MODULE NAME:

ACCOUNTING MODULE FOR SEQUESTRATION/EMISSIONS FROM SOILS AND PLANTS

MODULE CODE:

A-BIOTIC

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1. Parameters, Purpose and Applicability

1.1 Output Parameters(s):

Parameter Name	Parameter Description
S_BIO	Net biotic sequestration (t CO_2e)

1.2 Key Input Data:

- Baselines: tillage type, depth and frequency
- Baseline and project: livestock presence, type, number, manure application, production and management grass type, productivity and management
- ACR tool CPES[1]

1.3 Purpose

- To estimate sequestration and net greenhouse gas emission reductions from soils and plants as part of grazing land and livestock management greenhouse gas mitigation activities.
- The module is for large scale emissions.
- The module estimates both emissions in the baseline case and with project implementation.

1.4 Applicability Conditions

- The module is applicable to all projects implemented on grasslands outside of the continental USA (for projects in the USA where estimated impacts on biotic sequestration are below applicable thresholds, A-SMALLSCALE shall be used for biotic sequestration).
- Where with-project emissions are significantly elevated (see T-XANTE) the module shall be used, in all other cases it is optional.
- Model criteria specified in Section 1.1 must be met.

[1] *ACR Tool for Estimation of Stocks in Carbon Pools and Emissions from Emission Sources*. Available at: http://americancarbonregistry.org/carbon-accounting/tools-templates

2. Calculation Procedure

In this methodology carbon stocks and carbon sequestration in soil organic carbon and herbaceous vegetation are derived from a qualifying process model. Quantification of stocks and sequestration in trees and shrubs shall occur through use of the approved ACR tool CPES: "Tool for Estimation of Stocks in Carbon Pools and Emissions from Emission Sources".

The baseline shall be determined ex ante and shall be fixed for the Crediting Period. The with-project case shall be estimated ex ante but recalculated and reported at the time of verification.

The stocks in dead organic matter (dead wood and litter) are considered conservatively excluded and / or insignificant per section 5.3 of FRAMEWORK-GLLM.

2.1 Models

Soil carbon stocks and changes in soil carbon stocks shall be estimated using a process model. To be applicable the model shall have been accepted in a peer-reviewed scientific publication or publications and shall have the potential to model stocks of carbon in the soil to an identified depth (minimum of 20 cm) with consideration of:

- Crop / grass type and productivity
- Crop / grassland management (including tillage)
- Livestock presence, type and number
- Manure applied, produced and management of manure application/production

Where the models also project the carbon stock in herbaceous vegetation these estimates shall be used.

Examples of applicable models include Century[2], DayCent[3] and Roth-C[4]. For application to the project area the following criteria must be met. There must be studies (for example: scientific journals, university theses, local research studies or work carried out by the Project Proponent) that demonstrate that the use of the selected model is appropriate for: a) the IPCC climatic regions of 2006 IPCC AFOLU Guidelines or b) agroecological zone (AEZ) in which the project is

[2] http://www.nrel.colostate.edu/projects/century5/
[3] http://www.nrel.colostate.edu/projects/daycent/index.html
[4] http://www.rothamsted.ac.uk/aen/carbon/rothc.htm

situated using one of the options presented below[5]:

> Option 1: The studies used in support of the project should meet the guidance on model applicability as outlined in IPCC AFOLU 2006 guidelines in order to show that the model is applicable for the relevant IPCC climatic region. The guidance notes that an appropriate model should be capable of representing the relevant management practices and that the model inputs (i.e., driving variables) are validated from country or region-specific locations that are representatives of the variability of climate, soil and management systems in the country.
>
> Option 2: Where available, the use of national, regional or global level agroecological zone (AEZ) classification is appropriate to show that the model has been validated for similar AEZs. It is recognized that national level AEZ classifications are not readily available; therefore this methodology allows the use of the global and regional classification.

