the trees planted will be of leguminous tree species (Inga sp.). However, according to the Monitoring Methodology, any potential N_2O emissions from this source are assumed to be zero.
3. Non-CO_2 GHG emissions from biomass burning (e.g., from site preparation) – Not applicable: the project anticipates no biomass burning at any point during the crediting period.

Step 2. Quantification of increased emissions by Category 1 sources identified under Step 1. – For the calculation of emissions from identified sources pertaining to Category 1, the following formula shall be applied:

$$Emissions_{Cat1} = AFU * EC_{FU} * EF_{FU} \qquad \{3\}$$

Where:

$Emissions_{Cat1}$ (tCO_2e) = Emissions from Category 1 Sources
AFU (unit) = Amount of Fuel Used
EC_{FU} (TJ/ unit) = Energy Content of Fuel Used
EF_{FU} (tCO2e/TJ) = Emission Factor of Fuel Used

Step 3. Quantification of increased emissions by Category 2 sources identified under Step 1. – For the calculation of emissions the application of synthetic fertilizers, the following formula shall be applied:

$$Emissions_{Fert} = AFertU * NC * EF_{Fert} * GWP_{N2O} \qquad \{4\}$$

Where:

$Emissions_{Fert}$ (tCO_2e) = Emissions from synthetic fertilizer application
AFertU (kg) = Amount of Fertilizer Used
NC (%) = Nitrogen Content of fertilizer
EF_{Fert} (kg N_2O / kg N) = Emission Factor of fertilizer
GWP_{N2O} (tCO_2e / tN_2O) = Emission Factor of N2O (IPCC 1996 default is 310)

C.3.2. As appropriate, relevant data necessary for determining the baseline net GHG removals by sinks and how such data will be collected and archived:								
ID number	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived?**	**Comment**

				calculated (c) or estimated (e)		monitored	archived? (electronic/ paper)	
1	Spatial data (e.g., land use, vegetation, soil, geology, climate, topography)	Aereal photographs, maps, GPS data	-	M and C	Before the first verification	100 %	Electronic	Data used to stratify the project area and to quantify the number of hectares in each stratum.
8	Diameter at breast height (DBH)	Field measurements	cm	M	Before the first verification	100% of sampling plots*	Electronic and paper	In 20 x 20 m plots, the project will calculate Tree aboveground biomass (ID no. 13) of each tree using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11). DBH is only measured when > 5 cm.
9	Tree height (H)	Field measurements	m	M or E	Before the first verification	100% of sampling plots*	Electronic and paper	Indicator for ID no. b (see below).
10	Bole height (H_B) for calculation of Bole Volume (V)	Field measurements	m/m^3	C	Before the first verification	100% of sampling plots*	Electronic and paper	The project will calculate Tree aboveground biomass (ID no. 13) using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11)
11	Crown Expansion Factor (CEF)	Field measurements	-	C	Before the first verification	-	Electronic and paper	Of a limited number of trees of each species crowns or parts of crowns will be destructively harvested to determine crown biomass.
12	Wood density (WD)	Field measurements or from literature sources	g/cm^3	C	Before the first verification	A significant number of samples per tree species	Electronic and paper	Samples for the determination of WD will be taken from surrounding areas where mature trees are found of the species planted or naturally regenerated in the sample plots. The WD to be used in the formulae will be the average of the 5 samples.
13	Initial Tree aboveground biomass	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	The project will calculate Tree aboveground biomass (ID no. 13) using Bole Volume (ID no. 10), Wood Density (ID no. 12) and the Crown Expansion Factor (ID no. 11)
14	Initial Non-tree aboveground biomass	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	For all understorey vegetation and trees with DBH < 5 cm. Destructive harvesting of 2 x 2 m nested sample plots to establish dry weight.
15	Aboveground biomass	Project assumption	t/ha/yr	C	Before the first verification	100%	Electronic and paper	Assumed to be 0 for pastures and sugarcane and 0.233 t/ha/yr for abandoned pastures

	accumulation ($GROWTH_{AG}$)	based on field measurements						
16	Litter fall (LF)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
17	Dead wood fall (DWF)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
18	Aboveground biomass harvested (H_{ag})	Project assumption	t/ha	E	Before the first verification	100%	Electronic and paper	Assumed to be 0 for pastures and abandoned pastures and 100% in year 0 for sugarcane
19	Carbon to biomass ratio for aboveground biomass (CBR_{AG})	IPCC (1996)	%	M	Before the first verification	100%	Electronic and paper	CBR = 0.5
20	Belowground to aboveground biomass ratio (BABR)	Field measurements	%	M	Before the first verification	A limited number of samples	Electronic and paper	For calculation of belowground biomass. Of a limited number (5-10) of tree individuals of the species to be planted the entire root system will be dug up according to acknowledged scientific practice, in order to establish dry weight.
21	Belowground biomass accumulation ($GROWTH_{BG}$)	Project assumption based on field measurements	t/ha/yr	C	Before the first verification	100%	Electronic and paper	Assumed to be 0 for pastures and sugarcane and (0.233 * BABR) t/ha/yr for abandoned pastures
22	Fine root mortality (FRM)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
23	Coarse root mortality (CRM)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
24	Belowground biomass harvested (H_{bg})	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
25	Carbon to biomass ratio for belowground biomass (CBR_{BG})	IPCC (1996)	%	M	Before the first verification	100%	Electronic and paper	CBR = 0.5
26	Initial litter	Field	t/ha	C	Before the first	100% of	Electronic and	Destructive harvesting of 2 x 2 m nested sample

	biomass ($BCL_{t=0}$)	measurements			verification	sampling plots*	paper	plots to establish dry weight.
27	Portion of aboveground biomass that is fine	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	Follows from ID no.11 and ID no 14
28	Portion of belowground biomass that is fine	Project assumption	%	E	Before the first verification	100%	Electronic and paper	Assumed to be same as for aboveground biomass
29	Fine part of harvested biomass taken out of system	Project assumption	t/ha	E	Before the first verification	100%	Electronic and paper	Assumed to 100% in year 0 for sugarcane
30	Fine part of harvested biomass left in system (H_{fine})	Project assumption	t/ha	E	Before the first verification	100%	Electronic and paper	Assumed to be 0 in year 0 for sugarcane
31	Litter that decomposes in a given year (Ldecomp)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
32	Carbon to biomass ratio for litter biomass (CBR_L)	IPCC (1996)	%	M	Before the first verification	100%	Electronic and paper	CBR = 0.5
33	Initial dead wood biomass ($BCDW_{t=0}$)	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	Destructive harvesting of 2 x 2 m nested sample plots to establish dry weight.
36	Dead wood that decomposes in a given year (DWdecomp)	Project assumption	t/ha/yr or %/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
37	Carbon to biomass ratio for dead wood biomass (CBR_{DW})	IPCC (1996)	%	M	Before the first verification	100%	Electronic and paper	CBR = 0.5
38	Initial soil carbon content	Field measurements	t/ha	C	Before the first verification	100% of sampling plots*	Electronic and paper	Two mixed samples, each consisting of 5 sub-samples, are taken from each plot. One sample is

	($CCS_{t=0}$)							taken from the top 5 cm of mineral soil using a ring with know volume to establish bulk density. The other is analysed for carbon content in the laboratory of the Ministry of Agriculture.
39	Percentage of decomposing litter respired to the atmosphere (Lresp)	Project assumption	%/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
40	Percentage of decomposing dead wood respired to the atmosphere (DWresp)	Project assumption	%/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
41	Percentage of soil carbon content respired to the atmosphere (Sresp)	Project assumption	%/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses
42	Percentage of soil carbon content lost through erosion (Serosion)	Project assumption	%/yr	E	Before the first verification	100%	Electronic and paper	Assumed 0 for all three baseline land uses

C.3.2.1. Description of formulae and/or models used to monitor the estimation of the baseline net GHG removals by sinks (for each carbon pool, in units of CO_2 equivalent):

a) Aboveground Biomass Pool

Quantification of initial aboveground biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. The two main approaches are outlined here for tree biomass:

Tree biomass –

1. Direct use of allometric functions that calculate biomass from Diameter at Breast Height (DBH) and/or Height (H) and sometimes Wood Density (WD); or
2. Determination of Bole Biomass (BB) through bole Volume per hectare and WD, then determination of tree aboveground biomass through application of Crown Expansion Factor (CEF):

$$TAB = BB * CEF \quad \{1\}$$

Where:

TAB = Tree Aboveground Biomass
BB = Bole Biomass
CEF = Crown Expansion Factor

For non-tree vegetation biomass, the other component of aboveground biomass, direct application of biomass per hectare data from field measurements is usual.

Calculation of yearly changes in aboveground biomass content - Calculations of the changes in biomass content per hectare in the aboveground biomass pool during the crediting period are done by taking the initial biomass content per hectare ($BCAB_{t=0}$) and calculating the biomass content in the next year ($BCAB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCAB_{t=1} = BCAB_{t=0} + GROWTH_{AG} - LF - DWF - H_{ag} \quad \{2\}$$

Where:

$BCAB_{t=0}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 0

$BCAB_{t=1}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year 1
$GROWTH_{AG}$ (t/ha/yr) = Accumulation of biomass in tree and non-tree vegetation through photosynthesis or planting
LF (t/ha/yr) = Litter Fall (fine parts of biomass died naturally)
DWF (t/ha/yr) = Dead Wood Fall (coarse parts of biomass died naturally)
H_{ag} (t/ha) = Harvestings (total aboveground biomass anthropogenically removed from the site or left to be incorporated in the Litter and/or Dead Wood pools)

The tree component of GROWTH is usually derived from data on increase in bole volume, DBH or tree height, with which biomass can be derived using the same approaches as outlined above. For the non-tree vegetation component direct biomass increase data are usually used.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCAB_{t=n} = BCAB_{t=n} * CBR_{AG} \quad \{3\}$$

Where:
$CCAB_{t=n}$ = Carbon Content Aboveground Biomass Pool in year n
$BCAB_{t=n}$ = Biomass Content Aboveground Biomass Pool in year n
CBR_{AG} = Carbon to Biomass Ratio for aboveground biomass

b) Belowground Biomass Pool

Quantification of initial belowground biomass content – For the assessment of belowground biomass usually a Belowground to Aboveground Biomass Ratio (BABR) is applied. Initial belowground biomass content therefore follows from the quantification of aboveground biomass under a), using the formula:

$$BCBB_{t=n} = BCAB_{t=n} * BABR \quad \{4\}$$

Where:

$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n
$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n
BABR = Belowground to Aboveground Biomass Ratio

The BABR can vary according to different species or vegetation types present in the stratum. Project-specific BABR(s) may be determined by the project, in which case belowground biomass should be quantified according to an established and published methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation. However, quantification of belowground biomass is cumbersome and expensive and projects may therefore use a published BABR applicable to the project.

Calculation of yearly changes in belowground biomass content - Calculations of the changes in biomass content per hectare in the belowground biomass pool during the crediting period are done by taking the initial biomass content ($BCBB_{t=0}$) and calculating the biomass content in the next year ($BCBB_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCBB_{t=1} = BCBB_{t=0} + GROWTH_{BG} - CRM - FRT - H_{bg} \qquad \{5\}$$

Where:

$BCBB_{t=0}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 0
$BCBB_{t=1}$ (t/ha) = Biomass Content Belowground Biomass Pool in year 1
$GROWTH_{BG}$ * (t/ha/yr) = Tree and non-tree vegetation growth through photosynthesis or planting
FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)
CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of dead biomass died naturally)
H_{bg} (t/ha/yr) = Harvestings (total root biomass anthropogenically killed)

* Usually calculated from aboveground growth by applying the same Belowground to Aboveground Biomass Ratio.

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCBG_{t=n} = BCBG_{t=n} * CBR_{BG} \qquad \{6\}$$

Where:

$CCBG_{t=n}$ = Carbon Content Belowground Biomass Pool in year n

$BCBG_{t=n}$ = Biomass Content Belowground Biomass Pool in year n

CBR_{BG} = Carbon to Biomass Ratio for belowground biomass

c) Litter Pool

Quantification of initial litter biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in litter biomass content - Calculations of the changes in biomass content per hectare in the litter pool during the crediting period are done by taking the initial biomass content ($BCL_{t=0}$) and calculating the biomass content in the next year ($BCL_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCL_{t=1} = BCL_{t=0} + LF + FRM + H_{fine\text{-}in} - (BCL_{t=0} * Ldecomp) \qquad \{7\}$$

Where:

$BCL_{t=0}$ (t/ha) = Biomass Content Litter Pool in year 0

$BCL_{t=1}$ (t/ha) = Biomass Content Litter Pool in year 1

LF (t/ha/yr) = Litter Fall (fine parts of aboveground biomass died naturally)

FRM (t/ha/yr) = Fine Root Mortality (fine parts of belowground biomass died naturally)

$H_{fine-in}$ (t/ha) = The fine part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the dead wood pool after harvesting (see equation 8).

Ldecomp (%/yr) = Percentage of $BCL_{t=0}$ that decomposes

$$H_{fine-in} = (BCAB_{t=n} * PF_{AG}) + (BCBB_{t=n} * PF_{BG}) - H_{fine-out} \qquad \{8\}$$

Where:

$H_{fine-in}$ (t/ha) = Fine part of the biomass left in the forest system (above and belowground)

$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n

PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine

$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n

PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine

$H_{fine-out}$ (t/ha) = Fine part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCL_{t=n} = BCL_{t=n} * CBR_L \qquad \{9\}$$

Where:

$CCL_{t=n}$ = Carbon Content Litter Pool in year n

$BCL_{t=n}$ = Biomass Content Litter Pool in year n

CBR_L = Carbon to Biomass Ratio for litter

d) Dead Wood Pool

Quantification of initial dead wood biomass content – Initial biomass content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, Brown (1997) and IPCC (2003) provide comprehensive overviews of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in dead wood biomass content - Calculations of the changes in biomass content per hectare in the dead wood pool during the crediting period are done by taking the initial biomass content ($BCDW_{t=0}$) and calculating the biomass content in the next year ($BCDW_{t=1}$) and subsequent years by adding yearly influxes of biomass and subtracting outfluxes of biomass from the pool.

$$BCDW_{t=1} = BCDW_{t=0} + DWF + CRM + H_{coarse\text{-}in} - (BCDW_{t=0} * DWDecomp) \quad \{10\}$$

Where:

$BCDW_{t=0}$ (t/ha) = Biomass Content Dead Wood Pool in year 0

$BCDW_{t=1}$ (t/ha) = Biomass Content Dead Wood Pool in year 1

DWF (t/ha/yr) = Dead Wood Fall (coarse parts of aboveground biomass died naturally)

CRM (t/ha/yr) = Coarse Root Mortality (coarse parts of belowground biomass died naturally)

$H_{coarse\text{-}in}$ (t/ha) = The coarse part of the biomass left in the forest system (above and belowground) after harvesting, as opposed to harvested biomass taken out of the system or biomass incorporated into the litter pool after harvesting (see equation 11).

