VCS Module

VMD0045

Methods for monitoring greenhouse gas emissions and removals in ARR project activities on ~~peat and mineral~~wetland and terrestrial soil (M-ARR)

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Sectoral Scope 14

Module developed by:

Revision to include tidal wetland restoration and conservation activities (version 1.1 of this module) prepared by Silvestrum Climate Associates and Restore America's Estuaries.

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1 SOURCES

This module is one of numerous modules that constitute VCS methodology *VM0007 REDD+ Methodology Framework (REDD-MF)*.

This module uses the latest version of the following CDM tool and VCS modules:

- CDM methodology *AR-ACM0003 Afforestation and reforestation of lands except wetlands*
- CDM tool *AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
- *VMD0046 Methods for monitoring of soil carbon stock changes and greenhouse gas emissions and removals in peatland rewetting and conservation project activities (M-PEAT)*
- *VMD00XX Methods for monitoring of carbon stock changes and greenhouse gas emissions and removals in tidal wetland restoration and conservation project activities (M-TW)*

2 SUMMARY DESCRIPTION OF THE MODULE

This module provides procedures for the monitoring of GHG emissions and removals under the project scenario ($\Delta C_{WPS-ARR}$) of ARR project activities on peat and mineral soil.

3 DEFINITIONS

Definitions are set out in in VCS document *Program Definitions*, and REDD+ -MF. This module does not set out any further definitions.

4 APPLICABILITY CONDITIONS

This module is applicable under the following conditions:

- The applicability conditions provided in AR-ACM0003.[1]
- Applicability conditions included in *AR-ACM0003* and corresponding tools that exclude project activities on wetlands can be neglected for the purpose of their use in this module, as accounting procedures for the peat soil are provided in Mmodules *BLM-PEAT* and *M-TW*.

[1] In case there is a conflict between the CDM methodology requirements and the VCS rules, the VCS rules must be followed, as outlined in VCS AFOLU guidance document *Additional guidance for VCS Afforestation, Reforestation and Revegetation projects using CDM Afforestation/Reforestation Methodologies* available on the VCS website.

5 PROCEDURES

Net GHG emissions and removals under the ARR project scenario on mineral soils are estimated using the procedures provided in CDM methodology *AR-ACM0003 Afforestation and reforestation of lands except wetlands* and associated tools.

$$\Delta C_{WPS-ARR} = \sum_{t=1}^{t^*} (\Delta C_{ACTUAL,t_{ACM0003}})$$

Where:

$\Delta C_{WPS-ARR}$ Net GHG removals under the ARR project scenario up to time t^* (t CO_2e)

$\Delta C_{ACTUAL,t_{ACM0003}}$ Actual net GHG removals by sinks, in year t (t CO_2e)

t 1,2,3…..t^* time elapsed since project start (years)

ARR activities with a WRC component must estimate the net GHG emissions under the project scenario using:

- For the non-soil pools estimate: using *AR-ACM0003* and associated tools (where the estimation of carbon stock changes in the soil components and below-ground biomass must not be included) and procedures for herbaceous vegetation in ARR-WRC project activities provided below.

- For the soil pools estimate: using procedures provided in Mmodule *M-PEAT* or *M-TW*.

Net GHG removals under the ARR project scenario is estimated as follows:

$$\Delta C_{WPS-ARR} = \sum_{t=1}^{t^*} \Delta C_{ACTUAL,t} + \Delta C_{WPS-herb} \quad (1)$$

Where:

$\Delta C_{WPS-ARR}$ Net GHG removal under the ARR project scenario up to time year t^* (t CO_2e)

$\Delta C_{ACTUAL,t}$ $\Delta C_{ACTUAL,t_{ACM0003}}$ Actual net GHG removals by sinks, in year t (from *AR-ACM0003*) (t CO_2e)

$\Delta C_{WPS-herb}$ Net GHG removals under the ARR-WRC project scenario in herbaceous vegetation up to year t^* (t CO_2e)

$GHG_{WPS-WRC}$ Net GHG emissions in the WRC project scenario up to year t^* (t CO_2e)

t 1,2,3…t^* time elapsed since project start (years)

Procedures for the estimation of uncertainty for ARR project activities are provided in *AR-ACM0003*.

