AVOIDED PLANNED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Title	*Avoided Planned Conversion of Grasslands and Shrublands to Crop Production*
Version	*1.0*
Date of Issue	*28-August-2012*
Type	*Methodology*
Sectoral Scope	*Sectoral scope 14, AFOLU; project category ACoGS; project types APC-IA and APC-UA.*
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Reference Number	*Reference number is assigned by VCSA upon approval*

Relationship to Approved or Pending Methodologies

At the time of development, there are no ACoGS-specific methodologies in the VCS methodology approval process. There are several Agricultural Land Management (ALM) methodologies related to fire, grazing or other grassland management practices but they do not account for the avoided conversion of grassland systems. Similarly, there are numerous REDD methodologies and modules applicable to the avoided conversion of forested systems, but these are not applicable to the avoided conversion of grassland systems as the primary carbon pools leading to emissions in the baseline for each project type are substantially different. The pending *The Earth Partners' Methodology for Soil Carbon* (TEP) could potentially be applicable to ACoGS. This methodology differs from the TEP methodology in that ex-post carbon pools and emission sources may be estimated without direct field measurements; instead, these sources can be estimated with peer-reviewed biogeochemical process models or empirical models. This methodology also differs from the TEP methodology in that non-CO2 GHGs may be estimated with biogeochemical models other than DNDC, such as Century or DayCent. Finally, this methodology has guidance on baseline determination specific to ACoGS, and the specific forms of conversion, namely Avoided Planned Conversion- Identified and Unidentified Agent. Collectively, these differences would entail more than a revision of the *TEP Methodology for Soil Carbon*.

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1. SOURCES

- Adoption of Sustainable Agricultural Land Management, VM0017, Version 1
- California Air Resources Board Compliance Offset Protocol - U.S. Forest Projects
- CDM A/R Methodological Tool “Estimation of direct nitrous oxide emission from nitrogen fertilization”
- CDM A/R Methodological Tool “Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project”
- Climate Action Reserve Forest Project Protocol Version 3.2
- IPCC 2006 Guidelines for National Greenhouse Gas Inventories, Volume 4, Agriculture Forestry and Other Land Use
- Methodology for Carbon Accounting of Grouped Mosaic and Landscape-scale REDD Projects, Terra Global Capital
- Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities
- Tool for testing significance of GHG emissions in A/R CDM project activities
- VCS AFOLU Module VMD008 Estimation of baseline carbon stock changes and greenhouse gas emissions from planned deforestation (BL-PK).v1.0
- VCS AFOLU Non-Permanence Risk Tool: VCS Version 3

2. SUMMARY DESCRIPTION OF THE METHODOLOGY

This methodology estimates the emissions avoided from preventing the conversion of grasslands and shrublands to commodity crop production. Grassland and shrubland soils are significant reservoirs of organic carbon that, if left uncultivated, will continue to store this carbon belowground. Grassland and shrubland ecosystems may also support greater plant biomass than annual cropland, especially belowground. In addition to the avoided cultivation and oxidation of soil organic carbon, several crop production practices, such as fertilizer applications, may also be avoided. Livestock, primarily cattle, are anticipated to be common in the project scenario and their associated emissions from enteric fermentation and manure deposition are accounted for.

This methodology accounts for two Avoided Planned Conversion baseline scenarios: where the conversion agent is identified and where unidentified. Projects that can identify the conversion agent are required to demonstrate proof of intent to convert by the identified agent. Where the specific conversion agent cannot be identified but a class of likely agents can, the Avoided Planned Conversion – Unidentified Agent baseline approach is used to determine the probability of conversion. This approach is based on the relative ratio of the property’s appraised value in the baseline and project scenarios, similar to the Compliance Offset Protocol U.S. Forest Projects adopted by the California Air Resources Board in October 2011.

The removal of project lands from the supply of potential cropland is expected to create leakage effects, all in the form of market leakage. A default market leakage estimate is proposed to account for these effects. Standardized values for leakage and baseline determination are specific to the United States and Canada.

Additionality	Project Method
Crediting Baseline	Project Method

3. DEFINITIONS

If not explicitly defined here, the current VCS definitions apply.

Identified Agent is the known entity that is planning to convert a particular parcel of grassland or shrubland to cropland (e.g., a particular local landowner).

Land Conservation Agreement is an easement, covenant, deed restrictions, or other legal agreement that may be employed to maintain the project land cover during the Project Crediting Period. The Land Conservation Agreement, as defined in this methodology, does not necessarily contain language pertaining to ownership of carbon or greenhouse gas emissions.

Participant Field refers to a particular parcel of grassland or shrubland where conversion to cropland is planned, analogous to the VCS definition of Project Activity Instance.

Project Area refers to the collective area where project activities are implemented.

Project Participant refers to a landowner or manager of a Participant Field (project activity instance) when the landowner is not the Project Proponent.

Project Region refers to the larger region including and encompassing the entire Project Area. The Project Region may be an eco-region or geographic administrative unit.

Stratum is an area of land within which the value of a variable, and the processes leading to change in that variable, are relatively homogenous.

Unidentified Agent refers to a particular entity that cannot be uniquely identified, but that belongs to a class of known conversion agents (e.g., farm corporations), and is planning to convert a particular parcel or grassland or shrubland to cropland.

Acronyms

ACoGS	Avoided Conversion of Grasslands and Shrublands
AFOLU	Agriculture, Forestry and Other Land Use
APC-IA	Avoided Planned Conversion- Identified Agent
APC-UA	Avoided Planned Conversion- Unidentified Agent
DNDC	DeNitrification-DeComposition Model
LU/LC	Land Use/Land Cover
PD	Project Description
VCS	Verified Carbon Standard
VCU	Verified Carbon Unit

4. APPLICABILITY CONDITIONS

This methodology has been designed for use by projects intending to avoid the planned conversion of grasslands or shrublands to cropland. In addition to satisfying the latest VCS AFOLU Requirements for ACoGS projects and other VCS program requirements, project activities must satisfy the following conditions for this methodology to apply:

a. All Participant Fields in the Project Area are currently grassland or shrubland, have qualified as grassland or shrubland for at least 10 years prior to the Project Start Date[1], will remain as grassland or shrubland throughout the Project Crediting Period, and are legally able to be converted and would be converted to cropland in the absence of the project activity. Baseline project scenarios fall under Avoided Planned Conversion (APC) project type, as specified in the most recent version of the VCS AFOLU Requirements.
b. All Participant Fields enrolled in the Project Area must be subject to a Land Conservation Agreement entered into by the Project Participant prohibiting the conversion of the land from grassland or shrubland for the duration of the project.
c. All Participant Fields must have the 'highest and best use' identified as cropland through an independent appraisal, as defined in 6.1.2.1.
d. Land may remain in use for animal husbandry and be subject to prescribed burning or wildfires during the project scenario, so long as prescribed burning conforms to current best management practices in the Project Region and does not knowingly contribute to the succession of native grasslands or shrublands to an alternative vegetation type.
e. Projects must avoid the complete conversion of grasslands or shrublands to cropland and not the degradation of grasslands or shrublands.
f. Project Proponents can demonstrate control over the Participant Fields and Project Area, and own rights to the greenhouse gas benefits of the project activity for the length of the Project Crediting Period.
g. The Project Area can include either one continuous parcel, or multiple discrete parcels of land. If the Project Area consists of multiple discrete parcels, Project Proponents must demonstrate that each discrete parcel meets all applicability criteria of the methodology.
h. Project Areas shall not include grasslands on organic soils or peatlands, or grasslands on non-forest wetlands.
i. Where livestock are present in the project scenario, manure may not be managed, stored, or dispersed in liquid form. Livestock shall be primarily forage fed and not managed in a confined area, e.g., feedlot.
j. In the project scenario, overgrazing or overstocking leading to the progressive loss of vegetative cover shall not occur, allowing carbon pools to remain at a steady state. Supplemental management practices that increase carbon stocks are allowable but the resultant emissions avoided or removed are not eligible for crediting unless quantified through a separate ALM methodology.
k. The Project Area is located in the United States or Canada.

5. PROJECT BOUNDARY

5.1 Spatial Boundary

There are three primary spatial boundaries used in this methodology, **Participant Fields**, the **Project Area** and the **Project Region**. The discrete parcels where project activities are implemented are individually referred to as Participant Fields (project activity instance) and collectively referred to as the Project Area. The Project Area shall include only those grassland or

[1] In the case of aggregated projects, Participant Fields must have qualified as grassland or shrubland for at least 10 years prior to the date the Project Participants agreed to enroll that field into the aggregate.

shrubland areas subject to planned conversion (by an Identified or Unidentified Agent) and where project activities to avoid such conversion are being implemented. Other areas that may fall within relevant property boundaries but for which grassland-shrubland to cropland conversion is not applicable (e.g., non-grassland land cover, waterways, residences, etc.) are not included in the Project Area.

The Project Region may be an eco-region or geographic administrative unit of relatively homogenous economic conditions and governance at which baseline activities are occurring, e.g. a state, county, watershed, irrigation district, Major Land Resource Area, etc. The Project Region is the highest-level geographical boundary and is used in this methodology for demonstrating baseline conditions – i.e., demonstration of historical conversion activities and easements (Sections 6.1.2.2 and **Error! Reference source not found.**), identification of baseline management practices and the quantification of greenhouse gas emission reductions and avoidance, i.e., to define the applicability of models and emission factors.

The Project Region shall be further stratified to account for heterogeneity within the Project Region according to the procedures in Section 5.1.1.

In situations where the Project Proponent (e.g., an aggregator) is not the Project Participant (e.g., an owner of a Participant Field), the Project Proponent must demonstrate ownership or control over avoidance activity through an easement, covenant, or other legal instrument restricting the management of conversion activities. In situations where the Project Proponent does not take fee-title possession of the land, a conveyance of the associated greenhouse gas benefits of the avoided conversion activity must be possessed to demonstrate clear ownership of potential VCUs. Project Proponents must also demonstrate during the Project Crediting Period that each Participant Field and Project Participant is subject to the conversion restrictions imposed by the ACoGS activity (e.g., via a conservation easement).

5.1.1 Stratification

Stratification is a sampling strategy that is often employed to reduce the number of samples required to provide an estimate for a variable of interest within a defined confidence interval and/or allowable sampling error. The objective of stratification for this section is to define areas with relatively homogenous levels of a particular carbon pool (e.g., soil organic carbon) to provide cost-effective project and baseline GHG estimation at the scale of the Project Region, yet remain accurate enough for estimation at the scale of the Project Area. The specific stratification approach and scale may vary depending upon project circumstances.[2] Projects involving multiple Participant Fields may elect to stratify across the larger Project Region whereas single projects may stratify across a single Participant Field. Soils are typically heterogeneous with respect to edaphic properties, local climates, land cover/land-uses, management histories, etc., and stratification shall account for these differences as appropriate.

Strata representing the baseline activity, but materially similar to the Project Area, shall also be included in the stratification design. Strata representing transition land uses/land covers (LU/LC) are not necessary for grasslands as conversion is assumed to instantaneously change the

[2] In cases where stratification would lead to a greater sampling intensity than without stratification, projects may apply a sampling approach without stratifying the project area (i.e., effectively treating the entire project area as one stratum).

LU/LC. In shrubland systems where the transition to the baseline LU/LC exceeds one year, then strata representing the transitional stages shall also be identified and included.

Stratification accuracy, precision and details such as sample design and plot selection shall be determined following best practices and detailed in the Project Description and Monitoring Plan. Where appropriate, stratification shall account for:

- Soil type
- Soil productivity
- Crop yield and grassland biomass productivities
- Land use/land cover
- Precipitation gradients

5.1.1.1 Baseline Agricultural Management Systems

Projected baseline management practices shall identify: tillage intensity, i.e. practice, depth and and frequency; crop rotations; fertilizer rates and application methods; and other relevant management decisions for the identified baseline land use scenario and resulting biogeochemical processes. Input shall be informed from producer surveys conducted by government agricultural agencies or university extension offices[3]; the expert opinion of an university extension personnel working in the region and systems of interest, personnel of a governmental agriculture agency field office (e.g., United States Department of Agriculture's Risk Management Agency, Farm Service Agency, Natural Resources Conservation Service) with jurisdiction in the Project Region; or cropland management plans approved by a lending agency. Alternatively, a survey conducted by the Project Proponent may be used where the above sources are unavailable, unreliable or outdated, or aggregated at a scale larger than the Project Region.

Where applicable, the following baseline data must be identified:

- Tillage practices
- Typical crops grown in a rotation
- Typical length of rotation
- Average applied N rates per identified crop
- Type of fertilizer and application methods employed
- Average application rates of other nutrients, or inputs, if applicable
- Whether crops are irrigated or not
- Other necessary inputs for modeling relevant biogeochemical processes

5.1.2 Recording the Project Area and Project Region

The Participant Field shall be specified with geodetic polygons (kml files) where project activities are being implemented, per the requirements of the VCS Standard and as elaborated in the monitoring criteria. The Project Region shall also be recorded with geodetic polygons (kml files) and must include all of the Project Area within its boundaries. The Project Region may be comprised of non-contiguous areas so long as the relevant eco-regions or geographic

[3] The smallest geographic extent for such data shall be used. For example, if fertilizer rates are available at the county-level and state-level, the county-level estimate shall be used.

administrative boundaries still capture all Participant Fields in the Project Area within the boundaries of the Project Region. A kml file shall be made available, clearly defining the boundaries of the Project Region in the PD at time of validation.

5.2 Temporal Boundary

The dates and time frames for the following project events must be defined in the project description:

- Project Crediting Period start date
- Length of the Project Crediting Period, including end date
- Dates and intervals of project baseline revaluation (baseline revaluation every 10 years, unless catastrophic or other structural shifts occur to justify a revaluation at time of next verification).
- Time of enrollment for new Participant Fields included in the project.

The following temporal boundaries shall be defined in the project description:

- Timeline showing when project activities will be implemented
- Timeline for monitoring, reporting, and/or verification activities

5.2.1 Project Crediting Period

The earliest Project Crediting Period start date for AFOLU projects shall be 1 January 2002 or as defined in most recent version of the *VCS Standard*. Project Crediting Periods for ACoGS projects applying this methodology must be a minimum of 20 years, renewable up to four times for a maximum project duration of 100 years. However, crediting for project activities in each Participant Field shall be limited to the timeframe in which changes are conservatively expected in that field's biological carbon pools. Specifically, crediting for avoided conversion may only occur for 20 years following the occurrence of conversion activities in the baseline on each Participant Field.

