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Methodology for Avoided Conversion of Grasslands and Shrublands to Crop Production

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A. METHODOLOGY DESCRIPTION

A.1 Acronyms

AC	Avoided Conversion
ACoGS	Avoided Conversion of Grasslands and Shrublands
ACR	American Carbon Registry
AFOLU	Agriculture, Forestry and Other Land Use
APEX	Agricultural Policy Environmental eXtender Model
CRP	Conservation Reserve Program
DAYCENT	Daily Time Step Version of the CENTURY Biogeochemical Model
DNDC	DeNitrification-DeComposition Model
ERT	Emission Reduction Ton
GHG	Greenhouse Gas
IA	Identified Agent
IPCC	Intergovernmental Panel on Climate Change
LU/LC	Land Use/Land Cover
REDD	Reduced Emissions from Deforestation and Degradation
tCO_2e	tonnes of carbon dioxide equivalent
UA	Unidentified Agent

A.2 Summary Description of the Methodology

This methodology estimates the emissions avoided from preventing the conversion of Grasslands and Shrublands to annual crop production[1]. Conversion of Grassland and Shrubland to uses other than

[1] Eligible project types may include, but are not limited to, the avoided conversion of native rangeland, and grasslands established under the Conservation Reserve Program (United States) or the Permanent Cover Program (Canada)

annual Cropland is not an eligible activity under this methodology. Grassland and Shrubland soils are significant reservoirs of organic carbon that will, if left uncultivated, 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 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 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.

A.3 Definitions

If not explicitly defined here, the current definitions in the latest version of the American Carbon Registry Standard apply.

Cropland is a land-use category that includes areas used for the production of crops for harvest on cultivated lands. Cultivated crops include row crops or close grown crops and also hay or pasture in rotation with cultivated crops. Cropland also includes land with alley cropping and windbreaks as well as lands in temporary fallow.[2]

Grassland and Shrubland is a land-use category on which the plant cover is composed principally of grasses, grass-like plants (i.e., sedges and rushes), forbs, or shrubs suitable for grazing and browsing, and includes both pastures and native rangelands. This includes areas where practices such as clearing, burning, chaining, and/or chemicals are applied to maintain the grass vegetation. Savannas, some wetlands and deserts, in addition to tundra are considered Grassland. Woody plant communities of low forbs and shrubs, such as mesquite, chaparral, mountain shrub, and pinyon-juniper, are also classified as Grassland and Shrubland if they do not meet the criteria for Forest Land. Grassland includes land

[2&3] http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2011-Chapter-7-LULUCF.pdf managed with agroforestry practices such as silvipasture and windbreaks, assuming the stand or woodlot does not meet the criteria for Forest Land.[3]

Forest Land is land with at least 10 percent cover (or equivalent stocking) by live Trees of any size, including land that formerly had such Tree cover and that will be naturally or artificially regenerated. To qualify, the area must be at least 1 acre in size. Forest Land includes transition zones, such as areas between Forest and non-Forest Lands that have at least 10% cover (or equivalent stocking) with live Trees and forest areas adjacent to urban and built-up lands.[4]

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 restriction, 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 by an identified agent or anticipated by an unidentified agent, analogous to the use of project activity in the ACR Standard.

Project Area refers to the collection of all participant fields where project activities are implemented.

Project Crediting Period is the length for which project activities are eligible to earn ERTs and the baseline determination remains valid.

Project Participant refers to a landowner or the manager of a Participant Field.

Project Proponent is the entity with overall control of the project and an ACR account holder. This may be the rangeland owner/manager themselves; a project developer working with a single rangeland owner/manager; or a project developer/aggregator aggregating multiple project participants.

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.

Project Term is the duration for which the Project Proponent commits to project continuance, monitoring and verification. **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.

[4] http://americancarbonregistry.org/carbon-accounting/carbon-accounting/forest-carbon-project-standard-v2.0.

Tree is a woody perennial plant, typically large, with a single well-defined stem carrying a more or less definite crown; sometimes defined as attaining a minimum diameter of 3 inches (7.6 cm) and a minimum height of 15 ft (4.6 m) at maturity.[5]

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)who plan to convert Grassland or Shrubland to Cropland in the Project Area.

A.4 Applicability Conditions

This methodology has been designed for use by projects intending to avoid the planned conversion of Grasslands or Shrublands to annual Cropland. Conversion of Grassland and Shrubland to uses other than annual Cropland is not an eligible activity under this methodology. In addition to satisfying the latest ACR 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 Start Date[6], will remain as Grassland or Shrubland throughout the Project Term, and are legally able to be converted and would be converted to Cropland in the absence of the project activity.

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 Term or longer.

c. All Participant Fields must have the 'highest and best use' identified as Cropland through an independent appraisal, as defined in Section D.2.2.1 , and the appraised value of each Field as Cropland must be at least 40% greater than its value as Grassland or Shrubland in the project scenario.

d. Land may remain in use for livestock grazing and/or haying 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. This methodology is only applicable to projects avoiding complete conversion, i.e the complete removal of initial vegetation community through complete tillage, chemical treatment, fire, or combinations thereof which are followed by seeding of an annual crop.

[5] http://socrates.lv-hrc.nevada.edu/fia/ab/issues/pending/glossary/Glossary_5_30_06.pdf

[6] 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.

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 Term.

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 or Shrublands on organic soils or peatlands, or Grasslands or Shrublands on wetlands. Baseline crop production systems shall not include flood-irrigation or perennial crops, and the project shall not include any form of irrigation.

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. There are no restrictions on the application of synthetic or organic amendments, i.e. manure, in the baseline scenario.

j. In the project scenario, overgrazing, overstocking, or overuse of prescribed fires 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 in the project scenario are allowable but the resultant emissions avoided or removed are not eligible for crediting unless quantified through a separate methodology.

k. The Project Area is located in the United States or Canada.

B. PROJECT BOUNDARIES

B.1 Spatial Boundary

There are three primary spatial boundaries used in this methodology, **Participant Fields**, the **Project Area** and the **Project Region (Figure B.1)**. The discrete parcels where project activities are implemented are individually referred to as a Participant Field (project activity) and collectively referred to as the Project Area. The Project Area shall include only those Grassland or 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 Demonstration of Historical Conversion and E.2 Common Practice), 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.

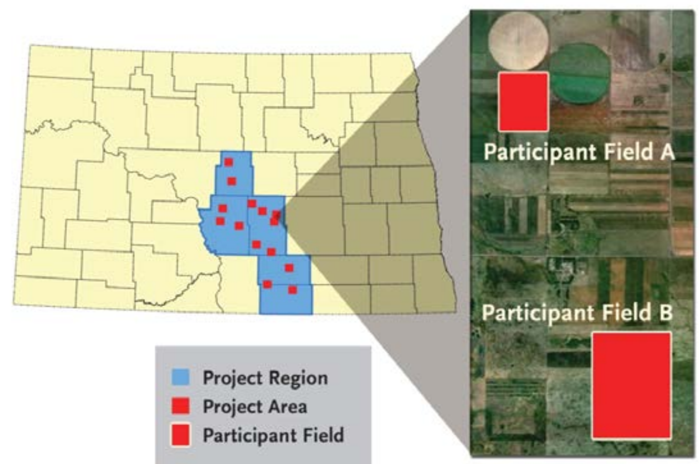


Figure B.1

The Project Region shall be further stratified to account for heterogeneity within the Project Region according to the procedures in Section B.1.1 Stratification.

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 that a Land Conservation Agreement restricts the management of conversion activities (e.g. via a conservation easement) for the duration of the Project Term on each Participant Field. 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 from the Project Participant to the Project Proponent must demonstrate clear ownership of any ERTs generated by the project activity.

B.1.1 Stratification

Within a project area, spatial heterogeneity that materially affects the quantification of GHG pools and emissions as reflected in the equations in this methodology (either in the baseline or project scenarios) should be accounted for via stratification. Some heterogeneity is already accounted for in the methodology, such as crop variety, which is already considered in several equations quantifying baseline carbon pools and emissions. Other sources of heterogeneity include soil and climatic variation that may affect soil and biomass carbon pools in both baseline and project scenarios. In such cases the Project Area should be stratified to account for this heterogeneity. Stratification can occur both in field sampling protocols and in modeling exercises. In both cases, stratification operates by classifying the Project Area into different categories (e.g. soil textural class), and quantifying pools or emissions separately for each category that occurs within the Project Area. For field sampling, this requires duplicating the sampling effort within areas representative of each category. For modeling efforts, this requires estimating parameter values separately for each category.

The objective of stratification is to reduce uncertainty of pool and emission estimates at the Project Area level. Projects covering homogenous areas may not need to use stratification. Projects involving multiple Participant Fields may elect to stratify across the larger Project Region whereas projects involving a single Participant Field may stratify across the single Participant Field.

Strata representing transition land uses/land covers (LU/LC) are not necessary for Grasslands as conversion is assumed to instantaneously change the 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 GHG Project Plan. Stratification must consider the biogeochemical and/or empirical models that will be applied for the methodology, where each stratum can be represented by a unique model parameterization. Stratification shall account for differences within the Project Area in climate, soils, and land cover that materially affect pools and emissions. It is not necessary to use the same strata for each pool. For example, the factors that affect soil carbon may differ from those that affect aboveground biomass.

