VCS MODULE VMD0024

ESTIMATION OF CARBON STOCKS IN THE DEAD WOOD 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 and calculating dead wood biomass where dead wood is distributed across the stratum, as well as where it is concentrated in piles or windrows.

3 DEFINITIONS

Dead Wood: See *VCS Program Definitions.*

Project Area: The area or areas of land on which the project proponent will undertake the project activities.

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

Introduction

Dead wood will be found in one of two conditions:

- Standing
- Lying

Standing dead wood must be inventoried using the same plot methods as those laid out in the module *VMD0022 Estimation of Carbon in Living Plant Biomass*, Step 2(C) for measurement of living trees using plots. This work should be undertaken at the same time as the inventory of living trees.

Lying dead wood includes all lying organic matter greater than 10 cm in diameter, and may be found in two distributions:

- Distributed – the dead wood is scattered across the ground where it fell
- Concentrated – the dead wood has been concentrated into piles, windrows, etc, usually by human action, but also possibly by the action of water or other natural agents

Therefore total dead wood in the stratum must be quantified as:

$$Bdw_s = B_{dwt} + B_{dwd} + B_{dwc} \quad (8.1)$$

Where:

Bdw_s = Total dead wood biomass in the stratum, tonnes

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B_{dwt} = Standing dead wood biomass in the stratum, tonnes

B_{dwd} = Distributed dead wood biomass in the stratum, tonnes

B_{dwc} = Concentrated dead wood biomass, tonnes

Separate methods will be used to inventory distributed and concentrated dead wood.

Method A: Inventorying distributed dead wood

Distributed dead wood must be inventoried using a line intersect method, using the following steps:

Step 1: Establishment of lines

Dead wood is measured along lines laid out throughout the stratum. Lines must be laid out systematically, cover the entire area, and run through all variations in ecosystem make-up, process, or conditions which are found within the stratum, in an unbiased manner. For instance, a typical approach might be to lay out lines beginning from a randomly located starting point, running in a randomly selected direction, evenly spaced across the block. Note, however, that even with a random starting point and direction, the project proponent must ensure that sampling is not biased, as could occur if the random direction and spacing happened to coincide with repetitions of natural or manmade features such as roads or stream channels. Lines are divided into 100m segments.

Step 2: Measurement of dead wood

For each piece of dead wood greater than 10 cm in diameter that crosses the line. measure the average diameter perpendicular to the grain of the piece at that point. Where a piece of dead wood is not round, this may require several measurements. Optionally the average can be calculated as the maximum diameter measured plus the minimum diameter measured, divided by two. Each measured piece is also identified as by species and soundness. Soundness should be classified as sound, intermediate or rotten. Defining these classes will be at the discretion of the field team, but the classes must be discrete, cover the full range of dead wood found, and be clearly identifiable based on the use of consistent field techniques. Typical field techniques may include assessment of the degree of penetration with a knife or other instrument. A clear dividing line must also be defined between dead wood and material sufficiently rotted that it will be quantified as litter or humus, to avoid double counting. Typically any material which substantially retains the shape of the original wood is considered dead wood, while material which has disintegrated is defined as litter or humus, depending on the degree of disintegration. Samples of each species and soundness class found must be taken and the dry mass of the material (g/cm^3) determined.

Step 3: Calculation of dead wood cross section per 100 m interval

For each 100m section of the line, the following equation must be used to calculate the mass per centimeter of length for each piece of wood detected along the line section.

$$DW_l = (dw_d \cdot 2^{-1})^2 \cdot \pi \cdot WM_s \quad (8.2)$$

Where:

DW_l = The mass of the wood per unit of length, g/cm

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dw_d = The average diameter of the piece of dead wood at the line, cm

WM_s = Density of the wood of the species and soundness class, g/cm^3

The factor DW_l must then be summed for all pieces of wood in each 100m line segment:

$$DW_s = \sum_{w}^{x} DW_l \quad (8.3)$$

Where:

DW_s = The total mass of the wood for an area of 1 cm wide by 100m long, g/10,000cm^2

DW_l = The mass of the wood per unit of length, g/cm^2

w = The pieces of wood found in the line segment

x = The total number of pieces of wood found in the line segment

Step 4: Statistical analysis

Determine the confidence interval of the factor DWs for the lines segments found in the stratum. The standard error of the mean should be less than ± 10% with 90% confidence interval, subject to the guidance given in the section on statistics below.