Long-term average in case of harvesting

Where reforestation or revegetation activities in the project scenario include harvesting, the maximum number of GHG credits generated by these activities over the crediting period must not exceed the long-term average GHG benefit. The long-term average is calculated per the requirements set out in the VCS Program Document, *AFOLU Requirements*, with the following modifications:

$$LA = \frac{\sum_{t=1}^{n} NGR_{ARR,t}}{n} \quad (2)$$

Where:

LA	The long-term average GHG benefit in the ARR project with harvesting in time period *n*; t CO_2-e
$NGR_{ARR,t}$	Total net GHG removals of the ARR project activity in year *t* (annualized from *REDD+ MF*, Section 8.4.3) (t CO_2e)
n	Total number of years in the established time period

Projects may account for long-term carbon storage in wood products. In this case, the parameter $C_{TREE,PROJ,t}$ in *AR-Tool14* must be read as $C_{TREE,PROJ,i,t} + C_{WP,i,t}$. Procedures for the calculation of $C_{WP,i,t}$ are provided in Module *CP-WP*.

For the determination of the number of buffer credits to be withheld, the long-term average change in carbon stock is calculated as follows:

$$LC = \frac{\sum_{t=1}^{n}(C_{TREE\_PROJ,t} + C_{SHRUB\_PROJ,t} + C_{WPS-herb,t}) - \sum_{t=1}^{n}(C_{TREE\_BSL,t} + C_{SHRUB\_BSL,t} + C_{BSL-herb,t})}{n} \quad (3)$$

Where:

LC	The long-term average change in carbon stock in the ARR project with harvesting in time period *n*; t CO_2-e
$C_{TREE\_PROJ,t}$	Carbon stock in tree biomass in the project scenario within the project boundary in year *t* (from *AR-Tool14*) (t CO_2e)
$C_{SHRUB\_PROJ,t}$	Carbon stock in shrub biomass in the project scenario within the project boundary in year *t* (from *AR-Tool14*) (t CO_2e)
$C_{WPS-herb,t}$	Carbon stock in herbaceous vegetation in the project scenario in all strata in year *t* (t CO_2 ha^{-1})
$C_{TREE\_BSL,t}$	Carbon stock in tree biomass in the baseline scenario within the project boundary in year *t* (from *AR-Tool14*) (t CO_2e)
$C_{SHRUB\_BSL,t}$	Carbon stock in shrub biomass in the project scenario within the baseline boundary in year *t* (from *AR-Tool14*) (t CO_2e)

$C_{BSL\text{-}herb,t}$	Carbon stock in herbaceous vegetation in the baseline scenario in all strata in year *t* (t CO_2 ha^{-1})
n	Total number of years in the established time period

ARR on wetlands influenced by sea level rise

Biomass may be lost due to submergence following sea level rise. For strata where conversion to open water occurs during the crediting period, the maximum number of GHG credits generated over the crediting period by the ARR project activity must not exceed the long-term average GHG benefit, as in the case of harvesting, as calculated in Equation 2. For strata where conversion to open water is expected after the crediting period but before *t* = 100, to account for the associated loss of tree and shrub biomass, the maximum stock in tree and shrub biomass ($C_{TREE,i,t}$ and $C_{SHRUB,i,t}$, respectively) used in *AR-Tool14* is limited to $C_{AVG\text{-}TREE,i}$, as calculated in Equation 4 and $C_{AVG\text{-}SHRUB,i}$ as calculated in Equation 5, where *n* = 100.

$$C_{AVG-TREE\_PROJ,j} = \frac{\sum_{t=1}^{n} C_{TREE\_PROJ,i,t}}{n} \quad (4)$$

Where:

$C_{AVG\text{-}TREE\_PROJ,i}$	Long-term average carbon stock in baseline or project tree biomass within the project area (in stratum *i*) in time period *n*; t CO_2-e
$C_{TREE\_PROJ,i,t}$	Carbon stock in baseline or project tree biomass within the project area (in stratum *i*) in year *t* (derived from application of *AR-Tool14*); t CO_2-e yr^{-1}
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3 … *n* years elapsed since the project start date
n	Total number of years in the established time period

$$C_{AVG-SHRUB\_PROJ,j} = \frac{\sum_{t=1}^{n} C_{SHRUB\_PROJ,i,t}}{n} \quad (5)$$

Where:

$C_{AVG\text{-}SHRUB\_PROJ,i}$	Long-term average carbon stock in baseline or project shrub biomass within the project area (in stratum *i*) in time period *n*; t CO_2-e
$C_{SHRUB\_PROJ,i,t}$	Carbon stock in baseline or project shrub biomass within the project area (in stratum *i*) in year *t* (derived from application of *AR-Tool14*); t CO_2-e yr^{-1}
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3 … *n* years elapsed since the project start date
n	Total number of years in the established time period

The long-term average carbon stock must be calculated for both the baseline (where '*PROJ*' must be replaced by '*BSL*') and the project scenario.