For soil carbon, there are several variables that are good predictors of soil carbon, which could be used to stratify sampling: climate, soil texture, topographic position and/or soil taxa. Project Proponents should follow stratification guidelines for each of the following items:

1. Soil texture is a consistent, strong predictor of soil carbon in landscape-scale studies of soil carbon (e.g. Brejda et al. 2001). Soil texture can be measured in a variety of ways, such as percent sand or soil textural class. It is presumed that most stratification will occur by soil textural class as these are readily available from soil surveys and other resource inventories. Alternatively, where soils have been mapped to the soil series, soil taxa can be used for

stratification, where separate estimates are provided for each soil taxa that are expected to differ in their carbon content.

2. Climate. Where project areas are large enough to contain significant climatic variation, climatic zones should be used as an additional basis for stratification. Ecoregions or Major Land Resource Areas that are defined to have similar climates would be appropriate classification system for stratification purposes (Brejda et al. 2001). Options include 1) 2006 MLRA Geographic Database, http://soils.usda.gov/survey/geography/mlra/; 2) Bailey's Ecoregions (Bailey 1989), http://nationalatlas.gov/mld/ecoregp.html; 3) EPA's Level III Ecoregions (Omernik 1987), http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm.

For other pools or emission sources, stratification should be implemented when known sources of variation (e.g. soils, climate, land cover) are expected to alter estimates by more than 50% of expected average values within the Project Area.

B.1.1.1 Baseline Cropland Management Systems

Projected baseline management practices shall identify: tillage intensity, i.e. practice, depth 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. Inputs shall be informed from producer surveys conducted by government agricultural agencies or university extension offices[7]; the expert opinion of 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 cropping sequence (including fallow)
- 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
- Whether cover crops or fire are utilized
- Other necessary inputs for modeling relevant biogeochemical processes

[7] 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.

B.1.2 Recording the Project Area and Project Region

The Participant Field shall be specified with geodetic polygons (kml or other GIS files) where project activities are being implemented, as elaborated in the monitoring criteria. The Project Region shall also be recorded with geodetic polygons (kml or other GIS 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 all Participant Fields are contained within the Project Area (noting that the Project Area must be fully contained within the boundaries of the Project Region). A kml or other GIS file shall be made available in the GHG Project Plan at time of validation, clearly defining the boundaries of the Participant Fields and Project Region.

B.2 Temporal Boundary

The dates and time frames for the following project events must be defined in the GHG Project Plan:

- Project Crediting Period start date.
- Length of the Project Crediting Period, including end date.
- Dates and intervals of project baseline revaluation (baseline revaluation up to every 5 years)
- Date of enrollment for new Participant Fields included in the project.
- Demonstration that each Participant Field was in a Grassland or Shrubland land cover at 10 years prior to time of executing the Land Conservation Agreement.

The following temporal boundaries shall be defined in the GHG Project Plan:

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

B.2.1 Project Crediting Period

The earliest Project Crediting Period start date for AFOLU projects shall be 01 November 1997 or later or as defined in most recent version of the *ACR Standard*. Project Crediting Period for ACoGS projects applying this methodology must be a maximum of 5 years, renewable up to the length of the Project Term. 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 terrestrial 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 up to 5 year intervals. Baseline land use scenarios do not need to be re-assessed for previously enrolled Participant Fields. Baseline management scenario re-evaluation shall include re-assessment of all practices and inputs considered in Section B.1.1.1 Baseline Cropland Management Systems.

B.2.2 Project Term

The Project Term is the duration of crediting, monitoring and reporting of Project Activities. The minimum Project Term is 20 years, and may be renewed up to four times, for a total Project Term of 100 years.

C. CARBON POOLS 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 three percent of the total *ex ante* estimate of 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*.

C.1 Carbon Pools

The Project Proponent must account for all carbon pools that are likely to significantly decrease in the project scenario relative to the baseline for all Participant Fields. The Project Proponent 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 non-Tree woody biomass	Optional	When present, likely to be a source of carbon loss in baseline scenario. Above-ground Tree biomass is conservatively excluded as it may remain intact or decay over a long time period; 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 include 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.

C.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 N amendment sources. Indirect N fertilizer emissions are optional.
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	No	Not a significant gas for this source.
	N_2O	No	
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.

D. 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 E, PROCEDURE FOR DETERMINING 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 *ACR Tool for Determining REDD Project Baseline and Additionality* 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 D.1 Financial Viability of Conversion), 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 E, 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 D.1 Identification of Agent(s). Baseline projections of the land-use scenario are static and made ex ante, with no adjustments during the Project Term.

D.1 Financial Viability of Conversion

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 40%[8] 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

[8] The selection of a minimum 40% land value differential was informed by a similar criteria employed by the California Air Resources Board Forestry Protocol for Avoided Conversion, and the best available data, including studies of land use change that observed correlations between increasing cropland returns and grassland conversion (Claassen et al. 2011, Secchi et al. 2011, Rashford et al. 2012, Wright and Wimberly 2013).

qualification standards outlined for government tax codes (i.e. Internal Revenue Code, Section 170 (f)(11)(E)(ii) for the United States).

The appraised value for the 'highest and best use' shall also be considered in Section F.1.3 Discount for Uncertainty of Conversion.

D.2 Identification of Agent(s)

There are two potential Cropland conversion scenarios addressed by this methodology: those by an Identified Agent and those by an Unidentified Agent.

Within a Project Area, it is not necessary for all Participant Fields to have the same form of conversion agent, i.e., 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 GHG Project Plan. The appropriate baseline land use scenario shall then be applied to each Participant Field, and shall not be changed after project validation.

D.2.1 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 conversion may include decisions by individual land owners or community groups to not convert their lands. Including those 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 Term, not to convert their land(s).

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. 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.

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 been created within the last 5 years prior to the Start Date, or in the case of multiple project activities, within the last 5 years prior to the date the new Participant Field 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 Section D.2.2.1 , And either

- A new breakings request[9] 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.

D.2.2 Demonstration of an Unidentified Agent

This category includes activities that reduce net GHG emissions by stopping conversion of Grasslands or Shrublands: a) that are legally authorized and documented for conversion, b) where a specific agent of planned conversion is not clearly identifiable, yet c) where 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.

D.2.2.1 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 documentation of historical 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 5 years of the Start Date.

[9] 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.

D.3 Baseline Management

The Project Proponent shall assess the baseline management practices at the start of the project, and every 5 years for the duration of the project. Baseline management projections are made *ex ante*, and adjusted throughout the project at 5 year intervals at time of baseline re-assessment. Each assessment will assess baseline management for the subsequent 5 year period (i.e. the baseline management scenario for the previous 5 years will not be altered). New baseline management scenarios are applied to all Participant Fields, including those previously enrolled, such that the baseline scenario for each Participant Field may change every 5 years. Requirements for Baseline Management estimation are found in the Baseline Cropland Management Systems Section B.1.1.1 (Baseline Cropland Management Systems).

E. PROCEDURE FOR DETERMINING ADDITIONALITY

Additionality shall be satisfied using an independent appraisal to satisfy ACR's Three-Prong Additionality Test through the demonstration of regulatory surplus, a lack of common practice and a financial implementation barrier.

E.1 Regulatory Surplus

The project activity must meet the requirements on regulatory surplus set out under the project method as described in the latest ACR Standard documentation. Specifically, the project activity shall not be mandated by any law, statute or other regulatory framework. The appraisal process, Section D.2.2.1), will determine what laws and regulations affect the use and/or management of the parcel and what restrictions they would impose on the baseline and project activities. Appraisal results therefore may be used to supplement a determination of the Regulatory Surplus of project activities.

E.2 Common Practice

For both Identified Agent and Unidentified Agent, the following criteria should be used to complete the Common Practice Test to demonstrate that project activities create additional carbon storage beyond what would happen under a continuation of current common practices. For projects involving multiple project activities, i.e. Participant Fields, the common practice test must be passed at the Project level, rather than for each Participant Field. It is also assumed that perpetual or 99 year easements will be the primary tool to encumber the Project Area. In recognition that easements, covenants, deed restrictions, or other legal agreements may be employed to maintain the project land cover during the Project Crediting Period, these agreements are collectively referred to as the Land Conservation Agreement. The Land Conservation Agreement may not necessarily contain language pertaining to carbon or greenhouse gas ownership, which may be transferred in a separate agreement. In many areas, easements are a frequently used tool of conservation practitioners. The following steps ensure that project activities are additional to historic or baseline adoption of Land Conservation Agreements in the Project Region, and not common practice.

Step 1- Entity Acquiring Land Conservation Agreement

Is the Land Conservation Agreement held and purchased by a land trust, government agency, or other entity that holds similar Land Conservation Agreements in the Project Region? If no, project activity satisfies common practice analysis, otherwise proceed to Step 2.

Step 2- Historic Availability of Easements in Project Region

If the answer to any of the following questions is yes, the project activity shall be deemed additional. If none of the below conditions apply, the project activity shall not be considered additional. Project

Proponents shall provide sufficient evidence in the GHG Project Plan to prove additionality based on at least one of these criteria.

