

VCS MODULE VMD0017  
REDD METHODOLOGICAL MODULE:  
ESTIMATION OF UNCERTAINTY FOR REDD  
PROJECT ACTIVITIES  
(X-UNC)

Version 2.0

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Sectoral Scope 14

Document Prepared by The Field Museum with TerraCarbon

## Table of Contents

1	Sources .....	3
2	Summary Description of the Module .....	3
3	Definitions and Acronyms .....	3
4	Applicability Conditions .....	3
5	Procedures .....	4
	Part 1 – Uncertainty in Baseline Estimates .....	4
	Part 2 – Uncertainty <i>Ex-Post</i> in the With-Project Scenario .....	9
	Part 3 – Total Error in REDD Project Activity .....	11
	Part 4 – Implications for Project Accounting .....	12
6	Parameters .....	12
7	References and Other Information .....	16

## 1 SOURCES

This module is one of numerous modules that comprise the VCS approved methodology VM0007: REDD Methodology Modules.

## 2 SUMMARY DESCRIPTION OF THE MODULE

This module allows for estimating uncertainty in the estimation of emissions and removals in REDD project activities. The module shall also be used for project planning purposes. Use of the module while planning the project can assure the monitoring is of sufficient intensity to minimize uncertainty deductions. The purpose of the methodology is for calculating *ex-ante* and *ex-post* a precision level and any deduction in credits for lack of precision following project implementation and monitoring. The module assesses uncertainty in baseline estimations and in estimations of with-project sequestration, emissions and leakage.

## 3 DEFINITIONS AND ACRONYMS

### Definitions

There are no unique definitions in this module.

### Acronyms

DP - Forest area that is cleared per additional person(s) entering the population

RRD – Reference region for projecting rate of deforestation

## 4 APPLICABILITY CONDITIONS

The module is mandatory. It is applicable for estimating the uncertainty of estimates of emissions and removals of CO<sub>2</sub>-e generated from REDD project activities. The module focuses on the following sources of uncertainty:

- Determination of rates of deforestation and degradation
- Uncertainty associated with estimation of stocks in carbon pools and changes in carbon stocks
- Uncertainty in assessment of project emissions

Where an uncertainty value is not known or cannot be simply calculated, then a project must justify that it is using an indisputably conservative number and an uncertainty of 0% may be used for this component.

Guidance on uncertainty – a precision target of a 95% confidence interval equal to or less than 15% of the recorded value shall be targeted. This is especially important in terms of project planning for measurement of carbon stocks; sufficient measurement plots should be included to achieve this precision level across the measured stocks.

## 5 PROCEDURES

### Parameters

This module provides procedures to determine the following parameter:

Parameter	SI Unit	Description
<i>Adjusted-C<sub>REDD</sub></i>	t CO <sub>2</sub> -e	Total net GHG emission reductions at time <i>t</i> adjusted to account for uncertainty

Estimated carbon emissions and removals arising from AFOLU activities have uncertainties associated with the measures/estimates of: area or other activity data, carbon stocks, biomass growth rates, expansion factors, and other coefficients. It is assumed that the uncertainties associated with the estimates of the various input data are available, either as default values given in IPCC Guidelines (2006), IPCC GPG-LULUCF (2003), expert judgment<sup>1</sup>, or estimates based on sound statistical sampling.

Alternatively, (indisputably) conservative estimates can also be used instead of uncertainties, provided that they are based on verifiable literature sources or expert judgment. In this case the uncertainty is assumed to be zero. However, this module provides a procedure to combine uncertainty information and conservative estimates resulting in an overall *ex-post* project uncertainty.

### Planning to Diminish Uncertainty

It is important that the process of project planning consider uncertainty. Procedures including stratification (see module **X-STR**), and the allocation of sufficient measurement plots can help ensure that low uncertainty in carbon stocks results and ultimately full crediting can result.

It is good practice to apply this module at an early stage to identify the data sources with the highest uncertainty to allow the opportunity to conduct further work to diminish uncertainty.