DWDecomp (%/yr) = Percentage of $BCDW_{t=0}$ that decomposes

$$H_{coarse\text{-}in} = (BCAB_{t=n} * (1-PF_{AG})) + (BCBB_{t=n} * (1-PF_{BG})) - H_{coarse\text{-}out} \quad \{11\}$$

Where:

$H_{coarse-in}$ (t/ha) = Coarse part of the biomass left in the forest system (above and belowground)
$BCAB_{t=n}$ (t/ha) = Biomass Content Aboveground Biomass Pool in year n
PF_{AG} (%) = Portion of $BCAB_{t=n}$ that is fine
$BCBB_{t=n}$ (t/ha) = Biomass Content Belowground Biomass Pool in year n
PF_{BG} (%) = Portion of $BCBB_{t=n}$ that is fine
$H_{coarse-out}$ (t/ha) = Coarse part of the biomass taken out of the forest system (above and belowground)

Conversion to carbon content - Biomass content is converted to carbon content through multiplying by a Carbon to Biomass Ratio (CBR). IPCC (1996) recommends a default CBR of 0.5. If project specific CBR data are available these may be used.

$$CCDW_{t=n} = BCDW_{t=n} * CBR_{DW} \quad \{12\}$$

Where:
$CCDW_{t=n}$ = Carbon Content Dead Wood Pool in year n
$BCDW_{t=n}$ = Biomass Content Dead Wood Pool in year n
CBR_{DW} = Carbon to Biomass Ratio for dead wood

e) Soil Organic Carbon Pool

Quantification of initial soil organic carbon content – Initial carbon content per hectare at year 0 before the afforestation or reforestation activity should be quantified according to an established methodological approach. For example, IPCC (2003) provides a comprehensive overview of such methodologies, including their quantification parameters and field techniques for data generation.

Calculation of yearly changes in soil organic carbon content - Calculations of the changes in carbon stocks per hectare in the soil organic carbon pool during the crediting period are done by taking the initial carbon content ($CCS_{t=0}$) and calculating the carbon content in the next year ($CCS_{t=1}$) and subsequent years by adding yearly influxes of carbon and subtracting outfluxes of carbon from the pool.

$$CCS_{t=1} = CCS_{t=0} + CCL_{t=0}*Ldecomp*(1-Lresp) + (CCDW_{t=0}*DWdecomp*(1-DWresp) - Sresp - Serosion \quad \{13\}$$

Where:

$CCS_{t=0}$ (tC/ha)	= Carbon Content Soil Pool in year 0
$CCS_{t=1}$ (tC/ha)	= Carbon Content Soil Pool in year 1
$CCL_{t=0}$ (tC/ha)	= Carbon Content Litter Pool in year 0
Ldecomp (%/yr)	= Percentage of $CCL_{t=0}$ that decomposes
Lresp (%/yr)	= Percentage of Ldecomp that is respired to the atmosphere
$CCDW_{t=0}$ (tC/ha)	= Carbon Content Dead Wood Pool in year 0
DWdecomp (%/yr)	= Percentage of $CCDW_{t=0}$ that decomposes
Dwresp	= Percentage of DWDecomp that is respired to the atmosphere
Sresp	= Percentage of $CCS_{t=0}$ that is respired to the atmosphere
Serosion	= Percentage of $CCS_{t=0}$ that is lost from the system through erosion processes

C.4. Treatment of leakage in the monitoring plan:

For reforestation, the main type of leakage is activity shifting by farmers who depend on the developed land.

Potential leakage in the project site

Project Component	Driver of Baseline Condition	Potential Leakage
Reforestation	No economic activity Agriculture Ranching	▪ Farming and ranching activity may be shifted by clearing forests areas (-) ▪ Clearing of new forests to replace grassland pastures reforested (-)

As these are abandoned pasturelands with no prior use, the project will not generate any products that need to be transported to markets. Therefore, the only expected emissions from sources outside the project boundaries as a result of project implementation are from transportation of personnel, for example between Quito and the project area. Since the monitoring of fuel costs incurred by the project and potential contractors will be done for the project as a whole, including for fuel combusted outside of the project boundary, the quantification of leakage is thus internalized and needs not be calculated separately. As a risk mitigation strategy, the project will address the potential shift with the following mitigation measures:

a. **Education and Benefit Sharing.** Maquipucuna Foundation has established strong ties with the local community and impressed upon the importance of reforestation and the potential economic benefits from alternative activities such as ecotourism. In addition to showcasing the benefits from the project such as watershed protection, the project is working with local communities to provide them with trees for planting and restoration on their own lands. Additionally, the project will employ upto 20 people from the local community to work on reforestation activities.

b. **Enforcement of laws and patrolling**. The project will employ and train guards from the local community to protect and patrol the border of the project site. While law officially establishes the borders, these inspectors will be trained how to deal with hunters if encountered in the reserves, on environmental laws, and put out forest fires for conservation areas. Additionally, inspectors in turn will be come educators both through words and actions as they interact with both community members and outsiders in their role as inspectors and encourage others to manage their own forested properties.

A leakage assessment will also be integrated into the monitoring plan to assess the potential of leakage as the project moves forward. Finally, in addition to using conservative estimates for the baseline scenario and with project case, the project has discounted the carbon benefit from the project by 10%. In this way, the risk to the carbon buyer is limited even further.

C.4.1. If applicable, please describe the data and information that will be collected in order to monitor leakage of the proposed A/R CDM project activity:								
ID number ***(Please use numbers to ease cross-referencing to D.3)***	**Data variable**	**Source of data**	**Data unit**	**Measured (m), calculated (c) or estimated (e)**	**Recording frequency**	**Proportion of data to be monitored**	**How will the data be archived? (electronic/ paper)**	**Comment**

C.4.2. Description of formulae and/or models used to estimate leakage (for each GHG, source, carbon pool, in units of CO_2 equivalent):

Not applicable

C.4.3. Please specify the procedures for the periodic review of implementation of activities and measures to minimize leakage:

No leakage is expected from this project and no activities to minimize it are being planned.

C.5. Description of formulae and/or models used to estimate net anthropogenic GHG removals by sinks for the proposed A/R CDM project activity (for each GHG, carbon pool, in units of CO_2 equivalent):

NAR = ANR –BNR – L

Where:

NAR = Net Anthropogenic GHG Removals by Sinks

ANR = Actual Net GHG Removals by Sinks (monitored – see Section C.3.1)

BNR = Baseline Net GHG Removals by Sinks (assumed – see Section C.3.2)

L = Leakage (assumed to be 0 - see Section C.4)

C.6. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored:		
Data ***(Indicate table and ID number e.g. 3.-1.; 3.2.)***	**Uncertainty level of data (High/Medium/Low)**	**Explain QA/QC procedures planned for these data, or why such procedures are not necessary.**
1. Spatial data	Low	All spatial data used for monitoring will be ground-truthed with GPS measurements
Data from various literature sources	Various	Literature sources will be routinely monitored for updates in constants and variables produced from outside data.
Field measurements	Medium	All field measurements will be done by an independent external organization (EcoPar) and reviewed by professional staff of The Maquipucuna Foundation and Conservation International (CI)

C.7. Please describe the operational and management structure(s) that the project operator will implement in order to monitor actual GHG removals by sinks and any leakage generated by the proposed A/R CDM project activity:

Monitoring, including field measurements and data analysis, will be contracted out to the Corporación EcoPar, a professional research and data generation and processing organization specialized in forest ecology, forestry, geography and natural resource management. Data and results generated by the monitoring will be reviewed by staff of The Maquipucuna Foundation, technical assistants, Jatun Sacha Foundation and Conservation International (CI)., and stored principally in the EcoPar and Maquipucuna offices, with additional back-ups in the CI office. Reports will be distributed to the Designated Operational Entity (DOE) for certification as instructed by the CDM EB.

C.8. Name of person/entity determining the monitoring methodology:

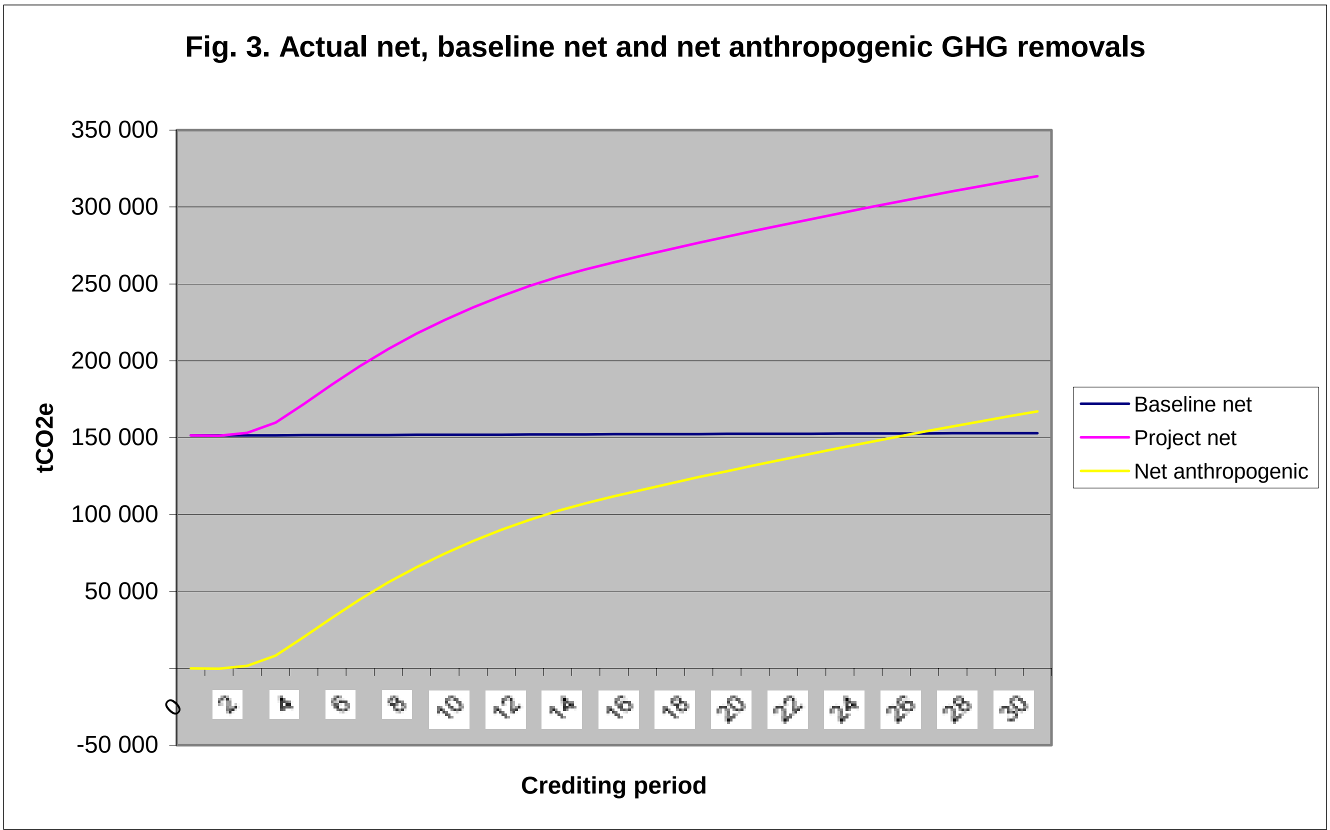
The exact number and location of sampling plots will be determined by Corporación EcoPar in the first year of field monitoring, taking into account the variability of terrain and the locations of areas under different planting schedules.

Mr. Jan Fehse of EcoSecurities Ltd. determined the CDM Monitoring Methodology to be applied by this project.

SECTION D. Estimation of net anthropogenic GHG removals by sinks:

D.1. Estimate of the actual net GHG removals by sinks:

The project's actual net GHG removals by sinks are estimated to be 320,117 tCO_2 over 30 years (See Figure 1 and Section D.5).



D.2. Estimated baseline net GHG removals by sinks:

The project's baseline net GHG removals by sinks are estimated to be 153,011tCO_2 over 30 years (See Figure 1 and Section D.5).

D.3. Estimated leakage:

Leakage is estimated to be zero. Any emissions from fuel consumption outside the project boundary are internalized in the total fuel use (see also the Monitoring Plan in Section C).

D.4. The sum of D.1 minus D.2 minus D.3 representing the net anthropogenic GHG removals by sinks of the proposed A/R CDM project activity:

The project's net anthropogenic GHG removals by sinks are estimated to be 320,117 – 153,011 = 167,106 tCO_2 over 30 years (See Figure 1 and Section D.5).

D.5. Table providing values obtained when applying formulae above:

Table 2: Actual, baseline and net anthropogenic GHG removals

Year	*Actual net GHG removals (tCO2)*	*Baseline net GHG removals (tCO2)*	*Net anthropogenic GHG removals (tCO2)*
0	151,432	151,432	0
1	151,206	151,443	-237
2	153,131	151,476	1,656
3	159,821	151,531	8,291
4	171,890	151,586	20,305
5	184,509	151,640	32,869
6	196,581	151,695	44,886
7	207,584	151,750	55,834
8	217,568	151,805	65,763
9	226,584	151,860	74,724
10	234,720	151,915	82,805
11	242,070	151,969	90,100
12	248,642	152,024	96,617
13	254,409	152,079	102,330
14	259,450	152,134	107,316
15	264,064	152,189	111,875
16	268,415	152,244	116,171
17	272,597	152,298	120,298
18	276,662	152,353	124,309
19	280,641	152,408	128,233
20	284,550	152,463	132,087
21	288,396	152,518	135,878
22	292,180	152,573	139,608
23	295,904	152,627	143,277
24	299,565	152,682	146,883
25	303,161	152,737	150,424
26	306,691	152,792	153,899
27	310,152	152,847	157,305
28	313,544	152,901	160,642
29	316,865	152,956	163,909
30	320,117	153,011	167,106

See Annex 3 for more detailed results of the baseline study.

SECTION E. Environmental impacts of the proposed A/R CDM project activity:

E.1. Documentation on the analysis of the environmental impacts, including impacts on biodiversity and natural ecosystems, and impacts outside the project boundary of the proposed A/R CDM project activity:

The project, in principle, should have few or no negative environmental impacts, given its objectives, design and location. The project aims to replace exotic pasture land with highly diverse plantations of native tree species. These will be maintained for at least thirty years without any harvest, and should serve to buffer, connect and expand adjacent patches of neighbouring forest.

The project developers have conducted a preliminary review of the project's environmental and social impacts during this project design phase based on the "Community, Conservation and Biodiversity Project Design Standards" (Climate, Community and Biodiversity Alliance, 2005). These standards are the product of an ongoing peer-reviewed process to develop a quantifiable mean for identifying projects with clear, verifiable triple benefits for climate, local communities and biodiversity conservation. The standards are being developed under the auspices of the Climate, Community and Biodiversity Alliance, a corporate/non-governmental organization partnership including Conservation International, the Nature Conservancy, the Hamburg Institute of International Economics and Pelangi. The CCB standards are also being reviewed by the Tropical Agricultural Research and Higher Education Center (CATIE), the World Agroforestry Center (ICRAF) andthe Center for International Forestry Research (CIFOR). For this exercise the 2.1 Draft (10 January 2005) was applied. The most recent version of the standards can be downloaded from www.climate-standards.org

Baseline at the Project Site: Overview of pertinent biodiversity attributes in the absence of project
The project activity is located at the western foothills of the Andes in Ecuador between two global 'hotspots' of biodiversity (Choco-Western Ecuador and the Tropical Andes) and has representative characteristics of both bioregions, making it a hyperdiverse region for both flora and fauna. This is due to the combination of the Andes cordillera and equatorial location, which creates a great diversity of habitat heterogeneity and microclimatic variation, resulting in not only high rates of diversity, but also high rates of endemism (>20%). It was characterized by Dr. David Neill as the most well-studied Reserve in the western Andes, and Dr. Alwyn Gentry described it as conservationally significant due to its preservation of pristine cloud forest in close proximity to urban centers. Despite numerous scientific studies at the Reserve, new species of flora and fauna are still found every year, many new to the Reserve and some new to science.