- Are the project's Land Conservation Agreements the first on Grassland or Shrubland in the Project Region?
- If easement programs or other programs implementing land use restrictions such as those in a Land Conservation Agreement have been in existence in the Project Region, has there been a decrease in funding available from historical funding sources for Conservation Agreements over the past 5 years?
- If easement or other Agreement programs have been in existence, regardless of funding status, has there been an essential distinction in the competitiveness of Agreement offers prior to the project activity due to funding sources or administrative restrictions that have hindered Agreements from remaining competitive with incentives for conversation to Cropland, e.g. easement costs have outpaced funding availability from non-carbon offset sources such that the annual enrollment, as measured by acreage, has decreased?
- Are Agreements implemented on parcels that are at elevated risk of conversion relative to other Agreements (existing and candidate), which may have been targeted for objectives other than risk of conversion, e.g., biodiversity conservation?
- Does carbon finance provide funding for 100% of the Agreement, e.g. no additional financial sources are used to implement project activities?

E.3 Financial Implementation Barrier

Projects must complete an independent appraisal of the Project Area Grasslands and Shrublands, as noted in Section D.2.2.1 . An appraisal will identify alternative land-uses and management practices that are legally permissible in the consideration of the 'highest and best use' of the property. Section D provides further guidance on alternative scenarios that shall be considered in the appraisal process. Appraisal results will also confirm or disprove the financial viability of the identified baseline, crop agriculture, relative to other potential uses and baseline land use scenarios. In order to pass this step, each Participant Field must have Cropland identified as the 'highest and best use' and have an appraised Cropland value that is **40%** or more above the land's value as Grassland or Shrubland.

In consideration of the findings from Sections E.1, E.2 and E.3, the following project activity is deemed additional:

- Implementation of a Land Conservation Agreement on Grasslands and/or Shrublands whose 'highest and best use' has been identified through an independent appraisal as Cropland and where the land's estimated value as Cropland is at least 40% higher than its value as Grassland or Shrubland and where such Conservation Agreements can be shown to satisfy a Common Practice Analysis, Section E2.

F. QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

F.1 Baseline Emissions

In the GHG Project Plan, the Project Proponent shall describe common practice in the Project Region for clearing and converting Grassland/Shrubland areas to Cropland. Such a description should include practices likely to affect the carbon pools and GHG sources described in Section C.

Baseline emissions shall be calculated as:

Total Baseline Emissions

$$BE_y = \sum_{p}^{P} \left(BE_{p,y} * \left(1 - ACD_p\right)\right) \quad \text{Eq. 0.1}$$

Where:

BE_y	Baseline emissions in year *y, y = 0 at project start date;* tCO_2e
$BE_{p,y}$	Baseline emissions from Participant Field *p* in year *y*; tCO_2e
ACD_p	Avoided Conversion Discount for uncertainty of conversion for Participant Field *p* (see Section F.1.3 Discount for Uncertainty of Conversion)
P	Total number of Participant Fields in the Project Area
p	Participant Field

Baseline Emissions from each participant field

$$BE_{p,y} = \Big(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} \\ C_{AGB,BL_{p,y}} \quad - \ C_{SOC,BL_{p,y}}\Big) + E_{N_2O,BL,p,y} \quad \text{Eq. 0.2}$$

$C_{AGB,BL_{p,y}}$	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

F.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. 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. Model validation must be employed to indicate whether models may be used for estimating each pool and source. For an example see Chamberlain et al. (2011). Where employed, the model shall meet the following criteria:

- Be peer-reviewed
- Be validated for the Project Region, including the management systems identified in both the project and baseline scenario, using peer-reviewed or other quality-controlled data (i.e. such as that collected as part of a Government soils inventory or experiment), appropriate for the Project Region.
- Be parameterized using peer-reviewed or other quality-controlled data appropriate to each identified strata.
- At a minimum, be able to make predictions at the scale of a Stratum or Project Area, whichever is smallest.
- Be validated for localized weather and climate conditions (average annual precipitation and temperature) applicable to the Project Area.
- Be able to account for changes to soil organic matter and nutrient dynamics that occur following the conversion of Grassland or Shrubland to Cropland.
- Estimate size of relevant carbon pools on an annual basis.

Output from models should include estimates of uncertainties associated with all pools and sources. In cases where variances are not included in model outputs, additional uncertainty analyses should be performed (e.g., Monte Carlo simulations). In cases where input variances can be calculated through Monte Carlo simulations, then these shall be performed and reported as well.

In addition to process-based models, peer-reviewed empirical models calibrated to the Project Region may also be applied for relevant pools and sources. It is intended that common biogeochemical models of ecosystems, including but not limited to DAYCENT, DNDC, and APEX, be considered eligible models, as long as they are validated for the Project Region and meet the uncertainty criteria as specified in Section G.3.3.4 Uncertainty Assessment and Conservativeness.

F.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 D.1.1 and D.1.2. The extent of conversion for both scenarios is limited to the area identified in D.1.

The conversion rate determines the $FC_{p,y}$ factor, used in Eqs. 0.5 and 0.9, which is 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 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 baseline scenario rate of conversion for the identified conversion agent, as identified in Section D.2.1 Demonstration of an Identified Agent specifying the planned extent and rate of conversion in annual increments.

Unless otherwise specified, it is considered conservative for projects with an **Unidentified Agent** to determine that conversion will commence in project Year 1, following the imposition of the Land Conservation Agreement on the Participant Field in project Year zero. A one year lag reflects that 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 0.

It is recognized that land management decisions and ownership size vary geographically. 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 considered to be converted in Year 1. Where the Participant Field is larger than the previously identified largest track and the Project Proponent can demonstrate there is capability on the behalf of conversion agents to convert larger tracts up to the size of the Participant Field, then 100% of Participant Field is to be converted in Year 1. Where this cannot be demonstrated then conversion in Year 1 shall be limited to the previously largest tract, with subsequent conversion occurring at later years and treated as separate Participant Fields.

F.1.3 Discount for Uncertainty of Conversion

This methodology 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 D.2.2.1 would be subject to conversion by Identified or Unidentified Agents. The application of this standardized additionality screen, as with any standardized test, includes some risk for Type 1 errors, 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. To account for the potential for a Type 1 error in the baseline scenario, 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 D.2.2.1), including any subsidies or other incentives to avoid conversion that were received prior to the Start Date, of each Participant Field in the Project Area as Cropland is more than 100% greater than (i.e. double) the value of the current Grassland land use, then the discount factor shall be set at zero (i.e. no discount applied). However, if the appraised value as Cropland is 40-100% greater than its Grassland/Shrubland value, then a discount factor of 0.5 must be applied. 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. 0.2), 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:

Avoided Conversion Discount Factor

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

$$\text{If } \left(\frac{VB_p}{VP_p}\right) > 2.0, \text{then } ACD_p = 0 \qquad \text{Eq. 0.3}$$

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/Shrubland land use for Participant Field *p*; US Dollars

F.1.4 Aboveground Biomass (Woody and Non-woody)

In the baseline scenario, this methodology accounts for both the 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:

Baseline Aboveground Biomass

$$C_{AGB,BL_{p,y}} = C_{AGB_{grass},BL_{p,y}} + C_{AGB_{crop},BL_{p,y}} \quad \text{Eq. 0.4}$$

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 F.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 F.1.4.2 Carbon Stocks of Aboveground Crop Biomass; tCO_2e.

F.1.4.1 Carbon Stocks of Pre-Existing Non-Tree Aboveground Biomass

In the conversion of Grassland to Cropland, this methodology treats carbon in aboveground non-Tree biomass[10] to be primarily released to the atmosphere in the first 5 years following conversion. Projects that opt to 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 F.2.1 Above-ground biomass (woody and non-woody). 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 is converted and the decomposition of biomass in the portion of the field that is converted.

[10] Because this methodology treats the loss of aboveground biomass upon conversion as lost to the atmosphere over a 5 year period, projects are permitted to account for aboveground non-Tree biomass that is lost upon conversion to Cropland. However, project may not include aboveground Tree biomass in this calculation as the decay period is much longer. Tree biomass removed from the Participant Field during conversion in the baseline scenario 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.

Most fields are prepared for conversion to Cropland by destroying existing aboveground biomass through herbicide application and plowing, although it is possible to direct seed into Grassland. The most conservative scenario is that biomass would decompose as slow as litter in an untilled Cropland. Equation 0.5 contains a decomposition parameter based on leaf decomposition in a no-till corn field. Project Proponents may use a less conservative estimate of 100% decomposition of aboveground biomass the year following conversion in cases where tillage is used in the baseline scenario. The aboveground biomass estimate, whether crop or non-Tree biomass from the project scenario, shall be the annual peak biomass, i.e. maximum annual growth prior to grazing, harvest or other disturbance.

