VCS MODULE VMD0023

ESTIMATION OF CARBON STOCKS IN THE LITTER POOL

Version 1.0

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Sectoral Scope 14

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1 SOURCES

None

2 SUMMARY DESCRIPTION OF THE MODULE

The module consists of methods for sampling litter pools for continuous and point source litter types, estimating the total litter biomass within an area and calculating the carbon content of the liter pool.

3 DEFINITIONS

Litter: See *VCS Program Definitions.*

Stratification: The division of an area into sub-units (strata) which are relatively homogenous for the value of the variable on which the stratification is based, which are repeatable in the landscape, and could reasonably be expected to be similarly identified and classified by different people.

4 APPLICABILITY CONDITIONS

None

5 PROCEDURES

Litter for the purposes of this methodology includes all dead organic matter lying on the surface and less than 4 cm in diameter. Organic matter greater than 4 cm in diameter will be accounted using the module *VMD0024 Estimation of carbon stocks in the dead wood pool.*

Three types of litter distribution can occur:

- Dispersed – Litter is present throughout the area more or less evenly. For instance, litter derived from grasses and forbs will often be dispersed throughout the area where the grass is growing.
- Accumulated – Litter has been accumulated in specific locations, typically by the action of wind or water, or by human action.
- Point source – Litter originates from a point source which is not uniformly distributed throughout the area, such as a tree in a savanna ecosystem. Point source litter is distributed around the source, and may not occur at all in gaps where no source is present.

Measurement of litter accumulations must be undertaken differently for each type of litter. Prior to collection of litter data, the area must be stratified to reflect differences in biological community or physical conditions which may lead to different amounts or patterns of litter accumulation. Where more than one type of litter is found in a single stratum (for instance in the case of a savanna with scattered trees, where both dispersed and point source litter may be found), more than one form of measurement and estimation method should be used in a single stratum.

Therefore the total litter biomass for a stratum will be

$$Bl_s = B_{ld} + B_{la} + B_{lp} \quad (7.1)$$

Where:

Bl_s	=	Litter biomass per stratum, t
B_{ld}	=	Dispersed litter biomass per stratum, t
B_{la}	=	Accumulated litter biomass per stratum, t
B_{lp}	=	Point source litter biomass per stratum, t

The types of litter are accounted as follows:

1) Dispersed

Dispersed litter types must be sampled using area collection plots. Plots must be distributed randomly or systematically, and may be associated with other types of plots such as soil plots. Because litter does vary seasonally, it is critical that repeated litter plots be put into place on approximately the same date each time samples are taken to minimize seasonal variability.

Typically, a one square meter frame is laid on the ground, and all the litter within the frame is collected. Collected material must not include living biomass. Litter collected must include all dead biomass, both standing and fallen. Where very small or very large amounts of litter are found, other sizes of plots may be used. The collected litter is oven dried, and weighed. Within a given stratum, sufficient plots must be installed to meet the statistical requirements identified in the section on statistics below. Litter biomass from dispersed litter types is calculated using the following equation:

$$B_{ld} = A \cdot L_w \cdot n^{-1} \cdot PS_l^{-1} \cdot 10^1 \quad (7.2)$$

Where:

B_{ld}	=	Dispersed litter biomass per stratum, t
A	=	Stratum area, hectares
L_w	=	Total dry litter weight of the collected litter, kg
n	=	Number of litter plots, #
PS_l	=	Plot size of the litter plot, m^2

2) Accumulated

Accumulated litter must be measured using the same methods and equations as dispersed litter, with the following differences:

- The percentage of the area of the stratum covered in accumulated litter must be estimated. Depending on the type of litter accumulation it may be possible using very high resolution (sub centimeter multi-spectral) remote sensing to directly detect the litter accumulations, or to

map conditions such as lee pockets where litter accumulates. Where remote sensing cannot detect litter accumulations, the percentage of the stratum area covered in accumulated litter must be estimated by walking a systematic or random path across the stratum, and maintaining line intersect notes to note the beginning and ending points each time the path crosses a litter accumulation. If the line intersect method is used, the percentage of the line crossing accumulated litter will be the percentage of the area accounted as having accumulated area, and the area covered by accumulated litter is therefore estimated as:

$$A_{al} = LI\%_{al} \cdot A \quad (7.3)$$

Where:

A_{al} = The area covered with accumulated litter, hectares

$LI\%_{al}$ = The percentage of the traverse line which covers accumulated litter areas, non-dimensional

A = Stratum area, hectares

- The same sample plots as those used for dispersed litter must be used. However, plots must be located only in areas of accumulated litter. As above, sufficient plots must be installed to meet the statistical requirements identified in the section on statistics below.