### Part 1 – Uncertainty in Baseline Estimates

#### Step 1: Assess uncertainty in projection of baseline rate of deforestation or degradation

##### Relevant modules:

<b>BL-PL</b>	“Estimation of baseline carbon stock changes and greenhouse gas emissions from planned deforestation”
<b>BL-UP</b>	“Estimation of baseline carbon stock changes and greenhouse gas emissions from unplanned deforestation”

<sup>1</sup> Justification should be supplied for all values derived from expert judgement

BL-DFW	“Estimation of baseline emissions from forest degradation caused by extraction of wood for fuel”
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**Relevant parameters:**

$A_{BSL,RR,unplanned}$	BL-UP
$D\%_{planned,i,t}$	BL-PL

It is here assumed that there is zero uncertainty in baseline rate of deforestation or degradation where numbers are equal to a long-term average (BL-UP), are based on actual deforestation plans (BL-PL) or are derived from PRA (BL-DFW). In these specific cases assume:

$$Uncertainty_{BSL,RATE} = 0$$

In all other scenarios the uncertainty in rate shall be a component of net project uncertainty.

- a. Planned Deforestation: where rate of deforestation is derived from measurements of proxy areas (see module BL-PL):

The uncertainty shall be equal to the 95% confidence interval as a percentage of the mean of the area deforested in each proxy ( $D\%_{pn}$ ) divided by the number of years over which deforestation occurred in each proxy ( $Yrs_{pn}$ ).

- b. Unplanned deforestation: where deforestation rate is derived using regression equations of past deforestation rate versus time, or deforested area versus population (population driver approach), the uncertainty introduced by this analysis must be incorporated (see module BL-UP). Uncertainty in the baseline rate of deforestation ( $Uncertainty_{BSL,RATE}$ ) is calculated referencing the 95% confidence limits of the regression model, calculated using standard regression analysis techniques<sup>2</sup>. For the value of the referenced independent variable (time or population) at time  $t$ , the half-width of the 95% confidence interval for the dependent variable (predicted deforestation) is calculated as a percent of the dependent variable (modeled) value. Uncertainty cannot be less than zero.

$$Uncertainty_{BSL,RATE,t} = \text{Half-width of the 95\% confidence interval for } A_{BSL,RRD,unplanned,t} / A_{BSL,RRD,unplanned,t} \quad (1)$$

Where:

$Uncertainty_{BSL,RATE,t}$       Uncertainty in the baseline rate of deforestation at time  $t$ , %

$A_{BSL,RRD,unplanned ,t}$       Projected area of unplanned baseline deforestation in the RRD at time  $t$ ; ha

<sup>2</sup> E.g. Hamilton, L.C. 1992. Regression with Graphics. Duxbury Press. Belmont, California. 363 pp.

Note that for time  $t$ , the value of the independent variable referenced is the value for the entire RRD (or RRD subset). For the population driver approach, the relevant value is total population (static approach) at time  $t$  or total change in population (dynamic approach) at time  $t - t-1$ , summed across all component population census units. If multiple subsets of the RRD are used, as in for the population driver approach where each RRD <sub>$j$</sub>  may have its own regression, total uncertainty in the baseline rate is calculated by propagating errors below is calculated using equation 1):

$$Uncertainty_{BSL,RATE,t} = \frac{\sqrt{\sum_{j=1}^N (Uncertainty_{BSL,RATE,t,j} * \sum_i^M A_{BSL,i,j,unplanned,t})^2}}{\sum_{j=1}^N \sum_i^M A_{BSL,i,j,unplanned,t}} \quad (2)$$

Where:

$Uncertainty_{BSL,RATE,t}$	Uncertainty in the baseline rate of deforestation at time $t$ , %
$Uncertainty_{BSL,RATE,t,j}$	Uncertainty in the baseline rate of deforestation at time $t$ for RRD subset $j$ ; %
$A_{BSL,i,j,unplanned,t}$	Projected area of unplanned baseline deforestation in census unit $i$ member of RRD subset $j$ in year $t$ ; ha
$t$	1, 2, 3, ... $t$ years elapsed since the start of the REDD VCS project activity
$j$	1, 2, 3, ... $N$ subsets of RRD (sets of census units with separate $DP$ parameters)
$i$	1, 2, 3, ... $M$ population census units