Baseline Aboveground Grass Biomass Loss

$$C_{AGB_{grass},BL_{p,y}} = C_{AGB,PR_{p,y}} * \left(1 - \sum_{t=0}^{y} FC_{p,t,y}\right) + C_{AGB,PR_{p,y}} * \sum_{t=0}^{y} \left(FC_{p,t,y} * e^{(-0.77*(y-t))}\right) \qquad \text{Eq. 0.5}$$

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.
$C_{AGB,PR_{p,y}}$	Carbon stock of aboveground non-Tree biomass for Participant Field *p*, as determined from Section F.2.1 Above-ground biomass (woody and non-woody)tCO_2e.
$FC_{p,t,y}$	The proportion of Participant Field *p* that is converted to Cropland in year t, time of conversion, in year *y* of the baseline scenario, determined based on rates and extents of conversion defined in Section F.1.2 Suitability, Rate and Extent of Conversion dimensionless.
$e^{(-0.77*(y-t))}$	Proportion of aboveground biomass following conversion. Note that because conversion often occurs over multiple years, and decay is a nonlinear function, it is necessary to track carbon loss from a given year's conversion event. The decay rate (0.77) is based on leaf decomposition in no-till Cropland (Kochsiek et al. 2009).
t	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 20; years

F.1.4.2 Carbon Stocks of Aboveground Crop Biomass

In the baseline scenario (i.e., annual crop production), the aboveground biomass each year is assumed equal to biomass losses from harvest and mortality in that same year, and there is no carryover of aboveground crop biomass between years. 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 AFOLU 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 aboveground biomass values will conform to each crop year.

Similar to the soil organic carbon pool, a peer-reviewed process model that meets the requirements of Section F.1.1 Use of Models for GHG Estimation and that produces aboveground vegetation estimates as an output may be used to calculate $C_{AGB_{crop},BL_{b,y}}$. 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 $C_{AGB_{crop},BL_{b,y}}$. 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. A default harvest index of 0.50 can be used for maize (Ciampitti and Vyn 2012), of 0.46 for soybean (Johnson et al. 2006), and 0.45 for wheat (Johson et al. 2006). Average 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:

Baseline Aboveground Biomass for Participant Field P

$$C_{AGB_{crop},BL_{p,y}} = \sum_{b}^{B} C_{AGB_{crop},BL_{b,y}} \qquad \text{Eq. 0.6}$$

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
$C_{AGB_{crop},BL_{b,y}}$	Carbon stock of aboveground crop biomass in the baseline for crop type *b* in year *y*; tCO_2e

B	Total number of crop types

Baseline Aboveground Biomass by Crop Type

$$C_{AGB_{crop},BL_{b,y}} = DM_{BL,b,y} * CF_b * \frac{44}{12} * A_b \quad \text{Eq. 0.7}$$

$DM_{BL,b,y}$	Annualized average dry matter in the baseline for crop type *b* in 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	Area of crop type *b*; hectares

F.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 by multiplying an appropriate root-to-shoot ratio to $C_{AGB,BL_{p,y}}$. This methodology assumes all below-ground biomass carbon stocks from these pools begin decomposing at a rate specified in Equation 0.9 upon conversion to Cropland in the baseline scenario.

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

Baseline Belowground biomass

$$C_{BGB,BL_{p,y}} = C_{BGB_{grass},BL_{p,y}} + C_{BGB_{crop},BL_{p,y}} \quad \text{Eq. 0.8}$$

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.

A peer-reviewed process model that meets the requirements of Section F.1.1 Use of Models for GHG Estimation, and that produces belowground vegetation estimates as an output, may be used to calculate $C_{BGB,BL_{p,y}}$. 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 $C_{BGB,BL_{p,y}}$. These are considered conservative approaches to account for the uncertainty of crop selection in the rotation in the baseline scenario.

F.1.5.1 Carbon Stocks of Pre-Existing Non-Tree Belowground Biomass

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 F.2.2 Below-ground Biomass). 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 and the decomposition of biomass in the portion of the field that was converted. The decomposition rate is specified in Equation 0.9, based on a comprehensive global analysis of root decomposition (Silver and Miya 2001). Project Proponents may replace the default rate with a value based on peer reviewed literature that is more current or site-specific than the default value suggested here.

Baseline Belowground Grass Biomass Loss

$$C_{BGB_{grass},BL_{p,y}} = C_{BGB,PR_{p,y}} * \left(1 - \sum_{t=0}^{y} FC_{p,t,y}\right) + C_{BGB,PR_{p,y}} * \sum_{t=0}^{y} FC_{p,t,y} * e^{(-1.41*(y-t))} \quad \text{Eq. 0.9}$$

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.
$C_{BGB,PR_{p,y}}$	Initial (year *y*=0) carbon stock of belowground non-Tree biomass for Participant Field *p*, as determined from Section F.2.2 Below-ground Biomass; tCO_2e.

$FC_{p,t,y}$	The cumulative proportion of Participant Field *p* that has been converted to Cropland in year t, time of conversion, as of year *y* in the baseline scenario, determined based on rates and extents of conversion defined in Section F.1.2 Suitability, Rate and Extent of Conversion dimensionless.
$e^{(-1.41*(y-t))}$	The decay function for belowground biomass following conversion. Note that because conversion often occurs over multiple years, and decay is a nonlinear function, it is necessary to track carbon loss from a given year's conversion event, and then sum the loss from all years, as shown in Eq. 0.9. The decay rate (1.41) is based on average grass root decomposition from 46 studies (Silver and Miya 2001). For woody biomass, a decay rate of 0.44 should be used for broadleaved species and a decay rate of 0.30 should be used for conifer species (Silver and Miya 2001).
t	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 20; years

Alternatively, $C_{BGB_{grass}BL_{p,y}}$ values may be derived from default values in an approved process model meeting criteria in F.1.1, 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**.**

F.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 F.1.4.2 Carbon Stocks of Aboveground Crop Biomass and the application of a suitable root-to-shoot ratio. For maize a default value of 0.07 should be used. This is based on a comprehensive analysis of root-to-shoot ratios in maize (Amos and Walters 2006). The review of root-to-shoot ratio in maize provides a value based on an analysis that does not include grain or cobs in its measure of shoot; our default value represents a modified value that can be used to calculate root biomass based on total aboveground biomass, including grain and cobs (Amos and Walters 2006).

Baseline Belowground Crop Biomass

$$C_{BGB_{crop},BL_{p,y}} = \sum_{b}^{B} R_b * C_{AGB_{crop},BL_{b,y}} \quad \text{Eq 0.10}$$

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
$C_{AGB_{crop},BL_{b,y}}$	Carbon stock of aboveground crop biomass of crop type *b* and year *y* of the baseline scenario, as calculated in Eq. 0.7; tCO_2e
B	Total number of crop types

Alternatively, $C_{BGB_{crop},BL_{p,y}}$ values may be derived from default values in an approved process model meeting criteria in F.1.1, 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**.**

F.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 relatively 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 ACR tool or module to directly measure SOC stocks and changes such as the latest version of the ACR *Tool for Estimation of Stocks in Carbon Pools and Emissions from Emission Sources*. This shall be performed in conjunction with Section B.1.1 Stratification. Whatever approach is deployed, estimates should be available to the affected depth at which SOC changes are expected to occur in response to baseline activities. The affected depth chosen for sampling shall be justified to the validator. Further, direct sampling shall separate and exclude visible root biomass from SOC estimates. If models are utilized, they shall similarly be calibrated with samples that have excluded visible root biomass. 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:

$$C_{SOC,BL_{p,y}} = \sum_{i}^{p,i} C_{SOC_{i,y=0}} * A_{p,i} * (1 - EF_{t,y}) * FC_{py} \quad \text{Eq. 0.11}$$

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 soil stratum *i*, fixed for project duration; $tCO_2e\ (ha)^{-1}$
$EF_{t,y}$	Emission factor for the fraction of soil organic carbon pool remaining *t* years since conversion to Cropland in year *y*; dimensionless
$FC_{p,y}$	Proportion of Participant Field *p* that has been converted to Cropland in the baseline scenario for year *y*, as described in Section F.1.2 Suitability, Rate and Extent of Conversion dimensionless
$A_{p,i}$	Area of participant field *p* in soil strata *i*; hectares
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* = 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 GL AFOLU 2006 (adapted from Eq. 2.25, Ch2, p 2.30)[11], in which case:

$$EF_{t,y} = \frac{1 - (FSOC_{LU} * FSOC_{MG} * FSOC_{IN})}{D} * t \quad \text{Eq. 0.12}$$

Where:

$EF_{t,y}$	Emission factor describing the fraction of soil organic carbon pool remaining *t* years since conversion to Cropland in year *y*; dimensionless
$FSOC_{LU}$	Fraction of soil organic carbon pool remaining after transition period, accounting for land use factors; dimensionless
$FSOC_{MG}$	Fraction of soil organic carbon pool remaining after transition period, accounting for management factors; dimensionless

[11] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf

$FSOC_{IN}$	Fraction of soil organic carbon pool remaining after transition period, accounting for input of organic matter; dimensionless
D	Transition period for soil organic carbon, 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 $EF_{t,y}$ 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 F.1.1 Use of Models for GHG Estimation 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 field measurements at sites that have and have not been converted to Cropland, but are otherwise materially similar to each other and to the Project Area (e.g. in soil type and climate), provided that 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 Cropland sample sites have been converted to Cropland, and at a minimum shall be measured following the same management treatments for duration of 5 years. Empirical data on soil carbon emissions shall be adjusted for uncertainty as described in section 5.2.35 of IPCC GL AFOLU 2006.