If post-stratification is undertaken, confidence intervals must be recalculated.

Step 5: Calculation of dead wood biomass per stratum

Dead wood biomass within the stratum must be calculated using the following equation:

$$B_{dwd} = A \bullet 10^{-2} \bullet ls\#^{-1} \bullet \sum_{ls}^{y} DW_s \quad (8.4)$$

Where:

B_{dwd} = Distributed dead wood biomass in the stratum, tonnes

A = The area of the stratum, hectares

$ls\#$ = The number of 100m line segments sampled in the stratum, number

DW_s = The total mass of the wood for an area of 1 cm wide by 100m long, g/10,000cm^2

y = The number of line segments sampled

Method B: Inventorying concentrated dead wood

Where dead wood has been concentrated into windrows or piles, the following steps must be undertaken:

Step 1: Estimate the amount of dead wood piles or windrow

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Estimate the number of dead wood piles, or the length (meters) of windrows in the stratum. This can often be efficiently accomplished using remote sensing, since piles or windrows are often big enough to show up at higher resolutions. Where distinct size classes of piles or windrows exist, these must be accounted separately. Where remote sensing cannot be used, the following estimation techniques must be used:

- Windrows: lay out a line or lines perpendicular to the direction of the windrows, and reasonably covering the area, similar to the line intersect methods used for the distributed dead wood above, and count the number of windrows crossed. The total length of windrow must be calculated using the following equation:

$$WL = w\# \cdot ls\#^{-1} \cdot 10^2 \cdot A \quad (8.5)$$

Where:

WL	=	The total length of windrows in the stratum, meters
w#	=	The number of windrows counted during the survey, number
ls#	=	The total number of 100m line segments surveyed along the lines, number
A	=	The areas of the stratum, hectares

- Piles: lay out 1 hectare plots by locating the corners of a 100m by 100 m area, and count the number of piles within the plot. Plots must be laid out systematically, and must be located throughout the stratum. The total number of piles will be:

$$P\# = Totp \cdot plt\#^{-1} \cdot A \quad (8.6)$$

Where:

P#	=	The number of piles in the stratum, number
Totp	=	The total number of piles counted in all of the plots, number
plt#	=	The total area plotted, hectares, (= the number of plots)
A	=	The area of the stratum, hectares

Step 2: Estimate the volume per pile or meter of row

Using measurements and standard geometric formulae, measure a number of windrows or piles, and estimate the gross volume per pile, or per meter of windrow. Sufficient measurements should be taken to achieve a standard error of the mean of less than 10% with 90% confidence, subject to the guidance given in the section on statistics below. As noted above, where distinct size classes of piles or windrows exist, and where those size classes have been counted or measured for length separately, the volumes for each size class must be summarized separately.

Step 3: Estimate the concentration of dead wood

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Estimate the percentage of the volume of the pile or windrow that is made up of wood. This can be done by cutting apart a measured portion of a pile or row, and measuring and calculating the volume of each piece of wood in it. During this process wood must be assessed for soundness, as discussed for dispersed dead wood above, and species, where species can be identified.

Step 4: Estimate the average dead wood dry specific gravity

Samples of each combination of species and soundness class found must be taken and the mass of the material (g/cm^3) determined. Based on the percentage of each species and soundness class identified, calculate the average dead wood dry specific gravity.