Where a project area consists of multiple sites, it is recognized that studies demonstrating model validity using either Option 1 or Option 2 may not be available for each of the sites in the project area. In such cases the study used should be capable of demonstrating that the following two conditions are met:

- i) The model is validated for at least 50% of the total project area relevant to biotic sequestration where the project area covers up to 50,000 ha; or at least 75% of the total project area where project area relevant to biotic sequestration covers greater than 50,000 ha; and
- ii) The area for which the model is validated generates at least two-thirds of the total project emission reductions from biotic sequestration.

[5] IPCC. 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

2.2 Quantification

2.2.1 Running the Model and Model Outputs

The output for soil shall be the carbon stock (in t C/ha) to an identified depth at the specific point in time. This shall vary by stratum (*i*) where variation exists in historical use and management, current management and edaphoclimatic factors, and thus the model shall be run for every stratum (though not for every field)[6].

The output for living biomass shall be carbon stock (in t C/ha) at the specific point in time. This shall vary by stratum (*i*) where variation exists in vegetation type/species, historical use and management, current management and edaphoclimatic factors, and thus the model shall be run for every stratum (though not for every field).

Where project and site specific data can be input into the model, defaults supplied by the model shall not be used without justification.

For the baseline, the stock at the start of the project for declining baseline stocks or the stock at equilibrium[7] for increasing baseline stocks shall be used in all instances for both soil carbon and living biomass. In the project case, values shall vary up to the date where the model predicts equilibrium to be reached.

The following parameters shall be output from the process model and shall be used in calculations presented in this module:

$SOC_{BSL,i}$	The carbon stock in soil organic carbon in the baseline case in stratum *i*; t C/ha
$SOC_{P,i,t}$	The carbon stock in soil organic carbon in the project case in stratum *i* at time *t*; t C/ha
$HB_{BSL,i,}$	The carbon stock in herbaceous biomass in the baseline case in stratum *i*; t C/ha
$HB_{P,i,t}$	The carbon stock in herbaceous biomass in the project case in stratum *i* at time *t*; t C/ha

[6] Stratification factors that should be considered include: slope, aspect, topography, proximity to water, landcover type/ landcover species, soil type.

[7] The point at which stocks are no longer increasing but instead remain stable.

2.2.2 Outputs of CPES

The following are the outputs of CPES:

Parameter	SI Unit	Description
$C_{AB\_tree,\, i,\, t}$	t CO_2-e ha^{-1}	Carbon stock in aboveground tree biomass in strata *i* at time *t*
$C_{BB\_tree,\, i,\, t}$	t CO_2-e ha^{-1}	Carbon stock in belowground tree biomass in strata *i* at time *t*
$C_{AB\_non\text{-}tree,\, i,\, t}$	t CO_2-e ha^{-1}	Carbon stock in aboveground non-tree biomass in strata *i* at time *t*
$C_{BB\_non\text{-}tree,\, i,\, t}$	t CO_2-e ha^{-1}	Carbon stock in belowground non-tree biomass in strata *i* at time *t*

These outputs shall be combined as follows. In equation 1 the outputs of CPES using baseline parameterization are used. In equation 2 the outputs from CPES using project parameterization are used. In the project scenario stocks shall be monitored.

$$TS_{BSL,i,t} = C_{AB\_tree,i,t} + C_{BB\_tree,i,t} + C_{AB\_non-tree,i,t} + C_{BB\_non-tree,i,t} \quad \textbf{(1)}$$

Where:

$TS_{BSL,i}$	Mean biomass carbon stock in trees and shrubs in the baseline in stratum *i*; t CO_2-e ha^{-1}
$C_{AB\_tree,i,t}$	Mean aboveground tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{BB\_tree,i,t}$	Mean belowground tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{AB\_nontree,i,t}$	Mean aboveground non-tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{BB\_nontree,i,t}$	Mean belowground non-tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}

$$TS_{P,i,t} = C_{AB\_tree,i,t} + C_{BB\_tree,i,t} + C_{AB\_non-tree,i,t} + C_{BB\_non-tree,i,t} \quad \textbf{(2)}$$