Uncertainty is then propagated across years to produce an estimate of cumulative uncertainty through year  $t$ .

$$Uncertainty_{BSL,RATE,t*} = \frac{\sqrt{\sum_{t=1}^{t*} (Uncertainty_{BSL,RATE,t} * \sum_{j=1}^N \sum_i^M A_{BSL,i,j,unplanned,t})^2}}{\sum_{t=1}^{t*} \sum_{j=1}^N \sum_i^M A_{BSL,i,j,unplanned,t}} \quad (3)$$

Where:

$Uncertainty_{BSL,RATE,t*}$	Cumulative uncertainty in the baseline rate of deforestation through time $t$ , %
$Uncertainty_{BSL,RATE,t}$	Uncertainty in the baseline rate of deforestation at time $t$ , %
$A_{BSL,i,j,unplanned,t}$	Projected area of unplanned baseline deforestation in census unit $i$ member of RRD subset $j$ in year $t$ ; ha
$t$	1, 2, 3, ... $t^*$ years elapsed since the start of the REDD VCS project activity
$i$	1, 2, 3, ... $M$ population census units

## Step 2: Assess uncertainty of emissions and removals in project area

### Relevant modules:

CP-AB	“Estimation of carbon stocks and changes in carbon stocks in the above-ground and below ground biomass carbon pool”
CP-D	“Estimation of carbon stocks and changes in carbon stocks in the dead-wood carbon pool”
CP-L	“Estimation of carbon stocks in the litter carbon pool”
CP-S	“Estimation of carbon stocks in the soil organic carbon pool”
CP-W	“Estimation of carbon stocks and changes in carbon stocks in the wood products carbon pool”
E-BB	“Estimation of non-CO <sub>2</sub> emissions from biomass burning”
E-FFC	“Estimation of emissions from fossil fuel combustion”
E-NA	“Estimation of direct N <sub>2</sub> O emissions from nitrogen application”

### Relevant parameters:

$C_{AB-tree}$	CP-AB
$C_{BB-tree}$	CP-AB
$C_{DW}$	CP-D
$C_{LI}$	CP-L
$C_{SOC}$	CP-S
$C_{WP}$	CP-W
$E_{BiomassBurn}$	E-BB
$E_{FC}$	E-FFC
$N_2O_{direct-N}$	E-NA

Uncertainty should be expressed as the 95% confidence interval as a percentage of the mean.

$$Uncertainty_{BSL,SS,i} = \frac{\sqrt{\sum_1^n (U_{BSL,SS,i,pool\#} * E_{BSL,SS,i,pool\#})^2}}{\sum_1^n E_{BSL,SS,i,pool\#}} \quad (4)$$

Where:

$Uncertainty_{BSL,SS,i}$  Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case in stratum  $i$ ; %

$U_{BSL,SS,i,pool\#}$  Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case in stratum  $i$  (1,2...n represent different carbon pools and/or GHG sources); %

$E_{BSL,SS,i,pool\#}$  Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in stratum  $i$  (1,2...n represent different carbon pools and/or GHG sources) in the baseline case; t CO<sub>2</sub>-e

$i$  1, 2, 3 ...  $M$  strata

### Step 3: Estimate total uncertainty in baseline scenario

To assess uncertainty across combined strata:

$$Uncertainty_{BSL,SS} = \frac{\sqrt{\sum_{i=1}^M (U_{BSL,SS,i} * E_{BSL,SS,i})^2}}{\sum_{i=1}^M E_{BSL,SS,i}} \quad (5)$$

Where:

$Uncertainty_{BSL,SS}$  Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case; %

$Uncertainty_{BSL,SS,i}$  Percentage uncertainty in the combined carbon stocks and greenhouse gas sources in stratum  $i$  in the baseline case; %

$E_{BSL,SS,t,i}$  Sum of combined carbon stocks and GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning in stratum  $i$  (1,2...n represent different carbon pools and/or GHG sources) multiplied by the area of stratum  $i$  ( $A_i$ ) in the baseline case; t CO<sub>2</sub>-e