F.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 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.

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:

Baseline N_2O Emissions

$$E_{BL,N_2O_{p,y}} = E_{BL,N_2O,direct_{p,y}} + E_{BL,N_2O,indirect_{p,y}} \quad \text{Eq. 0.13}$$

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 N 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 N to Participant Field *p* in the baseline scenario for year *y*; tCO_2e

F.1.7.1 Direct Nitrogen Emissions

Where nitrogen inputs are applied in the baseline scenario, a peer reviewed biogeochemical model calibrated and validated for the project region, Section F.1.1 Use of Models for GHG Estimation 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 that activity data be monitored, but as the baseline is an avoided scenario, updated regional application information as identified in B.1.1.1 Baseline Cropland Management Systems may be used to estimate nitrogen fertilization activity.

Per the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization (Version 01)*, direct N_2O emissions for each Participant Field in the Project Area shall be estimated as:

Baseline Direct N_2O Emissions

$$E_{BL,N_2O,direct_{p,y}} = \left(F_{BL,SN_{p,y}} + F_{BL,ON_{p,y}}\right) * EF_N * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 0.14}$$

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 N amendments applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
EF_N	Emission Factor for emission from N inputs; t-N_2O-N(t-N input)$^{-1}$
$\frac{44}{28}$	Ratio of molecular weights of N_2O to N; 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)

Baseline Synthetic Fertilizer N_2O Emissions

$$F_{BL,SN_{p,y}} = \sum_{j}^{J} M_{BL,SN_{p,j,y}} * N_{BL,SN_j} * (1 - Frac_{SN}) \quad \text{Eq. 0.15}$$

$F_{BL,SN_{p,y}}$	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
$M_{BL,SN_{p,j,y}}$	Mass of synthetic fertilizer type *j* applied to Participant Field *p* in year *y*; tonnes
N_{BL,SN_j}	Nitrogen content of synthetic fertilizer type j; t-N(tonne fertilizer)$^{-1}$
$Frac_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless

Baseline Organic Fertilizer N_2O Emissions

$$F_{BL,ON_{p,y}} = \sum_{k}^{K} M_{BL,ON_{p,k,y}} * N_{BL,ON_k} * (1 - Frac_{ON}) \quad \text{Eq. 0.16}$$

$M_{BL,ON_{p,k,y}}$	Mass of organic N amendment type *k* applied to Participant Field *p* in year *y*; tonnes
N_{BL,ON_k}	Nitrogen content of organic N amendment type k; t-N (tonne fertilizer)$^{-1}$
$Frac_{ON}$	Fraction of organic amendment nitrogen that volatilizes as NH_3 and NO_X; dimensionless

J	Number of synthetic fertilizer types
K	Number of organic N amendments types

F.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 GL AFOLU 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:

Baseline Indirect N_2O Emissions

$$E_{BLN_2O,indirect_{p,y}} = E_{BL,N_2O,volat_{p,y}} + E_{BL,N_2O,leach_{p,y}}$$ Eq. 0.17

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

Baseline Volatilization N_2O Emissions

$$E_{BL,N_2O,volat_{p,y}} = \Big((F_{BL,SN_{p,y}} * Frac_{SN}) + (F_{BL,ON_{p,y}} * Frac_{ON})\Big) * EF_{AD} * \frac{44}{28} * GWP_{N_2O}$$ Eq. 0.18

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
$F_{BL,SN_{p,y}}$	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

$Frac_{SN}$	Fraction of synthetic N applied to soils that volatilizes as NH_3 and NO_x, kg N volatilized (kg of N applied)$^{-1}$
$F_{BL,ON_{p,y}}$	Mass of organic N amendments applied to Participant Field *p* in the baseline scenario in year *y* adjusted for volatilization as NH_3 and NO_X; t-N
$Frac_{ON}$	Fraction of organic N applied to soils that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$
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)
GWP_{N_2O}	Global Warming Potential for N_2O; tCO_2e $(tN_2O)^{-1}$ (IPCC default = 310, valid for the first commitment period)

Baseline Leaching N_2O Emissions

$$E_{BL,N_2O,leach_{p,y}} = \left(F_{BL,SN_{p,y}} + F_{BL,ON_{p,y}} + F_{BL,SOM_{p,y}}\right) * Frac_{Leach} * EF_{Leach} * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 0.19}$$

Where:

$E_{BL,N_2O,leach_{p,y}}$	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 N amendments 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 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, t N yr^{-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)

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)

F.1.8 Fossil Fuel Emissions

The use of farm machinery, and potentially construction equipment, to assist with the conversion and ongoing crop management process, is 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.2 of the Verified Carbon Standard (VCS) Methodology *Adoption of Sustainable Agricultural Land Management.* 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:

Baseline Fossil Fuel Emissions

$$E_{BL,FFp,y} = \sum_{v}^{V} \sum_{f}^{F} \left(FF_{BL_{p,v,f,y}} * EF_f \right) \qquad \text{Eq. 0.20}$$

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
$FF_{BL_{p,v,f,y}}$	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_f	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. Source: VCS SALM *Tool VI.2*
v	Type of vehicle/equipment
V	Total number of types of vehicle/equipment used in the project activity
f	Type of fossil fuel
F	Total number of fuel types

F.2 Project Emissions

For each Participant Field, Eq. 0.21 specifies the net difference in soil organic carbon, above and below ground biomass, emissions from N amendments, biomass burning, fossil fuel use and enteric CH_4 emissions from livestock from project and baseline activities.

The greatest net GHG benefit from ACoGS projects is anticipated to be the avoided release of SOC. 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 accounting for activities that may increase these stocks. Projects seeking to gain offset credit for any management activity that causes growth in these pools over time must apply a separate methodology approved for use by the ACR.

Total Project Emissions shall be calculated as:

$$PE_y = \sum_{p}^{P} PE_{p,y} \quad \text{Eq. 0.21}$$

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
P	Total Project Participant Fields

Project Emissions in Year y for Participant Field p

$$PE_{p,y} = C_{AGB,PR_{p,y-1}} - C_{AGB,PR_{p,y}} + C_{BGB,PR_{p,y-1}} - C_{BGB,PR_{p,y}} + E_{PR,N_{p,y}} + E_{FERM_{p,y}} + E_{FF,PRy,p} \quad \text{Eq. 0.22}$$

Where:

$C_{AGB,PR_{p,y}}$	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

$E_{PR,N_{p,y}}$	Project emissions from nitrogen applications in Participant Field *p* in *y*; tCO_2e
$E_{PR,Livestock_{p,y}}$	Project emissions from livestock – enteric fermentation in Participant Field *p* in year *y*; tCO_2e
$E_{FF,PRy,p}$	Emissions due to the use of fossil fuels in project management, $t\,CO_2e$

F.2.1 Above-ground biomass (woody and non-woody)

As described in the methods for baseline above-ground biomass carbon (Section F.1.4 Aboveground Biomass (Woody and Non-woody) 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 following conversion to Cropland. Typical aboveground biomass may include grasses, leguminous and non-leguminous forbs, shrubs and trees.

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

Initial carbon stocks in woody and non-woody biomass pools may be based upon direct field measurement or remote sensing for each biomass type, in a year where growing season precipitation is within 30% of average annual growing season precipitation, or averaged over three years. Remote sensing data should be calibrated to the Project Area with field samples. Above-ground biomass shall be calculated for each Participant Field in the Project Area as:

Project Aboveground Biomass

$$C_{AGB,PR_{p,y}} = \sum_{b}^{B} C_{AGB_{b,y=0}} \quad \text{Eq. 0.23}$$

Initial Project Aboveground Biomass

$$C_{AGB_{b,y=0}} = DM_{b,y=0} * CF_b * \frac{44}{12} * A_b \quad \text{Eq. 0.24}$$

Where:

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

$C_{AGB_{b,y=0}}$	Initial (year *y*=0) carbon stock of above-ground biomass for biomass type *b*; tCO_2e
B	Total number of biomass types
$DM_{b,y=0}$	Dry matter for biomass type *b* 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	Area of biomass type *b*; hectares
$\frac{44}{12}$	Molar fraction for converting Carbon to CO_2

Alternatively, $C_{AGB_{p,y=0}}$values may be derived from default values in an approved process model meeting criteria in F.1.1, 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**.**

F.2.2 Below-ground Biomass

As described in the methods for baseline below-ground biomass carbon, Section F.1.5 Belowground Biomass**,** 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 F.2.1 Above-ground biomass (woody and non-woody), 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 is 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 carbon-to-shoot carbon ratio, R_b. In Grasslands, a global database finds that carbon concentration in roots and shoots are relatively equivalent across sites (median 44% in leaves and 43% in roots; Craine et al. 2005). Therefore, root-to-shoot ratios are equivalent to the root carbon-to-shoot carbon ratios in Grasslands. As a default value, Project Proponents can use Mokany et al. (2006) which suggests root:shoot ratios of 4.2 for temperate Grassland, 4.5 for cool temperate Grassland, and 1.8 for Shrubland. Project Proponents can replace the default rate with a value based on peer reviewed literature that is more current or site-specific than the default values suggested here, e.g. Gill et al. (2002).