Where:

$TS_{P,i,t}$	Mean biomass carbon stock in trees and shrubs in the project scenario in

	stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{AB\_tree,i,t}$	Mean aboveground biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{BB\_tree,i,t}$	Mean belowground tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{AB\_nontree,i,t}$	Mean aboveground non-tree biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}
$C_{BB\_nontree,i,t}$	Mean belowground biomass carbon stock in stratum *i* at time *t*; t CO_2-e ha^{-1}

2.3 Baseline summation

The carbon stock in the baseline case shall be equal to the equilibrium stock in soil organic carbon and living biomass:

$$C_{BSL,i} = A_i * \left(SOC_{BSL,i} + HB_{BSL,i} + TS_{BSL,i}\right) \quad \textbf{(3)}$$

Where:

$C_{BSL,i}$	Carbon stock in the baseline case in stratum *i*; t C
A_i	Area of stratum *i*; ha *
$SOC_{BSL,i}$	The carbon stock in soil organic carbon in the baseline case in stratum *i*; t C/ha
$HB_{BSL,i,}$	The carbon stock in herbaceous biomass in the baseline case in stratum *i*; t C/ha
$TS_{BSL,i}$	Mean biomass carbon stock in trees and shrubs in the baseline in stratum *i*; t CO_2-e/ha^{-1}

** Where stratum area is in acres convert to hectares by multiplying by 0.4047*

2.4 With-project summation

The with-project carbon stock shall be estimated using the equations in this section. When applying these equations for the *ex ante* calculation of project emissions, Project Proponents shall provide estimates of the values of those parameters that are not available before the start of monitoring activities. Project Proponents must retain a conservative approach in making these estimates.

$$C_{P,i,t} = A_i * \left(SOC_{P,i,t} + HB_{P,i,t} + TS_{P,i,t}\right) \quad \textbf{(4)}$$

Where:

$C_{P,i,t}$	Carbon stock in the with-project case in stratum *i* at time *t*; t C
A_i	Area of stratum *i*; ha *
$SOC_{P,i,t}$	The carbon stock in soil organic carbon in the project case in stratum *i* at time *t*; t C/ha
$HB_{P,i,t,}$	The carbon stock in herbaceous biomass in the project case in stratum *i* at time *t*; t C/ha
$TS_{P,i}$	Mean biomass carbon stock in trees and shrubs in the project case in stratum *i* at time *t*; t CO_2-e ha^{-1}

** Where stratum area is in acres convert to hectares by multiplying by 0.4047*

2.5 Total net summation

Total net sequestration (or emission) from soil organic carbon and living biomass will be equal to baseline minus the project:

$$S\_BIO_{prelim} = \frac{44}{12} * \sum_i \left(C_{P,i,t} - C_{BSL,i} \right) \quad (5)$$

Where:

S_BIO_{prelim}	Net biotic sequestration/emission at time *t* prior to uncertainty deductions; t CO_2-e
$C_{P,i,t}$	Carbon stock in the with-project case in stratum *i* at time *t*; t C
$C_{BSL,i}$	Carbon stock in the baseline case in stratum *i*; t C

2.6 Uncertainty

Uncertainty shall be quantified by means of a Monte Carlo simulation. If this is incorporated in the model this facet shall be used and reported. The analysis shall include uncertainties across soil carbon, herbaceous vegetation and tree biomass, and between baseline and project scenarios. The output (S_BIO_{ERROR}) shall be the half width of the ultimate calculated 90% confidence interval divided by estimated net biotic sequestration.