The specific sites to be reforested are dominated by aggressive pasture grasses, originally of African origin, primarily *Setaria sphacelata*. These pastures have very limited biological diversity, are exceedingly slow to regenerate to natural forest and generally act as barriers to dispersal by forest-dependent birds and mammals.

These reforestation sites, however, are adjacent to exceedingly species-rich natural forest, including both areas in primary and secondary growth. These Choco/Andean forests are home to over 1700 species of vascular plants (Webster and Rhode, 2001) and over 55 species of mammals (possibly up to 77 species). Three hundred and forty seven species of birds, 20% of Ecuador's bird fauna have also been reported for the Maquipucuna Reserve (as of August, 2004, based on studies of James Andrews, J. M. Carrión, D. Gardner, L. Kiff, M. Marín, Francisco Sornoza, Niels Krabbe, Paul Greenfield, F. Sarmiento, Niall O´Dea, and Francisco Prieto).

According to the classification of Harling (1979), this area could be called 'cloud forest', a term commonly used for areas across Tropical America, but that should be divided into two categories of 'lower montane wet forest' and 'high montane cloud forest. The first of these two covers the majority (80%) of the Reserve, from 900-2500 masl and is the vegetation type on the north side of the Reserve where the reforestation areas are located. The high montane cloud forest occupies the highest areas of the Reserve (2,500-2,900 masl).

In the absence of the project, much of the adjacent forest areas would be maintained and protected by the Maquipucuna Foundation. Approximately 6,000 has are protected by the Maquipucuna Foundation, while a larger contiguous area of forest is owned by local farmers. Though portions of this surrounding forest are protected by law, it is likely that deforestation will continue.

Conservation plan

Project Conservation Goals

The project aims to reforest 468 hectares, increasing the area of forest under conservation management by the Maquipucuna Foundation. Given their proximity to natural forest, these reforestation areas should be rapidly enriched by dispersal of plants and animals from adjacent areas, rapidly increasing biological diversity form the relatively limited suite of species initially planted.

These new areas will contribute to increasing the altitudinal gradient covered by existing primary and secondary forests (currently 1200-2800 m, extending down to 1000 m with the project), reduce edge effects on natural forest, and expand habitat and population sizes for native plant and animal species.

Active engagement and ongoing presence by Maquipucuna personnel in these reforestation areas will also serve to improve control from encroachment and other threats on adjacent areas of natural forest.

Threats to biodiversity

The principal proximate threats to biodiversity in the area include:

- Deforestation associated with the expansion of agriculture.
- Illegal hunting, especially of the endangered Andean spectacled bear (*Tremarctos ornatus*), but also of large rodents (*Agouti paca, Dasyprocta punctata*), collared peccary (*Pecari tajacu*), howler monkeys (*Alouatta palliata*), and birds (guans, toucans).
- Logging, especially high-grading of valuable hardwoods.

These threats will be mitigated in the immediate area of the reforestation project. In the longer term, the experience gained and demonstrated by Maquipucuna in CDM-financed reforestation will serve as a model and platform to develop further community-based projects that should serve to significantly expand forest cover, enhance biodiversity values and reduce threats.

Table 3: Summary of Threats and Project Contribution to Mitigation

Threat	**Project Contribution to Mitigation**
Deforestation	Project will contribute to expansion of 500 hectares of forest area; Presence by project personnel will serve to control threats and incursions into adjacent Reserve areas.
Illegal hunting	Increased presence of project staff will help reduce hunting pressures in adjacent areas of natural forest; Expanded habitat area will contribute modestly to improving viability of populations of game animals.
Logging	Project will have little short-term impact on logging activity in the region, though project presence will contribute to control of illegal hunting in neighbouring forests; In future years, reforestation techniques will serve as platform for future replication with farmers and communities, providing long-term alternative sources of timber.

Strategies

Spatial design of the plantations is a key factor in maximizing biodiversity benefits. The fact that all reforestation areas are contiguous with existing natural forest means that they will contribute most effectively in terms of connectivity, buffering and potential for enrichment from natural seed sources.

In addition, these reforestation areas will be integrated into the broader activities of the Maquipucuna Reserve, particularly control. The project includes resources to equip and train guards to protect the project boundary and adjacent natural forests. These guards will be selected from local community members with an interest in conservation and as such will simultaneously serve as outreach educators.

Not harming threatened species

Plants: There are 51 endemic orchids within the borders of the Reserve, 32 of which are classified by the IUCN as vulnerable. However there are also over 55 unnamed species currently on the Reserve's orchid list, any one of which are likely rare or endemic, several of which are likely new to science. Expansion of forest areas will increase potential habitat and reduce edge effects, potentially contributing to species survival.

Mammals: The following threatened mammal species are found in the project area, based on the IUCN Red List for Ecuador.

Table 4: Threatened Mammal Species of the Project Area

Chironectes minimus	Water possum	Near Threatened
Caluromys derbianus	Central American Woolly Possum	Near Threatened
Mazama rufina	Little red brocket deer	Near Threatened
Leopardus tigrinus	Oncilla	Vulnerable
Puma concolor	Puma	Vulnerable
Nasuella olivacea	Mountain coatimundi	Insufficient data
Tremarctos ornatus	Andean spectacled bear	Endangered
Alouatta palliata	Howler monkey	Vulnerable
Cabassous centralis	Northern Naked-Tailed Armadillo	Near threatened

All species indicated would have habitat and populations potentially enhanced by reforestation; none would in any way be impacted negatively by project activities.

Birds: The following species of rare, range-restricted or threatened birds reported for the Reserve and were the basis for BirdLife International's recognition of this as an "Important Bird Area". It should be noted that not all species are found at the lower elevations (1000-1500 masl) of the project site

Table 5: Rare, range-restricted or threatened birds of Maquipucuna

Scientific Name	Common Name
Merganetta armata	Torrent Duck
Tigrisoma fasciatum	Fasciated Tiger-Heron
Egretta thula	Snowy Egret
Bubulcus ibis	Cattle Egret
Butorides striatus	Striated Heron
Accipiter collaris	Semicollared Hawk
Leucopternis plumbea	Plumbeous Hawk
Morphnus guianensis	Crested Eagle
Oroaetus isidori	Black and chestnut Eagle
Penelope montagnii	Andean Guan
Aburria aburri	Wattled Guan
Odontophorus melanonotus	Dark backed Wood Quail
Columba goodsoni	Dusky Pigeon
Leptotila pallida	Pallid Dove
Pionus chalcopterus	Bronze winged Parrot

Glaucidium nubicola	Cloud forest Pygmy Owl
Phaethornis yaruqui	White whiskered Hermit
Urosticte benjamini	Purple bibbed Whitetip
Heliodoxa imperatrix	Empress Brilliant
Coeligena wilsoni	Brown Inca
Boissonneaua flavescens	Buff tailed Coronet
Heliangelus strophianus	Gorgeted Sunangel
Haplophaedia lugens	Hoary Puffleg
Aglaiocercus coelestis	Violet-tailed Sylph
Micromonacha lanceolata	Lanceolated Monklet
Capito squamatus	Orange-fronted Barbet
Semnornis ramphastinus	Toucan Barbet
Aulacorhynchus haematopygus	Crimson rumped Toucanet
Andigena laminirostris	Plate billed Mountain Toucan
Ramphastos brevis	Chocó Toucan
Campephilus gayaquilensis	Guayaquil Woodpecker
Thripadectes virgaticeps	Streak capped Treehunter
Thripadectes ignobilis	Uniform Treehunter
Myrmeciza nigricauda	Esmeraldas Antbird
Grallaria gigantea	Giant Antpitta
Grallaria alleni	Moustached Antpitta
Grallaria flavotincta	Yellow breasted Antpitta
Scytalopus vicinior	Nariño Tapaculo
Scytalopus spillmanni	Spillmann´s Tapaculo
Uromyias agilis	Agile Tit-Tyrant
Ampelioides tschudii	Scaled Fruiteater
Cephalopterus penduliger	Long wattled Umbrellabird
Machaeropterus deliciosus	Club winged Manakin
Cyanolyca turcosa	Turquoise Jay
Cyanolyca pulchra	Beatiful Jay
Cyclarhis nigrirostris	Black billed Peppershrike
Entomodestes coracinus	Black Solitaire
Turdus maculirostris	Ecuadorian Thrush
Cinnycerthia unirufa	Rufous Wren
Diglossa lafresnayii	Glossy Flowerpiercer
Diglossa humeralis	Black Flowerpiercer
Chlorophonia flavirostris	Yellow collared Chlorophonia
Chlorochrysa phoenicotis	Glistening green Tanager
Tangara rufigula	Rufous throated Tanager
Tangara heinei	Black capped Tanager
Tangara vitriolina	Scrub Tanager
Anisognathus notabilis	Black chinned Mountain Tanager
Chlorothraupis stolzmanni	Ochre breasted Tanager
Chlorospingus semifuscus	Dusky Bush Tanager
Saltator atripennis	Black winged Saltator

Native versus Non-Native Species

The project will reforest only with native species in order to complement and expand coverage of natural forest.

Helping Threatened, Rare & Endemic Species

Inasmuch as the threatened, rare and endemic species of the area are primarily forest species, the establishment of plantations analogous in species and structural terms to the natural forest will increase habitat and population viability.

Long-term monitoring will be required to evaluate the extent to which plant and animal species are dispersing to these plantation areas and exploiting this new habitat and resources.

Water Resources

The Maquipucuna Reserve and adjacent areas for reforestation lie within the upper watershed of the Guayllabamba River watershed.

The main rivers draining the area include the Umachaca, Santa Rosa, Tulambi, Pichán and Afilana rivers, which together drain into the Alambi river, which in turn feeds the Guayllabamba. Deforestation and pollution from human settlements are the two main threats to water resources in the region.

There is limited hydrological baseline data available for these areas. There is considerable international and academic debate on how land use and land-use change in general impact water resources, and especially regarding the impacts of forests and reforestation (see Bruijnzeel, 2004 for a comprehensive review). Re-establishment of forests on these deforested areas should in the medium term contribute to stabilization of flow regimes, increased capture of horizontal precipitation and reduced erosion and sedimentation.

Long term monitoring will be required to quantitatively evaluate these impacts. Given the relatively limited areas to be reforested in each catchment it is unlikely that effects will be easily discernable, but should tend to be positive. A preliminary study of the effects of land use on aquatic ecosystem health in small headwater streams within the Maquipucuna Reserve, found lower suspended solids and turbidity, and lower nitrate levels in primary and secondary forest as compared to grazed and abandoned pastures (Thom, 2000). Reforestation should thus contribute to improving these water quality parameters.

Project Location

The project is located in an area defined as a priority in both national and international conservation and biodiversity analyses:

- The project activity lies at the interface of two of Conservation International’s global “hotspots” for biodiversity conservation: the Tropical Andes and the Chocó-Darién-Western Ecuador Hotspots.
- BirdLife International identified the area as one of its Important Bird Areas, based on avian diversity and endemism.

- Dinerstein et al (1995) identified the montane forests of the northwestern Andes (Ecuador and Colombia) as "Vulnerable, Globally Outstanding, and Highest Priority at Regional Scale."
- Ecuador's Ministry of Environment, in its most recent strategy and policy framework document highlighted this area of northwest Ecuador as one of the top five conservation priorities in the nation.

Other Issues

The CCB standards focus largely on biodiversity and climate, though not on other potentially important environmental issues. Given the scale and nature of this project, impacts will tend to be small-scale and positive, but the following additional areas bear consideration.

Chemical and fertilizer use

The project will use small amounts of chemical fertilizer (50 Grams of NPK fertilizer (18% N) for every tree planted.) Small amounts of nutrients on a one-time basis at planting should be largely taken up by growing trees and should not generate soil or water impacts.

The project proponents do plan to use a preplanting application of herbicide (glyphosate) in order to temporarily eliminate the pasture grasses in the planting lines. This herbicide will be applied with backpack sprayers.

Given the rapid degradation of glyphosate and the fact that it will be applied in strips over a portion of the area, significant soil and water impacts are unlikely.

Waste management

During plantation establishment and the first few years of maintenance relatively large numbers of workers will be needed.

Maquipucuna will develop mechanisms for handling solid waste generated by the project as well as for dealing with human waste.

To the extent that machinery is used (e.g. motorized brush cutters), provisions must also be made for handling fuel and spent oil.

Prior to implementation Maquipucuna will develop protocols and training to address these issues.

Soil impacts

Soil impacts are likely to be minimal and positive. The project does not envision any mechanical site preparation or earth moving. Excavation will be limited to small (40 cm x 40 cm) holes dug for tree planting. Site will maintain vegetation cover during all stages of site preparation, planting and maintenance, thus minimizing any erosion risk. The fact that the project does not include a harvest component means that there will be no soil damage from extraction, nor export of nutrients from the project site.

Fire

Fires are not a risk in this humid area of the Andean foothills. There is no historic record of extensive forest fires in natural forests in this area.

Pests and diseases

Pests and diseases do not represent significant risks to project benefits, nor is the project likely to generate risks in this regard. The use of native species and locally produced seed minimizes the risk of introducing new pests or pathogens. The highly diverse mixed-species reforestation of the project minimize risks of disease affecting the integrity of the reforested areas overall. If disease and pests affect some individuals or species within the mix, the use of species from different genera and families in a mixed array should effectively impede the possibility of the entire forest area suffering damage or mortality.

E.2. If any negative impact is considered significant by the project participants or the host Party, a statement that project participants have undertaken an environmental impact assessment, in accordance with the procedures required by the host Party, including conclusions and all references to support documentation:

No significant negative impacts.

E.3. Description of planned monitoring and remedial measures to address significant impacts referred to in section E.2. above:

No significant negative environmental impacts.

SECTION F. Socio-economic impacts of the proposed A/R CDM project activity:

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F.1. Documentation on the analysis of the socio-economic impacts, including impacts outside the project boundary of the proposed A/R CDM project activity:

Socio-economic aspects of the project have been evaluated using the Climate, Community and Biodiversity Standards, in particular the criteria and requirements for community and relevant cross-cutting issues (Climate, Community and Biodiversity Alliance, 2005).

Overview of communities located near the project site

The project will be carried out within the Parish of Nanegal, within the Quito Metropolitan District. The area is rural, with virtually all families deriving their income from agriculture, cattle, sugar cane processing (small-scale distilleries or sugar cake production), and ecotourism..

Nanegal has a total population of 2,560, according to 2001 census data. Some key socio-economic indicators are summarized in Table 6:

Table 6: Summary of Socio-economic Indicators for Project Area

Literacy	82.7%
Percentage of population having completed primary school	49.5%
Percentage of population having completed secondary school	5.3%
Access to electricity (percentage of households)	61.2%
Population below poverty line	85%

The population is disperse with small settlements including Santa Marianita, Nanegal, La Delicia, Palmitopamba, Chacapata, La Perla and Playa Rica. The project will depend on local workers for virtually all the reforestation work in order to provide additional community benefits in the form of employment and income, as well as to train and familiarize interested local families in reforestation techniques. It is the aim of the project, after this initial phase on Maquipucuna properties to expand project activities with interested communities and families.

