GRAZING LAND AND LIVESTOCK MANAGEMENT GREENHOUSE GAS MITIGATION METHODOLOGY

MODULE NAME:
ACCOUNTING MODULE FOR SMALL-SCALE EMISSIONS WITHIN THE US

MODULE CODE:
A-SMALLSCALE

Output Parameter(s)
Parameter Name: S_BIO_{SS}
Parameter Description: Net small-scale biotic sequestration/emissions (t CO_2e)
Parameter Name: $E\text{-}FERT_{SS}$
Parameter Description: Net small-scale fertilizer emissions (t CO_2e)
Parameter Name: $E\text{-}FF$
Parameter Description: Net small-scale fossil fuel emissions (t CO_2e)

Key Input Data:
- Historic land management
- Planned project land management
- Soil type
- Fertilizer inputs
- Fossil fuel use

American Carbon Registry

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Purpose
To estimate emissions and net emission reductions from continental US-based grazing land and livestock management where reductions from focal sources are more than 5,000 t CO_2-e annually but less than 60,000 t CO_2-e annually *and* direct emissions are less than 60,000 t CO_2-e annually.

The module estimates both emissions in the baseline case and with project implementation.

Applicability Conditions
The module is applicable to all continental US-based grazing land and livestock management greenhouse gas emissions under this methodology.

Where reductions from focal sources are more than 5,000 t CO_2-e annually but less than 60,000 t CO_2-e annually *and* direct emissions are less than 60,000 t CO_2-e annually (see T-XANTE) the module shall be used in all cases where the large-scale modules (A-BIOTIC and A-FERTILIZER) have not been voluntarily elected. For fossil fuels in the US the module is mandatory for all projects where emissions reductions exceed 5,000 t CO_2-e annually.

1.0 Calculation Procedure

For biotic sequestration the baseline shall be static, remaining fixed for the entire crediting period. *Ex ante* an estimate will be made of both baseline and with-project emissions. *Ex post* at the time of reporting, project emissions shall be calculated based on climatic conditions and other variable factors.

For fertilizer emissions and fossil fuel emissions, the baseline shall be dynamic. *Ex ante* an estimate will be made of both baseline and with-project emissions. *Ex post* at the time of reporting, baseline and project emissions shall be calculated based on climatic conditions and other variable factors specific to the project and time period.

1.1 Model

The module uses the whole-farm calculation model COMET 2.0 available at:

http://www.comet2.colostate.edu/

"Comet 2.0 ^{TM} is a user-friendly, web-based tool that provides estimates of carbon sequestration and net greenhouse gas emissions from soils and biomass for US farms and ranches. It links a large set of databases containing information on soils, climate and management practices to dynamically run the Century ecosystem simulation model as well as empirical models for soil N_2O emissions and CO_2 from fuel usage for field operations. The system uses farm-specific information to provide mean estimates and uncertainty for CO_2 emissions and sequestration from soils and woody biomass and soil N_2O emissions for annual crops, hay, pasture and range, perennial woody crops (orchards, vineyards), agroforestry practices, and fossil fuel usage."

1.1.1 Running the model

The Comet 2.0 model is user-friendly and provides guidance on each set of required inputs where needed. Users should enter separate parcels for each area in which differences exist in historic management, planned project management or soil type.

Management is disaggregated by: crop / grass-hay / pasture-range / agroforestry / orchard-vineyard / CRP. Within these categories further disaggregation occurs by for example specific practice/crop, by tillage practice and by irrigation.

Fertilizer application and fossil fuels used should also be added where indicated (although users can elect to use A-MICROSCALE where applicable or will be required to use the large scale A-BIOTIC and A-FERTILIZER where applicable).