2.6.1 Uncertainty Deduction

If S_BIO_{ERROR} ≤ 10% of S_BIO_{prelim} then no deduction for uncertainty is required (S_BIO_{prelim} = S_BIO). If S_BIO_{ERROR} > 10% of S_BIO_{prelim} then the modified value for S_BIO to account for uncertainty shall be:

$$S\_BIO = S\_BIO_{prelim} * \left(1 - \left(S\_BIO_{ERROR} - 10\%\right)\right) \quad \textbf{(6)}$$

Where:

S_BIO	Net biotic sequestration/emission; t CO_2-e
S_BIO_{prelim}	Net biotic sequestration/emission prior to uncertainty deductions; t
S_BIO_{ERROR}	Total uncertainty for biotic sequestration/emission; %

Where S_BIO is positive (increases in sequestered stocks by the project).

$$S\_BIO = S\_BIO_{prelim} * \left(1 + \left(S\_BIO_{ERROR} - 10\%\right)\right) \quad \textbf{(7)}$$

Where:

S_BIO	Net biotic sequestration/emission; t CO_2-e
S_BIO_{prelim}	Net biotic sequestration/emission prior to uncertainty deductions; t
S_BIO_{ERROR}	Total uncertainty for biotic sequestration/emission; %

Where S_BIO is negative (decreases in sequestered stocks by the project).

2.7 Model Validation

At project start and every five years a minimum of ten samples shall be collected for each of soil organic carbon and (where relevant) living biomass. The half-width of the 90% confidence interval for the samples taken must be equal to 20% or less of the mean, where this criterion is not met additional samples must be taken. Samples shall be collected from a single randomly selected stratum. A different stratum shall be sampled every five years. The estimate of stocks returned by the model ($SOC_{P,i,t}$, $LB_{P,i,t,}$) must lie within the 90% confidence interval of sample for offset verification to occur. Where the estimate of stock does not conform users must either take additional samples to justify the model return, or must re-run the model altering input parameters to achieve a new conforming estimate for both baseline (only at start of baseline period) and with-project cases.

Measurements methods for samples shall follow accepted protocols for example:

Pearson, TRH, S.L. Brown and R.A. Birdsey. 2007. Measurement guidelines for the sequestration of forest carbon. Gen. Tech. Rep. NRS-18.Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 42 p. Available at: http://www.treesearch.fs.fed.us/pubs/13292

Pearson, T., S. Walker and S. Brown. 2006. Guidebook for the Formulation of Afforestation and Reforestation Projects under the Clean Development Mechanism. Prepared for International Tropical Timber Organization. Available at: http://www.winrock.org/Ecosystems/tools.asp

2.8 Permanence

The number of credits to be held in the ACR buffer pool is determined as a percentage of the total carbon stock benefits.

$$Buffer_{GLLM} = S\_BIO * (1 - Buffer\%) \quad \textbf{(8)}$$

Where:

$Buffer_{GLLM}$	Buffer withholding for GLLM projects; t CO_2-e
S_BIO	Net biotic sequestration/emission; t CO_2-e
Buffer%	Buffer withholding percentage; %

Buffer withholding percentages are based on the project's overall risk classification. This risk classification is derived using an ACR-approved risk assessment tool per the *ACR Forest Carbon Project Standard.* The risk assessment yields a percentage of ERTs generated by the project activity that must be deposited into the ACR buffer pool to mitigate future reversals. The buffer deposit may be made in project ERTs or alternately in ERTs of any other type and vintage. Alternately if the Project Proponent has elected to use another ACR-approved risk mitigation product in lieu of a buffer contribution, *Buffer%* = 0.

3. Input Data Sources and Requirements

In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, Project Proponents must retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to overestimation of net GHG emissions reductions or net sequestration must be selected.

It is a requirement that project developers include an explanation and justification for all parameters selected and used in the module.

Parameter	**Selected model inputs**
Units	Multiple
Description	Inputs to the selected soil organic carbon and living biomass estimation model
Relevant Section	1.1 / 1.2
Relevant Equation(s)	-
Source of Data	Multiple
Data Requirements	To be specified in the PDD
Collection Procedure	To be specified in the PDD
Revision Frequency	Project case prior to each verification; baseline prior to baseline renewal
Comments	