Project baseline land use scenarios for additional project activities, i.e. subsequently enrolled Participant Fields, shall be re-evaluated at 10 year intervals. Baseline land use scenarios do not need to be re-assessed for previously enrolled project activities. Baseline management scenario re-evaluation shall include assessment of current and likely crop management practices in the region and changes in the expected crop-rotations.

5.3 Carbon Pool and Greenhouse Gas Boundaries

Each Participant Field must account for all carbon pools and GHG sources that are likely to result in a significant increase in GHG emissions or decreased carbon storage in the project scenario relative to the baseline.

Specific carbon pools and GHG sources, including carbon pools and GHG sources that cause project and leakage emissions, may be deemed *de minimis* and do not have to be accounted for if in aggregate the omitted decrease in carbon stocks (in carbon pools) or increase in GHG emissions (from GHG sources) amounts to less than five percent of the total GHG benefit generated by the project. The latest version of the CDM A/R *Tool for testing significance of GHG* *emissions in A/R CDM project activities* may be used to determine whether decreases in carbon pools and increases in GHG emissions are *de minimis*.

5.3.1 Carbon Pools

The Participant Field must account for all carbon pools that are likely to significantly decrease in the project scenario relative to the baseline. The Participant Field may elect to include optional carbon pools that are likely to increase in the project scenario relative to the baseline.

Carbon Pools	Included?	Justification/Explanation
Above-ground woody biomass	Optional	When present, likely to be a source of carbon loss in baseline scenario. Above-ground tree biomass is conservatively excluded; projects may elect to account for above-ground non-tree woody biomass.
Above-ground non-woody biomass	Optional	Likely to be a source of carbon loss in the baseline scenario and it is optional to exclude for both the baseline and project scenario. Where Project Proponents elect to include this pool in the project scenario, it must also be included in the baseline scenario.
Litter	No	Not a major pool in the baseline or project scenario.
Below-ground biomass	Optional	Likely to be a significant source of carbon loss in baseline scenario. Below-ground tree biomass is conservatively excluded; projects may elect to account for below-ground non-tree biomass.
Soil organic carbon	Yes	Major carbon pool subject to project activity.
Dead wood	No	Not a major carbon pool in the baseline or project scenario.
Wood products	No	Not a major carbon pool in the baseline or project scenario.

5.3.2 Greenhouse Gas Sources

The project must account for any significant increases in the GHG emissions for the project scenario relative to the baseline. The project may elect to account for optional GHG emissions sources that decrease in the project scenario relative to the baseline.

Sources	Gas	Included?	Justification/Explanation
Soil Management	CO_2	No	Accounted for in soil organic carbon pool.
	CH_4	No	Not a significant gas for this source.
	N_2O	Yes	Covers emissions from synthetic and organic fertilizer sources and N-fixing plants. Indirect N fertilizer emissions are optional, however.
Fossil fuel combustion	CO_2	Optional	Baseline emissions likely larger than project scenario, may be conservatively excluded.
	CH_4	No	Not a significant gas for this source.
	N_2O	No	Not a significant gas for this source.
Biomass burning	CO_2	No	Accounted for in biomass pools.
	CH_4	Yes	May be conservatively excluded in the baseline but must be included in the project case if fire occurs.
	N_2O	Yes	
Livestock emissions	CO_2	No	Not a significant gas for this source.
	CH_4	Yes	Major gas for this source.
	N_2O	No	Emissions of N_2O from livestock waste are captured under Soil Management emissions.

6. PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

This section provides for the transparent identification of the baseline scenario (including both the land-use scenario and corresponding management practices) and should be performed in conjunction with Section 7 (Procedure for Demonstrating Additionality). The initial analysis of alternative land-use scenarios should be used to identify all possible land uses in the absence of project activities. Project Proponents are encouraged to see the latest version of the *VCS Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities* for criteria and further guidance in identifying and assessing alternative land uses to the project activity.

Alternative land use scenarios for potential project lands must, at a minimum, include the following:

- Persistence of grassland or shrubland on unprotected lands
- Persistence of grassland or shrubland on lands protected by non-project activities
- Conversion of grassland or shrubland to annual cropland
- Conversion of grassland or shrubland to a LU/LC other than annual cropland

As further described in Section 6.1.2.1, the Project Area will undergo an independent appraisal that considers alternative land uses and assesses the ‘highest and best use’ of the land(s) in the Project Area. The appraisal process, in combination with the additionality analysis outlined in Section 7 will screen the alternative land use scenarios that are evaluated to identify the baseline land use scenario. Project activities that identify cropland as the most viable baseline scenario in the absence of the project shall follow the additional guidance on agent identification in Section 6.1. Baseline projections of the land-use scenario are static and made ex-ante, with no adjustments during the project lifetime.

6.1 Identification of Agent(s)

There are two potential cropland conversion scenarios addressed by this methodology; those by an Identified Agent (6.1.1) and those by an Unidentified Agent (6.1.2).

Within a Project Area, it is not necessary for all Participant Fields to have the same form of conversion agent, e.g., some may be Identified Agents while others may be Unidentified Agents. In such cases, the appropriate category for each Participant Field should be determined, clearly distinguished and described in the Project Description (PD). The appropriate baseline land use scenario shall then be applied to each Participant Field, and shall not be changed after project validation.

6.1.1 Demonstration of an Identified Agent

This category includes activities that reduce net GHG emissions by stopping conversion of grasslands or shrublands that are legally authorized and documented for conversion and where the agent of planned conversion is identifiable.

Avoided planned conversion may include decisions by individual land owners or community groups, whose land is legally zoned for agriculture, and is not subject to an agreement, easement, or other covenant that restricts the conversion of the area to a new land use for the duration of the project crediting period, not to convert their land(s). Similarly, an owner of land zoned for conversion to crop agriculture may choose to protect lands by partnering with an NGO or conservation organization either in a joint management agreement, conservation easement, or outright sale or lease.

The Project Proponent must provide verifiable documentation identifying each specific agent of planned conversion in the Project Area. All claims of planned conversion in the baseline scenario must be corroborated with documentation of an imminent and site-specific threat of conversion for the Participant Field. Conversion agents must be identified through documentation of an offer or bid to lease or purchase the Participant Field in the Project Area[4].

In addition, the Project Proponent must provide documentation justifying the expectation that the identified agent(s) will convert the grassland to cropland. Supporting documentation must have

[4] In circumstances where the Participant Field is expected to be converted to cropland by the current land owner(s) or land manager(s) without the sale or lease of the land, the documentation of an offer or bid to lease the Participant Field shall not be required. All other requirements for identifying the conversion agent shall still apply.

been created within the past five years of the Project Start Date, or in the case of multiple project activity instances, within the past five years of the date the new parcel is enrolled in the project. Such documentation must include a parcel-specific appraisal, market study report or general narrative (collectively termed appraisal), as specified in 6.1.2.1,

And either:

- A new breakings request[5] that includes the Participant Field, submitted by the current landowner, the current lessee, or the identified agent(s), and approved by the appropriate government agency(ies). Where a new breakings request has been submitted, but not approved, at time of validation, an approved Request shall be provided at time of subsequent verification.

Or at least two of the following:

- A signed affidavit by the current grassland or shrubland landowner(s) (or manager with authority to convert) affirming the intention to convert Participant Fields to cropland in the absence of Project Activities.
- A documented history of similar conversion activities by the identified agent.
- Other verifiable documentation of the intent and ability of the identified agent(s) to convert Participant Fields to cropland.

6.1.2 Demonstration of an Unidentified Agent

This category includes activities that reduce net GHG emissions by stopping conversion of grasslands or shrublands that: a) are legally authorized and documented for conversion, b) where a specific agent of planned conversion is not clearly identifiable, yet c) it is possible to identify a class of likely agents. One way this could occur is if a landowner intends to rent or sell their land and the most probable use of the land after renting or selling is conversion to cropland agriculture, but the renter or buyer has yet to be identified. Demonstration of the probable use can be accomplished with demonstration of imminent threat of conversion and a financial viability test.

6.1.2.1 Financial Viability of Conversion

In cases where the conversion of land to cropland in the Project Area is expected but a specific conversion agent has not yet been identified, the Project Proponent must provide verifiable documentation that the conversion of the Project Area to croplands is financially viable. Such documentation shall include a parcel-specific appraisal, market study report or general narrative (collectively termed appraisal) of the Project Area performed by a certified general appraiser demonstrating that the converted state (cropland) is the highest and best use of the land and would have a higher value than the unconverted state (grassland or shrubland). The appraisal shall be performed in accordance in substance and principles similar to Uniform Standards of Professional Appraisal Practice (USPAP) and the appraiser must meet the qualification standards outlined for government tax codes (i.e. Internal Revenue Code, Section 170 (f)(11)(E)(ii) for the United States).

[5] A new breakings request is a form submitted to a government agency or agricultural lender in order to become eligible for governmental farm programs or funding.

The appraised value for the 'highest and best use' shall also be considered in Section 8.1.3 (Discount for Uncertainty of).

6.1.2.2 Demonstration of Historical Conversion

In addition to demonstrating the higher financial value of the converted state, the Project Proponent must also demonstrate an imminent threat for converting project grasslands and shrublands into cropland. Such documentation shall include historical documentation of conversion activities occurring in the Project Region on similarly situated lands and at the scale of planned conversion. Similarly situated lands include those with values for soil productivity, precipitation, slope, distance to markets, or other relevant characteristics identified in the Appraisal process, that are within 25% of Project Area values. Documented grassland/shrubland-to-cropland conversion in the Project Region used to satisfy this criterion must have occurred within five years of the Project Start Date.

6.2 Baseline Management

The Project Proponent shall assess the baseline management practices at the start of the project, and every 10 years for the duration of the project. Baseline management projections are made ex-ante, and adjusted throughout the project at 10 year intervals at time of baseline re-assessment. Requirements for Baseline Management estimation are found in Section 5.1.1.1.

7. PROCEDURE FOR DEMONSTRATING ADDITIONALITY

Additionality shall be satisfied using a Project Method, demonstrated with the most recent version of the VCS *Tool for the Demonstration and Assessment of Additionality in VCS AFOLU Project Activities*. One option to demonstrating the completion of Steps 1 and 2 of the *Tool* is to use the Appraisal product, as specified in Section 6.1.2.1, with the per unit land value, dollars per acre or hectare as the suitable financial unit of analysis. An appraisal will also identify alternative land-uses and management practices that are legally capable in the consideration of the 'highest and best use' of the property for both APC-UA and APC-IA.

8. QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

In the Project Description, the Project Proponent shall describe common practice in the Project Region for clearing and converting grassland areas to cropland. Such a description should include practices likely to affect the carbon pools and GHG sources described in **Section 5.3**.

Baseline emissions shall be calculated as:

$$BE_y = \sum_p^P \left(BE_{p,y} * (1 - ACD_p)\right) \qquad \text{Eq. 8.1.1}$$

$$BE_{p,y} = \left(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}}\right) + E_{N_2O,BL,_{p,y}} + E_{BB,BL_{p,y}}$$ Eq. 8.1.2

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WhWhere:

BE_y	Baseline emissions in year *y*; tCO_2e
$BE_{p,y}$	Baseline emissions from Participant Field *p* in year *y*; tCO_2e
ACD_p	Avoided Conversion Discount for probability of conversion for Participant Field *p* (see Section 8.1.3)
P	Total number of Participant Fields in the Project Area
$C_{AGB,BL_{p,y}}$	Carbon stock of above-ground biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$E_{N_2O,BL_{p,y}}$	N_2O emissions from Participant Field *p* in the baseline scenario for year *y*; tCO_2e
$E_{BB,BL_{p,y}}$	Emissions of non-CO_2 GHGs in the baseline scenario due to biomass burning in Participant Field *p* in year *y*; tCO_2e

8.1.1 Use of Models for GHG Estimation

Models can be a useful tool for estimating greenhouse gas (GHG) dynamics in the baseline scenario, as well as in the project scenario. The use of process-based biogeochemical models, such as DeNitrification-Decompostion (DNDC), DAYCENT, APEX, and others, may be used to estimate changes in various carbon pools and GHG sources in this methodology. Estimation procedures for each pool and source will indicate whether models may be used for their estimation, and where employed, the model shall meet the following criteria:

- Be peer-reviewed
- Be calibrated and validated for the Project Region, including the management systems identified in both the project and baseline scenario.
- At a minimum, be able to make predictions at the scale of a stratum or Project Area, whichever is smallest.
- Incorporate localized climate conditions as they affect relevant biogeochemical processes.
- Be able to account for soil dynamics that occur during conversion of grassland or shrubland to cropland.
- Include mean and variance estimates of pools and sources that are model outputs.

In addition to process-based models, peer-reviewed empirical models calibrated to the Project Region may also be applied for relevant pools and sources.

8.1.2 Suitability, Rate and Extent of Conversion

All claims of planned conversion in the baseline scenario must be site-specific and corroborated with documentation of the suitability of these lands for conversion to cropland, as demonstrated in 6.1.1 and 6.1.2. The extent of conversion for both scenarios is limited to the area identified in 6.1.2.1.

The conversion rate determines the $FC_{p,y}$ factor, the cumulative proportion of Participant Field p that has been converted to cropland as of year y in the baseline scenario, used in subsequent equations.

Projects addressing APC with an **Identified Agent** must use a customized conversion rate and extent specifically determined for the identified conversion agent. Project Proponent must provide verifiable documentation of the rate of conversion for the identified conversion agent, as identified in Section 6.1.1, specifying the planned extent and rate of conversion.

Unless otherwise specified, it is considered conservative for projects addressing APC with an **Unidentified Agent** to determine that conversion will commence in project Year 2, following the imposition of the Land Conservation Agreement on the Participant Field in project year one. A one year lag is considered conservative as pre-conversion management practices (e.g. burn, chemical treatment) may be needed in year one, and/or weather and seasonal factors could prevent conversion activity from proceeding in Year 1.

For Participant Fields equal to, or less than 260 hectares (640 acres, or a Section), 100% of the area is converted at time of conversion, Year 2. Two hundred sixty hectares is the equivalent of a Section of land, as determined by the U.S. Public Land Survey System, and is a typical unit of land use decision making in grassland and shrubland dominant regions of the United States. For projects outside of the United States, Project Proponents shall demonstrate the typical survey unit of land used for land management decisions and shall use this rate in place of 260 ha.