The outputs shall be:

- annual soil carbon stock change in baseline scenario and project scenario:

$\Delta C_{BSL,p}$ Annual change in carbon stock in the baseline scenario for parcel p; t C/yr
$\Delta C_{P,p}$ Annual change in carbon stock in the project scenario for parcel p; t C/yr

- uncertainty in carbon stock change in baseline scenario and project scenario:

$\Delta C_{BSL,ERROR,p}$ Uncertainty in annual change in carbon stock in the baseline scenario for parcel p; %
$\Delta C_{P,ERROR,p}$ Uncertainty in annual change in carbon stock in the project scenario for parcel p; %

- annual N_2O flux in baseline scenario and project scenario:

$N2O_{BSL,p}$ Annual flux of nitrous oxide in the baseline scenario for parcel p; kg N_2O/yr
$N2O_{P,p}$ Annual flux of nitrous oxide in the project scenario for parcel p; kg N_2O/yr

- uncertainty in N_2O flux in baseline scenario and project scenario:

$N2O_{BSL,ERROR,p}$ Uncertainty in nitrous oxide flux in the baseline scenario for parcel p; %
$N2O_{P,ERROR,p}$ Uncertainty in nitrous oxide flux in the project scenario for parcel p; %

- annual fossil fuel emissions in baseline scenario and project scenario:

$FUEL_{BSL,}$ Annual fossil fuel emission in the baseline scenario; t CO_2-e/yr
$FUEL_P$ Annual fossil fuel emissions in the project scenario; t CO_2-e/yr

Where COMET 2.0 gives no estimate of uncertainty (for biotic sequestration or fertilizer emissions) a value of 20% shall be adopted.

1.2 Biotic Sequestration

Biotic sequestration derived from COMET 2.0 will be summed for both baseline and project scenario and converted to carbon dioxide equivalents:

$$\Delta C_{BSL} = \left(\sum_p \Delta C_{BSL,p} \right) * \frac{44}{12} \tag{1}$$

Where:
ΔC_{BSL} Annual change in carbon stock in the baseline scenario; t CO_2-e/yr
$\Delta C_{BSL,p}$ Annual change in carbon stock in the baseline scenario for parcel p; t C/yr

$$\Delta C_P = \left(\sum_p \Delta C_{P,p} \right) * \frac{44}{12} \tag{2}$$

Where:
ΔC_P Annual change in carbon stock in the project scenario; t CO_2-e/yr
$\Delta C_{P,p}$ Annual change in carbon stock in the project scenario for parcel p; t C/yr

The net small-scale biotic sequestration (prior to consideration of uncertainty) will be equal to the changes occurring in the project case minus changes occurring in the baseline case:

$$S-BIO_{ss,\,prelim} = \Delta C_P - \Delta C_{BSL} \tag{3}$$

Where:
$SSBS_{prelim}$ Net small scale biotic sequestration/emission prior to uncertainty deductions; t CO_2-e
ΔC_P Annual change in carbon stock in the project scenario; t CO_2-e/yr
ΔC_{BSL} Annual change in carbon stock in the baseline scenario; t CO_2-e/yr

Calculation of uncertainty requires the propagation of errors across the various parcels and between the baseline and project cases:

$$\Delta C_{BSL,ERROR} = \frac{\sqrt{\sum_p \left(\Delta C_{BSL,p} * \Delta C_{BSL,ERROR,p} \right)^2}}{\sum_p \Delta C_{BSL,p}} \tag{4}$$

Where:
$\Delta C_{BSL,ERROR,p}$ Uncertainty in annual change in carbon stock in the baseline scenario; %
$\Delta C_{BSL,p}$ Annual change in carbon stock in the baseline scenario for parcel p; t C/yr
$\Delta C_{BSL,ERROR,p}$ Uncertainty in annual change in carbon stock in the baseline scenario for parcel p; %

$$\Delta C_{P,ERROR} = \frac{\sqrt{\sum_{p}\left(\Delta C_{P,p} * \Delta C_{P,ERROR,p}\right)^2}}{\sum_{p}\Delta C_{P,p}} \tag{5}$$

Where:

$\Delta C_{P,ERROR,p}$	Uncertainty in annual change in carbon stock in the project scenario; %
$\Delta C_{P,p}$	Annual change in carbon stock in the project scenario for parcel p; t C/yr
$\Delta C_{P,ERROR,p}$	Uncertainty in annual change in carbon stock in the project scenario for parcel p; %

$$S\_BIO_{SS,ERROR} = \frac{\sqrt{\left(\Delta C_{BSL} * \Delta C_{BSL,ERROR}\right)^2 + \left(\Delta C_{P} * \Delta C_{P,ERROR}\right)^2}}{\left(\Delta C_{BSL} + \Delta C_{P}\right)} \tag{6}$$