Step 5: Calculate the total dead wood biomass in piles and windrows

Total dead wood biomass in piles and windrows per stratum must be calculated using the following formula:

$$B_{dwc} = \sum_{w}^{s} (wl_s \bullet wv_s \bullet \%ww_s \bullet WM_{aw}) + \sum_{p}^{r} (\# p_r \bullet pv_r \bullet \% pw_r \bullet WM_{ap}) \quad (8.7)$$

Where:

B_{dwc}	=	Biomass of dead wood in piles and windrows, t
s	=	Number of different windrow sizes #
wl_s	=	The length of windrow in size class w in the stratum, m
wv_s	=	The volume of the windrow in size class s per meter of length, m^3/m
$\%ww_s$	=	The percentage of wood by volume in windrow size class s, m^3/m^3
WM_{aw}	=	The average specific gravity of the dry wood in the windrows, t/m^3
p	=	Pile sizes
r	=	The number of different pile size classes
$\#p_r$	=	The number of piles in size class r in the stratum
pv_r	=	The average pile volume in size class r, m^3
$\%pw_r$	=	The percentage of wood by volume in size class r. m^3/m^3
WM_{ap}	=	The average density of the dry wood in piles, t/m^3

Statistical Calculations

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

a. Re-stratify: Where the variance in the samples appears to be correlated to geographic or other factors, re-stratification should be considered, as discussed in the module *VMD0018 Methods to Determine Stratification*. If re-stratification is undertaken, confidence intervals should 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

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required confidence standards, unless the project proponent chooses to utilize option c, below, for that stratum.

b. Increase the number of line segments or samples: Where the variance appears to be inherent to and distributed across the stratum, the project proponent may choose to install further line segments or samples. An estimate of the required number of further line segments or samples can be calculated, using the equation 8.8, and further line segments or samples installed, located systematically or randomly.

$$N = t^2 \cdot s^2 \cdot (0.1 \cdot m)^{-2} \quad (8.8)$$

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

Recalculate the value of wv_s, pv_r or DWs

c. In some cases, due to project size or other factors, installing enough lines or samples to meet the required confidence interval for a given dead wood type may not be economically viable. In these cases, the project proponent may proceed with data gathered to a lower confidence interval. However, the project proponent must recalculate the total estimated biomass for the relevant dead wood type (wv_s, pv_r or DWs) as follows:

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

$$total = total \bullet (1 + (ci - 0.1)) \quad (8.9)$$

Where:

total	=	wv_s, pv_r or DWs
ci	=	The calculated confidence interval at 90% confidence

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

$$total = total \bullet (1 - (ci - 0.1)) \quad (8.10)$$

Where

total	=	wv_s, pv_r or DWs
ci	=	The calculated confidence interval at 90% confidence.

6 PARAMETERS

Data Unit / Parameter:	Bdw_s
Data unit:	tonnes
Description:	Total dead wood biomass in the stratum
Source of data:	Calculated

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Justification of choice of data or description of measurement methods and procedures applied:	The mass of the wood per unit of length on the line intersect
Any comment:	

Data Unit / Parameter:	DW_l
Data unit:	g/cm
Description:	Mass of the wood per unit of length
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	The mass of the wood per unit of length on the line intersect
Any comment:	

Data Unit / Parameter:	dw_d
Data unit:	cm
Description:	Average diameter of the piece of dead wood at the line
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The average diameter of the piece of dead wood at the line
Any comment:	

Data Unit / Parameter:	WM_s
Data unit:	g/cm^3
Description:	Density of the wood of a species
Source of data:	Measured from samples
Justification of choice of data or description of measurement methods and procedures applied:	The dry mass of the wood of a species
Any comment:	

Data Unit / Parameter:	DW_s
Data unit:	g/cm
Description:	Mass of the wood per unit of length,
Source of data:	Field Survey
Justification of choice of data or description of measurement methods and procedures applied:	The total mass of the wood per unit of length for the 100m line segment,

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Any comment:	

Data Unit / Parameter:	W
Data unit:	#
Description:	Pieces of wood found in the line segment
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The pieces of wood found in the line segment
Any comment:	

Data Unit / Parameter:	x
Data unit:	#
Description:	Total number of pieces of wood
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The total number of pieces of wood found on the line segment.
Any comment:	

Data Unit / Parameter:	B_{dwd}
Data unit:	tonnes
Description:	Distributed dead wood biomass in the stratum
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Distributed dead wood biomass in the stratum
Any comment:	

Data Unit / Parameter:	A
Data unit:	hectares
Description:	Area of the stratum
Source of data:	Field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The area of the stratum
Any comment:	