$i$  1, 2, 3 ...  $M$  strata



Incorporating rate uncertainty:

$$Uncertainty_{BSL,t^*} = \sqrt{Uncertainty_{BSL,RATE,t^*}^2 + Uncertainty_{BSL,SS}^2} \quad (6)$$

Where:

$Uncertainty_{BSL,t^*}$  Cumulative uncertainty in baseline scenario through time  $t$ ; %

$Uncertainty_{BSL,RATE,t^*}$  Cumulative uncertainty in the baseline rate of deforestation *through* time  $t$ ; %

$Uncertainty_{BSL,SS}$  Total uncertainty in the combined carbon stocks and greenhouse gas sources in the baseline case; %

$t$  1, 2, 3, ...  $t^*$  years elapsed since the start of the REDD VCS project activity

## Part 2 – Uncertainty *Ex-Post* in the With-Project Scenario

Relevant modules:

CP-AB	“Estimation of carbon stocks and changes in carbon stocks in the above-ground and below-ground biomass carbon pools”
CP-D	“Estimation of carbon stocks and changes in carbon stocks in the dead-wood carbon pool”
CP-L	“Estimation of carbon stocks in the litter carbon pool”
CP-S	“Estimation of carbon stocks in the soil organic carbon pool”
CP-W	“Estimation of carbon stocks and changes in carbon stocks in the wood products carbon pool”
E-BB	“Estimation of non-CO2 emissions from biomass burning”
E-FFC	“Estimation of emissions from fossil fuel combustion”
E-NA	“Estimation of direct N2O emissions from nitrogen application”

Relevant parameters:

$C_{AB-tree}$	CP-AB
$C_{BB-tree}$	CP-AB

$C_{DW}$	CP-D
$C_{LI}$	CP-L
$C_{SOC}$	CP-S
$C_{WP}$	CP-W
$E_{BiomassBurn}$	E-BB
$E_{FC}$	E-FFC
$N_2O_{direct-N}$	E-NA

Area of deforestation or degradation in the with-project scenario should be tracked directly using the same accuracy assessment criterion as used in the baseline (accuracy of 90% or more—see module **BL-UP**).

$$Uncertainty_{P,i} = \frac{\sqrt{\sum_1^n (U_{P,SS,i,pool\#} * E_{P,SS,i,pool\#})^2}}{\sum_1^n E_{P,SS,i,pool\#}} \quad (7)$$

Where:

$Uncertainty_{P,i}$       Uncertainty in the combined carbon stocks and greenhouse gas sources in the with-project case in stratum  $i$ ; %

$U_{P,SS,i,pool\#}$       Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks, greenhouse gas sources and leakage emissions in the with-project case in stratum  $i$  (1,2...n represent different carbon pools and/or GHG sources); %

$E_{P,SS,i,pool\#}$       Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning) in stratum  $i$  (1,2...n represent different carbon pools and/or GHG sources) in the with-project case; t CO<sub>2</sub>-e

$i$                       1, 2, 3 ...  $M$  strata

To assess uncertainty across combined strata:

$$Uncertainty_P = \frac{\sqrt{(Uncertainty_{P,i1} * E_{P,i1})^2 + (Uncertainty_{P,i2} * E_{P,i2})^2 + \dots + (Uncertainty_{P,iM} * E_{P,iM})^2}}{E_{P,i1} + E_{P,i2} + \dots + E_{P,iM}} \quad (8)$$

Where:

$Uncertainty_P$	Total uncertainty in project scenario; %
$Uncertainty_{P,i}$	Uncertainty in baseline project in stratum $i$ ; %
$E_{P,SS,i}$	Sum of combined carbon stocks and GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning in stratum $i$ (1,2...n represent different carbon pools and/or GHG sources) multiplied by the area of stratum $i$ ( $A_i$ ) in the with-project case; t CO <sub>2</sub> -e
$i$	1, 2, 3 ... $M$ strata