Participant Fields larger than 260 hectares may only count up to 260 hectares per year until total suitable area is converted. It is recognized that land management decisions and ownership size vary geographically, and it is possible that in less densely populated regions for land use change to occur on a larger scale than 260 hectares. Where applicable, Project Proponents may obtain from the appropriate government office (Farm Service Agency, Natural Resource Conservation Service, others), the size of the largest tract of the same land cover as the participant field that was converted in the previous 5 years. If Participant Field is equal to, or smaller in size than this value, 100% of Participant Field is converted in Year 2.

8.1.3 Discount for Uncertainty of Conversion

This methodology reasonably assumes Participant Fields with cropland appraised as the 'highest and best use' and a corresponding value at least 40% higher than the project grassland or shrubland LU/LC, as identified in Section 6.1.2.1, would be subject to conversion by Identified or Unidentified Agents. To account for the potential for a Type 1 error, or "false positives," where grassland or shrubland parcels deemed as converted in the baseline scenario may not have actually converted due to unique or extenuating circumstances, Participant Fields with Unidentified Agents of conversion shall apply an additional discount factor based on the appraised values of the cropland and grassland/shrubland. For Participant Fields with Identified Agents, the discount factor shall be set at zero (i.e., no discount applied).

If the fair market value (as determined by a verifiable statement from a certified appraiser, following the requirements of Section 6.1.2.1), including any subsidies or other incentives to avoid conversion that were received prior to the Project Start Date, of each Participant Field in the Project Area as cropland is not more than 100% greater than the value of the current grassland land use, then a discount must be applied each year to the Participant Field's quantified GHG reductions and removals. If quantified GHG reductions and removals for the baseline scenario from the Participant Field for the year are positive (i.e., $BE_{p,y} > 0$ in Eq. 8.1.2), then the following formula must be used to calculate the Participant Field's appropriate Avoided Conversion Discount factor, ACD_p. If the Participant Field's quantified avoided GHG emissions in the baseline for the year are negative, then ACD_p must be set at 1 for that Participant Field for that year.

The Avoided Conversion Discount factor, ACD_p, shall be calculated as:

$$\text{If } 1.4 < \left(\frac{VB_p}{VP_p}\right) < 2.0, \text{then } ACD_p = 0.5$$

$$\text{If } \left(\frac{VB_p}{VP_p}\right) > 2.0, \text{then } ACD_p = 0$$

Eq. 8.1.3

Where:

ACD_p The Avoided Conversion Discount factor for Participant Field *p*; dimensionless

VB_p The appraised fair market value of the cropland land use for Participant Field *p*; US Dollars

VP_p The appraised fair market value of the current grassland land use for Participant Field *p*; US Dollars

8.1.4 Aboveground Biomass (Woody and Non-woody)

In the baseline scenario, this methodology accounts for both the transitional loss of pre-existing grassland and shrubland aboveground biomass as Participant Fields are converted over time, as well as the aboveground biomass in annual crops grown following conversion. The aboveground biomass in the baseline scenario shall be calculated each year as:

$$C_{AGB,BL_{p,y}} = C_{AGB_{grass},BL_{p,y}} + C_{AGB_{crop},BL_{p,y}}$$

Eq. 8.1.4

Where:

$C_{AGB,BL_{p,y}}$ Carbon stock of aboveground biomass in Participant Field *p* in year *y* in the baseline scenario; tCO_2e.

$C_{AGB_{grass},BL_{p,y}}$ Remaining carbon stock of preexisting non-tree aboveground biomass for Participant Field *p* in year *y* in the baseline scenario, as calculated from Section 8.1.4.1; tCO_2e.

$C_{AGB_{crop},BL_{p,y}}$ Carbon stock of aboveground crop biomass in Participant Field *p* in year *y* in the baseline scenario, as calculated from Section 8.1.4.2; tCO_2e.

8.1.4.1 Carbon Stocks of Pre-Existing Non-tree Aboveground Biomass

In the conversion of grassland to cropland, this methodology treats all carbon in aboveground non-tree biomass[6] as released to the atmosphere in the year of conversion. Projects that opt to

[6] Because this methodology treats the loss of aboveground biomass upon conversion as an immediate loss of carbon to the atmosphere, projects are permitted to account for aboveground non-tree biomass in that is lost upon conversion to cropland, but may not include aboveground tree biomass in this calculation. Tree biomass removed from the Participant Field during conversion in the baseline scenario

account for the removal of aboveground biomass in conversion to cropland will do so by first quantifying initial carbon stocks for above-ground grass and shrub biomass in the project scenario (see Section 8.2.1). That is, for projects accounting for the loss of aboveground biomass in this conversion, the initial (year y=0) carbon stocks in aboveground biomass for each Participant Field in both the project and baseline scenarios shall be equal and based upon the estimation of initial carbon storage in aboveground non-tree biomass.

Following the initiation of conversion to cropland on each Participant Field in the baseline scenario, the loss of carbon from aboveground biomass due to conversion shall be based upon the proportion of that field that has been converted.

$$C_{AGB_{grass},BL_{p,y}} = C_{AGB_{p,y=0}} * \left(1 - FC_{p,y}\right) \quad \text{Eq. 8.1.5}$$

Where:

$C_{AGB_{grass},BL_{p,y}}$	Carbon stock of pre-existing aboveground non-tree biomass from Participant Field p in year y in the baseline scenario; tCO_2e.
$C_{AGB_{p,y=0}}$	Initial (year y=0) carbon stock of aboveground non-tree biomass for Participant Field p, as determined from Section 8.2.1; tCO_2e.
$FC_{p,y}$	The cumulative proportion of Participant Field p that has been converted to cropland as of year y in the baseline scenario, determined based on rates and extents of conversion defined in Section 8.1.2; dimensionless.

Where fire is used as part of the conversion process, procedures in Section 8.1.8 (Biomass burning) should be used to account for non-CO_2 GHG emissions associated with using fire to clear grass and shrub cover.

8.1.4.2 Carbon Stocks of Aboveground Crop Biomass

In the baseline scenario (i.e., annual crop production), the increase in aboveground biomass each year is assumed equal to biomass losses from harvest and mortality in that same year. Furthermore, there is no net accumulation of aboveground biomass stocks once areas have been converted for the duration of the Project Crediting Period (IPCC GL 2006, Ch. 5, 5.2.1.1). Following the completion of the full extent of conversion, $C_{AGB_{crop},BL_{p,y}}$ will remain static, except in rotational cropping systems where crops with different aboveground biomass values from previous years are being rotated in.

Similar to the soil organic carbon pool, a peer-reviewed process model that meets the requirements of Section 8.1.1and that produces aboveground vegetation estimates as an output may be used to calculate $C_{AGB_{crop},BL_{b,i,y}}$. Where process models require specific crops in a given year, crop selection and assignment to years shall not be done in a manner that would underestimate $C_{AGB_{crop},BL_{b,i,y}}$. These are considered conservative approaches to account for the uncertainty of crop selection in the rotation in the baseline scenario.
A fixed ratio of crop yield to plant biomass, the Harvest Index ratio, obtainable from peer reviewed literature, may be used in place of a model estimate, or to populate the model estimate. Average

may be expected to decay over several years and/or some portion could remain intact over long periods in harvested wood products. This methodology conservatively excludes accounting for the loss of aboveground tree biomass in the baseline scenario.

crop yields must be obtained from government or extension crop yield reports for the smallest available administrative unit containing the Participant Field, e.g., county.

Carbon stocks in aboveground biomass in the baseline scenario should be calculated for each Participant Field in the Project Area each year as:

$$C_{AGB_{crop},BL_{p,y}} = \sum_{i}^{I} \sum_{b}^{B} C_{AGB_{crop},BL_{b,i,y}} * F_{p,i,y} \qquad \text{Eq. 8.1.6}$$

$$C_{AGB_{crop},BL_{b,i,y}} = dm_{BL,b,i,y} * CF_b * \frac{44}{12} * A_{b,i} \qquad \text{Eq. 8.1.7}$$

Where:

$C_{AGB_{crop},BL_{p,y}}$	Carbon stock of aboveground crop biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$C_{AGB_{crop},BL_{b,i,y}}$	Carbon stock of aboveground crop biomass in the baseline for crop type *b* in stratum *i* and year *y*; tCO_2e
$FC_{p,i,y}$	The proportion of Participant Field *p* included in stratum *i* in year *y*; hectares Participant Field *p* (hectares stratum *i*)$^{-1}$
I	Total number of strata
B	Total number of crop types
$dm_{BL,b,i,y}$	Annualized average dry matter in the baseline for crop type *b* in stratum *i* and year *y*; tonnes dry matter per ha
CF_b	Carbon fraction of dry matter for crop type *b*; t-C (tonnes dry matter)$^{-1}$
$A_{b,i}$	Area of stratum *i*, crop type *b*; hectares

8.1.5 Belowground Biomass

Belowground biomass is expected to be significantly higher under project activities relative to baseline activities. The conversion of grassland to cropland is expected to result in the removal or rapid decomposition of belowground biomass. The amount of carbon stored in belowground biomass pool may be estimated through the application of an appropriate root-to-shoot ratio to $C_{AGB,BL_{p,y}}$. This methodology assumes all below-ground biomass carbon stocks from these pools are lost upon conversion to cropland in the baseline scenario.

Carbon stocking in belowground biomass in the baseline shall be calculated for each Participant Field in the Project Area as:

$$C_{BGB,BL_{p,y}} = C_{BGB_{grass},BL_{p,y}} + C_{BGB_{crop},BL_{p,y}} \qquad \text{Eq. 8.1.8}$$

Where:

$C_{BGB,BL_{p,y}}$	Carbon stock of belowground biomass in Participant Field *p* in year *y* in the baseline scenario; tCO_2e.
$C_{BGB_{grass},BL_{p,y}}$	Remaining carbon stock of preexisting non-tree belowground biomass for Participant Field *p* in year *y* in the baseline scenario; tCO_2e.

$C_{BGB_{crop},BL_{p,y}}$ Carbon stock of belowground crop biomass in Participant Field *p* in year *y* in the baseline scenario; tCO_2e.

8.1.5.1 Carbon Stocks of Pre-Existing Non-tree Belowground Biomass

In the conversion of grassland to cropland, this methodology treats all carbon in belowground non-tree biomass as released to the atmosphere in the year of conversion. Projects that opt to account for the decomposition or removal of belowground biomass in conversion to cropland will do so by first quantifying initial carbon stocks for belowground non-tree biomass in the project scenario (see Section 8.2.2). That is, for projects accounting for the loss of belowground biomass in this conversion, the initial (year *y*=0) carbon stocks in belowground biomass for each Participant Field in both the project and baseline scenarios shall be equal and based upon the estimation of initial carbon storage in belowground non-tree biomass.

Following the initiation of conversion to cropland on each Participant Field in the baseline scenario, the loss of carbon from belowground biomass due to conversion shall be based upon the proportion of that field that has been converted.

$$C_{BGB_{grass},BL_{p,y}} = C_{BGB_{p,y=0}} * \left(1 - FC_{p,y}\right) \qquad \text{Eq. 8.1.9}$$

Where:

$C_{BGB_{grass},BL_{p,y}}$	Carbon stock of pre-existing belowground non-tree biomass from Participant Field *p* in year *y* in the baseline scenario; tCO_2e.
$C_{BGB_{p,y=0}}$	Initial (year *y*=0) carbon stock of belowground non-tree biomass for Participant Field *p*, as determined from Section 8.2.2; tCO_2e.
$FC_{p,y}$	The cumulative proportion of Participant Field *p* that has been converted to cropland as of year *y* in the baseline scenario, determined based on rates and extents of conversion defined in Section 8.1.2; dimensionless.

8.1.5.2 Carbon Stocks of Belowground Crop Biomass

Following the conversion of each Participant Field to cropland in the baseline scenario, carbon stocks of belowground crop biomass shall be quantified based upon the estimation of above-ground crop biomass (as determined in Section 8.1.4.2) and the application of a suitable root-to-shoot ratio.

$$C_{BGB_{crop},BL_{p,y}} = \sum_{i}^{I} \sum_{b}^{B} R_b * C_{AGB_{crop},BL_{b,i,y}} * F_{p,i,y} \qquad \text{Eq 8.1.10}$$

Where:

$C_{BGB_{crop},BL_{p,y}}$	Carbon stock of belowground crop biomass for Participant Field *p* in the baseline scenario in year y; tCO_2e
R_b	Root-to-shoot ratio of crop type *b*; dimensionless
$C_{AGB_{crop},BL_{b,i,y}}$	Carbon stock of aboveground crop biomass of crop type *b*, in stratum *i*, and year *y* of the baseline scenario, as calculated in Eq. 8.1.7; tCO_2e

$F_{p,i,y}$	The proportion of Participant Field *p* included in stratum *i* in year *y*; hectares Participant Field *p* (hectares stratum *i*)$^{-1}$
I	Total number of strata
B	Total number of crop biomass types

8.1.6 Soil Organic Carbon

The soil carbon pool is expected to be the primary source of emissions for ACoGS projects, as soil carbon accounts for approximately 90% of ecosystem carbon in grassland and rangeland systems (Schuman et al. 2001). Direct measurement of changes in soil carbon in the baseline scenario is not possible as conversion of grassland and shrublands is avoided rather than allowed to happen.

Initial soil organic carbon stocks shall be quantified based on a stratification of the Participant Field, Project Area, or Project Region into strata representing homogenous carbon stocks that can then be estimated through a combination of direct measurement or regional soil carbon inventories and databases. Direct measurement of SOC shall follow a suitable direct measurement protocol such as the ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques, or other approved VCS tool or module to directly measure SOC stocks and changes. This shall be performed in conjunction with Section 5.1.1, Stratification.