With the intervention of Fundación Maquipucuna, over the past 12 years ecotourism has emerged as an important economic activity for the communities of Santa Marianita, La Delicia, and Yunguilla. The Ecotourism program has received two prestigious international awards (Ecotourism Showcase 2000 and the Skal 2003) for its contribution to conservation of biodiversity and the sustainable development of the communities. The carbon activity will serve as a showcase and may add to the attraction by tourists.

In other nearby communities coffee was an important activity a few decades ago. About 8 years ago, the World Bank and the government of Ecuador intervened to revive coffee. Other communities by their own initiative are planting coffee or cleaning their coffee parcels. For example La Perla has planted over 30 ha of coffee in the past two years. Fundación Maquipucuna is assisting coffee farmers with processing, marketing, and with technical assistance to obtain organic bird-friendly (shade-grown) certification. Farmers are producing organic, shade-grown, gourmet quality coffee that has sold at 4 times higher prices than market value.

Describe current land use and tenure in the project site and surrounding areas

The project site itself is property of the Maquipucuna Foundation. The areas to be reforested are divided in 8 discrete but contiguous properties, purchased by Maquipucuna between 1992 and 2001. This land has clear and established title from the Maquipucuna Foundation, as certified after due diligence by the Ecuadorian law firm Paz & Horowitz.

The areas to be reforested are currently covered by the land uses indicated in Table 7.

Table 7: Current land cover of project reforestation areas

Land cover	Area (has)	Comments
Sugar cane fields	11.91	Annual production sold as standing cane for alcohol and sugar cake production
Pasture	342.82	Used for grazing cattle of Maquipucuna employees (42 head) and renters (5 head)
Abandoned pasture	113.47	Pasture in arrested succession, with some regeneration of Piper sp.

In the surrounding areas, the landscape is dominated by pastures, sugar cane and forest. The forest is largely restricted to the Maquipucuna Reserve and the Protected Forest Guayllabamba.

Most of the area was cleared 30-40 years ago, although Nanegal is an old settlement dating back to the early 19th century, and where sugar cane was the dominant land use. Landholdings are generally long-established and land tenure relatively clear as well. Medium-sized farms of 20-100 hectares are the norm.

Land tenure issues (non-encroachment on private, government or communal property)
This project, as already mentioned, would take place on lands clearly titled to Maquipucuna and would not entail any encroachment issues.

Defining & Engaging Community Stakeholders

Given that the project will take place in areas within Maquipucuna's Reserve, there are few community stakeholders in this phase of the project. Nevertheless a public information and stakeholder consultation meeting was held, as documented in Section G, and the project will continue to provide information and engage community members during implementation.

Worker Safety

The project entails minimal risks to worker health and safety, inasmuch as it is a manual reforestation project with no harvest component. During the implementation phase, training will be included regarding:

- Proper operation and protective equipment of brushcutters
- Proper safety precautions, handling and protective equipment for application of herbicide

Maquipucuna and Jatun Sacha will provide training and information to work crews for all relevant phases of planting and maintenance.

Transparency

Project documentation, including the Project Design Document, evaluations, progress reports and responses to grievances will be kept on file and publicly available at the following locations:

- Designated National Authority for the CDM (AN-MDL) in Quito
- Technical Office, Ministry of the Environment, Nanegalito
- Community Center, Santa Marianitas

Key project documents will be translated into Spanish.

Employing Stakeholders in Project Management

Technical and operational management of the project will be by Fundación Maquipucuna and Fundación Jatun Sacha staff. Additional community members will be involved in seed collection, plant propagation, planting and maintenance, although not in project management as such.

Community outreach

The Maquipucuna Foundation has an excellent and long-standing relationship with local communities and a permanent presence in the area, both at their reserve and ecotourism operation and through projects in all the surrounding communities. Maquipucuna also runs a training center in Marianitas where people from surrounding communities receive training.

Maquipucuna will promote the project in the communities of Palmitopamba, Chapacata, Nanegal and Santa Marianita. It will train a group of local people and will select the best to work in the project.

Maquipucuna will continue searching for funding opportunities to develop a community based CDM reforestation project to transform pastures with organic gourmet coffee and native bamboo (Guadua angustifolia).

Stakeholder Grievances

All Maquipucuna staff working in the area will be instructed to make note, in writing, of grievances that may arise. These will be considered, addressed and answered in writing within 30 days.

The project will hold an annual field day inviting community members as well as government authorities to visit the project and review progress. These meetings will also serve to identify and receive comments and potential grievances.

Other issues

The CCB Standards place considerable emphasis on questions of process in order to engage, inform and respond to community stakeholders. In addition to the criteria mentioned above, a reforestation project may also have positive or negative impacts on livelihoods, income and access to resources.

- ***Employment and income***

The project will have a moderate but positive impact on employment and income in the project area. During the first five years of reforestation establishment, the project will employ 20-30 members of local communities for seed collection, plant propagation, planting and maintenance on a nearly full-time basis. Wages will be at least the legal minimum with all officially required benefits.

Employment will have a positive economic impact on participating community members and their families. Given the relatively small number of workers that will be involved in the project it should not lead to inflationary pressures or other broader economic impacts in the communities neighboring the project.

- ***Access to resources***

The areas to be reforested by the project are not currently supplying critical resources to community stakeholders. A portion of the area currently in pasture is rented out on an occasional basis to neighboring cattle owners. However, the conversion of these areas to reforestation should not have livelihood impacts for the cattle owners nor economic impacts in the broader project area given the surfeit of under exploited pasturelands in the area.

F.2. If any negative impact is considered significant by the project participants or the host Party, a statement that project participants have undertaken a socioeconomic impact assessment, in accordance with the procedures required by the host Party, including conclusions and all references to support documentation:

No significant negative impacts.

F.3. Description of planned monitoring and remedial measures to address significant impacts referred to in section F.2 above:

No significant negative impacts.

SECTION G. Stakeholders' comments:

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G.1. Brief description of how comments by local stakeholders have been invited and compiled:

A stakeholder workshop was held with community leaders and representatives in the village of Santa Marianita on 28 January, 2005, 14h00-18h00. Community leaders were identified and invited based on Maquipucuna's longstanding (15+ years) relationships and presence in the project area. Invitations were made in writing with follow-up visits to promote attendance.

The meeting served to provide basic information regarding climate change and the CDM, present details of the proposed project and its impacts, and to have an extensive discussion regarding the project's design.

G.2. Summary of the comments received:

Comments and questions were discussed regarding different aspects of the project. These are summarized below, approximately in the order that community representatives expressed them:

- Reforestation is an important activity for this area since it protects water sources which have been declining, provides habitat for plants and animals, and because forests are an important attraction for ecotourism in Nanegal.

- How much carbon can these forests sequester? When do they sequester most? (Response: These plantations are expected to sequester approximately 300 T-CO_2/hectare over 30 years. They will begin capturing carbon as soon as the trees begin to grow).

- While the reforestation strategy – creating mixed plantations without harvest for conservation purposes – may be interesting for Maquipucuna on their lands, reforestation with farmers would have to be designed differently. Large blocks of conservation forest would not be attractive to most farmers on their lands since these areas currently provide their primary income. Alternatives proposed included:
    - Other commercial species, including exotics (teak, gmelina, eucalyptus, bamboo/guadua);
    - Harvest of some products for fence posts or timber;
    - Different planting arrangements that aren't pure plantations, for example, agroforestry systems with coffee, living fence rows, dispersed shade trees in cattle pastures.

- CI and Maquipucuna indicated that they hope that this first block of approximately 500 hectares on Maquipucuna's lands serve as an experience that will lay the groundwork for developing future CDM projects with communities and farmers in the area.

- Does the CDM provide any incentives to protect existing forests? (Response: Unfortunately, no).

- Would guadua (a native bamboo) be a good alternative for this sort of project? (Response: It can certainly be considered. Species has good growth rates, multiple uses and provides good watershed protection, however it sequesters less C per area than trees.).

- Could the project provide some free or low-cost trees from their nurseries to community members who want to plant on their lands?

- While some participants indicated that the project should include more exotic species which grow much better than the native species proposed, others stated that the choice of native species is a good one, and that these should perform well in local conditions. Guaba (*Inga spp*.) is very good for eliminating aggressive grasses and fixes nitrogen. Nogal (*Juglans neotropica*) has pest problems. Project should make sure to plant in mixed stands with other species.

- Bracciaria and pasto miel (*Setaria sphacelata*), are very aggressive and hard to eliminate by hand. The project should consider applications of herbicide (only Roundup, not gramoxone) at least 3 times to allow the trees to develop adequately.

- Seed availability may be a problem for some species. Maquipucuna should make sure to carefully evaluate calendar for seed production and availability, and should also evaluate the need to get special tree-climbing equipment to gather some sorts of seeds.

- Maintenance and planting schedule proposed by Maquipucuna looks appropriate based on farmers' experience and the average yield of labor for these tasks.

- It would be good for the project to try to integrate other participants, especially local schools.

- This project is an important contribution to development of the community. The local Parish Board is interested in development that goes beyond typical works in bricks and mortar. Conservation International is interested in helping to support the Board's efforts to develop a Development Master Plan for the community.

G.3. Report on how due account was taken of any comments received:

- Project will guarantee availability of some free or low-cost trees to farmers interested in planting on their lands.
- Efforts will be made to continue to integrate local authorities, community members and schools in reforestation efforts (especially seed collection).
- Future phases of this project, working with local farmers, will need to identify mixed reforestation strategies that integrate conservation and income benefits for participants.
- A systematic approach for receiving comments from stakeholders on this project will be established through bi-annual meetings with the local communities.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROPOSED A/R CDM PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funds will be used for the proposed CDM project activity.

Annex 3

BASELINE INFORMATION

1. Baseline economic data explanation

An overview and comparison of economic parameters for the three identified candidate baseline land uses is given in Table 1.

Table 1. Comparison of economic parameters for the three candidate baseline land uses.

Candidate Baseline Land Use	*Investment required for establishment ($/ha)**	*Recurrence of investment**	*Time before first revenues (months)**	*Net revenues ($/ha/yr)**	*Management/workload required**
Sugarcane	2,500	Every 20 years	18	442	High
Pastures	300	Once-off	5	280**	Low
Abandoned pastures	0	Once-off	N/A	0	None
Conservation reforestation	1,478	Once-off	N/A	0	High in first 6 years, none thereafter

* Data from Maquipucuna Foundation records.
** Assuming 2 heads of cattle per ha.

2. Model description - Ecosecurities' ECO_2Forestry model - modelling concepts

Units and baselines

A project within dECO_2 consists of a number of *Units*. Each unit represents a type of ecosystem under a specified management regime, and covers an indicated area of land. Units can be *project units*, or *baseline units*. The baseline units comprise the pre-existing vegetation and management system. The project units define the species and management system to be adopted under the project. There is a 1:1 correspondence between project units and baseline units. That is, each project unit will have a defined baseline unit of the same area.

dECO_2 gives detailed outputs for carbon sequestration by species components and carbon pools for each project and baseline unit as a series of graphs and tables.

In most cases, large projects will not be established in a single year, but will involve the progressive conversion of the baseline land use to the project over a number of years. dECO_2 allows the total unit area (*eg*.. 10,000 ha) to be converted over a fixed period (*eg*. 20 years). Output graphs show both the per ha carbon pools and those for the whole project over time. The difference between the baseline and the project can be shown in two ways:

- **By conversion**. In this case the total unit area is shown from the start of the project, and is assumed to be converted progressively from the baseline to the project vegetation and management system.

- **By establishment**. In this case the unit area is assumed to increase by fixed amounts each year up to the stipulated maximum. The net sequestered carbon is shown as the difference between the project and baseline units of the same areas, each comprising a mosaic of equal annual age classes.

In each case, the net sequestered carbon will be the same. The total carbon for the project and the baseline will differ according to the area assumptions. The first method is appropriate for conversion of a large area of natural forest to a new management system. The second method is more suitable when establishing plantations.

Vegetation types and management systems

dECO_2 is configured to work with three basic types of model for vegetation growth and interaction through competition and shading. These three basic types can occur together in a single ecosystem. They are:

- **Planted tree species**. These may be forest plantations, or tree crops such as coffee or cocoa which are planted. Within the model, plantation crops have an age parameter, and a rotation. Trees can be felled and re-planted at the end of the rotation. Importantly, harvesting operations are specified relative to age within the rotation. Growth is handled via a growth model that can be calibrated to correspond to published yield tables or curves. Mortality is handled via a life-expectancy function that is age-dependent.

- **Natural forest tree species.** These are assumed to be mixed-aged, naturally regenerating groups of species. There is no age within the model for these components, and harvesting operations must be specified relative to the start of the project. A logistic growth model is used that is based on current annual increment, initial volume, and annual mortality rate.

- **Other vegetation species.** This can include any type of shrub, herbs or grasses, and can be used for planted species such as bananas which are difficult to characterise with tree-type biomass parameters. A logistic growth model based on above-ground biomass productivity and maximum biomass is used.

These vegetation types can be established in mixtures. A competition and shading model controls the interaction of the vegetation layers.

Harvesting for trees can be specified in terms of volume or percentage of standing volume. For other vegetation, it can be specified in terms of biomass or percentage of standing biomass.

Harvesting for plantation species must be specified relative to age within the rotation. For other crops, it is given relative to year zero within the unit.

Three special types of harvesting are allowed:

- **A clearing operation**, in which the crop is entirely removed and does not regenerate within the model. This is usually applied to removing a baseline crop within the project unit.

- **A regular annual harvest** can be specified to simulate agricultural cropping of any type. This can also be applied to the gathering of dead wood on the ground as a necromass harvesting operation.

- **A clearfell and replant operation** can be specified for plantation trees.

Each harvesting operation is specified relative to a particular species. Any mixture of different types of harvesting for species is allowed, in the same or in different years.