### Part 3 – Total Error in REDD Project Activity

Calculation of leakage is conservative in all instances and therefore uncertainty is not considered here. Total project uncertainty is therefore equal to the combined uncertainty in baseline and with-project estimates:

$$C_{REDD\_ERROR,t^*} = \sqrt{Uncertainty_{BSL,t^*}^2 + Uncertainty_P^2} \quad (9)$$

Where:

$C_{REDD\_ERROR,t^*}$	Cumulative uncertainty for REDD project activity through time $t$ ; %
$Uncertainty_{BSL,t^*}$	Cumulative uncertainty in baseline scenario through time $t$ ; %
$Uncertainty_P$	Total uncertainty in the with-project scenario; %
$t$	1, 2, 3, ... $t^*$ years elapsed since the start of the REDD VCS project activity

Where no ex post (re-)measurements of carbon pools or GHG sources have been made, i.e. uncertainty from these sources is already included in  $Uncertainty_{BSL,t^*}$ , cumulative project uncertainty through time  $t$  is therefore equal to uncertainty in baseline estimates:

$$C_{REDD\_ERROR,t^*} = Uncertainty_{BSL,t^*} \quad (10)$$

Where:

$C_{REDD\_ERROR,t^*}$	Cumulative uncertainty for REDD project activity through time $t$ ; %
$Uncertainty_{BSL,t^*}$	Cumulative uncertainty in baseline scenario through time $t$ ; %
$t$	1, 2, 3, ... $t^*$ years elapsed since the start of the REDD VCS project activity

## Part 4 – Implications for Project Accounting

The allowable uncertainty under this methodology is +/- 15% of  $C_{REDD,t}$  at the 95% confidence level. Where this precision level is met then no deduction should result for uncertainty. Where uncertainty exceeds 15% of  $C_{REDD,t}$  at the 95% confidence level then the deduction shall be equal to the amount that the uncertainty exceeds the allowable level.

adjusted value for  $C_{REDD,t}$  to account for uncertainty shall be calculated as:

$$Adjusted\_C_{REDD,t} = C_{REDD,t} * (100\% - C_{REDD\_ERROR,t} + 15\%) \quad (11)$$

Where:

$Adjusted\_C_{REDD,t}$	Cumulative total net GHG emission reductions through time $t$ adjusted to account for uncertainty; t CO <sub>2</sub> -e
$C_{REDD,t}$	Cumulative total net GHG emission reductions through time $t$ ; t CO <sub>2</sub> -e
$C_{REDD\_ERROR,t}$	Cumulative uncertainty for REDD project activity through time $t$ ; %
$t$	1, 2, 3, ... $t$ years elapsed since the start of the REDD VCS project activity

## 6 PARAMETERS

Data / parameter:	$E_{BSL\ SS,i, pool\#}$
Data unit:	t CO <sub>2</sub> -e
Used in equations:	4, 5
Description:	Carbon stock or GHG sources (e.g. trees, dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in the baseline case
Source of data:	The terms denoting significant carbon stocks, GHG sources or leakage emissions from baseline modules ( <b>BL-DFW</b> , <b>BL-PL</b> , <b>BL-UP</b> ) used to calculate net emission reductions.
Measurement procedures (if any):	
Monitoring frequency:	Monitored at least once every ten years (or when the baseline is revisited)
Quality Assurance /	

Quality Control	
Any comment:	Baseline stocks and sources are estimated ex-ante for each baseline period

<b>Data / parameter:</b>	$E_{P,SS,i, Pool\#}$
Data unit:	t CO <sub>2</sub> -e
Used in equations:	7, 8
Description:	Carbon stock or GHG sources (e.g. trees, down dead wood, soil organic carbon, emission from fertilizer addition, emission from biomass burning etc.) in the with-project case
Source of data:	The terms denoting significant carbon stocks, GHG sources or leakage emissions used in calculating net emission reductions from the following relevant modules: <b>CP-AB, CP-D, CP-L, CP-S, CP-W, E-BB, E-FFC, E-NA.</b>
Measurement procedures (if any):	
Monitoring frequency:	Monitored at least once every five years
Quality Assurance / Quality Control	
Any comment:	The <i>ex-ante</i> estimation shall be derived directly from the estimations originating in the relevant modules: <b>CP-AB, CP-D, CP-L, CP-S, CP-W, E-BB, E-FFC, E-NA.</b>