Through one or a combination of the above approaches, total soil organic carbon stocks in the baseline scenario for each Participant Field in the Project Area shall be calculated as:

$$C_{SOC,BL_{p,y}} = \sum_{i}^{I} \sum_{t=0}^{t \leq 20} C_{SOC_{i,y=0}} * EF_{t,i,y} * F_{i,y} * FC_{t,y} \qquad \text{Eq. 8.1.11}$$

Where:

$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$C_{SOC_{i,y=0}}$	Total initial (year *y*=0) soil organic carbon stock for stratum *i*, fixed for project duration (see Section 8.1.6); tCO_2e
$EF_{t,i,y}$	Emission factor for stratum *i* in year *y*, the fraction of soil organic carbon pool remaining *t* years since conversion to cropland
$F_{i,y}$	The proportion of Participant Field *p* included in stratum *i* in year *y*; hectares Participant Field *p* (hectares stratum *i*)$^{-1}$
$FC_{t,y}$	Proportion of Participant Field *p* that has been converted to cropland in the baseline scenario for *t* years as of year *y*, as described in Section 8.1.2; dimensionless
I	Total number of strata
t	Time since conversion of grassland to cropland in the baseline scenario, maximum value of 20; years

By default, this method assumes the emissions from soil organic carbon following conversion proceed linearly for 20 years (i.e., $D_i = 20$), at which point a new equilibrium level of SOC is reached in the converted state. A linear EF function may be used per the IPCC AFOLU Guidelines 2006 (adapted from Eq. 2.25, Ch2, p2.30), in which case:

$$EF_{t,i,y} = \frac{1-(FSOC_{LU_i} * FSOC_{MG_i} * FSOC_{IN_i})}{D_i} * t$$ Eq. 8.1.12

Where:

$EF_{t,i,y}$	Emission factor describing the fraction of soil organic carbon pool remaining *t* years since conversion to cropland for stratum *i* in year *y*; dimensionless
$FSOC_{LU_i}$	Fraction of soil organic carbon pool remaining after transition period, accounting for land use factors in stratum *i*; dimensionless
$FSOC_{MG_i}$	Fraction of soil organic carbon pool remaining after transition period, accounting for management factors for stratum *i*; dimensionless
$FSOC_{IN_i}$	Fraction of soil organic carbon pool remaining after transition period, accounting for input of organic matter factors for stratum *i*; dimensionless
D_i	Transition period for soil organic carbon for stratum *i*, time period for transition between equilibrium SOC values, default value of 20; years
t	Time since conversion of grassland to cropland in the baseline scenario, maximum value of 20; years

Alternatively, a non-linear function may be used to calculate $EF_{t,i,y}$ values for each soil organic carbon stratum if the function and derived values are:

- Derived from a peer-reviewed study of soils and a region similar to the Project Area or Project Region, or
- An output from a biogeochemical model, e.g., DNDC, DAYCENT, or others addressed in Section 8.1.1, that requires input data for management practices, climatology, and/or other factors determined significant to the rate of soil carbon oxidation and resulting emission factor, or
- An empirical result from a pair-wise field measurement at a site materially similar to the Project Area, and soil samples are collected from the relevant soil layers that would be affected by the conversion process and baseline activity. A sample-based emission factor shall not be projected for a period of time longer than the collection period, and at a minimum shall be measured following the same management treatments for duration of 5 years. Use of pair-wise samples from similar lands shall be adjusted for uncertainty as described on page 22 of the VCS Standard version 3.1 or the equivalent section of the latest version of the VCS Standard, or section 5.2.35 of IPCC GL AFOLU 2006.

8.1.7 Soil N_2O emissions

Several pools and sources contribute to soil N emissions, including both direct and indirect emissions from nitrogen fertilizer application, both synthetic and organic, as well as the presence of N-fixing plant species such as legumes. Process models such as DAYCENT or DNDC are capable of estimating N_2O emissions based on a systems approach and may be used for to estimate N_2O(in aggregate, from all sources). Otherwise, a source-specific estimation approach accounting for the N_2O emission of each source individually must be employed. Soil N emissions are therefore estimated as:

Both direct and indirect emissions of N_2O may be quantified for projects with organic or inorganic nitrogen fertilizer application in the baseline scenario.

Baseline emissions of N_2O from the application of nitrogen fertilizer can be calculated for each Participant Field in the Project Area as:

$$E_{BL,N_2O_{p,y}} = E_{BL,N_2O,direct_{p,y}} + E_{BL,N_2O,indirect_{p,y}} \quad \text{Eq. 8.1.13}$$

Where:

$E_{BL,N_2O_{p,y}}$	Total N_2O emissions from Participant Field *p* in year *y*; tCO_2e
$E_{BL,N_2O,direct_{p,y}}$	Direct N_2O emissions from the addition of nitrogen containing content to Participant Field *p* in the baseline scenario for year *y*; tCO_2e
$E_{BL,N_2O,indirect_{p,y}}$	Indirect N_2O emissions from the addition of nitrogen containing content to Participant Field *p* in the baseline scenario for year *y*; tCO_2e

8.1.7.1 Direct Nitrogen Emissions

Where fertilizer inputs are applied in the baseline scenario, a peer reviewed biogeochemical model calibrated and validated for the project region, Section 8.1.1 may be used for estimates of direct N_2O emissions from fertilizer use. Otherwise, the latest version of the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization* shall be used to estimate direct N_2O emissions. This tool requires activity data be monitored, but as the baseline is an avoided scenario, updated regional application information as identified in 6.2 may be used for estimates.

The presence of N-Fixing plants can be a source of N emissions, especially if their abundance is significantly greater in either the baseline or project scenarios. Where N-fixing plant emissions exceed *de minimis*, Tool VI.1 of the *Adoption of Sustainable Agricultural Land Management Methodology* must be used, or a suitable approved model approach as specified in Section 8.1.1. It is optional, but conservative to exclude this source where baseline rotations include soybeans or alfalfa, as baseline N_2O emissions from N-fixing plants will likely exceed those of project conditions.

Per the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization*, direct N_2O emissions for each Participant Field in the Project Area shall be estimated as:

$$E_{BL,N_2O,direct_{p,y}} = \left(F_{BL,SN_{p,y}} + F_{BL,ON_{p,y}} + F_{BL,NF_{p,y}}\right) * EF_N * MW_{N_2O} * GWP_{N_2O} \quad \text{Eq.8.1.14}$$

$$F_{BL,ON_{p,y}} = \sum_{k}^{K} M_{BL,ON_{p,k,y}} * N_{BL,ON_k} * (1 - Frac_{ON}) \quad \text{Eq. 8.1.15}$$

$$F_{BL,SN_{p,y}} = \sum_{j}^{J} M_{BL,SN_{p,j,y}} * N_{BL,SN_j} * (1 - Frac_{SN}) \quad \text{Eq. 8.1.16}$$

$$F_{BL,NFp,y} = \sum_{b}^{B} dm_{b,y} * \left(A_{BL_{p,i,y}} - A_{BL,burn_{p,i,y}} * C_f\right) * Frac_{Renew} * [R_{AGb} * N_{AGb} * +R_{BGb} * N_{BGb}] \quad \text{Eq. 8.1.17}$$

Where:

$E_{BL,N_2O,direct_{p,y}}$	Total direct N_2O emissions from nitrogen fertilizer application in the baseline scenario for Participant Field *p* in year *y*; tCO_2e
$F_{BL,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{BL,ON_{p,y}}$	Mass of organic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{BL,NF_{p,y}}$	Mass of N in plant residues (above and below ground), including N-fixing plants returned to soils annually in year t, t N (yr^{-1})
EF_N	Emission Factor for emission from N inputs; $t\text{-}N_2O\text{-}N(t\text{-}N\ input)^{-1}$
MW_{N_2O}	Ratio of molecular weights of N_2O to N (44/28); $t\text{-}N_2O(t\text{-}N)^{-1}$
GWP_{N_2O}	Global Warming Potential for N_2O; $tCO_2e\ (tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)
$M_{BL,SN_{p,j,y}}$	Mass of synthetic fertilizer type *j* applied to Participant Field *p* in year *y*; tonnes
$M_{BL,ON_{p,k,y}}$	Mass of organic fertilizer type *k* applied to Participant Field *p* in year *y*; tonnes
N_{BL,SN_j}	Nitrogen content of synthetic fertilizer type j; $t\text{-}N(tonne\ fertilizer)^{-1}$
N_{BL,ON_k}	Nitrogen content of organic fertilizer type j; $t\text{-}N(tonne\ fertilizer)^{-1}$
$Frac_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
$Frac_{ON}$	Fraction of organic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
J	Number of synthetic fertilizer types
K	Number of organic fertilizer types
$dm_{BL,b,y}$	Annualized average dry matter in the baseline for crop type *b* year *y*; tonnes dry matter per ha
$A_{BL_{p,i,y}}$	Total area of harvested of n-fixing crop *I,* year *y;* ha $(yr)^{-1}$
$A_{BL,burn_{p,i,y}}$	Total area of n-fixing burnt in year *y;* ha $(yr)^{-1}$
C_f	Combustion factor, dimensionless
$Frac_{Renew}$	fraction of total area under crop that is renewed annually. For annual crops, $Frac_{Renew} = 1$
R_{AGb}	ratio of above-ground residues dry matter to harvested yield for crop b in year t; t d.m $(t\ d.m.)^{-1}$
N_{AGb}	N content of above-ground residues for crop b; t N $(t\ d.m.)^{-1}$
R_{BGb}	ratio of below-ground residues dry matter to harvested yield for crop b in year t; t d.m $(t\ d.m.)^{-1}$
N_{BGb}	N content of below-ground residues for crop b; t N $(t\ d.m.)^{-1}$

8.1.7.2 Indirect Nitrogen Fertilizer Emissions

Indirect N_2O emission estimates are optional but may be calculated using the equations below, or as an output from an approved biogeochemical model. The below method is derived from the IPCC AFOLU GL 2006, Chapter 11, Equations 11.9 and 11.10.

Indirect N_2O emissions for each Participant Field in the Project Area shall be calculated as:

$$E_{BLN_2O,indirect_{p,y}} = E_{BL,N_2O,volat_{p,y}} + E_{BL,N_2O,leach_{p,y}} \quad \text{Eq. 8.1.18}$$

$$E_{BL,N_2O,volat_{p,y}} = \left((F_{BL,SN_{p,y}} * Frac_{SN}) + (F_{BL,ON_{p,y}} * Frac_{ON})\right) * EF_{AD} * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 8.1.19}$$

$$E_{BL,N_2O,leach_{p,y}} = \left(F_{BL,SN_{p,y}} + F_{BL,ON_{p,y}} + F_{BL,SOM_{p,y}}\right) * Frac_{Leach} * EF_{Leach} * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 8.1.20}$$

Where:

$E_{BL,N_2O,volat_{p,y}}$	Indirect N_2O emissions produced from Participant Field *p* from N volatilized following N application at the crop site in the baseline scenario in year *y*; tCO_2e
$E_{BL,N_2O,leach_{p,y}}$	Indirect N_2O emissions produced from leaching and runoff of N volatilized in regions where leaching and runoff occurs, as a result of N application at the crop site in Participant Field *p* in the baseline scenario in year *y*; tCO_2e
$F_{BL,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{BL,ON_{p,y}}$	Mass of organic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{BL,SOM_{p,y}}$	Mass of annualized of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of changes in land use or management in regions where leaching/runoff occurs, kg N yr^{-1}
EF_{AD}	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [tonnes N_2O-N (tonnes NH_3-N + NO_x-N volatilized)$^{-1}$] (IPCC default Tier 1 = 0.01)
EF_{Leach}	Emission factor for N_2O emissions from N leaching and runoff, tonnes N_2O-N (tonnes N leached and runoff)$^{-1}$ (IPCC default Tier 1 = 0.0075)
$Frac_{SN}$	Fraction of synthetic N applied to soils that volatilizes as NH_3 and NO_x, kg N volatilized (kf of N applied)$^{-1}$
$Frac_{ON}$	Fraction of organic N applied to soils that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$
$Frac_{Leach}$	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs, dimensionless (IPCC default Tier 1 = 0.03)
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e $(tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)

8.1.8 Biomass burning

Biomass burning is commonly used to remove above-ground grassland vegetation prior to conversion, as an ongoing management tool to incorporate crop residue into the soil, and also as a rangeland management practice to stimulate forage production and to control invasive plants. Grassland vegetation that is combusted during the fire process is either returned immediately to the soil as an amendment or is later regained through vegetation re-growth within the year (synchrony), with the assumption that soil fertility is maintained or improved from the fire activity (IPCC 2006, Chapter 2.4). Changes in the biomass pools and CO_2 emissions resulting from fire are therefore excluded from estimation under this source. The N_2O and CH_4 emissions resulting from fire events are estimated based on the equations from the CDM A/R Tool *Estimation of non-CO2 GHG emissions resulting from burning of biomass attributable to an A/R CDM project activity* and calculated as:

$$E_{BL,BB_{p,y}} = \sum_{i}^{I} \sum_{b}^{B} \left(A_{BL,burn_{p,i,y}} * B_{b,y} * CB_{b,i} * \left(EF_{CH_4,b,i} * GWP_{CH_4} + EF_{N_2O,b,i} * GWP_{N_2O} \right) \right)$$

Eq. 8.1.21

Where:

$E_{BL,BB_{p,y}}$	Emissions of non-CO_2 GHGs in the baseline scenario due to biomass burning in Participant Field *p* in year *y*; tCO_2e
$A_{BL,burn_{p,i,y}}$	Area burnt in the baseline scenario in Participant Field *p* within stratum *i* in year *y*; hectares
$B_{b,y}$	Above-ground biomass stock for biomass type *b* before burning in the baseline scenario in year *y*; tonnes dry matter ha^{-1}
$CB_{b,i}$	Combustion factor for biomass type b, stratum *i*; dimensionless (default values derived from Table 2.6 of IPCC, 2006)
$EF_{CH_4,b,i}$	Emission factor for CH_4 for biomass type *b* in stratum *i* (default values derived from Table 2.5 of IPCC, 2006)
GWP_{CH_4}	Global warming potential for CH_4 (default value from IPCC SAR: CH_4 = 21, valid for the first commitment period)
$EF_{N_2O,b,i}$	Emission factor for N_2O for biomass type *b* in stratum *i* (default values derived from Table 2.5 of IPCC, 2006)
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e $(tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)

The burning of biomass in the baseline scenario could potentially occur during two distinct phases of the baseline: 1) prior to or at time of conversion to remove aboveground vegetation for preparation of cropping, and 2) burning of crop residues between crops in a rotation. In either scenario, the value of $B_{b,y}$ should be that of the Participant Area in year y, e.g., $B_{b,i,y=0}$ for scenario one.