Where:

$S\_BIO_{SS,ERROR}$	Total uncertainty for small scale biotic sequestration/emission; %
ΔC_{BSL}	Annual change in carbon stock in the projection scenario; t CO_2-e/yr
ΔC_{P}	Annual change in carbon stock in the project scenario; t CO_2-e/yr
$\Delta C_{BSL,ERROR,p}$	Uncertainty in annual change in carbon stock in the baseline scenario; %
$\Delta C_{P,ERROR,p}$	Uncertainty in annual change in carbon stock in the project scenario; %

As COMET 2.0 calculates 95% confidence intervals, deductions begin where uncertainty exceeds 15% of the mean:

If $S\_BIO_{SS,ERROR} \leq 15\%$ of $S\_BIO_{SS,prelim}$ then no deduction for uncertainty is required ($S\_BIO_{SS,prelim} = S\_BIO_{SS}$).

If $S\_BIO_{SS,ERROR} > 15\%$ of $S\_BIO_{SS,relim}$ then the modified value for S_BIO to account for uncertainty shall be:

$$S\_BIO_{SS} = S\_BIO_{SS,prelim} - \left(S\_BIO_{SS,prelim} * \left(S\_BIO_{SS,ERROR} - 15\%\right)\right) \tag{7}$$

Where:

S_BIO_{SS}	Net small scale biotic sequestration/emission; t CO_2-e
$S\_BIO_{SS,prelim}$	Net small scale biotic sequestration/emission prior to uncertainty deductions;
$S\_BIO_{SS,ERROR}$	Total uncertainty for small scale biotic sequestration/emission; %

1.2.1 Permanence

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

$$Buffer_{GLLM} = S\_BIO_{SS} * (1 - Buffer\%)$$ (8)

Where:
Buffer$_{GLLM}$ Buffer withholding for GLLM projects; t CO_2-e
S_BIO$_{SS}$ Net small scale 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.*[1] 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.

1.3 Fertilizer Emissions

Fertilizer emissions derived from COMET 2.0 will be summed for both baseline and project scenario and converted to carbon dioxide equivalents:

$$N2O_{BSL} = \left(\sum_{p} N2O_{BSL,p} \right) * \frac{310}{1000}$$ (8)

Where:
N2O$_{BSL}$ Annual flux of nitrous oxide in the baseline scenario; t CO_2e/yr
N2O$_{BSL,p}$ Annual flux of nitrous oxide in the baseline scenario for parcel *p*; kg N_2O/yr
310   Global warming potential of N_2O (SAR-100 value in IPCC AR4 2007)
1000   Conversion from kg to metric tonnes

$$N2O_P = \left(\sum_{p} N2O_{P,p} \right) * \frac{310}{1000}$$ (9)

Where:
N2O$_P$ Annual flux of nitrous oxide in the project scenario; t CO_2e/yr
N2O$_{P,p}$ Annual flux of nitrous oxide in the project scenario for parcel *p*; kg N_2O/yr
310   Global warming potential of N_2O (SAR-100 value in IPCC AR4 2007)
1000   Conversion from kg to metric tonnes

The net small-scale fertilizer emissions (prior to consideration of uncertainty) will be equal to the changes occurring in the project case minus changes occurring in the baseline case:

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[1] ACR has currently approved use of the most updated version of the VCS "Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination."

$$E\_FERT_{SS,pre\lim} = N2O_{BSL} - N2O_P \tag{10}$$

Where:

$E\_FERT_{SS,prelim}$ Net small scale fertilizer emissions prior to uncertainty deductions; t CO_2-e