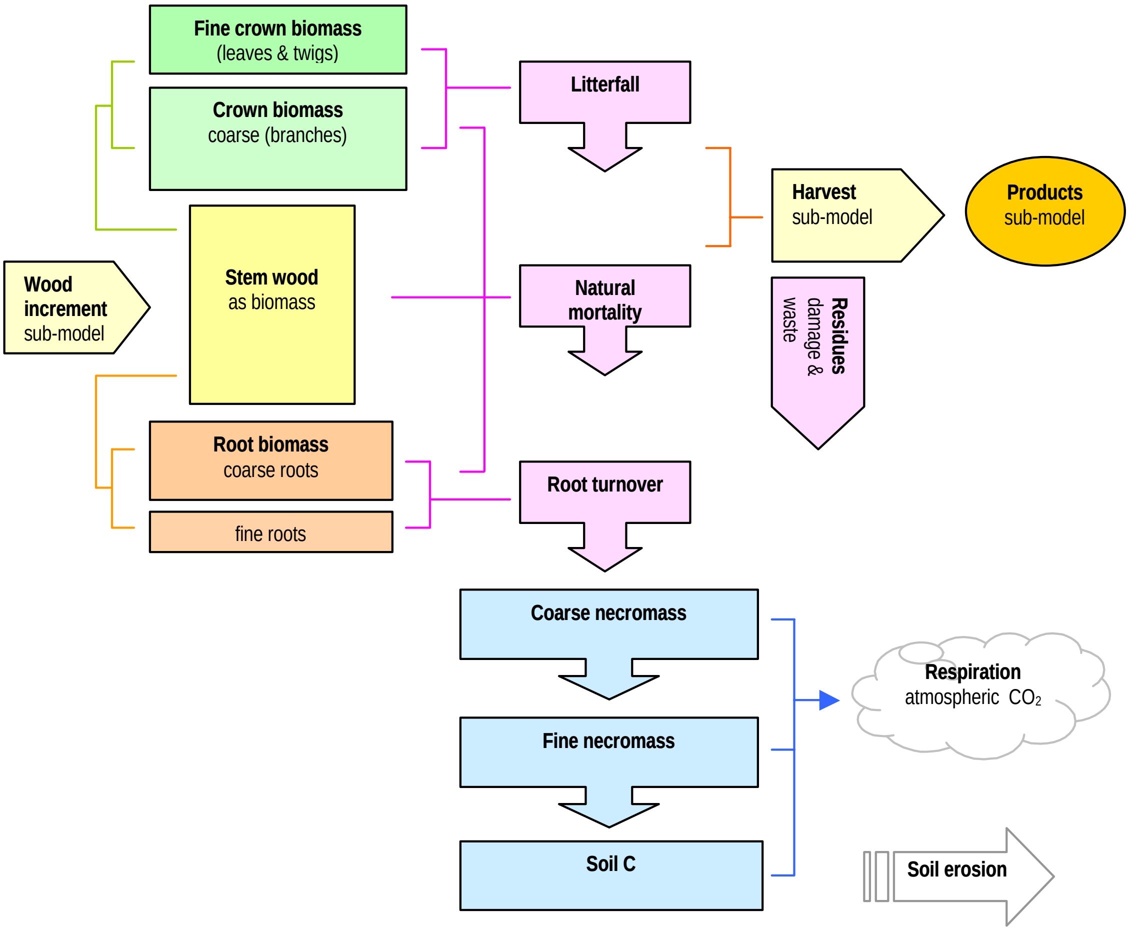
For trees, harvesting normally is assumed to come from stem volume, but a percentage of the crown wood can also be stipulated for harvesting if required.

This mixture of vegetation components and harvesting operations gives a very flexible scheme that can represent almost any type of forestry or agro-forestry situation, including pure agriculture and unmanaged natural vegetation types or conservation scenarios.

The basic carbon model

The diagram below shows the basic carbon model for trees. Increment is calculated in terms of stem volume current annual increment (see **Tree growth models** 165 ページの). This is converted to increment in terms of carbon via the wood density and carbon:biomass ratio coefficients. Crown fine and coarse biomass, and root fine and coarse biomass are then calculated via expansion coefficients. Litterfall is deducted from coarse and fine crown components and added to the coarse and fine necromass pools

Figure 1: Basic structure of the carbon model for tree vegetation



according to the litterfall turnover rate for the species. Root turnover is handled similarly. Natural mortality includes stem wood, as well as coarse and fine crown and root components, all of which are added to necromass, with dead stem wood added as coarse necromass.

Harvested products are removed from the system, except for residues. The roots and crowns of harvested trees are allocated to coarse and fine necromass. Stem residues are allocated to coarse necromass. If a percentage of the crown is harvested, it is deducted from the proportion of the felled tree crowns added to coarse necromass.

Coarse necromass decays to fine necromass at a specified rate, during which a percentage of the decaying material is lost to the atmosphere as respiration. A similar process occurs as fine necromass decays to soil carbon. Soil carbon itself is respired to atmospheric CO_2 at a given rate or is lost from the system due to erosion processes.

The calculations for non-tree components are similar except that there is no separate pool for coarse crown and stem wood. The entire above ground plant is treated similarly to tree crowns. Increment is in terms of above-ground biomass productivity.

These calculations are carried out annually. Separate vegetation pools are maintained for each species within each unit. Separate necromass pools are maintained for each unit.

Tree growth models

Growth of plantation trees is modelled using the modified Schumacher function (Alder, 1980; Stage 1963):

$$V = \alpha.exp(-\beta.t^{-\gamma}) \qquad \{eq.1\}$$

where V is total volume (standing volume plus accrued thinnings) and t is stand age. α,β and γ are coefficients. A growth modelling tool forms part of $dECO_2$ which allows this function to be fitted to supplied yield table data using the mouse

Within $dECO_2$, the derivative of this function is used to calculate increment directly for plantation trees, in the form

$$dV/dt = \alpha\beta\gamma.exp(-\beta t^{-\gamma})/t^{\gamma+1} \qquad \{eq.2\}$$

In the growth modelling tool, control points on the graph define the asymptote, or maximum attainable volume, and the age and value of the maximum mean annual increment. These points can be adjusted to give the α, β and γ coefficients directly because of the following relations:

- The asymptote (maximum value) on the volume-age curve is the α coefficient.
- The γ coefficient is related to maximum mean annual increment ΔV_m at age t_m through:

$$\gamma = -1/\{ln(\Delta V_m.\ t_m/\alpha)+1\} \qquad \{eq.3\}$$

- The β coefficient can then be determined from:

$$\beta = -\ ln(\Delta V_m.\ t_m/\alpha).\ t_m^{\gamma} \qquad \{eq.4\}$$

These calculations are carried out automatically by the growth modelling tool to give the coefficients required for the growth function in the carbon model for plantation trees{eq. 2}.

Growth models for natural forest trees and other vegetation

Natural forest trees use a growth function based on current annual increment (I), and annual mortality rate (m). The relation between CAI and AMR defines a maximum volume assuming a simple logistic growth function, of the form:

$$V_{t+1} = V_t + I - V_t.m \qquad \{eq.5\}$$

At its limit, $V_{t+1}=V_t$, (ie. there is no net volume growth), and therefore:

$$V_{max} = I/m \qquad \{eq.6\}$$

Thus for example, if current annual increment is 6 m^3/ha/yr and mortality is 2%, then the maximum volume will be 6/0.02 or 300 m^3/ha for that species.

For the other vegetation species, there will rarely be information about mortality rates, but there will usually be data on equilibrium biomass and on biomass productivity. Using a variant of equation {6}, the turnover rate (a combination of litterfall and mortality) can be calculated as:

$$r = P/B \qquad \{eq. 7\}$$

where P is the biomass productivity, in t/ha/yr, and B is the equilibrium or maximum biomass.

Data for these simple models are available for many forest and other plant species (*eg.*. Cannell, 1982), whereas more complex models would be difficult to calibrate for many cases.

Competition and shading models

$dECO_2$ has a competition model that influences growth rates and mortality of species depending on the density of competing vegetation layers. This process is controlled by two species coefficients: The *maximum vegetation height* (MVH), and the *shade persistence factor* (SPF). The height index H_i of a vegetation layer is estimated from the following function:

$$H_i = (B_t/B_m)^{1/3}.MVH \qquad \{eq. 8\}$$

where B_t is the current biomass of a species component, and B_m is its asymptotic value. The competition index for a given species is then taken as:

$$C_{i,s} = 1 - \Sigma B_{t,k}/\Sigma f_k.B_{m,k} \qquad \{eq. 9\}$$

where the k subscript indicates any species whose H_i value is greater than the subject species *s*. The *shade persistence factor* (SPF), f_k, can be used to control the light-sensitivity of a species. As f_k tends to zero, the competitive effect is amplified, simulating a more pioneer-type, light demanding species.

This index will be zero if the subject species is overtopped by other species at their asymptotic biomass, or 1 if there are no competing species. It is used to modify calculated increment or mortality as follows:

$$\left.\begin{array}{l}\Delta B^* = \Delta B.C_i \\ m^* = m^{Ci}\end{array}\right\} \qquad \{eq. 10\}$$

where ΔB, m are increment and mortality rate as calculated without competition, and ΔB^*, m* are after competition is allowed for, C_i is the competition index as per equation {9}.

For plantation trees where spacing is controlled and which are managed according to a planned thinning schedule which is implicit in the yield function supplied, the competition model is not applied. This is accomplished in the $dECO_2$ setup by defining a percentage of growing space occupied by the plantation species at canopy closure. In this case growth will follow exactly the supplied yield function.

For natural forest and other vegetation species, the competition model is always applied. However, setting a shade persistence factor (SPF) to 1 or higher will reduce competition effects to a minimum.

Life expectancy and mortality models

Mortality in natural forests and in non-tree species is modelled as a percentage of the current biomass that dies in each year, or *annual mortality rate* (AMR). A constant mortality rate is equivalent to an exponential decay model for the population (Sheil *et al.*, 1995), with the quantity remaining after time t (N_t) being derived from the initial population N_o by:

$$N_t = N_o.exp(-\lambda t) \qquad \{eq.11\}$$

λ is related to AMR by transformation as:

$$\lambda = - ln(1 - AMR) \qquad \{eq.12\}$$

The exponential function in terms of AMR is written as:

$$N_t = N_o.(1 - AMR)^t \qquad \{eq.13\}$$

The exponential function is commonly defined by the *half-life parameter*, which is the time taken for the population to be reduced by half. Half-life and AMR are related by the equation:

$$t_{1/2} = -0.69315/ln(1 – AMR) \qquad \{eq.14\}$$

Any process of decay or turnover described by a constant percentage rate can also be characterised by a half-life. The figure below shows the relationship between half-life and AMR for rates from 1% to 99%, based on equation {14}.

Figure 2: Exponential half-life and Annual Mortality Rate

As well as being true for AMR, these relationships expressed in equations {11} to {14} and the figure above are also true for non-tree vegetation turnover. For non-tree vegetation, litterfall and stem mortality are combined into a single population turnover rate, which is calculated implicitly by the model from the coefficients for maximum biomass and biomass productivity (see equation {7}).

For plantations, another mortality model is used, as a constant mortality rate is inappropriate for even-aged crops. Such crops have a defined life span, which depends on the longevity of the species. For this, $dECO_2$ allows the input of a life span as a range of years (*eg.* 20-30 years). This is interpreted by the model as representing the 5% and 95% points on a cumulative mortality distribution; the intermediate mortality rates are defined by a Weibull function (Bailey & Dell, 1973; Alder, 1995):

$$N_t = N_o.exp(-[t/\alpha]^\beta) \qquad \{eq.15\}$$

The coefficients of the Weibull distribution, α and β, can be calculated from the life span, assuming this represents the 5% and 95% points of the cumulative mortality distribution, via the relationships:

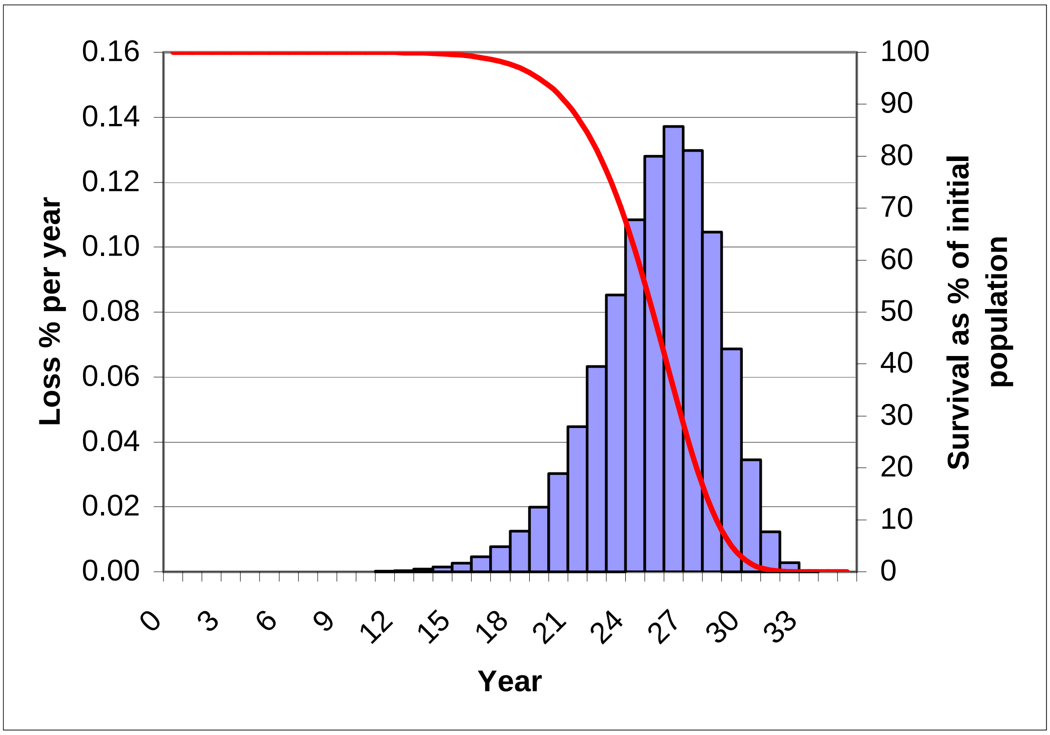
$$\left.\begin{aligned} \alpha &= exp[-ln(t_1) - k_1.ln(t_2)]/[1 - k_1] \\ \beta &= k_2/[\ln(t_1) - \ln(\alpha)] \end{aligned}\right\} \{eq.16\}$$

where t_1 and t_2 are the lower and upper age range defining the tree life span, k_1 is the constant -2.7070961[*] and k_2 is the constant -2.97019525[**].

In the simple case where β=1, then it can be seen that the Weibull function is the same as the Exponential (*cf.* equations {11} and {15} with λ = 1/α). To cater for this, $dECO_2$ allows a single age to be input as the life expectancy, instead of a range. This is then taken as the half-life, and will result in constant annual mortality being applied. For example, a half-life of 68 years is equivalent to 1% AMR (see figure above).

It will be noted that these basic mortality rates will be modified in the model due to competition from

Figure 3: Example of a Weibull function for a life expectancy from 20-30 years
Red line shows residual population [*right axis*]; blue histogram shows annual mortality rates [*left axis*]



taller vegetation layers, as noted by equation {10}.

[*] calculated from *ln*(-*ln*(0.95))/*ln*(-*ln*(0.05))

[**] calculated from *ln*(-*ln*(0.95))

The products sub-model

When a harvest is performed on a species, a number of products may be removed from the forest, say P_1, $P_2,\ldots P_n$. In addition, residues are produced during harvesting, including waste, offcuts etc. left in the forest, and waste produced during wood processing operations. These are symbolised by R_f (forest residues) and R_c (conversion residues) respectively. The total quantity specified for harvesting for that species and year, H will be:

$$H = \Sigma P_i + R_f + R_c \qquad \{eq.17\}$$

The harvest H is determined by the model from the growth function and the harvest level, which may be specified as a percentage of the standing crop or in absolute units of volume or biomass (for non-timber products).

The forest residues R_f are assumed to go directly to coarse necromass. The processing residues are assumed to decay to atmospheric CO_2 within 1 year.

Products can include various types of biomass-based fuels (solid fuelwood, charcoal, sawdust waste recycled for energy during processing, *etc.*). The model treats these as fossil fuel substitutes if they are specified, and requires that a *fossil fuel substitution factor* be specified for them. This factor is the ratio of carbon in the fuel product to the carbon in the fossil fuel which is being substituted, in terms of actual quantities used in the technical systems (boilers, ovens, kilns, *etc.*) in question to achieve a given result. As a first approximation, this may be the ratio of the calorific values.

Fuel products are assumed to be used within one year of production. The model does not allow for their extended storage.

Non-fuel products will decay back to atmospheric CO_2 after a longer or shorter period, depending on their use, via a variety of processes (fungal decay, burning, saprophytic digestion, etc.). Product life expectancy is specified using the same Weibull model as described in equations {15} and {16}. It may be specified as a range of years (*eg.* 5-10) or as a single value (*eg.* 5). In the first case, cumulative decay would be less than 5% up to 5 years, and more than 95% after 10 years, with the Weibull model calculating intermediate decay rates. In the second case, the exponential model would be applied (a constant annual decay rate), with a half-life of 5 years.