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Data Unit / Parameter:	ls#
Data unit:	#
Description:	Number of 100m line segments
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The number of 100m line segments sampled in the stratum
Any comment:	

Data Unit / Parameter:	ls
Data unit:	#
Description:	Line segments sampled
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The line segments sampled
Any comment:	

Data Unit / Parameter:	y
Data unit:	#
Description:	Number of line segments sampled
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The number of line segments sampled
Any comment:	

Data Unit / Parameter:	WL
Data unit:	M
Description:	Total length of windrows
Source of data:	Field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The total length of windrows in the stratum
Any comment:	

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Data Unit / Parameter:	w#
Data unit:	#
Description:	Number of windrows counted
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The number of windrows counted during the survey
Any comment:	

Data Unit / Parameter:	P#
Data unit:	#
Description:	Number of piles
Source of data:	Field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The number of piles in the stratum
Any comment:	

Data Unit / Parameter:	Totp
Data unit:	#
Description:	Total number of piles counted
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The total number of piles counted in all of the plots
Any comment:	

Data Unit / Parameter:	plt#
Data unit:	Hectares
Description:	Total area plotted
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The total area plotted, hectares, (= the number of plots)
Any comment:	

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Data Unit / Parameter:	z
Data unit:	#
Description:	Windrow size classes
Source of data:	Determined from the field survey
Justification of choice of data or description of measurement methods and procedures applied:	number of different windrow sizes
Any comment:	

Data Unit / Parameter:	B_{dwc}
Data unit:	T
Description:	Biomass of dead wood in piles and windrows
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Biomass of dead wood in piles and windrows
Any comment:	

Data Unit / Parameter:	wl_s
Data unit:	M
Description:	The length of windrow in size class w in the stratum, m
Source of data:	Field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The length of windrow in size class s,
Any comment:	

Data Unit / Parameter:	wv_s
Data unit:	m^3/m
Description:	Volume of the windrow in size class z
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The volume of the windrow in size class s per meter of length
Any comment:	

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Data Unit / Parameter:	$\%ww_s$
Data unit:	%
Description:	Percentage of wood by volume in windrow size class s
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The percentage of wood by volume in windrow size class s
Any comment:	

Data Unit / Parameter:	WM_{aw}
Data unit:	$t.m^{-3}$
Description:	Average specific gravity of the dry wood in the windrows
Source of data:	Measurement of samples taken in the field survey
Justification of choice of data or description of measurement methods and procedures applied:	The average specific gravity of the dry wood in the windrows
Any comment:	

Data Unit / Parameter:	p
Data unit:	#
Description:	Pile sizes
Source of data:	Classified from field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	Pile sizes
Any comment:	

Data Unit / Parameter:	r
Data unit:	#
Description:	Pile size classes
Source of data:	Classified from field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	The pile size classes
Any comment:	

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Data Unit / Parameter:	$\#p_r$
Data unit:	#
Description:	Number of different pile size classes
Source of data:	Classified from field survey or remote sensing
Justification of choice of data or description of measurement methods and procedures applied:	the number of different pile size classes
Any comment:	

Data Unit / Parameter:	pv_r
Data unit:	m^3
Description:	Average pile volume in size class r,
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The average pile volume in size class r,
Any comment:	

Data Unit / Parameter:	$\%pw_r$
Data unit:	m^3/m^3
Description:	Percentage of wood by volume in size class r.
Source of data:	Field survey
Justification of choice of data or description of measurement methods and procedures applied:	The percentage of wood by volume in size class r.
Any comment:	

Data Unit / Parameter:	WM_{ap}
Data unit:	t/m^3
Description:	Average specific gravity of the dry wood in piles
Source of data:	Measurement of samples taken in the field survey
Justification of choice of data or description of measurement methods and procedures applied:	The average specific gravity of the dry wood in piles
Any comment:	

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Data Unit / Parameter:	B_{dwt}
Data unit:	Tonnes
Description:	Standing dead wood
Source of data:	Calculated
Justification of choice of data or description of measurement methods and procedures applied:	Standing dead wood biomass in the stratum
Any comment:	

7 REFERENCES AND OTHER INFORMATION

None

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DOCUMENT HISTORY

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

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