8.1.9 Fossil Fuel Emissions

The use of farm machinery, and potentially construction equipment, to assist with the conversion process, are common in modern agriculture. The combustion of fossil fuels used for this machinery produces emissions that may optionally be accounted for with: *Estimation of emissions from the use of fossil fuels in agricultural management,* Tool VI of the Adoption of Agricultural Land Management Methodology. As the baseline scenario is an avoided activity, there will be no vehicle/equipment records to monitor for fuel usage. Project Proponents may use equipment hours/usage rates from published university extension reports for the identified crop, management practice and Project Region, or the recommendations of a qualified agriculture expert for recommended machinery and hours to support baseline activities. Projects that elect to account for fossil fuel emissions in the baseline scenario shall do so as:

$$E_{BL,FFp,y} = \sum_{v}^{V} \sum_{j}^{J} \left(FC_{BL_{p,v,j,y}} * EF_j \right) \quad \text{Eq. 8.1.22}$$

Where:

$E_{BL,FFp,y}$ Emissions due to the use of fossil fuels in agricultural management in the baseline scenario on Participant Field *p* in year *y*; t CO_2e

$FC_{BL_{p,v,j,y}}$ Volume of fossil fuel consumed in the baseline scenario on Participant Field *p* in vehicle/equipment type *v* with fuel type *j* during year *y*; litres

EF_j Emission factor for the type of fossil fuel combusted in vehicle or equipment, j For gasoline EFCO2e = 0.002810 t per liter. For diesel EFCO2e = 0.002886 t per liter.

v Type of vehicle/equipment

V Total number of types of vehicle/equipment used in the project activity

j Type of fossil fuel

J Total number of fuel types

8.2 Project Emissions

This methodology conservatively assumes that avoided conversion results in the maintenance (without increase) of carbon stocks in the pools of soil organic carbon, and above-ground and below-ground biomass remain at steady state throughout the project scenario. That is, for each included pool, projects must estimate initial carbon stocks and are only allowed to generate credits based on avoided losses from these stocks (i.e., assuming the change in these stocks is on average, zero), rather than activities that may increase these stocks. Projects wishing to account for any expected growth in these pools over time must apply a separate methodology (such as under Agricultural Land Management, ALM) approved for use by the VCS to do so. Total Project Emissions shall be calculated as:

$$PE_y = \sum_{p}^{P} PE_{p,y} \quad \text{Eq. 8.2.1}$$

$$PE_{p,y} = C_{AGB,PR_{p,y-1}} - C_{AGB,PR_{p,y}} + C_{BGB,PR_{p,y-1}} - C_{BGB,PR_{p,y}} + C_{SOC,PR_{p,y-1}} - C_{SOC,PR_{p,y}} + E_{PR,N_{p,y}} + E_{PR,BB_{p,y}} + E_{PR,Livestock_{p,y}} \quad \text{Eq. 8.2.2}$$

Where:

PE_y Total project emissions in year *y*; tCO_2e

$PE_{p,y}$ Total project emissions for Participant Field *p* in year *y*; tCO_2e

$C_{AGB,PR_{p,y}}$ Carbon stock of above-ground crop biomass for Participant Field *p* in the project scenario in year *y*; tCO_2e

$C_{BGB,PR_{p,y}}$ Carbon stock of below-ground crop biomass for Participant Field *p* in the project scenario in year *y*; tCO_2e

$C_{SOC,PR_{p,y}}$	Carbon stock of soil organic carbon for Participant Field *p* in the project scenario in year *y*; tCO_2e
$E_{PR,N_{p,y}}$	Project emissions from nitrogen applications in Participant Field *p* in *y*; tCO_2e
$E_{PR,BB_{p,y}}$	Project emissions from biomass burning in Participant Field *p* in year *y*; tCO_2e
$E_{PR,Livestock_{p,y}}$	Project emissions from livestock in Participant Field *p* in year *y*; tCO_2e

8.2.1 Above-ground biomass (woody and non-woody)

As described in the methods for baseline above-ground biomass carbon (**Section 8.1.4**), those projects electing to account for the emissions related to removal of above-ground woody and non-woody biomass in the baseline scenario shall account for these emissions by measuring initial carbon stocks in each of the elected pools. This methodology assumes all aboveground biomass from these pools is lost upon conversion to cropland.

Above-ground biomass is highly variable in rangeland systems, both geographically and temporally and is highly dependent upon precipitation. A conservative estimate of the above-ground biomass shall therefore be assumed to remain at a steady state for the duration of the project period.

Initial carbon stocks in woody and non-woody biomass pools may be based upon direct field measurement for each biomass type, in a year where growing season precipitation is within 40% of average annual growing season precipitation, and shall be calculated for each Participant Field in the Project Area as:

$$C_{AGB_{p,y}} = \sum_{i}^{I} \sum_{b}^{B} C_{AGB_{b,i,y=0}} * F_{p,i,y} \quad \text{Eq. 8.2.3}$$

$$C_{AGB,PR_{b,i,y=0}} = dm_{b,i,y=0} * CF_b * \frac{44}{12} * A_{b,i} \quad \text{Eq. 8.2.4}$$

Where:

$C_{AGB_{p,y}}$	Carbon stock of above-ground biomass for Participant Field *p* in year *y*; tCO_2e
$C_{AGB_{b,i,y=0}}$	Initial (year *y*=0) carbon stock of above-ground biomass for biomass type *b* in stratum *i*; tCO_2e
$F_{p,i,y}$	The proportion of Participant Field *p* included in stratum *i* in year *y*; hectares Participant Field *p* (hectares stratum *i*)$^{-1}$
I	Total number of strata
B	Total number of crop biomass types
$dm_{b,i,y=0}$	Dry matter for biomass type *b* in stratum *i* at project initiation (year *y*=0); tonnes dry matter ha-^{1}
CF_b	Carbon fraction of dry matter for biomass type *b*; t-C (tonnes dry matter)$^{-1}$
$A_{b,i}$	Area of stratum *i*, biomass type *b*; hectares

Alternatively, $C_{AGB_{p,y=0}}$values may be derived from default values in an approved process model, field measurements reported in peer-reviewed literature, an empirical model, or agricultural statistics for rangeland forage productivity in the Project Region produced by a government agency or University extension office**.**

8.2.2 Below-ground Biomass

As described in the methods for baseline below-ground biomass carbon, Section 8.1.5, those projects electing to account for the emissions related to removal of below-ground woody and non-woody biomass in the baseline scenario shall account for these emissions by calculating initial carbon stocks in each of the elected pools.

In the project scenario, as stated in Section 8.2.1, above-ground biomass stocks are assumed to remain in steady-state throughout the project duration; the corresponding carbon stock change in below-ground biomass pools are therefore also assumed to be zero over the project life. The amount of carbon stored in belowground biomass pool may be estimated through the application of an appropriate root-to-shoot ratio $C_{AGB_{p,y}}$.

Carbon stocks for below-ground biomass in the project scenario for each Participant Field shall be calculated as:

$$C_{BGB_{p,y}} = \sum_{i}^{I} \sum_{b}^{B} R_b * C_{AGB_{b,i,y=0}} * F_{p,i,y} \qquad \text{Eq. 8.2.5}$$

Where:

$C_{BGB_{p,y}}$	Carbon stock of above-ground biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e
R_b	Root-to-shoot ratio of biomass type *b*; dimensionless
$C_{AGB_{b,i,y=0}}$	Initial (year *y*=0) carbon stock in above-ground biomass of biomass type *b*, in stratum *i*; tCO_2e
$F_{p,i,y}$	The proportion of Participant Field *p* included in stratum *i* in year *y*; hectares Participant Field *p* (hectares stratum *i*)$^{-1}$

Although management activities in the project scenario, such as grazing, haying or prescribed fires have been demonstrated to stimulate below-ground biomass growth, these potential gains are conservatively excluded.

8.2.3 Soil organic carbon

In grassland ecosystems, the soil organic carbon pool is generally assumed to be a net sink of CO_2 (Liebig et al. 2005). In a steady state, soil organic carbon stocks in the project scenario are thus fixed at $C_{SOC_{i,y=0}}$ over the project life. Measurement and quantification methods for calculating $C_{SOC_{i,y=0}}$ are outlined in the treatment of soil organic carbon in the baseline scenario (**Section 8.1.6**).

8.2.4 Biomass burning

Biomass burning may be applied in the project scenario through the use of prescribed burning, or may occur naturally. This management tactic is typically applied to control the composition of vegetation for grazing or other purposes. The use of prescribed fire is not believed to affect long-term carbon balance in above-ground biomass, as re-growth typically recovers any biomass lost during the burn, Applicability Condition **Error! Reference source not found.**, (**Section 4.0**). This methodology thus assumes no year-to-year change in above-ground or below-ground carbon stocks when prescribed burns or natural fires occur in the project scenario. Projects must still account for the emissions of non-CO_2 GHGs associated with the combustion of aboveground biomass in the project scenario, as these are likely to be higher than in the baseline case, particularly if prescribed burns are applied multiple times over the project duration. The occurrence of natural fires must be accounted for by using an expected average fire return interval for the Project Region.
Because above-ground biomass is assumed to remain constant throughout the project period, emissions associated with biomass burning may assume the occurrence of biomass burning consumes the same amount of biomass as was present at project initiation.

Emissions of non-CO_2 GHGs from biomass burning in the project scenario shall be calculated for each Participant Field in the Project Area as:

$$E_{PR,BBp,y} = \sum_{i}^{I}\sum_{b}^{B}\left(A_{PR,burn_{p,i,y}} * dm_{b,i,y=0} * CB_{b,i} * \left(EF_{CH_4,b,i} * GWP_{CH_4} + EF_{N_2O,b,i} * GWP_{N_2O}\right)\right) \quad \text{Eq. 8.2.6}$$

Where:

$E_{PR,BBp,y}$	Emissions of non-CO_2 GHGs in the project scenario due to biomass burning in Participant Field *p* in year *y*; tCO_2e
$A_{PR,burn_{p,i,y}}$	Area burnt in the project scenario in Participant Field *p* within stratum *i* in year *y*; hectares
$dm_{b,i,y=0}$	Initial (year *y*=0) above-ground biomass stock for biomass type *b* before burning in the baseline scenario in stratum *i*, year *y*; tonnes dry matter $(ha)^{-1}$
$CB_{b,i}$	Combustion factor for biomass type b; dimensionless (default values derived from Table 2.6 of IPCC, 2006)
$EF_{CH_4,b,i}$	Emission factor for CH_4 for biomass type *b* in stratum *i* (default values derived from Table 2.5 of IPCC, 2006)
GWP_{CH_4}	Global warming potential for CH_4 (default values from IPCC SAR: CH_4 = 21)
$EF_{N_2O,b,i}$	Emission factor for N_2O for biomass type *b* in stratum *i* (default values derived from Table 2.5 of IPCC, 2006)
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e $(tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)

8.2.5 Soil Nitrogen Emissions

Both direct and indirect emissions of N_2O may be quantified for projects with organic or inorganic nitrogen fertilizer application, or livestock manure and urine deposition in the project scenario.

Project emissions of N_2O from the addition of nitrogen to the Project Area can be calculated for each Participant Field in the Project Area as:

$$E_{PR,N_2O_{p,y}} = E_{PR,N_2O,direct_{p,y}} + E_{PR,N_2O,indirect_{p,y}} \quad \text{Eq. 8.2.7}$$

Where:

$E_{PR,N_2O_{p,y}}$	N_2O emissions from nitrogen fertilizer application in Participant Field *p* in the baseline scenario for year *y*; tCO_2e
$E_{PR,N_2O,direct_{p,y}}$	Direct N_2O emissions from nitrogen inputs to Participant Field *p* in the baseline scenario for year *y*; tCO_2e
$E_{PR,N_2O,indirect_{p,y}}$	Indirect N_2O emissions from nitrogen inputs to Participant Field *p* in the baseline scenario for year *y*; tCO_2e

8.2.5.1 Direct Nitrogen Emissions

Where fertilizer inputs are applied in the baseline scenario, a peer reviewed biogeochemical model calibrated and validated for the project region, as defined in Section 8.1.1, may be used for estimates of direct N_2O emissions from fertilizer use. Otherwise, the latest version of the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization* shall be used to estimate direct N_2O emissions. This tool requires activity data be monitored, but updated regional application information as available from government agricultural or environmental agencies, University Extension offices, or other expert opinion may be used for ex-post and ex-ante estimates.