Products with a very sharply defined lifespan can be specified using a range such as 9.5-10 years. Life span can be a range less than one year. As noted above, for fuel products, lifespan is automatically assumed to be less than 1 year.

This scheme gives almost complete flexibility to the definition of products, and can allow complex wood processing and agro-forestry processing situations to be simulated.

3. Modeling results

The results of the ECO2Forestry Model are shown in Table 2 (totals) and Figures 4 to 15 (per-hectare results for baseline and project scenarios for the three strata).

Table 2. *Project and baseline stock totals, project emissions and net anthropogenic GHG removals .*

Year	Planted yr 1 (100 ha)	Planted yr 2 (200 ha)	Planted yr 3 (200 ha)	Project total (tC)	Project emissions (tCO2)	Project total minus emissions (tCO2)	Baseline yr1	Baseline yr 2	Baseline yr 3	Baseline total (tC)	Baseline total tCO2	Net anthropogenic GHG removals (tCO2)
0	8 252	16 505	16 505	41 262		151 432	8 252	16 505	16 505	41 262	151 432	0
1	8 218	16 505	16 505	41 228	100	151 206	8 255	16 505	16 505	41 265	151 443	-237
2	8 812	16 436	16 505	41 752	100	153 131	8 258	16 511	16 505	41 274	151 476	1,656
3	9 516	17 623	16 436	43 575	100	159 821	8 261	16 517	16 511	41 289	151 531	8,291
4	10 208	19 032	17 623	46 864	100	171 890	8 264	16 523	16 517	41 304	151 586	20,305
5	10 853	20 417	19 032	50 302	100	184 509	8 267	16 529	16 523	41 319	151 640	32,869
6	11 441	21 706	20 417	53 564		196 581	8 270	16 535	16 529	41 334	151 695	44,886
7	11 973	22 883	21 706	56 562		207 584	8 273	16 541	16 535	41 349	151 750	55,834
8	12 453	23 947	22 883	59 283		217 568	8 276	16 547	16 541	41 364	151 805	65,763
9	12 886	24 907	23 947	61 739		226 584	8 279	16 553	16 547	41 379	151 860	74,724
10	13 277	25 772	24 907	63 956		234 720	8 282	16 559	16 553	41 394	151 915	82,805
11	13 632	26 555	25 772	65 959		242 070	8 285	16 565	16 559	41 409	151 969	90,100
12	13 930	27 265	26 555	67 750		248 642	8 288	16 571	16 565	41 423	152 024	96,617
13	14 196	27 861	27 265	69 321		254 409	8 291	16 577	16 571	41 438	152 079	102,330
14	14 442	28 392	27 861	70 695		259 450	8 294	16 583	16 577	41 453	152 134	107,316
15	14 676	28 884	28 392	71 952		264 064	8 297	16 589	16 583	41 468	152 189	111,875
16	14 902	29 352	28 884	73 138		268 415	8 300	16 594	16 589	41 483	152 244	116,171
17	15 122	29 803	29 352	74 277		272 597	8 303	16 600	16 594	41 498	152 298	120,298
18	15 338	30 244	29 803	75 385		276 662	8 306	16 606	16 600	41 513	152 353	124,309
19	15 550	30 675	30 244	76 469		280 641	8 309	16 612	16 606	41 528	152 408	128,233
20	15 759	31 100	30 675	77 534		284 550	8 312	16 618	16 612	41 543	152 463	132,087
21	15 964	31 518	31 100	78 582		288 396	8 315	16 624	16 618	41 558	152 518	135,878
22	16 167	31 929	31 518	79 613		292 180	8 318	16 630	16 624	41 573	152 573	139,608
23	16 366	32 333	31 929	80 628		295 904	8 321	16 636	16 630	41 588	152 627	143,277
24	16 561	32 731	32 333	81 625		299 565	8 324	16 642	16 636	41 603	152 682	146,883
25	16 752	33 122	32 731	82 605		303 161	8 327	16 648	16 642	41 618	152 737	150,424
26	16 940	33 505	33 122	83 567		306 691	8 330	16 654	16 648	41 633	152 792	153,899
27	17 124	33 881	33 505	84 510		310 152	8 333	16 660	16 654	41 648	152 847	157,305
28	17 305	34 249	33 881	85 434		313 544	8 336	16 666	16 660	41 663	152 901	160,642
29	17 481	34 609	34 249	86 339		316 865	8 339	16 672	16 666	41 677	152 956	163,909
30	17 654	34 962	34 609	87 225		320 117	8 342	16 678	16 672	41 692	153 011	167,106

Note: Species codes in figure legends refer to the codes in the data table below.

Figure 4 Phytomass carbon by species on 1 ha :
Mixed forest planted on pastures in Maquipucuna
Maquipucuna CI

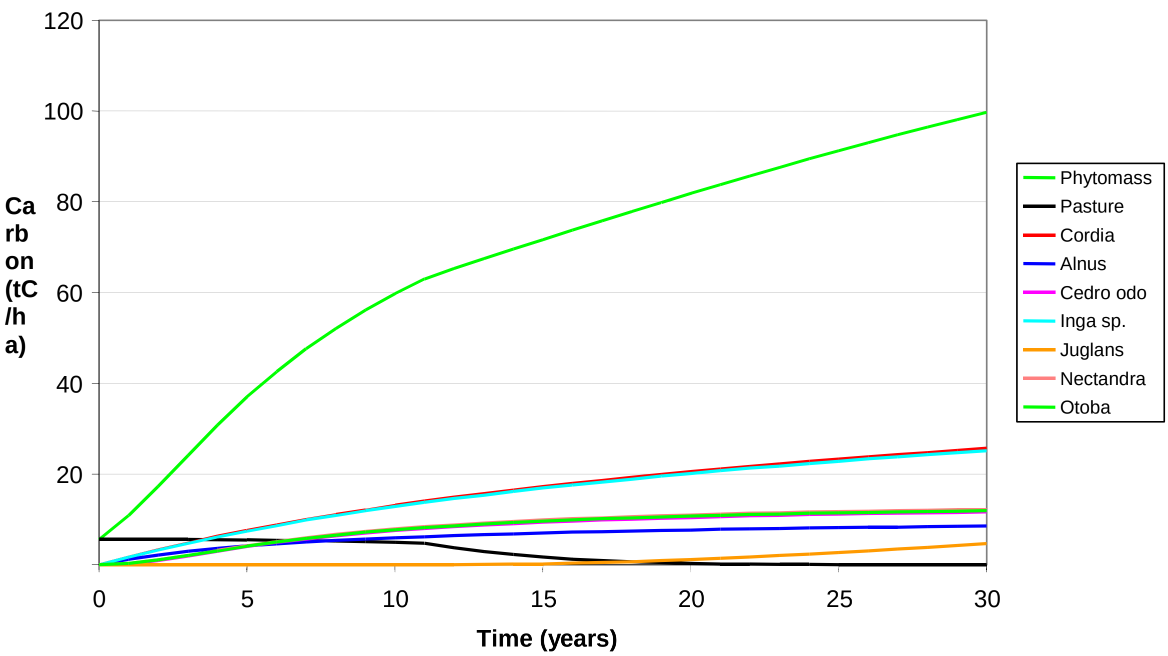


Figure 5 Carbon pool dynamics on 1 ha :
Mixed forest planted on pastures in Maquipucuna
Maquipucuna CI

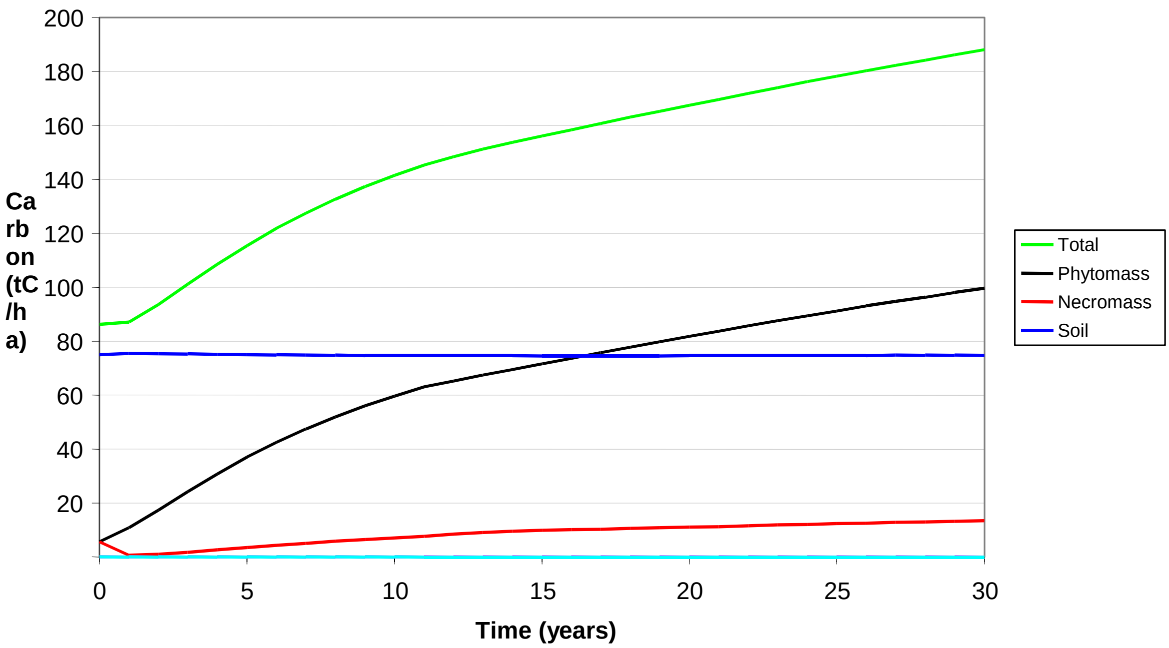


Figure 6 Baseline carbon pool dynamics on 1 ha : Pastures
Maquipucuna CI

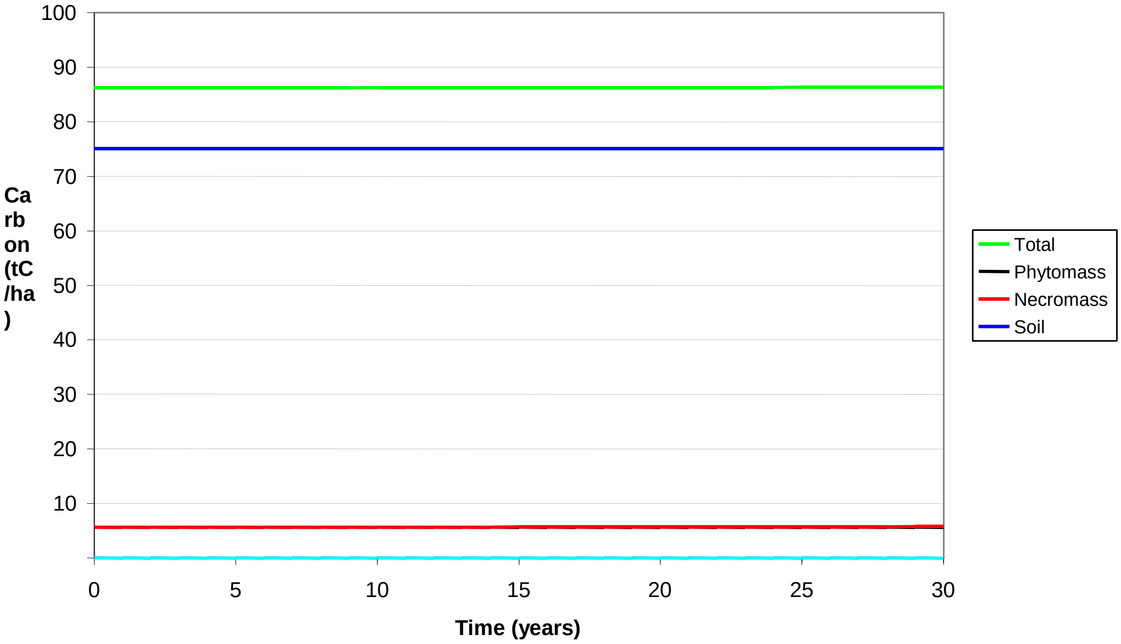


Figure 7 Gross and net sequestered carbon on 1 ha : Mixed forest planted on pastures in Maquipucuna
Maquipucuna CI

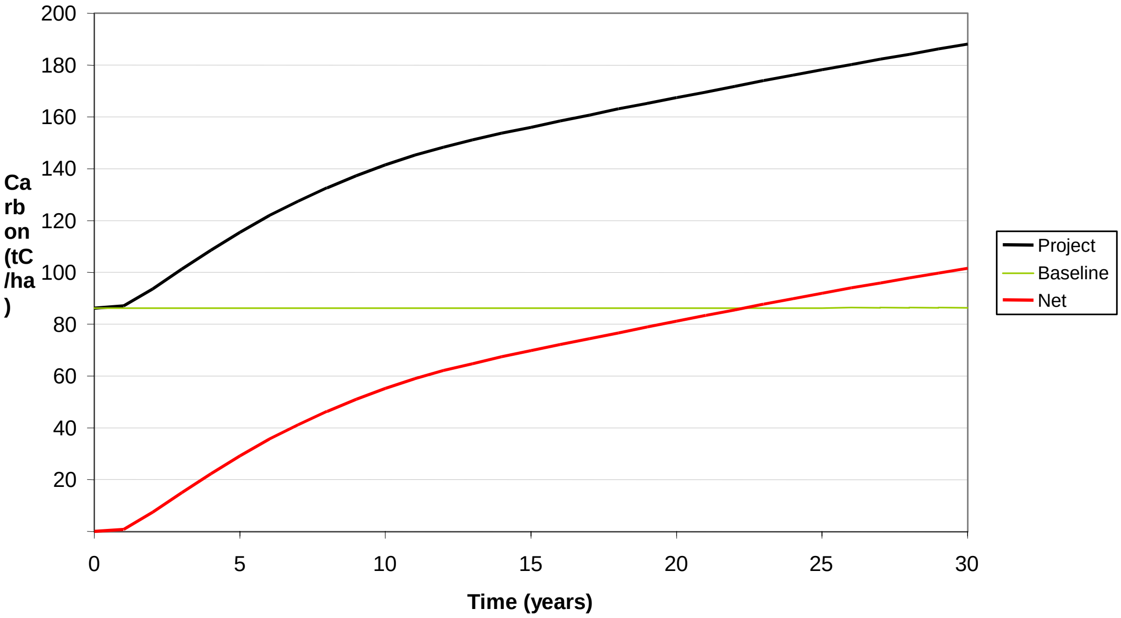


Figure 8 Phytomass carbon by species on 1 ha :
Mixed forest planted on abandoned pastures in Maquipucuna
Maquipucuna CI