Restoration projects which include afforestation or reforestation components may account for long-term carbon storage in wood products in case trees are harvested before dieback. In this case, the parameter $C_{TREE,t}$ in Equation 4 must be read as $C_{TREE,i,t} + C_{WP,i,t}$.

Herbaceous vegetation

Where the carbon stock change in herbaceous vegetation is quantified in the project scenario, it must also be quantified in the baseline scenario.

The net carbon stock change in herbaceous vegetation biomass in the project scenario is estimated using a carbon stock change approach as follows:

$$\Delta C_{WPS-herb} = \sum_{i-1}^{Mwps} \sum_{t=1}^{t*} \Delta C_{WPS-herb,i,t} \quad (6)$$

$$\Delta C_{WPS\text{-}herb,i,t} = (C_{WPS\text{-}herb,i,t} - C_{WPS\text{-}herb,i(t\text{-}T)}) / T \quad (7)$$

Where:

$\Delta C_{WPS\text{-}herb}$	Net GHG removals under the ARR project scenario in herbaceous vegetation up to time t^* (t CO_2e)
$\Delta C_{WPS\text{-}herb,i,t}$	Net carbon stock changes in herb carbon pools in the project scenario in stratum i in year t (t CO_2 yr^{-1})
$C_{WPS\text{-}herb,i,t}$	Carbon stock in herbaceous vegetation in the project scenario in stratum i in year t (t CO_2 ha^{-1})
i	1, 2, 3 …M_{WPS} strata in the project scenario
t	1, 2, 3 … t^* years elapsed since the start of the project activity
T	Time elapsed between two successive estimations ($T = t_2 - t_1$)

For tidal wetlands, a default factor for $C_{WPS\text{-}herb,i,t}$ may be applied as provided in Section 6.

The sampling method of herbaceous vegetation is provided in Section 6.2.

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	$\Delta C_{ACTUAL,t}$ ~~$DC_{ACTUAL,t}$~~ $_{ACM0003}$
Data unit	t CO_2e
Description	Actual net GHG removals by sinks, in year *t*
Equations	1~~, 2~~
Source of data	*AR-ACM0003 Afforestation and reforestation of lands except wetlands*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	*AR-ACM0003* is approved by the UNFCCC's CDM
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$C_{TREE\_PROJ,t}$
Data unit	t CO_2e
Description	Carbon stock in tree biomass in the project scenario within the project boundary in year *t*
Equations	3, 4
Source of data	*AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	*AR-Tool14* is approved by the UNFCCC's CDM
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$C_{SHRUB\_PROJ,t}$
Data unit	t CO_2e
Description	Carbon stock in shrub biomass in the project scenario within the project boundary in year *t*
Equations	3, 5
Source of data	*AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	*AR-Tool14* is approved by the UNFCCC's CDM
Purpose of Data	Calculation of project emissions
Comments	N/A

Data / Parameter	$C_{WPS-herb,i,t}$
Data unit	t CO_2e
Description	Carbon stock in herbaceous vegetation in the project scenario in stratum *i* in year *t*
Equations	7
Source of data	Default value or from own measurements

Value applied	11 t CO_2 ha^{-1} may be applied for strata with 100 percent herbaceous cover. For areas with a vegetation cover <100 percent, a 1:1 relationship between vegetation cover and carbon stock must be applied.
Justification of choice of data or description of measurement methods and procedures applied	Calculated from peak aboveground biomass data from 20 sites summarized in Mitsch and Gosselink 2007. The median of these studies is 1.3 kg dry matter m^{-2}. This was converted to the default factor value as follows: 1.3 × 0.45 × 0.5 × 44/12. The factor 0.45 converts organic matter mass to carbon mass; the factor 0.5 is used to average annual peak biomass (factor = 1) and annual minimum biomass (factor = 0, assuming ephemeral aboveground biomass and complete litter decomposition).
Purpose of Data	Calculation of project emissions
Comments	N/A

~~Data / Parameter~~	~~$GHG_{WPS-WRC}$~~
~~Data unit~~	~~t CO_2e~~
~~Description~~	~~Net GHG emissions in the WRC project scenario up to year *t**~~
~~Equations~~	~~2~~
~~Source of data~~	~~Module M-PEAT~~
~~Value applied~~	~~N/A~~
~~Justification of choice of data or description of measurement methods and procedures applied~~	~~See module M-PEAT~~
~~Purpose of Data~~	~~Calculation of project emissions~~
~~Comments~~	~~N/A~~