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

Project Belowground Biomass

$$C_{BGB,PR_{p,y}} = \sum_{b}^{B} R_b * C_{AGB_{b,y=0}} \qquad \text{Eq. 0.25}$$

Where:

$C_{BGB,PR_{p,y}}$	Carbon stock of below-ground biomass for Participant Field *p* in the project scenario in year *y*; tCO_2e
R_b	Root carbon-to-shoot carbon ratio of biomass type *b*; dimensionless
$C_{AGB_{b,y=0}}$	Initial (year *y*=0) carbon stock in above-ground biomass of biomass type *b i*; tCO_2e

Alternatively, $C_{BGB_{p,y}}$ values may be derived from default values in an approved process model meeting criteria in F.1.1, 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**.**

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.

F.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). Here we conservatively assume soil organic carbon stocks to be in a steady state, such that soil organic carbon stocks in the project scenario are thus fixed at $C_{SOC_{y=0}}$ over the project life. Measurement and quantification methods for calculating $C_{SOC_{y=0}}$ are outlined in the treatment of soil organic carbon in the baseline scenario (Section F.1.6 Soil Organic Carbon)

F.2.4 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:

Project Total N_2O Emissions

$$E_{PR,N_2O_{p,y}} = E_{PR,N_2O,direct_{p,y}} + E_{PR,N_2O,indirect_{p,y}} \qquad \text{Eq. 0.26}$$

Where:

$E_{PR,N_2O_{p,y}}$	N_2O emissions from total nitrogen inputs in Participant Field *p* in the project 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 project 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 project scenario for year *y*; tCO_2e

F.2.4.1 Direct Nitrogen Emissions

Where fertilizer inputs are applied in the project scenario, a peer reviewed biogeochemical model calibrated and validated for the project region, as defined in Section F.1.1 Use of Models for GHG Estimation 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. It is not anticipated that fertilizer applications are common practice for the project scenario.

Per the CDM A/R Methodological tool *Estimation of direct nitrous oxide emission from nitrogen fertilization (Version 01)*, direct N_2O emissions for each Participant Field in the Project Area shall be estimated as:

Project Direct N_2O Emissions

$$E_{PR,N_2O,direct_{p,y}} = \left[\left(F_{PR,SN_{p,y}} + F_{PR,ON_{p,y}}\right) * EF_N + F_{PRPp,y} * EF_{MNR}\right] * MW_{N_2O} * GWP_{N_2O} \quad \text{Eq. 0.27}$$

Where:

$E_{PR,N_2O,direct_{p,y}}$	Total direct N_2O emissions from nitrogen fertilizer application in the project 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 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

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)

Project Synthetic Fertilizer Application

$$F_{PR,SN_{p,y}} = \sum_{j}^{J} M_{PR,SN_{p,j,y}} * N_{PR,SN_j} * (1 - Frac_{SN})$$ Eq. 0.28

Where:

$M_{PR,SN_{p,j,y}}$	Mass of synthetic fertilizer type *j* applied to Participant Field *p* in year *y*; tonnes
N_{PR,SN_j}	Nitrogen content of synthetic fertilizer type j; t-N(tonne fertilizer)$^{-1}$
$Frac_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
J	Number of synthetic fertilizer types

Project Organic Fertilizer Application

$$F_{PR,ON_{p,y}} = \sum_{k}^{K} M_{PR,ON_{p,k,y}} * N_{PR,ON_k} * (1 - Frac_{ON})$$ Eq. 0.29

$M_{PR,ON_{p,k,y}}$	Mass of organic fertilizer type *k* applied to Participant Field *p* in year *y*; tonnes
N_{PR,ON_k}	Nitrogen content of organic fertilizer type k; t-N(tonne fertilizer)$^{-1}$

$Frac_{ON}$	Fraction of organic fertilizer nitrogen that volatilizes as NH_3 and NO_X; dimensionless
K	Number of organic fertilizer types

Project Excreta Nitrogen

$$F_{PRPp,y} = \sum_{l}^{L}\left(P_{p,l} * Nex_l\right)$$ Eq. 0.30

L	Number of livestock 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 $(animal)^{-1}$ $(yr)^{-1}$

With:

Nitrogen Excreta per Head of Livestock

$$Nex_l = \frac{N_{rate(l)} * \frac{TAM_l}{1000} * GD_{p,l,y}}{1000}$$ Eq. 0.31

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 $animal^{-1}$
$GD_{p,l,y}$	Grazing days per livestock type *l* on Participant Field *p* in year *y*; grazing days

F.2.4.2 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 meeting criteria in F.1.1. The below method is derived from the IPCC GL AFOLU 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:

Project Indirect N_2O Emissions

$$E_{PR,N_2O,indirect_{p,y}} = E_{PR,N_2O,volat_{p,y}} + E_{PR,N_2O,leach_{p,y}} \quad \text{Eq. 0.32}$$

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

Project Volatilization N_2O Emissions

$$E_{PR,N_2O,volat_{p,y}} = \Big((F_{PR,SN_{p,y}} * Frac_{SN}) + ((F_{PR,ON_{p,y}} + F_{PRPp,y}) * Frac_{ON})\Big) * EF_{AD} * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 0.33}$$

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

$F_{PR,SN_{p,y}}$ 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

$Frac_{SN}$ Fraction of synthetic N applied to soils that volatilizes as NH_3 and NO_x, kg N volatilized (kg of N applied)$^{-1}$

$F_{PR,ON_{p,y}}$ 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

$Frac_{ON}$ Fraction of organic N applied to soils that volatilizes as NH_3 and NOx, kg N volatilized (kg of N applied or deposited)$^{-1}$

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)

44/28 Ratio of molecular weights of N_2O to N; 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)

Project Leaching N_2O Emissions

$$E_{PR,N_2O,leach_{p,y}} = \left(F_{PR,SN_{p,y}} + F_{PR,ON_{p,y}} + F_{PRPp,y}\right) * Frac_{Leach} * EF_{Leach} * \frac{44}{28} * GWP_{N_2O} \quad \text{Eq. 0.34}$$

$F_{PR,SN_{p,y}}$ 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

$Frac_{Leach}$ 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)

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)

F.2.5 Livestock Emissions- Enteric Fermentation

Livestock, such as cattle, bison and sheep, produce CH_4 as a result of enteric fermentation in their rumen. Enteric fermentation emissions vary by species, breed, animal size, feed, environment and management systems (Ominski et al. 2007). Estimates of enteric fermentation can also vary widely depending on the level of specificity input data and use of defaults (Ominski et al. 2007). It is therefore encouraged that Project Proponents utilize the most representative input data where possible. Further, calves less than 6 months in age are assumed to have zero CH4 emissions as their diet will be primarily milk (US EPA 2013).

Estimates of enteric CH_4 emissions are restricted to rangeland/pasture manure systems where manure is left unmanaged once deposited by livestock (Applicability Condition i, Section A.5). It is recognized that in Grassland ecosystems, the net contribution of livestock in the system may be net GHG 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 from this methodology, but could be eligible for ERTs under a separate but complimentary *Grazing Land and Livestock Management* methodology. Manure deposited by livestock present in the project scenario shall be accounted for in Soil Nitrogen Emissions, Section F.2.4 Soil Nitrogen Emissions.

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

Project Enteric Fermentation

$$E_{FERMp,y} = \sum_{l}^{L} P_{p,l} * EF_l * GD_{p,l,y} * GWP_{CH4} \div 1000 \qquad \text{Eq. 0.35}$$

Where:

$E_{FERMp,y}$	CH_4 emission from enteric fermentation due to livestock on Participant Field *p* in year *y*; tCO_2e
L	Total number of livestock types in project scenario
$P_{p,l}$	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

Enteric Emission Factor per Head of Livestock

$$EF_l = \frac{GE * \left(\frac{Y_m}{100}\right)}{55.65} \qquad \text{Eq. 0.36}$$

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

F.2.6 Fossil Fuel Emissions

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

Project Fossil Fuel Emissions

$$E_{FF,PRp,y} = \sum_{v}^{V}\sum_{f}^{F}\left(FF_{PR_{p,v,f,y}} * EF_f\right) \quad \text{Eq. 0.37}$$

Where:

$E_{FF,PRp,y}$	Emissions due to the use of fossil fuels in project management, t CO_2e
$FF_{PR,p,v,f,y}$	Consumption of fossil fuel in vehicle/equipment type v during year y; litres (yr)$^{-1}$
EF_f	Emission factor for the type of fossil fuel combusted in vehicle or equipment, v For gasoline EFCO2e = 0.002810 t per liter. For diesel EFCO2e = 0.002886 t per liter. Source: VCS SALM Tool VI.2
v	Type of vehicle/equipment
V	Total number of types of vehicle/equipment used in the project activity
f	Type of fuel
F	Total number of fuel types

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.