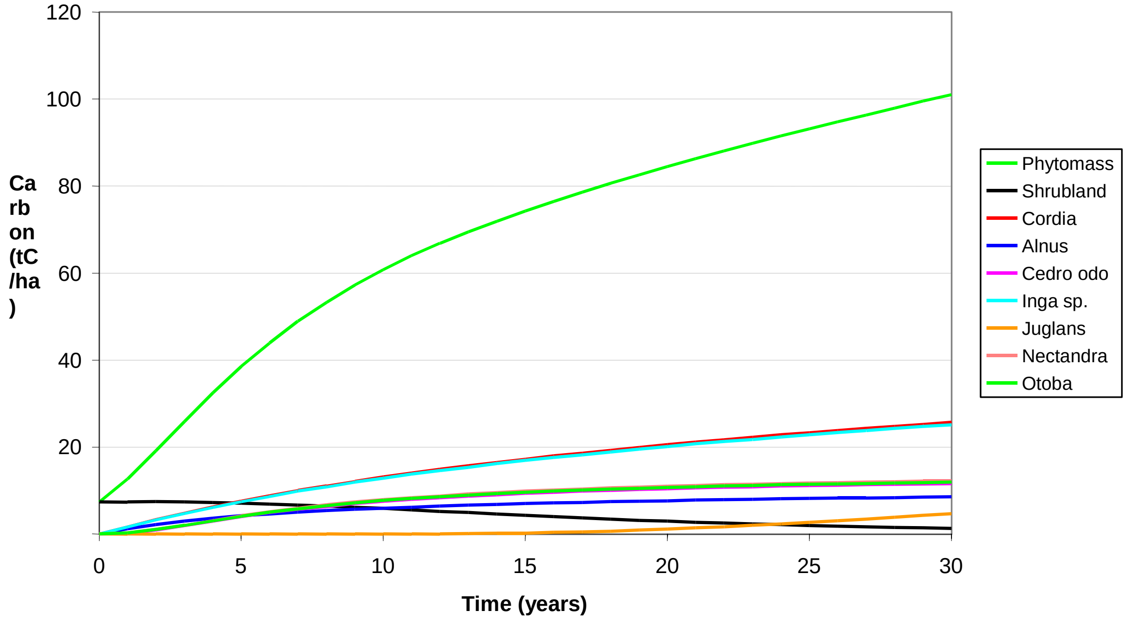


Figure 9 Carbon pool dynamics on 1 ha :
Mixed forest planted on abandoned pastures in Maquipucuna
Maquipucuna CI

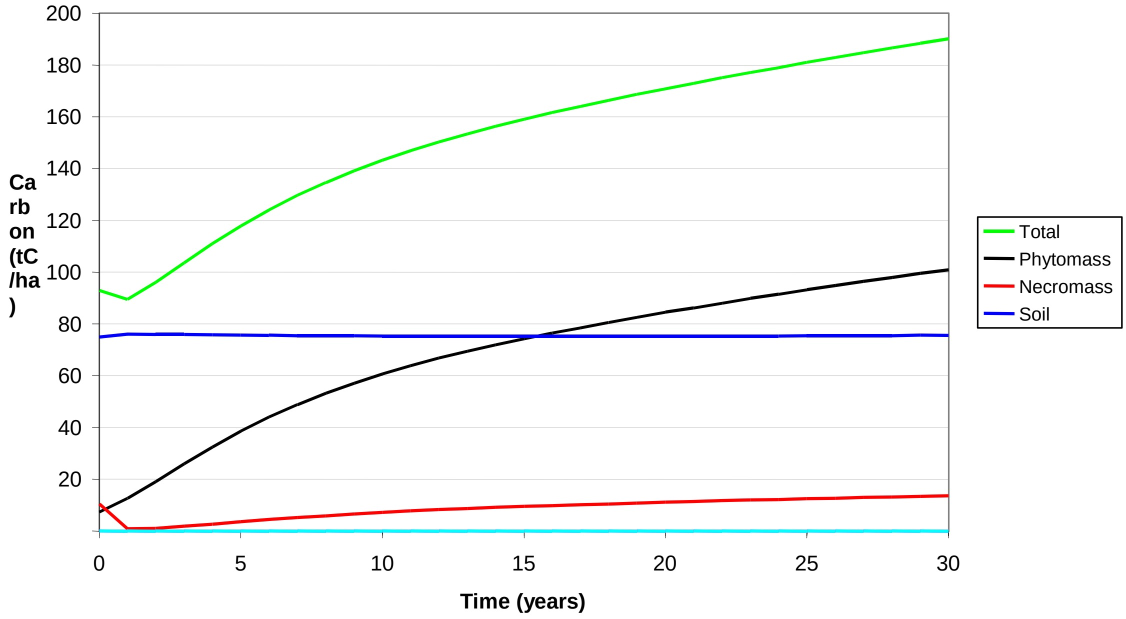


Figure 10 Baseline carbon pool dynamics on 1 ha : Abandoned pastures
Maquipucuna CI

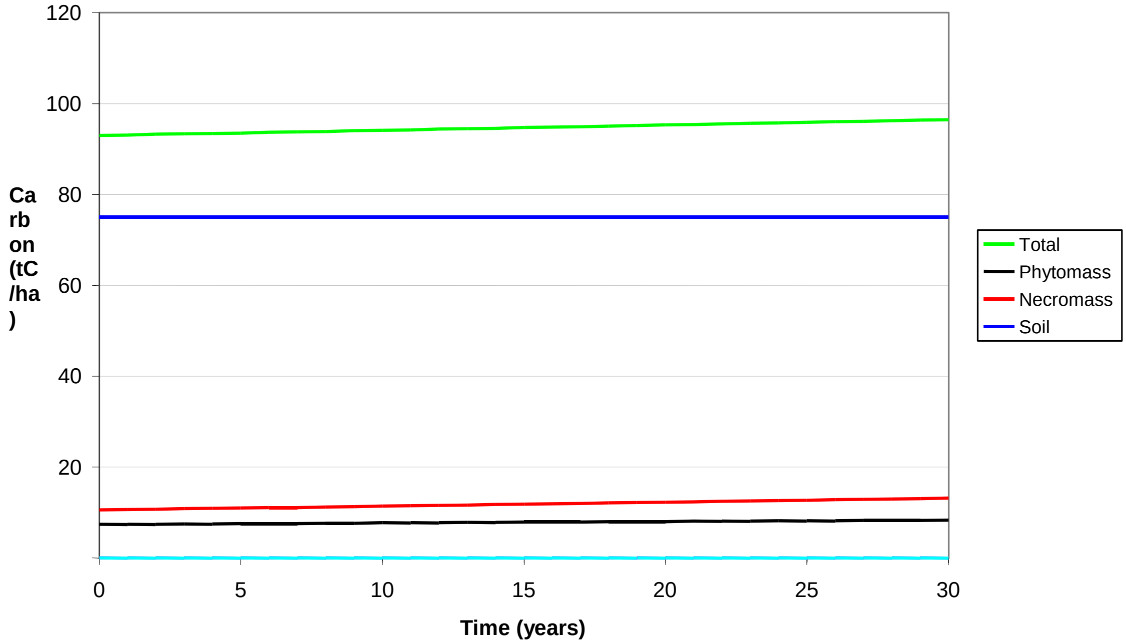


Figure 11 Gross and net sequestered carbon on 1 ha :
Mixed forest planted on abandoned pastures in Maquipucuna
Maquipucuna CI

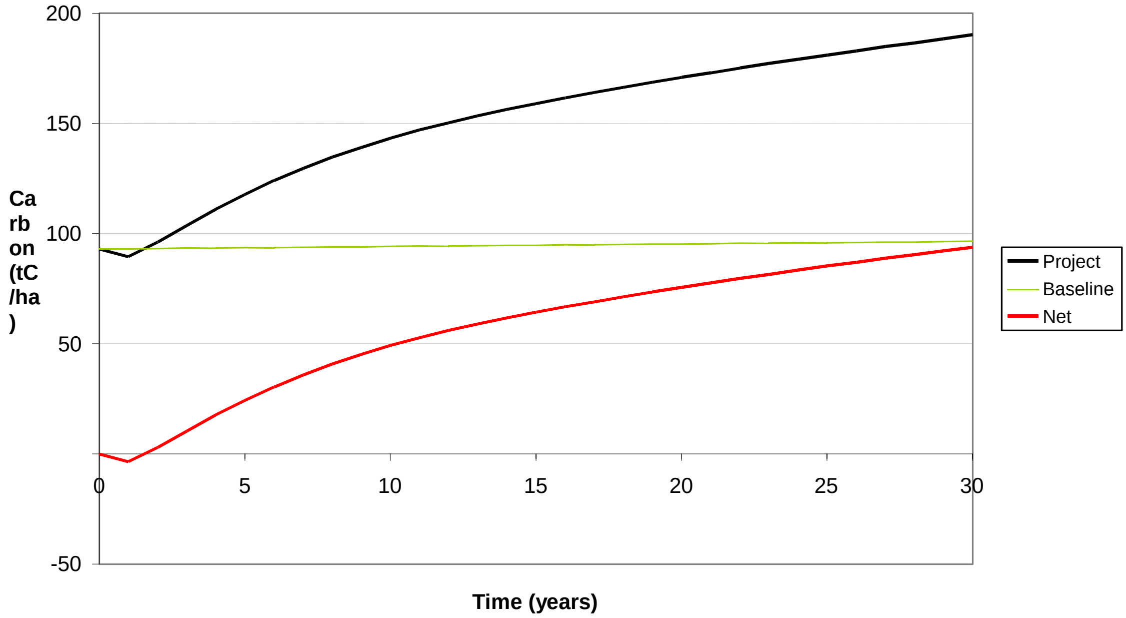


Figure 12 Phytomass carbon by species on 1 ha :
Mixed forest planted on sugarcane plantations in Maquipucuna
Maquipucuna CI

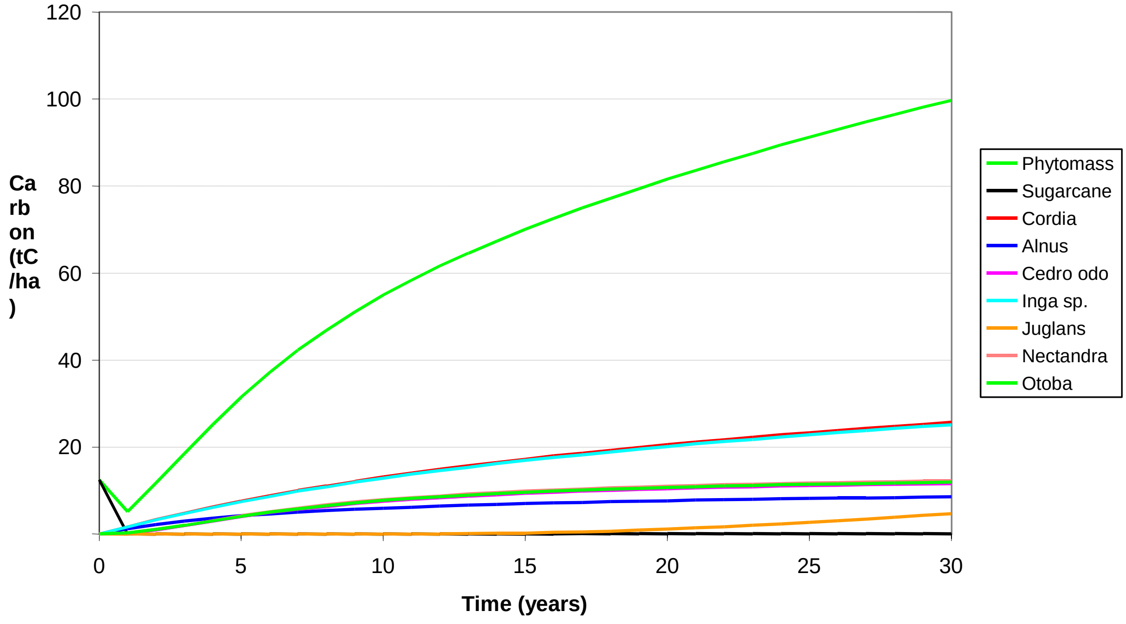


Figure 13 Carbon pool dynamics on 1 ha :
Mixed forest planted on sugarcane plantations in Maquipucuna
Maquipucuna CI