<b>Data / parameter:</b>	$U_{BSL,SS,i,pool\#}$
Data unit:	%
Used in equations:	4, 5
Description:	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the baseline case (1,2...n represent different carbon pools and/or GHG sources)
Source of data:	Calculations arising from field measurement data
Measurement procedures (if any):	Uncertainty in pools derived from field measurement with 95% confidence interval calculated as the standard error of the averaged plot measurements in each stratum multiplied by the t value for the 95% confidence level.

	<p>For wood products the uncertainty should be the confidence interval around the volume of timber extracted from the forest.</p> <p>For emission sources conservative parameters should be used sufficient to allow the uncertainty to be set as zero.</p>
Monitoring frequency:	Monitored at least once every ten years (or when the baseline is revisited)
Quality Assurance / Quality Control	
Any comment:	Baseline stocks and sources are estimated ex-ante for each baseline period

<b>Data / parameter:</b>	$U_{P,SS,i,pool\#}$
Data unit:	%
Used in equations:	7
Description:	Percentage uncertainty (expressed as 95% confidence interval as a percentage of the mean where appropriate) for carbon stocks and greenhouse gas sources in the with-project case (1,2...n represent different carbon pools and/or GHG sources)
Source of data:	Calculations arising from field measurement data
Measurement procedures (if any):	<p>Uncertainty in pools derived from field measurement with 95% confidence interval calculated as the standard error of the averaged plot measurements in each stratum multiplied by the t value for the 95% confidence level.</p> <p>For wood products the uncertainty should be the confidence interval around the volume of timber extracted from the forest.</p> <p>For emission sources conservative parameters should be used sufficient to allow the uncertainty to be set as zero.</p>
Monitoring frequency:	Monitored at least once every five years
Quality Assurance / Quality Control	
Any comment:	<i>Ex-ante</i> the uncertainty in the with-project carbon stocks and sources shall be equal to the calculated baseline uncertainty

<b>Data / parameter:</b>	$C_{REDD,t}$
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Data unit:	t CO <sub>2</sub> -e
Used in equations:	11
Description:	Net anthropogenic greenhouse emission reductions at time $t$ , t CO <sub>2</sub> -e
Module parameter originates in:	REDD-MF
Any comment:	

<b>Data / parameter:</b>	$D\%_{pn}$
Data unit:	%
Used in equations:	Uncertainty in baseline rate
Description:	Percent of deforestation in land parcel <sup>3</sup> $pn$ etc of a proxy area as a result of planned deforestation as defined in this module; %
Module parameter originates in:	BL-PL
Any comment:	

Data / parameter:	$Yrs_{pn}$
Data unit:	years
Used in equations:	Uncertainty in baseline rate
Description:	Number of years over which deforestation occurred in land parcel $pn$ in proxy area; years
Module parameter originates in:	BL-PL
Any comment:	

Data / parameter:	$A_{BSL,RRD,unplanned,t}$
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<sup>3</sup> Parcels are a unit of land area. A stratum may contain many parcels.

Data unit:	ha
Used in equations:	1
Description:	Projected area of unplanned baseline deforestation in the reference region in year $t$
Module parameter originates in:	BL-UP equations 3 (simple historic) and 13 (population driver)
Any comment:	

Data / parameter:	$A_{BSL,i,j,unplanned,t}$
Data unit:	ha
Used in equations:	2, 3
Description:	Projected area of unplanned baseline deforestation in census unit $i$ member of RRD subset $j$ in year $t$
Module parameter originates in:	BL-UP equation 12
Any comment:	

## 7 REFERENCES AND OTHER INFORMATION

There is no additional information required for this module.



## DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version released
v2.0	31 July 2012	This module was updated to revise the procedure for calculating uncertainty for the BL-UP (VMD0007) module. Also uncertainty is now calculated cumulatively in parallel with the procedure for calculating the associated parameters. This module was revised by The Field Museum and was prepared by TerraCarbon.