F.3 Leakage

There are two types of potential leakage from the avoided conversion of Grassland and Shrubland, market and activity shifting leakage. In certain scenarios, and in the production of certain crops, it is possible that attempts to estimate activity shifting leakage will double count market leakage. Leakage shall therefore be calculated as

Leakage Emissions

$$LE_y = MAX(LE_{M,y}, LE_{A,y}) \quad \text{Eq. 0.38}$$

Where

MAX Maximum

LE_y Leakage factor in year *y*

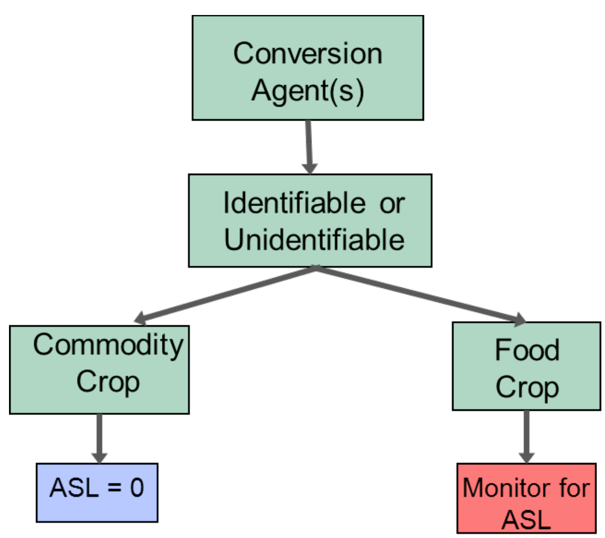
$LE_{M,y}$ Market Leakage in year *y*

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

F.3.1 Activity Shifting Leakage

Activity shifting leakage in an ACoGS project activity 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 F.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 0.1** 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

Where Activity Shifting conversion needs to be estimated, the difference between the average annual conversion rate in the Project Region for the 5 years prior to the Start Date and the average annual conversion rate during the Project Crediting Period may be used to estimate Activity Shifting leakage. 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 prior to and during the Project Crediting Period. 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 ACR REDD Methodology Module *Estimation of emissions from activity shifting for avoided planned deforestation* (LK-ASP).

F.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 relatively inelastic globally, requiring that the foregone production will be made up either through changes at 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 is 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 and upward pressure to increase production on non-project lands. 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 of additional non-Project lands (i.e. changes at the intensive margin). 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 additional 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. 0.39, which is derived from Murray, McCarl and Lee (2004).

Market Leakage

$$LE_{M,y} = \frac{E_S}{E_S - E_D} \qquad \text{Eq. 0.39}$$

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 be reliably used in the United States and Canada, 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 entirely from all productive uses, although some emergency haying and grazing is allowed, whereas ACoGS projects still allow grazing and livestock production.

Source	Estimate of market effects leakage	Approach
Taheripour, (2006.	≤20%	General equilibrium model of CRP leakage
Wu2000.	20%	Statistical estimate of leakage based on empirical land use data associated with the implementation of the CRP.
Barr et al. 2011.	<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 et al. 2007.	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 0.43, 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.

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

F.4 Summary of GHG Emission Reduction and/or Removals

Net Emissions Reduction

$$ER_y = BE_y - PE_y - NP_y - LD_y \qquad \text{Eq. 0.40}$$

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. 0.1, tCO_2e
PE_y	Project emissions in year *y*, result of Eq. 21, tCO_2e
NP_y	Non-Permanence deduction in year y, result of Eq. 0.46, tCO_2e
LD_y	Leakage deduction for year y, result of Eq. 0.42

Where $\mathrm{BE_y} < \mathrm{PE_y}$*, no ERTs shall be issued for that year.*

Non-Permanence Deduction

$$NP_y = BF_y * \sum_{p}^{P} \Big(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}} \Big) \qquad \text{Eq. 0.41}$$

Where:

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.[12]
$C_{AGB,BL_{p,y}}$	Carbon stock of aboveground biomass in Participant Field *p* in year *y* in the baseline scenario; tCO_2e. Eq. 0.4
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e. Eq. 0.8
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field *p* in the baseline scenario in year *y*; tCO_2e. Eq. 0.11

Leakage Deduction

$$LD_y = LE_y * \sum_{p}^{P} \left(C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}} \right) \quad \text{Eq. 0.42}$$

Where:

LE_y	Leakage in year *y*, result of Eq. 0.38
$C_{AGB,BL_{p,y}}$	Carbon stock of aboveground biomass in Participant Field *p* in year *y* in the baseline scenario; tCO_2e. Eq. 0.4
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field *p* in the baseline scenario in year *y*; tCO_2e. Eq. 0.8
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field *p* in the baseline scenario in year *y*; tCO_2e. Eq. 0.11

[12] As described in the ACR Standard V2.1 , the Project Proponent shall use the *VCS AFOLU Non-Permanence Risk Tool* until the ACR Tool for Risk Analysis and Buffer Determination is available.

G. MONITORING

G.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. Project Proponents are strongly encouraged to maintain area-based parameters in per Hectare units as well as the unit specified in this methodology, typically field p, to assist validation and verification events.

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 Proponents 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.

G.2 Data and Parameters Monitored

See Appendix A.

G.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 GHG Project Plan 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

G.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 GHG Project Plan Document shall specify the sampling design, sample size, plot size and determination of plot location. All sampling must be carried out such that a 90% Confidence Interval does not exceed 10% of the mean. Where uncertainty exceeds 10%, 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.

G.3.2 Data Archiving

All reports, measurements and other project related documents, including documentation of LU/LC conversion, shall be kept in an electronic format for at least 2 years following the end of the last Project Crediting Period. This information shall also be stored at a minimum of two locations in a durable, physical format, such as a Compact Disc. Where soil samples are collected, these shall be maintained until at least the next scheduled verification event, i.e. 5 years. Soil and other durable samples shall be stored in an air-dry condition in a cool, dry location.

G.3.3 Monitoring Tasks and the Monitoring Report

At each verification event, at most every 5 years, values for Parameters listed in Section F and Appendix A, shall be provided for and used to calculate ER_y, Equation 0.40 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 ERTs.

G.3.3.1 Net Project Scenario Pools and Emissions

At the 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, timing of grazing (if seasonal) and numbers (animal units)
- Condition of aboveground vegetation
- Frequency aboveground biomass is burned (managed and unmanaged)

G.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 Project Crediting Period. These variables are identified in Section B.1.1.1.

Since these practices will not be directly implemented in the Project Area, baseline parameters should be estimated based on the procedures outlined in Section B.1.1.1 Baseline Cropland Management Systems. Management practices will be updated every 5 years at a verification event and SOC stock equilibriums adjusted accordingly. However, the soil transition period shall not exceed the 20 year Project Term.

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 data 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. Where the Project Area exceeds a 100km radius, a single or averaged set of meteorological data may be utilized.

G.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 GHG Project Plan 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 D.2.2.1 , 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 D.2.2.1 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.

G.3.3.4 Uncertainty Assessment and Conservativeness

Estimation of uncertainty is required for each baseline and project carbon pool and GHG sources. Where uncertainties exceed 10% at the 90% confidence interval, an appropriate confidence deduction shall be applied, calculated as the lower bound of the 90% confidence interval. Uncertainties should be estimated with default values (such as those by the IPCC), estimates from peer-reviewed literature, directly estimated with appropriate statistical techniques, or generated by multiple model runs with a range of plausible values (as with Monte Carlo statistical techniques). Where process models are used to estimate pools and sources, they must estimate uncertainty as described here. It is anticipated that primary uncertainties to be estimated will include those for carbon pools and typical nitrogen fluxes, as most non-CO2 GHG uncertainty estimates will be based upon externally derived emission factors.

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 GHG Project Plan Document and/or Monitoring Report.

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APPENDIX A

A.1 Parameters Defined by Methodology Equations

Parameter	Unit	Description	Source	Used in Eq.
$C_{AGB_{p,y}}$	tCO_2e	Carbon stock of above-ground biomass for Participant Field *p* in year *y*		0.23
$C_{AGB,BL_{p,y}}$	tCO_2e	Carbon stock of above-ground biomass for Participant Field *p* in the baseline scenario in year *y*		0.4
$C_{AGB_{b,y=0}}$	tCO_2e	Initial (year *y*=0) carbon stock of above-ground biomass for biomass type *b*		0.24
$C_{AGB,PR\ p,y}$	tCO_2e	Carbon stock of above-ground biomass for Participant Field *p* in year *y*		0.23
$C_{AGB_{grass},BL_{p,y}}$	tCO_2e	Remaining carbon stock of preexisting non-Tree aboveground biomass for Participant Field *p* in year *y* in the baseline scenario, as calculated from Section F.1.4.1		0.5
$C_{AGB_{crop},BL_{p,y}}$	tCO_2e	Carbon stock of aboveground crop biomass in Participant Field *p* in year *y* in the baseline scenario		0.6
$C_{AGB_{crop},BL_{b,y}}$	tCO_2e	Carbon stock of aboveground crop biomass in the baseline for crop type *b* in year *y*		0.7
$C_{BGB,BL_{p,y}}$	tCO_2e	Carbon stock of belowground biomass in Participant Field *p* in		0.8