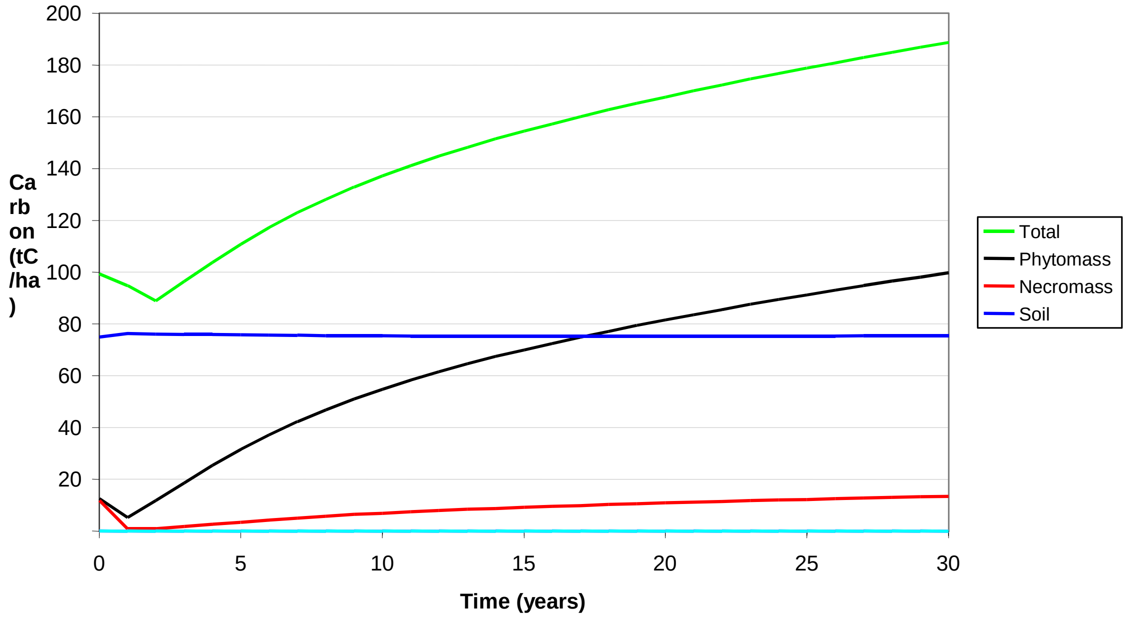


Figure 14 Baseline carbon pool dynamics on 1 ha : Sugarcane
Maquipucuna CI

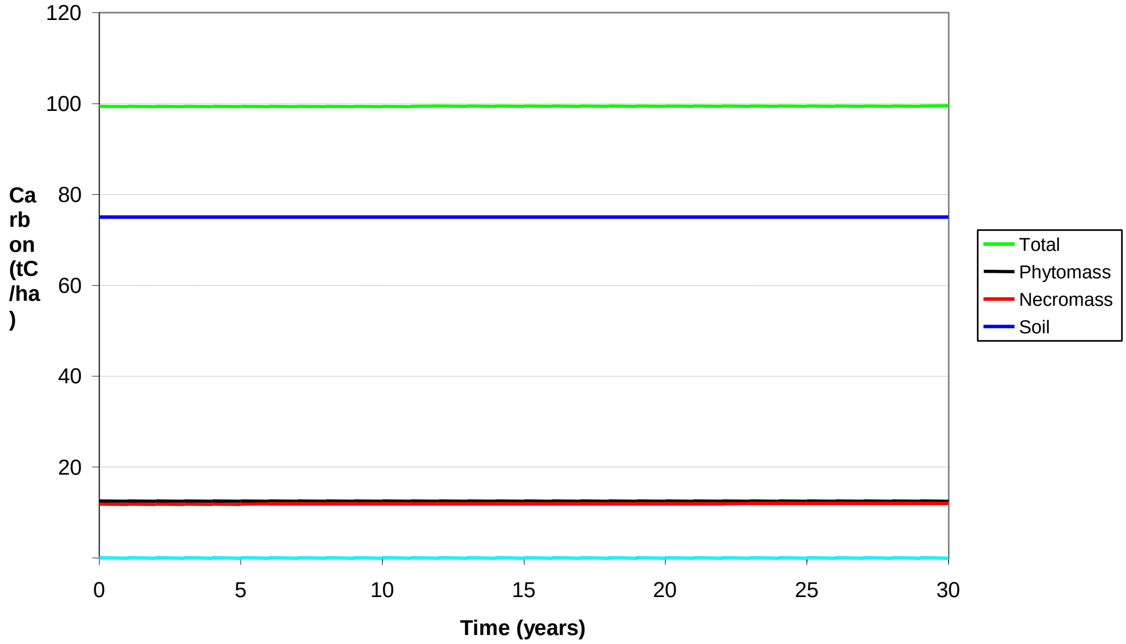
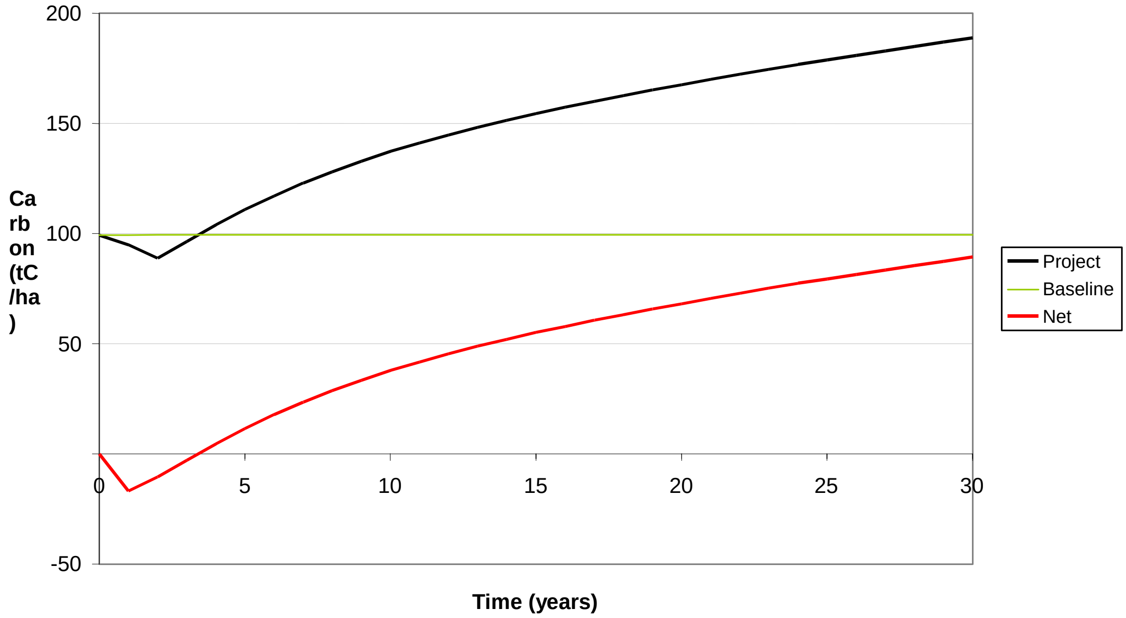


Figure 15 Gross and net sequestered carbon on 1 ha :
Mixed forest planted on sugarcane plantations in Maquipucuna
Maquipucuna CI



4. Model data and assumptions

Note: ESL = EcoSecurities Ltd.

Model input	Parameters used	Notes and references
PROJECT SPECIFICATIONS		
Title	Maquipucuna CI	
Project sub-unit 1: Mixed forest planted on pastures in Maquipucuna		
Unit title	Mixed forest planted on pastures in Maquipucuna	
Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Pasture	
Harvesting	(none)	
Site code	FORESTPAST	
Baseline	Pastures	
Project sub-unit 2: Mixed forest planted on abandoned pastures in Maquipucuna		
Unit title	Mixed forest planted on abandoned pastures in Maquipucuna	
Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Shrubland	
Harvesting	(none)	
Site code	FORESTSHRUB	
Baseline	Abandoned pastures	
Project sub-unit 3: Mixed forest planted on sugarcane plantations in Maquipucuna		
Unit title	Mixed forest planted on sugarcane plantations in Maquipucuna	
Species mixture	Cordia(14%), Alnus(14%), Cedro odo(14%), Inga sp.(14%), Juglans (14%), Nectandra(14%), Otoba(14%)	
Other plant species	Sugarcane	
Harvesting	Sugarcane: year 0, 100% as Sugar.	
Site code	FORESTCANE	
Baseline	Sugarcane	
BASELINE SPECIFICATIONS		
Baseline unit 1: Pastures		
Species mixture	(No tree species)	
Other plant species	Pasture	
Harvesting	(none)	
Site code	PAST	
Baseline unit 2: Abandoned pastures		
Species mixture	(No tree species)	
Other plant species	Shrubland	
Harvesting	(none)	
Site code	PASTSHR	
Baseline unit 3: Sugarcane		

Species mixture	(No tree species)	
Other plant species	Sugarcane	
Harvesting	(none)	
Site code	SUGAR	
TREE SPECIES PARAMETERS		
Coefficients for Cordia		
Species	Laurel (Cordia alliodora)	
Growth data (Volume)	Growth data approximated in model by Vtot= 1586.0 x exp(-4.920/Age$^{0.3736}$)	*From figure in Alder (1998)*
Wood density	0.5	*Average derived from Liegel & Stead (1990), Brown (1997) and ter Steege and Hammond (2001)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	80-100	*Liegel & Stead (1990)*
Maximum vegetation height	30	*Liegel & Stead (1990)*
Shade persistence factor	0.2	*Liegel & Stead (1990) comment that Laurel is an "intolerant pioneer species, demanding lots of light for best growth".*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Alnus		
Species	Aliso (Alnus acuminata)	
Growth data (Volume)	140.0 m3/ha at 8years 199.3 m3/ha at 30years 237.3 m3/ha at 45years	*Fehse et al. (1999)* *Fehse et al. (1999)* *Fehse et al. (1999)* *Growth data approximated in model by Vtot= 305.0 x exp(-3.040/Age$^{0.6278}$)*
Wood density	0.4	*Average derived from Fehse et al. (1999)*
Crown expansion factor	1.433	*Fehse et al. (1999)*
Root:shoot ratio	0.12	*Brown (1997) for tropical lowland forests*

Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	60-80	*ESL assumption*
Maximum vegetation height	25	*Fehse et al. (1999)*
Shade persistence factor	0.3	*ESL assumption - Alnus is pioneer species*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Cedro odo		
Species	Cedrela odorata	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*Aguirre (no date)* *EARTH (no date)* *Growth data approximated in model by* *$Vtot= 263.0 \times exp(-12.278/Age^{1.2194})$*
Wood density	0.4	*Cintron (no date)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997) for tropical lowland forests*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	80-100	*ESL assumption*
Maximum vegetation height	35	*USDA Forest Service (no date)*
Shade persistence factor	0.7	*ESL assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Inga sp.		
Species	Inga sp.	
Growth data (MAI)	Assumed same as Cordia alliodora	*Growth data approximated in model by* *$Vtot= 1586.0 \times exp(-4.920/Age^{0.3736})$*
Wood density	0.49	*Brown (1997)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*

Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	60-80	*ESL assumption*
Maximum vegetation height	30	*Lawrence (1993)*
Shade persistence factor	0.2	*Lawrence (1993): "forest gap regenerator"*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Juglans		
Species	Juglans neotropica	
Growth data (Volume)	No growth data available for this species. Assumed same as Tabebuia rosea since this is slow growing climax species, giving the most conservative estimate. Data from Roncancio (2001) for a 3x3 monospecific plantation	*Growth data approximated in model by* $Vtot= 307.0 \times exp(-358.135/Age^{1.5414})$
Wood density	0.66	*Estrada (1997)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	80-100	*ESL assumption*
Maximum vegetation height	30	*ESL assumption*
Shade persistence factor	1	*ESL assumption - this is a climax species*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Nectandra		
Species	Nectandra acutifolia	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*No growth data for this species. Assumed same as Cedrela odorata, giving the most conservative estimate* *Growth data approximated in model by* $Vtot= 263.0 \times exp(-12.278/Age^{1.2194})$

Wood density	0.42	*Martinez Amores (1989)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	80-100	*ESL assumption*
Maximum vegetation height	30	*ESL assumption*
Shade persistence factor	0.8	*ESL assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Otoba		
Species	Otoba gordonifolia	
Growth data (Volume)	173.0 m3/ha at 16years 215.0 m3/ha at 30years	*No growth data for this species. Assumed same as Cedrela odorata, giving the most conservative estimate* *Growth data approximated in model by* $Vtot= 263.0 \times exp(-12.278/Age^{1.2194})$
Wood density	0.41	*Martinez Amores (1989)*
Crown expansion factor	1.66	*Fehse et al (1998) for mature forests in Maquipucuna reserve at 2300 m altitutde. CEF tends to decrease with forest age, thus using this datum gives more conservative estimate. Brown (1997) gives CEF of 1.74*
Root:shoot ratio	0.12	*Brown (1997)*
Coarse crown ratio	0.8	*Rodriguez, 1988; Edwards & Grubb, 1977; Grimm & Fassbender, 1981; Ovington & Olson, 1970. In general: 80% branches, 10% twigs, 10% leaves.*
Coarse root ratio	0.8	*ESL assumption - assumed similar to aboveground ratio*
Litterfall rate	0.3	*ESL assumption, based on Alder & Montenegro (1999)*
Fine root turnover	0.3	*ESL assumption*
Life expectancy	80-100	*ESL assumption*
Maximum vegetation height	35	*ESL assumption*
Shade persistence factor	0.8	*ESL assumption*
OTHER VEGETATION SPECIES PARAMETERS		
Coefficients for Pasture		

Short species name	Pasture	*Mainly Setaria sp.*
Initial biomass, t/ha	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that living biomass constitutes 50% of biomass*
Maximum biomass, t/ha	11.2	*ESL assumption, pasture is assumed to have reached maximum biomass*
Maximum productivity, t/ha/yr	0.01	*ESL assumption - used to model steady state*
Maximum vegetation height	1	*EcoPar field data (2005)*
Root:shoot ratio	1	*Jackson et al. (1996)*
Coarse:fine ratio	0.98	*ESL assumption*
Shade persistence factor	0.05	*ESL assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Shrubland		
Short species name	Shrubland	*Abandoned pastures, dominated by Setaria sp. pasture, Piper shrub (Piperaceae) and Baccharis shrub (Asteraceae).*
Initial biomass, t/ha	14.7	*From field data by EcoPar (2005)*
Maximum biomass, t/ha	21.7	*ESL assumption - the shrubland is assumed to accumulate 3.5 t/ha over 15 years (difference between pasture and shrubland)*
Maximum productivity, t/ha/yr	0.233	*ESL assumption - 3.5/15*
Maximum vegetation height	3	*EcoPar field data (2005)*
Root:shoot ratio	1	*Jackson et al. (1996)*
Coarse:fine ratio	0.85	*ESL assumption*
Shade persistence factor	0.1	*ESL assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Coefficients for Sugarcane		
Short species name	Sugarcane	*Sugarcane*
Initial biomass, t/ha	25	*From field data by EcoPar (2005) on 7-month old sugarcane*
Maximum biomass, t/ha	25	*ESL assumption*
Maximum productivity, t/ha/yr	0.01	*ESL assumption - used to model steady state*
Maximum vegetation height	3	*EcoPar field data (2005)*
Root:shoot ratio	0.4	*ESL assumption*
Coarse:fine ratio	0.98	*ESL assumption*
Shade persistence factor	0.1	*ESL assumption*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
NECROMASS & SOIL PARAMETERS		
Coefficients for site code : FORESTPAST		
Initial fine necromass (t/ha)	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that dead biomass constitutes 50% of biomass*
Initial coarse necromass (t/ha)	0	*ESL assumption*

Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL assumption*
Coefficients for site code : FORESTSHRUB		
Initial fine necromass (t/ha)	21.2	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*All necromass measured by EcoPar (2005) is included in fine necromass*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL assumption*
Coefficients for site code : FORESTCANE		
Initial fine necromass (t/ha)	23.7	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*ESL assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0.95	*Songwe et al. (1995)*
Coarse necromass decomposition rate	0.5	*ESL assumption*
Fine necromass respiration	0.88	*Wilson (1998)*
Coarse necromass respiration	0.88	*Wilson (1998)*
Soil respiration rate	0.002	*ESL assumption - Soils were modelled to maintain a constant carbon stock, due to lack of data on impacts of reforestation on soil C. However, it is expected that soil C will increase over the crediting period. The modelling assumption is therefore considered to give a conservative estimate.*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*ESL assumption*
Coefficients for site code : PAST		

Initial fine necromass (t/ha)	11.2	*From field data by EcoPar (2005) - total dead and living biomass was measured. It is assumed that dead biomass constitutes 50% of biomass*
Initial coarse necromass (t/ha)	0	*ESL assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*
Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
Coefficients for site code : PASTSHR		
Initial fine necromass (t/ha)	21.2	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*All necromass measured by EcoPar (2005) is included in fine necromass*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*
Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
Coefficients for site code : SUGAR		
Initial fine necromass (t/ha)	23.7	*From field data by EcoPar (2005)*
Initial coarse necromass (t/ha)	0	*ESL assumption*
Initial soil organic matter (tC/ha)	75	*Field data from EcoPar (2005)*
Fine necromass decomposition rate	0	*Baseline assumed to be static*
Coarse necromass decomposition rate	0	*Baseline assumed to be static*
Fine necromass respiration	0	*Baseline assumed to be static*
Coarse necromass respiration	0	*Baseline assumed to be static*
Soil respiration rate	0	*Baseline assumed to be static*
Carbon:Biomass ratio	0.5	*IPCC (1996)*
Erosion loss,vegetated areas	0	*Baseline assumed to be static*
PRODUCT PARAMETERS		
Sugar	Product half-life: 0.1 yrs	*ESL assumption*

Assumptions on project emissions:

Project emissions have been estimated at 100 tCO_2/yr for the first five years of the project. This is considered to be a great over-estimation, which will lead to a more conservative estimate of actual net GHG removals.

Fuel consumption has not been estimated in detail. However, it is assumed that after the fifth year of the crediting period no significant emissions will occur. In the first five years, emissions from fossil fuel combustion will mainly occur due to planting and plantation management activities. We have estimated the yearly diesel consumption at 20,000 liters, with approximately 2.7 kg CO_2 emitted per consumed liter. This would amount to 54 tonnes of CO_2 per year.

50 Grams of NPK fertilizer (18% N) will be applied to every tree planted. In the first year, 50,000 trees will be planted, in the second and third year 100,000 each. In total, 2250 kg of N will be applied by the project. Using IPCC's default emission factor for synthetic fertilizers of 0.0125 kg N_2O per kg of N, and a Global Warming Potential of 310 for N_2O, the total emissions for this source are estimated at 8.7 tCO_2e.

Annex 4 -REFERENCES

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