Accumulated litter is therefore calculated using the following equation:

$$B_{la} = A_{al} \cdot L_w \cdot n^{-1} \cdot PS_l^{-1} \cdot 10^1 \quad (7.4)$$

Where:

B_{la} = Accumulated litter biomass per stratum, t

A_{al} = Area within the stratum covered with accumulated litter, hectares

L_w = Total dry litter weight of the collected litter, kg

n = Number of litter plots, #

PS_l = Plot size of the litter plot, m^2

3) Point source

Point source litter will typically be found surrounding the litter source, such as a tree. Litter accumulations will often vary in depth from the center to the perimeter of the area under and around the source. Thus measurements must be undertaken using the following steps:

1) Determine the minimum size of sources with litter accumulations.

In many cases, below a certain minimum size trees or other sources will have no measurable litter accumulation. If this is true, determine whether inventory data for the sources will allow sources below the minimum size to be typed out and removed from the inventory or not.

2) Estimate the number of sources per hectare.

Point source litter arises from discrete, non-continuous sources such as scattered trees. The number of sources per hectare must be estimated using any of the survey techniques noted in module *VMD0022 Estimation of Carbon Stocks in Living Plant Biomass*. Depending on the outcome of Step 1, the estimate of the number of sources may exclude sources that are below a certain minimum size.

3) Sample the litter depths.

Point source litter is typically distributed under and/or around the source, with litter depths varying with the distance from the source.

The following steps must be used to sample the litter*:*

i. Select sample sources. Sources must be selected systematically or randomly, and may, for example, be selected based on a selection rule at plots established for other measurements. If sources below a minimum size have been eliminated from the inventory in Step 2, these sources must not be selected. Based on field experience, amounts of point source litter vary widely from point to point. Thus project proponents are not expected to meet statistical precision requirements for this type of litter. However, project proponents are required to demonstrate that the points sources sample are representative of the range of sizes of sources. A minimum of 30 point sources must be sampled for each stratum where point source litter exists.

ii. Lay out a sample line. The sample line must run in a preselected direction (for instance a cardinal point) from the center of the source.

iii. Measure the litter depth. Litter depth must be measured at a series of preselected distances from the center. The first distance from the center will always be the radius of the stem of the point source. Within this radius the litter depth will be zero. Beyond that point distances shall be systematic and predetermined (measurements taken every 30 cm, for example). Measurements must be continued outward from the point source until litter from this source makes up less than 50% of the litter found. Measured litter depths must not include any layer of litter from other sources which may lie on top of the litter from the source in question, but will include such litter embedded within the litter layer

4) Determine the litter density.

Litter density must be determined by sampling a constant volume of undisturbed litter – for instance by pressing a can of known volume upside down into the litter to fill the can. The resulting litter samples must be totally dried, and weighed to determine a weight per unit volume.

5) Calculate the total point source litter biomass at each sampled point source based on calculation of the volume of litter in a series of rings beginning at the source and moving outward, using the following equation:

$$B_{lpy} = D_l \cdot ((dp_1 \cdot ((r_1^2 \cdot \pi) - (rs^2 \cdot \pi)) + \sum_x^z (dp_x \cdot ((r_x^2 \cdot \pi) - (r_{x-1}^2 \cdot \pi)))) \cdot 10^{-6} \quad (7.5)$$

Where:

B_{lpy}	=	Total point source litter biomass at sampled point source *y*, t
D_l	=	Density of the litter, g/cm3
dp_x	=	The depth of the litter layer at measurement point x (point 1 being closest to the center of the source), averaged across all of the samples, cm
r_x	=	The distance from the center to measurement point x, cm
rs	=	The radius of the stem of the litter source. If there is no stem, rs=0
x	=	The number of the measurement point, with point 1 being the closest to the center of the source
z	=	The number of the measurement point farthest from the center

Statistical calculations for point source litter must be calculated based on B_{lpy} following the guidance given in the section on statistical calculations below:

6) Calculate the total point source litter in the stratum

$$B_{lp} = A \cdot PS\# \cdot z^{-1} \cdot \sum_y B_{lpy} \quad (7.6)$$

Where:

B_{lp}	=	Total point source litter biomass in the stratum, t
B_{lpy}	=	Total point source litter biomass at sampled point source *y*, t
z	=	The number of sample points
A	=	Area of the stratum, ha
PS#	=	The number of accounted point sources per hectare

Statistical Calculations

Calculate the standard deviation and the confidence interval for total carbon for each type of litter independently. Where the confidence interval exceeds +/- 10% with 90% confidence for any of the litter types within the stratum, project proponents must undertake one or more of the following three actions:

a. Re-stratify: Where the variance in the samples appears to be correlated to geographic or other factors, re-stratification can be considered, as discussed in module *VMD0018 Methods to*