Per the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization*, direct N_2O emissions for each Participant Field in the Project Area shall be estimated as:

$$E_{PR,N_2O,direct_{p,y}} = \left[\left(F_{PR,SN_{p,y}} + F_{PR,ON_{p,y}} + F_{PR,NFp,y}\right) * EF_N + F_{PRPp,y} * EF_{MNR}\right] * MW_{N_2O} * GWP_{N_2O} \quad \text{Eq. 8.2.8}$$

$$F_{PR,SN_{p,y}} = \sum_{j}^{J} M_{PR,SN_{p,j,y}} * N_{PR,SN_j} * (1 - Frac_{SN}) \quad \text{Eq. 8.2.9}$$

$$F_{PR,ON_{p,y}} = \sum_{j}^{J} M_{PR,ON_{p,k,y}} * N_{PR,ON_k} * (1 - Frac_{ON}) \quad \text{Eq. 8.2.10}$$

$$F_{PRPp,y} = \sum_{l}^{L} \left(P_{p,l} * Nex_l * MS_l\right) \quad \text{Eq. 8.2.11}$$

$$F_{PR,NFp,y} = \sum_{b}^{B} dm_{b,y} * \left(A_{PR_{p,i,y}} - A_{PR,burn_{p,i,y}} * C_f\right) * Frac_{Renew} * [R_{AGb} * N_{AGb} * + R_{BGb} * N_{BGb}]$$ Eq. 8.2.12

Where:

$E_{PR,N_2O,direct_{p,y}}$	Total direct N_2O emissions from nitrogen fertilizer application in the baseline scenario for Participant Field *p* in year *y*; tCO_2e
$F_{PR,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{PR,ON_{p,y}}$	Mass of organic fertilizer nitrogen applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{PR,NFp,y}$	Amount of N in plant residues (above and below ground), including N-fixing plants returned to soils annually, t-N
EF_N	Emission Factor for emission from N inputs; t-N_2O-N(t-N input)$^{-1}$
$F_{PRPp,y}$	Mass of manure and urine N deposited by grazing animals on pasture, range and paddock, t-N
EF_{MNR}	Emission Factor for emission for manure inputs; t-N_2O-N(t-N input)$^{-1}$
MW_{N_2O}	Ratio of molecular weights of N_2O to N (44/28); t-N_2O(t-N)$^{-1}$
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e $(tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)
$M_{PR,SN_{p,j,y}}$	Mass of synthetic fertilizer type *j* applied to Participant Field *p* in year *y*; tonnes
$M_{PR,ON_{p,k,y}}$	Mass of organic fertilizer type *k* applied to Participant Field *p* in year *y*; tonnes
N_{PR,SN_j}	Nitrogen content of synthetic fertilizer type j; t-N(tonne fertilizer)$^{-1}$
N_{PR,ON_k}	Nitrogen content of organic fertilizer type k; t-N(tonne fertilizer)$^{-1}$
$Frac_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
$Frac_{ON}$	Fraction of organic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
J	Number of synthetic fertilizer types
K	Number of organic fertilizer types
$P_{p,l}$	Population of livestock type L; number of head
Nex_l	annual average N excretion per head of species/category, kg N (animal)$^{-1}$ (yr)$^{-1}$
MS_l	fraction of total annual N excretion for each livestock species/category L
$dm_{b,y}$	Dry matter for biomass type b in year y; tonnes dry matter (ha)$^{-1}$
$A_{PR_{p,i,y}}$	area harvested, hayed or grazed
$A_{PR,burn_{p,i,y}}$	area harvested, hayed or grazed subject to burning
C_f	Combustion factor, dimensionless
$Frac_{Renew}$	fraction of total area that is renewed annually. For countries where pastures are renewed on average every X years, *FracRenew* = 1/X. For annual crops *FracRenew* = 1.
R_{AGb}	ratio of above-ground residues dry matter (dm) to harvested, hayed or grazed yield for biomass b

N_{AGb}	N content of above-ground residues for biomass b; kg N (kg d.m.)$^{-1}$
R_{BGb}	ratio of below-ground residues dry matter (dm) to harvested, hayed or grazed yield for biomass b; kg d.m. (kg d.m.)$^{-1}$
N_{BGb}	N content of below-ground residues for biomass b; kg N (kg d.m.)$^{-1}$
Nex_l	annual average N excretion per head of species/category *T* in the country; kg N (animal)$^{-1}$ (yr)$^{-1}$

With:

$$Nex_l = N_{rate(l)} * \frac{TAM_l}{1000} * 365$$ Eq. 8.2.13

Where:

$N_{rate(l)}$	N excretion rate; kg N (1000 kg animal mass)$^{-1}$ day^{-1}
TAM_l	typical animal mass for livestock category *l*; kg animal^{-1}

8.2.5.2 Indirect Nitrogen Emissions

Indirect N_2O emission estimates are optional but may be calculated using the equations below, or as an output from an approved biogeochemical model. The below method is derived from the IPCC AFOLU GL 2006, Chapter 11, Equations 11.9 and 11.10.

Indirect N_2O emissions for each Participant Field in the Project Area shall be calculated as:

$$E_{PR,N_2O,indirect_{p,y}} = E_{PR,N_2O,volat_{p,y}} + E_{PR,N_2O,leach_{p,y}}$$ Eq. 8.2.14

$$E_{PR,N_2O,volat_{p,y}} = \left((F_{PR,SN_{p,y}} * Frac_{SN}) + ((F_{PR,ON_{p,y}} + F_{PRPp,y}) * Frac_{ON})\right) * EF_{AD} * \frac{44}{28} * GWP_{N_2O}$$ Eq. 8.2.15

$$E_{PR,N_2O,leach_{p,y}} = \left(F_{PR,SN_{p,y}} + F_{PR,ON_{p,y}} + F_{PRPp,y}\right) * Frac_{Leach} * EF_{Leach} * \frac{44}{28} * GWP_{N_2O}$$ Eq. 8.2.16

Where:

$E_{PR,N_2O,volat_{p,y}}$	Indirect N_2O emissions produced from Participant Field *p* from N volatilized following N application at the field site in the project scenario in year *y*; tCO_2e
$E_{PR,N_2O,leach_{p,y}}$	Indirect N_2O emissions produced from leaching and runoff of N volatilized in regions where leaching and runoff occurs, as a result of N application at the field site in Participant Field *p* in the project scenario in year *y*; tCO_2e
$F_{PR,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field *p* in the project scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{PR,ON_{p,y}}$	Mass of organic fertilizer nitrogen applied to Participant Field *p* in the project scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$F_{PRPp,y}$	Mass of manure and urine N deposited by grazing animals on pasture, range and paddock, t-N

EF_{AD}	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, [tonnes N_2O-N (tonnes NH_3-N + NO_x-N volatilized)-1] (IPCC default Tier 1 = 0.01)
EF_{Leach}	Emission factor for N_2O emissions from N leaching and runoff, tonnes N_2O-N (tonnes N leached and runoff)-1 (IPCC default Tier 1 = 0.0075)
$Frac_{SN}$	Fraction of synthetic N applied to soils that volatilizes as NH_3 and NO_x, kg N volatilized (kg of N applied)$^{-1}$
$Frac_{ON}$	Fraction of organic N applied to soils that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$
$Frac_{Leach}$	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs, dimensionless (IPCC default Tier 1 = 0.30)
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e (tN_2O)$^{-1}$ (IPCC default = 310, valid for the first commitment period)

8.2.6 Livestock Emissions- Enteric Fermentation

Livestock are capable of producing CH_4 emissions through enteric fermentation. Livestock emission estimations are constrained to rangeland/pasture manure systems where manure is left unmanaged once deposited by livestock (Applicability Condition h, **Section 4.0**). It is recognized that in grassland ecosystems, the net contribution of livestock in the system may be positive, i.e., net sequestration (Liebig et al. 2010). The effects of vegetation stimulation and soil nutrient amendments that grazing and natural manure management, as maintained from pre-project conditions, are assumed to be captured through estimates of soil and biomass carbon pools in the project scenario. Any net sequestration benefits from these activities in the project scenario are conservatively excluded. Manure deposited by livestock present in the project scenario shall be accounted for in Soil Nitrogen Emissions, Section 8.2.5.

Project emissions from livestock due to enteric fermentation shall be calculated for each Participant Field in the Project Area as:

$$E_{FERMp,y} = \sum_{l}^{L} P_{p,l} * EF_l * GD_{p,l,y} * GWP_{CH4} \div 1000 \quad \text{Eq. 8.2.17}$$

Where:

$E_{FERMp,y}$	CH_4 emission from enteric fermentation due to livestock on Participant Field *p* in year *y*; tCO_2e
$P_{p,l}$	Population of livestock type *l* on Participant Field *p*; head
$GD_{p,l,y}$	Grazing days per livestock type *l* on Participant Field *p* in year *y*; grazing days
EF_l	Enteric CH_4 emission factor for livestock type *l*; kg-CH_4 head^{-1}grazing day^{-1}.
GWP_{CH4}	Global warming potential for CH_4 (default values from IPCC SAR: CH_4 = 21)
1000	Conversion from kg to metric tonnes

$$EF_l = \frac{GE * \left(\frac{Y_m}{100}\right)}{55.65}$$ Eq. 8.2.18

Where:

GE	Gross energy intake; MJ head^{-1} day^{-1}
Y_m	Methane conversion factor, per cent of gross energy in feed converted to methane
55.65	Energy content of methane; MJ/kg CH_4

8.2.7 Fossil Fuel Emissions

Where fossil fuel emissions are accounted for in the baseline, project fossil fuel emissions must also be estimated.

$$E_{FF,PRy,p} = \sum_{p}^{P} \sum_{v}^{V} ET_{PR,v,y}$$ Eq. 8.2.19

Where:

$E_{FF,PRy,p}$	Emissions due to the use of fossil fuels in project management, t CO_2e
$ET_{PR,v,y}$	Emissions from fossil fuel combustion in vehicle/equipment type v
v	type of vehicle/equipment
V	total number of types of vehicle/equipment used in the project activity

Unlike the baseline scenario, Project Proponents are able to monitor machinery and equipment use in the project scenario and the quantity of fuel consumed. Where this information is not easily attainable or difficult to estimate, default fuel usage rates from the same sources used to identify fuel usage for the baseline scenario may be used.

$$ET_{PR,v,y} = FC_{PR.v,y} * E_v$$ Eq. 8.2.20

Where:

$ET_{PR,v,y}$	Emissions from fossil fuel combustion in vehicle/equipment type v during year y; t CO2e (yr)$^{-1}$
$FC_{PR,v,y}$	Consumption of fossil fuel in vehicle/equipment type j during year y; litres (yr)$^{-1}$
E_v	Emission factor for the type of fossil fuel combusted in vehicle or equipment, j For gasoline EFCO2e = 0.002810 t per liter. For diesel EFCO2e = 0.002886 t per liter.
v	Type of vehicle/equipment
V	Total number of types of vehicle/equipment used in the project activity

8.3 Leakage

There are two types of potential leakage from the avoided conversion of grassland and shrubland, market and activity shifting leakage. Leakage shall therefore be calculated as

$$LE_y = MAX(LE_{M,y}, LE_{A,y})$$ Eq. 8.3.1

Where

LE_y Leakage factor in year *y*

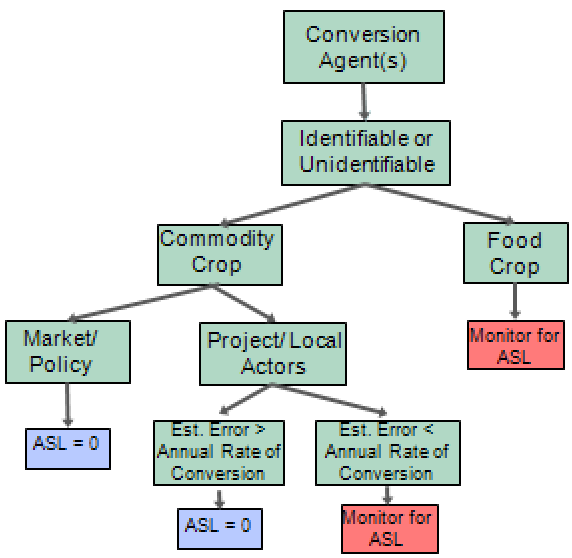
$LE_{M,y}$ Market Leakage in year *y*

$LE_{A,y}$ Activity Shifting Leakage in year *y*

8.3.1 Activity Shifting Leakage

Activity shifting leakage in the ACoGS APC will be market-based, and attempts to estimate activity-shifting and market leakage separately will potentially lead to double counting of leakage. Project Proponents are encouraged to use the following Leakage Decision Tree to determine if accounting for Activity Shifting Leakage (ASL) is necessary.

Figure 8.3.1



Grouped projects involving multiple landowners make monitoring activity-shifting leakage particularly challenging and subject to compounding uncertainty and double counting of market leakage. The following guidance shall be used in conjunction with **Figure 8.3.1** to determine whether Activity Shifting Leakage monitoring is required, or whether the default leakage rate shall be used.

Commodity or Food Crop

The crops identified in the baseline analysis shall be assessed if they are a food or commodity crop. A commodity crop is traded and consumed in national and/or international markets, traded on a recognized futures exchange, and individual producers are price takers (no ability to affect price). If the majority of crops in a rotation are considered a commodity crop, production is determined to be commodity-dependent, and leakage will therefore be market-driven. Attempts to monitor and estimate activity-shifting leakage in this scenario will lead to double counting of market leakage.

In contrast, non-commodity or food crops are more likely to be purchased or consumed locally or regionally and the displacement of their production will lead to unmet local demand, providing a driver for Activity Shifting leakage. In these scenarios, efforts should be made to monitor and estimate Activity Shifting leakage.

Market or Policy Drivers vs. Local or Project Induced Drivers

Leakage forces are separated into two primary categories: those driven by exogenous market or policy forces and those influenced locally where project activities affect future land-use and management decisions. Exogenous market or policy forces are identified as any conversion occurring for the production of commodity crops and where national or international policies can be attributed to facilitating or encouraging additional conversion. This includes the presence of insurance or support payments for baseline activities not available to project activities. Local or Project induced drivers include conversion to locally developed niche or specialized market segments that are driven by local demand, i.e. sold and consumed within a 200 mile radius, even if crop produced is a commodity crop.

Estimated Error vs. Estimated Rate of Conversion

Where conversion activities are reasonably attributable to project activities, the difference between the average annual conversion rate for the five years prior to the project start date to the average annual conversion rate during the project monitoring period may be used to estimate Activity Shifting leakage for Avoided Planned Conversion- Unidentified Agent. Project Proponents may rely on published estimates from the peer reviewed literature or government reports on land cover and land-use to estimate the relevant conversion rates. Estimation errors based on aggregation, sampling error or classification error from remotely sensed images may exceed estimates of annual conversion rates. In these situations it is considered conservative to use the default market leakage rate to account for all leakage.

Where ASL = 0, then:

$$LE_{A,y} = 0$$

Where required to monitor for ASL, Project Proponents shall follow the guidance provided, *mutatis mutandis,* in the VCS AFOLU Module VMD008 *Estimation of baseline carbon stock changes and greenhouse gas emissions from planned deforestation* (BL-PK).v1.0. In particular, Part 1, Steps 1-4, must be followed for both Identified Agents and the class of Unidentified Agents.

8.3.2 Market Leakage

Avoiding the conversion of grassland and shrubland will directly remove arable cropland that would otherwise enter into production. Food demand is inelastic globally, requiring that the foregone production will be made up either through changes in the intensive (fertilizer use, crop yield response) or extensive (indirect land use conversion) margin. Since the commodities being displaced are traded in national and international markets, and production responsive to numerous dynamic phenomena, estimation of market leakage requires use of detailed economic data and complex general equilibrium models. Completion of these analysis are expected to be beyond the capabilities of most Project Proponents, and therefore a simplified default approach is used to provide a default value of LE_{My} applicable to avoided conversion to commodity crops in North America that can be used for all Projects using this methodology.