6.2 Data and Parameters Monitored

Data / Parameter:	$\Delta C_{ACTUAL,t}$ ~~$DC_{ACTUAL,t_{ACM0003}}$~~
Data unit:	t CO_2e
Description:	Actual net GHG removals by sinks, in year *t*
Equations	1~~, 2~~
Source of data:	~~*A/R CDM consolidated methodology* AR-ACM0003 (*Afforestation and reforestation of lands except wetlands*)~~

Description of measurement methods and procedures to be applied:	See *AR-ACM0003*
Frequency of monitoring/recording:	See *AR-ACM0003*
QA/QC procedures to be applied:	See *AR-ACM0003*
Purpose of data:	Calculation of project emissions
Calculation method:	See *AR-ACM0003*
Comments:	N/A

Data / Parameter:	$C_{TREE\_PROJ,t}$
Data unit:	t CO_2e
Description:	Carbon stock in tree biomass in the project scenario within the project boundary in year *t*
Equations	3, 4
Source of data:	*AR-Tool14 Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*
Description of measurement methods and procedures to be applied:	See *AR-Tool14*
Frequency of monitoring/recording:	See *AR-Tool14*
QA/QC procedures to be applied:	See *AR-Tool14*
Purpose of data:	Calculation of project emissions
Calculation method:	See *AR-Tool14*
Comments:	N/A

Data / Parameter:	$C_{SHRUB\_PROJ,t}$
Data unit:	t CO_2e
Description:	Carbon stock in shrub biomass in the project scenario within the project boundary in year *t*
Equations	3, 5
Source of data:	*AR-Tool14 Estimation of carbon stocks and change in carbon*

	stocks of trees and shrubs in A/R CDM project activities
Description of measurement methods and procedures to be applied:	See *AR-Tool14*
Frequency of monitoring/recording:	See *AR-Tool14*
QA/QC procedures to be applied:	See *AR-Tool14*
Purpose of data:	Calculation of project emissions
Calculation method:	See *AR-Tool14*
Comments:	N/A

Data / Parameter:	$C_{WPS,herb,i,t}$
Data unit:	t CO_2e
Description:	Carbon stock in herbaceous vegetation in the project scenario in stratum *i* in year *t*
Equations	7
Source of data:	Default value or from own measurements
Description of measurement methods and procedures to be applied:	A default value (see Section 6.1) may be used. Vegetation cover must be determined by commonly used techniques in field biology. Aboveground herbaceous mass (herb) is defined as a pool that includes both living plant mass (i.e., biomass) and dead plant mass (i.e., litter). All living and dead herbaceous mass is clipped above the soil surface from inside each sample frame. Dry mass is determined either by drying the entire wet sample to a constant weight or by drying a subsample of the wet mass to determine a dry-to-wet mass ratio conversion factor. Because aboveground mass can be highly seasonal, the average pool must be calculated from at least two samples representing the minimum and maximum standing stocks. Alternatively, a conservative estimate of the pool may be determined from a sample taken at the time of minimum standing stock.
Frequency of monitoring/recording:	At each monitoring event. The default factor may be claimed only for the first year of the project crediting period, as herbaceous biomass quickly reaches a

	steady state.
QA/QC procedures to be applied:	See Section 9.3 of *REDD+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

~~Data / Parameter:~~	~~$GHG_{WPS-WRC}$~~
~~Data unit:~~	~~t CO_2e~~
~~Description:~~	~~Net GHG emissions in the REDD project scenario up to year *t**~~
~~Equations~~	~~2~~
~~Source of data:~~	~~Module M-PEAT~~
~~Description of measurement methods and procedures to be applied:~~	~~See module M-PEAT~~
~~Frequency of monitoring/recording:~~	~~See module M-PEAT~~
~~QA/QC procedures to be applied:~~	~~See module M-PEAT~~
~~Purpose of data:~~	~~Calculation of project emissions~~
~~Calculation method:~~	~~See module M-PEAT~~
~~Comments:~~	~~N/A~~

7 REFERENCE

Mitsch, W.J., and J.G. Gosselink 2007. *Wetlands*. 4th ed. John Wiley & Sons, Inc., Hoboken, NJ.

~~None.~~

DOCUMENT HISTORY

Version	Date	Comment
v1.0	9 March 2015	Initial version