Determine Stratification. If re-stratification is undertaken, confidence intervals must be re-calculated for the new strata. Re-stratification requires the installation of further randomly or systematically located plots if the confidence interval in one of the new strata fails to meet the required confidence standards, unless the project proponent chooses to utilize option c, below, for that stratum.

b. Increase the number of plots: Where the variance appears to be inherent to and distributed across the stratum, the project proponent may choose to install further plots. An estimate of the required number of further plots must be calculated, using the equation below (3), and further plots installed, located systematically or randomly.

$$N = t^2 \cdot s^2 \cdot (0.1 \cdot m)^{-2} \quad (7.7)$$

Where

N	=	Total number of plots expected to be required
t	=	Student t-test 0.90 value for n-1, n being the number of plots already established
s	=	Standard deviation for the existing plot values
m	=	Mean value of the variable from the existing plots

c. Recalculate the value of B_{ld}, B_{la} or B_{lp}: In some cases, due to project size or other factors, installing enough plots to meet the required confidence interval for a given litter type may not be economically viable. In these cases, project proponents can proceed with data gathered to a lower confidence interval if an appropriate confidence deduction is taken.

Increasing uncertainty caused by the reduced confidence interval will result in a deduction as determined by the *VCS Standard v3.4* or most recent version. The project proponents must recalculate the total estimated biomass for the relevant litter type ($B_{l,}$ B_{la} or B_{lp}) as follows:

1. Where sampling is undertaken prior to project commencement to determine the baseline:

$$total = total \bullet (1 + (ci - 0.1)) \quad (7.8)$$

Where:

total	=	B_{ld}, B_{la} or B_{lp}
ci	=	The calculated confidence interval at 90% confidence

2. Where sampling is undertaken after project commencement to determine carbon under the project scenario:

$$total = total \bullet (1 - (ci - 0.1)) \quad (7.9)$$

Where

total	=	$B_{ld,}$ B_{la} or B_{lp}

ci	=	The calculated confidence interval at 90% confidence

6 PARAMETERS

Data Unit / Parameter:	Bl_s
Data unit:	t
Description:	Litter biomass per stratum
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Litter biomass per stratum
Any comment:	

Data Unit / Parameter:	B_{ld}
Data unit:	t
Description:	Dispersed litter biomass per stratum
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Dispersed litter biomass per stratum
Any comment:	

Data Unit / Parameter:	B_{la}
Data unit:	t
Description:	Accumulated litter biomass per stratum
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Accumulated litter biomass per stratum
Any comment:	

Data Unit / Parameter:	B_{lp}
Data unit:	t
Description:	Point source litter biomass per stratum
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	point source litter biomass per stratum
Any comment:	

Data Unit / Parameter:	B_{lpy}
Data unit:	t
Description:	Point source litter biomass per sampled point source
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	point source litter biomass per stratum
Any comment:	

Data Unit / Parameter:	A
Data unit:	Hectares
Description:	Stratum area
Source of data:	From field surveys or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	Stratum area
Any comment:	

Data Unit / Parameter:	L_w
Data unit:	Kg
Description:	Total dry weight of the collected litter
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	Total dry weight of the collected litter
Any comment:	

Data Unit / Parameter:	n
Data unit:	#
Description:	Number of litter plots
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	Number of litter plots
Any comment:	

Data Unit / Parameter:	PS_l
Data unit:	m^2
Description:	Plot size of the litter plot
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	Plot size of the litter plot
Any comment:	

Data Unit / Parameter:	A_{al}
Data unit:	Hectares
Description:	Area within the stratum covered with accumulated litter
Source of data:	Field Survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	Area within the stratum covered with accumulated litter
Any comment:	

Data Unit / Parameter:	z
Data unit:	#
Description:	number of sample points for point source litter sampling
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The number of sample points for point source litter sampling at a given source
Any comment:	

Data Unit / Parameter:	D_l
Data unit:	g/cm^3
Description:	Density of the litter
Source of data:	Laboratory measurement of field samples
Justification of choice of data or description of measurement methods and procedures applied:	Density of the litter collected at the point source sampling points
Any comment:	

Data Unit / Parameter:	PS#
Data unit:	#
Description:	Number of accounted point sources per hectare
Source of data:	Field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The number of accounted point sources per hectare
Any comment:	

Data Unit / Parameter:	Dp_x
Data unit:	cm
Description:	Depth of the litter layer at measurement point x
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The depth of the litter layer at measurement point x (point 1 being closest to the center of the source), averaged across all of the samples,
Any comment:	

Data Unit / Parameter:	r_x
Data unit:	cm
Description:	Distance from the center to measurement point x
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The distance from the center to measurement point x for each point source sampling point
Any comment:	

7 REFERENCES AND OTHER INFORMATION

None

DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 Nov 2012	Initial version released