Market leakage is based on the law of supply and demand. Avoided conversion reduces the supply of otherwise arable cropland, which *ceteris paribus* puts upward pressure on prices, which puts downward pressure on quantity demanded. The relationship between price and supply and demand are quantified by price elasticities. Price increases can also lead to increased supply through mechanisms other than conversion. Price signals inspire farmers to produce more crops on their existing farmland, e.g., by investing in more labor, advanced technology, or inputs (Taheripour 2006). Price signals can also inspire increased investment in yield improvement (Ruttan and Hayami 1984). Thus, avoiding conversion to cropland is expected to reduce the net amount of land needed for crop production both by increasing yields on existing farmland and by decreasing the quantity of demand. Methods based only on short-run price elasticities generally capture decreased demand, but may not capture these mechanisms that contribute to meeting demand without requiring cropland expansion. Therefore, methods based only on price elasticities will tend to overestimate leakage, making them conservative from the standpoint of calculating offsets generated by a particular project.

The default leakage value is derived from Eq. 8.3.2, which is derived from Murray, McCarl and Lee (2004) and the VCS Market Leakage Tool v.1

$$LE_{M,y} = \frac{E_S}{E_S - E_D} \quad \text{Eq. 8.3.2}$$

Where:

$LE_{M,y}$	Market leakage in year *y*
E_S	Price elasticity of supply
E_D	Price elasticity of demand

Note that E_D is generally a negative number (demand goes down as price goes up) and E_S is generally a positive number (supply goes up as price goes up), so $LE_{M,y}$ will be a percentage that ranges from 0 to 100.

Elasticities are obtained from the FAPRI Elasticity Database (http://www.fapri.iastate.edu/tools/elasticity.aspx) and USDA ERS Elasticity Database (http://www.ers.usda.gov/Data/Elasticities/), and supplemented with estimates from the economics literature.

To obtain a default value that can reliably be used in the United States, we considered a range of approaches to estimating leakage and used the most conservative result. Several researchers have used estimates of leakage associated with the USDA Conservation Reserve Program (CRP). The retirement of land from crop production as in the Conservation Reserve Program should have similar or larger leakage effects as an avoided conversion project that keeps land out of crop production. Both approaches preclude marginal cropland from entering crop production. One might expect CRP to have greater leakage because of both the large scale of land retirement and because CRP typically removes land from productive use entirely whereas avoided grassland conversion projects will typically still allow grazing and livestock production.

Source	Estimate	Approach
Taheripour, F. 2006. Economic impacts of the Conservation Reserve Program: A general equilibrium framework. Page 33 American Agricultural Economics Association Annual Meeting, Long Beach, California.	≤20%	General equilibrium model of CRP leakage
Wu, J. 2000. Slippage effects of the Conservation Reserve Program. American Journal of Agricultural Economics **82**:979-992.	20%	Statistical estimate of leakage based on empirical land use data
Barr, K. J., B. A. Babcock, M. A. Carriquiry, A. M. Nassar, and L. Harfuch. 2011. Agricultural land elasticities in the United States and Brazil. Applied Economic Perspectives and Policy **33**:449-462.	<20%	Price elasticity of cropland supply was found to be 0.029. When combined with reasonable estimates of price elasticity of demand, this consistently results in leakage estimates of <20%.
Murray, B.C., B. Sohngen, and M.T. Ross. 2007. Economic consequences of consideration of permanence, leakage and additionality for soil carbon sequestration projects. Climatic Change **80**:127-143.	0-20%	Plausible leakage discount for cropland retirement based on previous literature.

A peer reviewed paper studied actual responses of U.S. land area to changes in prices and found that the price elasticity of cropland area in the United States is very low (0.029 was the highest of several estimates in the paper); (Barr et al. 2011). Unfortunately this paper does not provide a comparable estimate for price elasticity of demand. In the absence of a definitive estimate of demand, we are able to show that any reasonable estimate of the price elasticity of demand yields a leakage estimate that is no greater than 20% when paired with Barr et al.'s estimate for price elasticity of supply. Based on Equation 8.3.2, any estimate of the price elasticity of demand that is less than -0.116 would result in leakage of 20% or lower. We obtained 241 estimates from the USDA ERS database on own-price demand elasticities for commodities relevant to the United

States (corn, soy, legume, grain, cereal, oil, food). The mean demand elasticity was -0.44, and more than 90% of all values were less than -0.116.

Therefore the Project Proponent should use a conservative default value of 20% market leakage for avoided conversion of grasslands or shrublands to commodity crops in the United States.

$$LE_{M,y} = 0.20$$

Alternatively, Projects Proponents may use the latest version of the VCS Market Leakage Tool, or other approved approach from the latest version of the VCS rules to estimate LE_{My} .

8.4 Summary of GHG Emission Reduction and/or Removals

$$ER_y = BE_y - PE_y - NP_y - LD_y \qquad \text{Eq. 8.4.1}$$

$$NP_y = BF_y * \left(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}}\right) \qquad \text{Eq. 8.4.2}$$

$$LD_y = LE_y * \left(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}}\right) \qquad \text{Eq. 8.4.3}$$

Where:

ER_y	Net GHG emissions reductions and/or removals in year *y,* tCO_2e
BE_y	Baseline emissions in year *y*, result of Eq. 8.1.1., tCO_2e
PE_y	Project emissions in year *y*, result of Eq. 8.2.1., tCO_2e
NP_y	Non-Permanence deduction in year y, result of Eq. **8.4.2**, tCO_2e
BF_y	Non-Permanence buffer in year y, result of project analysis using use the latest version of the *VCS AFOLU Non-Permanence Risk Tool* to determine the overall project risk rating, applied as BF_y.
LE_y	Leakage in year *y*, result of Eq. 8.3.1.
LD_y	Leakage deduction for year y, result of Eq. **8.4.3**

Where $BE_y < PE_y$, *no VCUs shall be issued for that year.*

9. MONITORING

9.1 Data and Parameters Available at Validation

See Appendix A.

In addition to the parameters in Appendix A, the provisions in the tools referred to in this methodology apply.

When choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in the use of existing published data, Project

Participants must retain a conservative approach; that is, if different values for a parameter are equally plausible, a value that does not lead to overestimation of baseline emissions must be selected.

9.2 Data and Parameters Monitored

See Appendix A.

9.3 Description of the Monitoring Plan

At a minimum, the scope of monitoring activities required under this methodology includes the monitoring of:

- Conversion Agents
- Management practices of Conversion Agents in the baseline scenario
- Monitoring land-use change in the Project Region and of Project Area
- Livestock presence, numbers and grazing practices in the Project Area
- Vegetation type/species in Project Area

A Monitoring Plan, developed at time of validation and contained in the Project Description shall further specify the following:

- Monitoring tasks
- Frequency of monitoring tasks and reporting
- Monitoring Report requirements
- Measurement procedures and frequency of collection
- Quality Assurance/Quality Control measures
- Archiving measures
- Responsibilities, roles and qualifications of monitoring team

9.3.1 Sampling Design

Field measurements are optional for certain carbon pools and GHG sources. Where Project Proponents elect to employ direct measurements, the Monitoring Plan in the Project Description Document shall specify the sampling design, sample size, plot size and determination of plot location. All sampling must be carried out such that a 95% Confidence Interval does not exceed 15% of the mean. Where uncertainty exceeds 15%, estimated GHG benefits or values must be discounted. All measurements will be conducted according to relevant standards and subject to Quality Assurance/Quality Control measures, as specified in the Monitoring Plan.

9.3.2 Data Archiving

All reports, measurements and other project related documents shall be kept in an electronic format for up to 2 years following the end of the last crediting period. This information shall also be stored at multiple locations in a durable, physical format, such as a Compact Disc.

9.3.3 Monitoring Tasks and the Monitoring Report

At each verification event, at most every 5 years, values for Parameters listed in Section 9.3 and Appendix A, shall be provided for and used to calculate ER_y. The Monitoring Report will track changes in carbon pools and GHG sources between baseline and project activities, providing the basis of the Verification report and issuance of VCUs.

9.3.3.1 Net Project Scenario Pools and Emissions

At the Project Start Date and subsequent verification events, Project Proponents shall identify the Project Area, Project Region and Participant Fields. For each Participant Field, Project Proponents shall monitor and identify parameters for:

- Field Area
- Natural or other features that would preclude the baseline activity
- Presence of livestock, type and numbers
- Condition of aboveground vegetation
- Frequency aboveground biomass is burned (managed and unmanaged)

9.3.3.2 Net Baseline Scenario Pools and Emissions

Other elements in need of monitoring are conversion agents in the Project Region, and the management practices, use and intensity of agricultural inputs, and crops planted in the project region during the monitoring period. These variables include:

- Crop(s) planted
- Tillage practice employed
- Fertilizer application (quantity and application method)

Since the above practices will not be directly implemented in the Project Area, projected baseline parameters listed above should be based on the procedures outlined in Section 5.1.1.1. Management practices will be updated every 10 years at a verification event and SOC stock equilibriums adjusted accordingly. However, the soil transition period shall not exceed the 20 year crediting period.

Where historical data is used to provide parameter input or parameter values for ex-ante estimates for the baseline or project scenario, these data must be updated in the subsequent Monitoring Report and verification event.

Model input may require input that will not be collected by the Project Proponent, such as climate conditions and meteorological data. Necessary environmental parameters for use in biogeochemical modeling and determination of ex-post pools and sources estimated with a biogeochemical model are to be recorded. Sources for such variables may include national databases, or published data with the selection and collection of such data provided in a transparent manner in the Monitoring Report for easy verification and replication. Where meteorological data is collected from a regional meteorology station in the Project Region, information from the nearest station is advised, preferably within 100km of the Participant Field.

9.3.3.3 Addition of New Participant Fields During Verification Events

This methodology allows for the addition of new Participant Fields and expansion of the Project Area within the Project Region after initial PD validation. In order for the new areas to be included in the project, the Project Proponent must demonstrate that that the new areas satisfy all other methodology requirements, including:

- additionality
- leakage
- a location within Project Region
- the addition of the parcel does not require additional sampling or stratification, and if so, additional sampling and stratification is implemented
- satisfies all requirements and applicability conditions of the methodology
- management practices in the baseline and project scenario are similar to other Project Areas or can be accommodated in monitoring report.
- A current appraisal, or similar product identified in Section 6.1.2.1, is implemented for baseline determination.

In addition to the above qualifiers, the timing of program enrollment for each additional Participant Field should be recorded. Each Field should be given a unique ID to be tracked in a spatial database. Real estate appraisals or similar products as defined in Section 6.1.2.1, shall be updated if additional Participant Fields are enrolled in the project at a date later than the validity of the appraisal. By default, appraisals shall remain valid for 12 months after their issued effective date, unless catastrophic or other structural market changes would otherwise make their estimates invalid.

9.3.3.4 Uncertainty Assessment and Conservativeness

Estimation of uncertainty is required for all input data, modeled parameter estimates, and whenever measurement and monitoring of pools and sources is required. Where uncertainties exceed 15% at the 95% confidence interval or 10% at the 90% confidence interval, an appropriate confidence deduction shall be applied. Uncertainties should be estimated with default values (such as those by the IPCC), estimates from peer-reviewed literature, or directly estimated with appropriate statistical techniques. A prerequisite for biogeochemical process model use for estimation of pool and source parameters is the ability to estimate uncertainty, in which case the uncertainty estimates produced by the model shall be used for the associated parameter uncertainty estimates.

Where a range of plausible uncertainty values are available for a parameter or input, Project Proponents shall select the most conservative value so as not to overestimate project emission reductions. An alternative value may be used if Project Proponents can justify why the selected parameter or input value is more appropriate than the most conservatively available value, with the justification transparent in the Project Description Document and/or Monitoring Report.

10. REFERENCES AND OTHER INFORMATION

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Wu, J. 2000. *Slippage effects of the Conservation Reserve Program.* American Journal of Agricultural Economics **82**:979-992.

APPENDIX A

Parameters Available at Validation

Data Unit / Parameter:	CF_b
Data unit:	t-C(tonnes dry matter)-1
Description:	Carbon fraction of dry matter for biomass type *b*
Source of data:	Literature, Table 11.2 IPCC 2006 GL AFOLU
Any comment:	

Data Unit / Parameter:	R_b
Data unit:	dimensionless
Description:	Root-to-shoot ratio of biomass type *b*
Source of data:	Literature, IPCC defaults
Any comment:	

Data Unit / Parameter:	$FSOC_{i,LU}$
Data unit:	dimensionless
Description:	Fraction of soil organic carbon pool remaining after transition period, accounting for land use factors in stratum *i*
Source of data:	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL
Any comment:	

Data Unit / Parameter:	$FSOC_{i,MG}$
Data unit:	dimensionless
Description:	Fraction of soil organic carbon pool remaining after transition period, accounting for management factors for stratum *i*
Source of data:	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL
Any comment:	

Data Unit / Parameter:	$FSOC_{i,IN}$
Data unit:	dimensionless
Description:	Fraction of soil organic carbon pool remaining after transition period, accounting for input of organic matter factors for stratum *i*
Source of data:	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL
Any comment:	

Data Unit / Parameter:	D_i
Data unit:	years
Description:	Transition period for soil organic carbon for stratum *i*, time period for transition between equilibrium SOC values, default value of 20
Source of data:	Measured, Modeled, values from literature, or default value of 20 years
Any comment:	

Data Unit / Parameter:	t
Data unit:	years
Description:	Time since conversion of grassland to cropland in the baseline scenario, maximum value of 20
Source of data:	Measured
Any comment:	

Data Unit / Parameter:	EF_N
Data unit:	t-N_2O-N(t-N input)$^{-1}$
Description:	Emission Factor for emission from N inputs
Source of data:	
Any comment:	

Data Unit / Parameter:	MW_{N2O}
Data unit:	t-N_2O-N(t-N input)$^{-1}$
Description:	Ratio of molecular weights of N_2O to N (44/28)
Source of data:	Defined
Any comment:	

Data Unit / Parameter:	GWP_{N2O}
Data unit:	tCO2e (tN2O)-1
Description:	Global Warming Potential for N_2O
Source of data:	IPCC default = 310, valid for the first commitment period
Any comment:	

Data Unit / Parameter:	$N_{(BL/PR),SN,j}$
Data unit:	t-N(tonne fertilizer)$^{-1}$
Description:	Nitrogen content of synthetic fertilizer type j
Source of data:	Producer of fertilizer

Any comment:	

Data Unit / Parameter:	$N_{(BL/PR),ON,k}$
Data unit:	t-N(tonne fertilizer)$^{-1}$
Description:	Nitrogen content of organic nitrogen type k
Source of data:	Producer of nitrogen if a commerically produced product. Otherwise IPCC defauls or values from the literature.
Any comment:	

Data Unit / Parameter:	$Frac_{SN}$
Data unit:	dimensionless
Description:	Fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 and NO_X
Source of data:	Default value of 0.10 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 GL
Any comment:	The IPCC default value must be used, unless country or region specific synthetic nitrogen fertilizer volatilization estimates are available, and can be justified by the Project Proponent.