$N2O_{BSL}$ Annual flux of nitrous oxide in the baseline scenario; t CO_2e/yr

$N2O_P$ Annual flux of nitrous oxide in the project scenario; t CO_2e/yr

Calculation of uncertainty requires the propagation of errors across the various parcels and between the baseline and project cases:

$$N2O_{BSL,ERROR} = \frac{\sqrt{\sum_p \left(N2O_{BSL,p} * N2O_{BSL,ERROR,p} \right)^2}}{\sum_p N2O_{BSL,p}} \tag{11}$$

Where:

$N2O_{BSL,ERROR,}$ Uncertainty in nitrous oxide flux in the baseline scenario; %

$N2O_{BSL,p}$ Annual flux of nitrous oxide in the baseline scenario for parcel p; kg N_2O/yr

$N2O_{BSL,ERROR,p}$ Uncertainty in nitrous oxide flux in the baseline scenario for parcel p; %

$$N2O_{P,ERROR} = \frac{\sqrt{\sum_p \left(N2O_{P,p} * N2O_{P,ERROR,p} \right)^2}}{\sum_p N2O_{P,p}} \tag{12}$$

Where:

$N2O_{P,ERROR}$ Uncertainty in nitrous oxide flux in the project scenario; %

$N2O_{P,p}$ Annual flux of nitrous oxide in the project scenario for parcel p; kg N_2O/yr

$N2O_{P,ERROR,p}$ Uncertainty in nitrous oxide flux in the project scenario for parcel p; %

$$E\_FERT_{SS,ERROR} = \frac{\sqrt{\left(N2O_{BSL} * N2O_{BSL,ERROR} \right)^2 + \left(N2O_P * N2O_{P,ERROR} \right)^2}}{\left(N2O_{BSL} + N2O_P \right)} \tag{13}$$

Where:

$E\_FERT_{SS,ERROR}$ Total uncertainty for small scale fertilizer emissions; %

$N2O_{BSL}$ Annual flux of nitrous oxide in the baseline scenario; t CO_2e/yr

$N2O_P$ Annual flux of nitrous oxide in the project scenario; t CO_2e/yr

$N2O_{BSL,ERROR,}$ Uncertainty in nitrous oxide flux in the baseline scenario; %

$N2O_{P,ERROR}$ Uncertainty in nitrous oxide flux in the project scenario; %

As COMET 2.0 calculates 95% confidence intervals, deductions begin where uncertainty exceeds 15% of the mean:

If $E\_FERT_{SS,ERROR} \leq 15\%$ of $E\_FERT_{SS,prelim}$ then no deduction for uncertainty is required $(E\_FERT_{SS,prelim} = E\_FERT_{SS})$.

If $E\_FERT_{SS,ERROR} > 15\%$ of $E\_FERT_{SS,prelim}$ then the modified value for E_FERT to account for uncertainty shall be:

$$E\_FERT_{SS} = E\_FERT_{SS,pre\lim} - \left(E\_FERT_{SS,pre\lim} * \left(E\_FERT_{SS,ERROR} - 15\%\right)\right) \qquad \textbf{(14)}$$

Where:

E_FERT_{SS}	Net small scale fertilizer emissions; t CO_2-e
$E\_FERT_{SS,\,prelim}$	Net small scale fertilizer emissions prior to uncertainty deductions; t CO_2-e
$E\_FERT_{SS,\,ERROR}$	Total uncertainty for small scale fertilizer emissions; %

1.4 Fossil Fuel Emissions

Net fossil fuel emissions are equal to the difference between emissions in the baseline and project cases:

$$E\_FF = FUEL_{BSL} - FUEL_P \qquad \textbf{(15)}$$

Where:

E_FF	Net fossil fuel emissions; t CO_2e
$FUEL_{BSL,}$	Annual fossil fuel emission in the baseline scenario; t CO_2-e/yr
$FUEL_P$	Annual fossil fuel emissions in the project scenario; t CO_2-e/yr

2.0 Input Data Sources and Requirements

2.1 Data for validation

Parameter	Various as required by COMET model
Units	
Description	
Relevant Section	
Relevant Equation(s)	
Source of Data	
Data Requirements	
Collection Procedure	
Revision Frequency	
Comments	Use of defaults rather than entering in project specific data shall be justified