Data Unit / Parameter:	$Frac_{ON}$
Data unit:	dimensionless
Description:	Fraction of organic fertilizer nitrogen that volatilizes as NH_3 and NO_X
Source of data:	Default value of 0.20 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 GL
Any comment:	The IPCC default value must be used, unless country or region specific organic nitrogen fertilizer volatilization as NH_3 and NO_X estimates are available, and can be justified by the Project Proponent.

Data Unit / Parameter:	EF_{AD}
Data unit:	tonnes N_2O-N (tonnes NH_3-N + NO_x-N volatilized)$^{-1}$
Description:	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces
Source of data:	Default value of 0.10 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 GL
Any comment:	The IPCC default value must be used, unless country or region specific estimates of atmospheric deposition and reposition are available, and can be justified by the Project Proponent.

Data Unit / Parameter:	EF_{Leach}
Data unit:	tonnes N_2O-N (tonnes N leached and runoff)$^{-1}$

Description:	Emission factor for N_2O emissions from N leaching and runoff
Source of data:	Default value of 0.0075 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 GL
Any comment:	The IPCC default value must be used, unless country or region specific leaching and runoff estimates are available, and can be justified by the Project Proponent.

Data Unit / Parameter:	$Frac_{Leach}$
Data unit:	dimensionless
Description:	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs- N losses by leaching/runoff for regions where Σ(rain in rainy season) - Σ (PE in same period) > soil water holding capacity, OR where irrigation (except drip irrigation) is employed], kg N (kg N additions or deposition by grazing animals)-1
Source of data:	Default value of 0.30 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 GL
Any comment:	The IPCC default value must be used, unless country or region specific fraction of applied N leaching and runoff estimates are available, and can be justified by the Project Proponent.

Data Unit / Parameter:	$CB_{b,i}$
Data unit:	dimensionless
Description:	Combustion factor for biomass type b, stratum *i*; dimensionless
Source of data:	IPCC 2006 AFOLU GL, Table 2.6. More regionally appropriate rates may be used if justified by the Project Proponent.
Any comment:	

Data Unit / Parameter:	$EF_{CH4,b,i}$
Data unit:	g CH_4 $(kg)^{-1}$
Description:	Emission factor for CH_4 for biomass type *b* in stratum *i*
Source of data:	IPCC 2006 AFOLU GL, Table 2.5. More regionally appropriate rates may be used if justified by the Project Proponent.
Any comment:	

Data Unit / Parameter:	GWP_{CH4}
Data unit:	dimensionless
Description:	Global warming potential for CH_4
Source of data:	default values from IPCC SAR: CH_4 = 21
Any comment:	

Data Unit / Parameter:	$EF_{N2Ob,i}$

Data unit:	g N_2O $(kg)^{-1}$
Description:	Emission factor for N_2O for biomass type *b* in stratum *i*
Source of data:	IPCC 2006 AFOLU GL, Table 2.5. More regionally appropriate rates may be used if justified by the Project Proponent.
Any comment:	

Data Unit / Parameter:	Y_m
Data unit:	dimensionless
Description:	Methane conversion factor, per cent of gross energy in feed converted to methane
Source of data:	Default for Cattle or Buffalo-grazing: 6.5%; Default for Lambs (<1 year old): 4.5%; Default for Mature Sheep: 6.5% Source: Chapter 4, Tables 10.12 and 10.13, 2006 IPCC GL
Any comment:	Default values must be used for livestock grazing methane conversion factor, unless the Project Proponent can justify the use of national or more regionally based factors.

Data Unit / Parameter:	EF_l
Data unit:	kg-CH^4head^{-1}year^{-1}
Description:	Emission factor for methane from manure for livestock type *l*
Source of data:	Default value for Cattle in Cool Climate Zone: 1; default for Temperate or Warm Climate Zone: 2 Source: Chapter 10, Table 10.14, 2006 IPCC GL
Any comment:	

Data Unit / Parameter:	MS_l
Data unit:	dimensionless
Description:	fraction of total annual nitrogen excretion for each livestock species/category
Source of data:	
Any comment:	

Data Unit / Parameter:	$EF_{MNR,l}$
Data unit:	kg-N_2O head^{-1}year^{-1}
Description:	Emission factor for nitrous oxide from manure for livestock type *l*
Source of data:	Default values may be found Table 11.1, Chapter 11 IPCC 2006 GL

Data Unit / Parameter:	$N_{rate(l)}$
Data unit:	kg N (1000 kg animal mass)$^{-1}$ day^{-1}
Description:	Default N excretion rate

Source of data:	Default values may be found in Table 10.19, Chapter 10 IPCC 2006 GL
Any comment:	Default values must be used unless Project Proponent can demonstrate region-specific are more accurate to project conditions.

Data Unit / Parameter:	R_{BGB}
Data unit:	kg d.m. (kg d.m.)$^{-1}$
Description:	ratio of below-ground residues dry matter (dm) to harvested, hayed or grazed yield for biomass b
Source of data:	Default values may be found Table 11.2, Chapter 11 IPCC 2006 GL
Any comment:	

Data Unit / Parameter:	$F_{p,i,y}$
Data unit:	hectares Particpant Field p (hectares stratum i)$^{-1}$
Description:	Proportion of Participant Field p included in stratum i in year y
Source of data:	
Any comment:	

Data Unit / Parameter:	$C_{soil,y=0}$
Data unit:	t CO_2e
Description:	Project and total initial year soil organic carbon stock, fixed for project duration
Source of data:	Measured, modelled, or derived from literature. Where unavailble, default values from IPCC 2006 AFOLU GL, Table 2.3 may be used.
Any comment:	

Data Unit / Parameter:	EF_v
Data unit:	CO2e (liter)$^{-1}$
Description:	emission factor for the type of fossil fuel combusted. Default for gasoline = 0.002810 t per liter, diesel = 0.002886 t per liter.
Source of data:	
Any comment:	Default values are from the VCS approved methodology *Alternative Land Management,* Tool *VI.2 Estimation of emissions from the use of fossil fuels in agricultural management.*

Data Unit / Parameter:	*TAM*
Data unit:	kg (animal)$^{-1}$
Description:	typical animal mass for livestock category l

Source of data:	Literature, government reports, or expert opinion.
Any comment:	

Data Unit / Parameter:	$Frac_{Renew}$
Data unit:	
Description:	fraction of total area under crop production that is renewed annually
Source of data:	$Frac_{Renew}$ =1 per the Adoption of Sustainable Land Management Tool for *Estimation of direct nitrous oxide emisssions from N-fixing plants and crop residues*
Any comment:	

Data Unit / Parameter:	VA_p
Data unit:	dollars per hectare
Description:	The appraised fair market value of the cropland land use for Participant Field *p*
Source of data:	Appraisal or simliar product prepared by a certified appraiser.
Any comment:	

Data Unit / Parameter:	VP_p
Data unit:	dollars per hectare
Description:	The appraised fair market value of the current grassland land use for Participant Field *p*
Source of data:	Appraisal or simliar product prepared by a certified appraiser.
Any comment:	

Data Unit / Parameter:	$C_{AGBb,i,y=0}$
Data unit:	t CO_2e
Description:	Initial year carbon stock of above-ground biomass type b, stratum i
Source of data:	
Any comment:	

Data Unit / Parameter:	$A_{(BL/PR)b,i}$
Data unit:	hectares
Description:	Area harvest, hayed or grazed, stratum *i*,biomass type *b*
Source of data:	Baseline determination.
Any comment:	

Data Unit / Parameter:	$PF_{i,y}$
Data unit:	hectares Participant Field p (hectares stratum i)$^{-1}$
Description:	The proportion of Participant Field *p* included in stratum *i* in year *y*
Source of data:	
Any comment:	

Data Unit / Parameter:	$PF_{t,y}$
Data unit:	hectares Participant Field p (hectares stratum i)$^{-1}$
Description:	Proportion of Participant Field *t* that has been converted to cropland in the baseline scenario for *t* years as of year *y*
Source of data:	
Any comment:	

Data Unit / Parameter:	$NB_{G,b}$
Data unit:	t N (t d.m.)$^{-1}$
Description:	N content of below-ground residues for crop b
Source of data:	
Any comment:	

Data Unit / Parameter:	$RB_{G,b}$
Data unit:	t d.m.(t d.m.)$^{-1}$
Description:	ratio of below-ground residues dry matter to harvested yield for crop b in year t
Source of data:	
Any comment:	

Data Unit / Parameter:	$N_{AG,b}$
Data unit:	t N (t d.m.)$^{-1}$
Description:	N content of above-ground residues for crop b
Source of data:	
Any comment:	

Data Unit / Parameter:	$R_{AG,b}$
Data unit:	t d.m.(t d.m.)$^{-1}$
Description:	ratio of above-ground residues dry matter to harvested yield for crop b in year t
Source of data:	
Any comment:	

Parameters Monitored

Data Unit / Parameter:	$dm_{BL\ b,i,y}$
Data unit:	tonnes dry matter
Description:	Annualized average dry matter in the baseline for crop type *b* in stratum *i* and year *y*
Source of data:	Values from literature, where none are available use of Harvest Index applied to crop yield guides for the Project Region may be used, or the IPCC default value of 5.0 tonnes C $(ha)^{-1}$ for annual crops following one year after conversion (IPCC AFOLU GL 2006, Table 5.9)
Description of measurement methods and procedures to be applied:	Harvest Index: ratio of economic product dry mass to plant aboveground dry mass
Frequency of monitoring/recording:	At time of baseline re-evaluation, every 10 years.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$M_{(BL/PR),SN\ p,j,y}$
Data unit:	tonnes
Description:	Mass of synthetic nitrogen type j applied to Participant Field *p* in year *y*
Source of data:	Expert opinion or farm production guide.
Description of measurement methods and procedures to be applied:	County-level producer surveys conducted by a government agricultural agency(ies) or university extension offices, or the expert opinion of an university extension personnel working in the region and systems of interest, personnel of a governmental agriculture agency field office (e.g., USDA's RMA, FSA, NRCS) with jurisdiction in the Project Region, or cropland management plans approved by a lending agency.
Frequency of monitoring/recording:	At time of baseline re-evaluation, every 10 years.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$M(_{BL/PR),ON\ p,k,y}$
Data unit:	tonnes
Description:	Mass of organic nitrogen type *k*applied to Participant Field *p* in year *y*

Source of data:	Expert opinion or farm production guide.
Description of measurement methods and procedures to be applied:	County-level producer surveys conducted by a government agricultural agency(ies) or university extension offices, or the expert opinion of an university extension personnel working in the region and systems of interest, personnel of a governmental agriculture agency field office (e.g., USDA's RMA, FSA, NRCS) with jurisdiction in the Project Region, or cropland management plans approved by a lending agency.
Frequency of monitoring/recording:	At time of baseline re-evaluation, every 10 years.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$F_{BL,SOMp,y}$
Data unit:	t N $(yr)^{-1}$
Description:	Mass of annualized N mineralized in mineral soils associated with loss of soil C from organic matter as a result of changes in land use or management in regions where leaching/runoff occurs
Source of data:	
Description of measurement methods and procedures to be applied:	Equal to $((C_{SOIL,BLp,y}-C_{SOIL,BLp,y-1})/10)*1000$, based on an adaptation of Equation 11.8, IPCC GL AFOLU 2006
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$FC_{(BL/PR),v,y}$
Data unit:	liters $(yr)^{-1}$
Description:	Consumption of fossil fuel in vehicle/equipment type j during year y
Source of data:	Expert opinion or producer report that contains vehicle/equipment hours and fuel needed per unit of use.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$B_{b,i,y}$

Data unit:	tonnes dry matter $(ha)^{-1}$
Description:	Above-ground biomass stock for biomass type *b* before burning in stratum *i*, year *y*
Source of data:	Literature, region specific extension or other production report containing forage/dry matter content for vegetative system
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$dm_{b,i,y=0}$
Data unit:	tonnes dry matter
Description:	Dry matter for biomass type *b* in stratum *i* at project initiation (year *y*=0)
Source of data:	Literature, region specific extension or other production report containing forage content for vegetative system
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$P_{p,l}$
Data unit:	head of livestock
Description:	Population of livestock type *l* on Participant Field *p*
Source of data:	University extension or other production report containing average stocking rate per livestock type *l* in the project region, Project Proponent surveys.
Description of measurement methods and procedures to be applied:	Where the Project Proponent can demonstrate that any positive change in enteric methane would be *de minimus* then it is not required that livestock populations have to be monitored at the level of the Participant Field. This could be done by identifying the maximum stocking rate observed in the Project Region and calculating the difference in enteric methane emission between the baseline and maximum stocking rate.
Frequency of monitoring/recording:	

QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$GD_{p,l,y}$
Data unit:	days
Description:	Grazing days per livestock type *l* on Participant Field *p* in year *y*
Source of data:	University extension or other production report containing average grazing days per livestock type *l* in the project region.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	$A_{(BL/PR),burn\ p,i,y}$
Data unit:	hectares
Description:	Area burnt in Participant Field *p* within stratum *i* in year *y*
Source of data:	Baseline- expert opinion. Project- site visit or aerial survey.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	At time of verification for project scenario. Every 10 years at time of baseline reevaluation for the baseline scenario.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	*GE*
Data unit:	MJ/head/day
Description:	Gross energy intake of livestock
Source of data:	Calculated using equations 10.3 through 10.16 in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and Other Land Use (AFOLU)
Description of measurement methods and procedures to be applied:	

Frequency of monitoring/recording:	At time of verification.
QA/QC procedures to be applied:	
Any comment:	

Data Unit / Parameter:	*p*
Data unit:	Participant Field
Description:	Perimeter boundaries of participant fields participating in project
Source of data:	Land Conservation Agreement
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	At validation and time of verification.
QA/QC procedures to be applied:	
Any comment:	