		year *y* in the baseline scenario		
$C_{BGB_{crop},BL_{p,y}}$	tCO_2e	Carbon stock of belowground crop biomass in Participant Field *p* in year *y* in the baseline scenario		0.10
$C_{BGB_{grass},BL_{p,y}}$	tCO_2e	Carbon stock of pre-existing belowground non-Tree biomass from Participant Field *p* in year *y* in the baseline scenario		0.9
$C_{BGB,PR_{p,y}}$	tCO_2e	Carbon stock of below-ground crop biomass for Participant Field *p* in the project scenario in year *y*		0.25
$C_{SOC,BL_{p,y}}$	tCO_2e	Carbon stock of soil organic carbon for Participant Field *p* in the baseline scenario in year *y*		0.11
$F_{BL/PR,ON_{p,y}}$	t-N	Mass of organic N amendments applied to Participant Field *p* in the baseline/project scenario in year *y* adjusted for volatilization as NH_3 and NO_X		0.16 0.29
$F_{BL/PR,SN_{p,y}}$	t-N	Mass of synthetic fertilizer nitrogen applied to Participant Field *p* in the baseline/project scenario in year *y* adjusted for volatilization as NH_3 and NO_X		0.15 0.28
$E_{BL/PR,N_2O_{p,y}}$	tCO_2e	Total N_2O emissions from Participant Field *p* in the baseline/project scenario in year *y*		0.13; 0.26
$E_{BL/PR,N_2O,direct_{p,y}}$	tCO_2e	Direct N_2O emissions from the addition of N to Participant Field *p* in the baseline/project		0.27

		scenario for year *y*		
$E_{BL/PR,N_2O,indirect_{p,y}}$	tCO_2e	Indirect N_2O emissions from the addition of N to Participant Field *p* in the baseline/project scenario for year *y*		0.32
$E_{BL/PR,N_2O,volat_{p,y}}$	tCO_2e	Indirect N_2O emissions produced from Participant Field *p* from N volatilized following N application in the baseline/project scenario in year *y*		0.33
$E_{BL/PR,N_2O,leach_{p,y}}$	tCO_2e	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 in Participant Field *p* in the baseline/project scenario in year *y*		0.34
$E_{(BL/PR),FFp,y}$	tCO_2e	Emissions due to the use of fossil fuels in agricultural management in the baseline/project scenario on Participant Field *p* in year *y*		0.20 0.37
$EF_{t,y}$	d.u.	Emission factor for the fraction of soil organic carbon pool remaining *t* years since conversion to Cropland in year *y*		0.12
$Nex_{l,p,y}$	kg N $(animal)^{-1}$ $(yr)^{-1}$	Annual average N excretion per head of species/category *l*, Participant Field *p* in year *y*		0.31
$E_{FERMp,y}$	tCO_2e	CH_4 emission from enteric		0.35

		fermentation due to livestock on Participant Field *p* in year *y*		

A.2 Parameters Available at Validation

Parameter	Unit	Description	Source	Used in Eq.
A_b	ha	Area of biomass/crop type *b*	Analyses in B.1.1 and B.1.2	0.7; 0.24
$A_{p,i}$	ha	Area of Participant Field in soil strata *i*	B.1.1	0.11
$C_{AGB_{p,y=0}}$	tCO_2e	Initial (year *y*=0) carbon stock of aboveground non-Tree biomass for Participant Field *p*	Measured, Modeled, values from literature	0.5; 0.25
$C_{BGB_{p,y=0}}$	tCO_2e	Initial (year *y*=0) carbon stock of belowground non-Tree biomass for Participant Field *p*	Measured, Modeled, values from literature	0.9
$C_{SOC_{i,y=0}}$	$tCO_2e\ (ha)^{-1}$	Total initial (year *y*=0) soil organic carbon stock in soil strata *i*, fixed for project duration	Measured, modeled, or derived from literature. Where unavailable, default values from IPCC 2006 AFOLU GL, Table 2.3 may be used.	0.11
CF_b	$tC(t\ dry\ matter)^{-1}$	Carbon fraction of dry matter for biomass type *b*	Literature, Table 11.2 IPCC 2006 GL AFOLU	0.7; 0.24
D	year	Transition period for soil organic carbon, time period for transition between equilibrium SOC values, default value of 20	Measured, Modeled, values from literature, or default value of 20	0.12

			years (IPCC 2006 AFOLU GL, Ch. 2).	
$DM_{b,y=0}$	tCO_2e	Dry matter for biomass type *b* at project initiation (year *y*=0)	Measured, Modeled, values from literature	0.24
$e^{(-0.77*(y-t))}$	d.u.	The decay function for aboveground biomass following conversion	Kochsiek et al. 2009	0.5
$e^{(-1.41*(y-t))}$	d.u.	The decay function for belowground biomass following conversion	Silver and Miya 2001	0.9
EF_{AD}	tonnes N_2O-N (tonnes NH_3-N + NO_x-N volatilized)$^{-1}$	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces	IPCC default Tier 1 = 0.01, Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	0.18; 0.33
EF_f	tCO2e (liter of fuel)$^{-1}$	Emission factor for the type of fossil fuel combusted in vehicle or equipment, v	For gasoline $EFCO_2e$ = 0.002810 t per liter. For diesel $EFCO_2e$ = 0.002886 t per liter. Source: VCS SALM Tool VI.2	0.20; 0.37
EF_l	kg-CH_4 head^{-1}grazing day^{-1}	Enteric CH_4 emission factor for livestock type *l*	Default value for Cattle in Cool Climate Zone: 1; default for Temperate or Warm Climate Zone: 2 Source: Chapter 10, Table 10.14, IPCC 2006 AFOLU	0.35

			GL	
EF_N	t-N_2O-N(t-N input)$^{-1}$	Emission Factor for emission from N inputs	Literature, IPCC GL AFOLU 2006	0.14
EF_{Leach}	tonnes N_2O-N (tonnes N leached and runoff)$^{-1}$	Emission factor for N_2O emissions from N leaching and runoff	IPCC default Tier 1 = 0.0075 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	0.19; 0.34
EF_{MNR}	t-N_2O-N(t-N input)$^{-1}$	Emission Factor for emission for manure inputs	Default values may be found Table 11.1, Chapter 11 IPCC 2006 AFOLU GL	0.27
$Frac_{ON}$	kg N volatilized (kg of N applied or deposited)$^{-1}$	Fraction of organic N applied to soils that volatilizes as NH_3 and NO_x	Default value of 0.20 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	0.16; 0.18; 0.29; 0.33
$Frac_{SN}$	kg N volatilized (kg of N applied or deposited)$^{-1}$	Fraction of synthetic N applied to soils that volatilizes as NH_3 and NO_x	Default value of 0.10 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	0.15; 0.18; 0.28; 0.33
$Frac_{Leach}$	d.u.	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs	IPCC default Tier 1 = 0.03 Source: Chapter 11 , Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	0.19; 0.34

GWP_{CH4}	tCO_2e	Global warming potential for CH_4 ; default value: CH_4 = 21	IPCC SAR	Multiple
GWP_{N_2O}	tCO_2e	Global Warming Potential for N_2O default value: N_2O = 310	IPCC SAR	Multiple
VB_p	US Dollars	The appraised fair market value of the Cropland land use for Participant Field *p*	Appraisal or similar product prepared by a certified appraiser.	0.3
VP_p	US Dollars	The appraised fair market value of the current Grassland/Shrubland land use for Participant Field *p*	Appraisal or similar product prepared by a certified appraiser.	0.3
Y_m	d.u.	Methane conversion factor, per cent of gross energy in feed converted to methane	Suggested Default for Cattle or Buffalo-grazing: 6.5%; Lambs (<1 year old): 4.5%; and Mature Sheep: 6.5% Source: Chapter 4, Tables 10.12 and 10.13, IPCC 2006 AFOLU GL	0.36
P		Total number of participant fields, p	Project Proponent	Multiple
t	years	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 20	NA	0.12
R_b	d.u.	Root carbon-to-shoot carbon ratio of (crop) biomass type *b*	Literature, IPCC defaults	0.10; 0.25
$\frac{44}{12}$	d.u.	Molar fraction for converting Carbon	NA	0.7;

		to CO_2		0.24
$\frac{44}{28}$	$t\text{-}N_2O(t\text{-}N)^{-1}$	Ratio of molecular weights of N_2O to N	NA	0.14; 0.18

d.u.: *dimensionless unit*

A.3 Parameters Monitored

Parameter	Unit	Description	Source	Used in Eq.
B		Total number of crop/biomass types b		0.6; 0.10; 0.11; 0.24
$dm_{BL,b,y}$	t dry matter $(ha)^{-1}$	Annualized average dry matter in the baseline for crop type *b* in year *y*	Harvest Index: ratio of economic product dry mass to plant aboveground dry mass. Alternatively, 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 2006 AFOLU GL, Table 5.9)	0.7
$F_{BL,SOM_{p,y}}$	t N yr^{-1}	Mass of annualized of N mineralized in mineral soils associated with loss of soil C from soil organic matter as a result of	Equal to $(\lvert C_{SOIL,BLp,y}-C_{SOIL,BLp,y-1}\rvert/15)$, based on an adaptation of	0.19

		changes in land use or management in regions where leaching/runoff occurs	Equation 11.8, IPCC 2006 AFOLU GL	
$F_{PRPp,y}$	t-N	Mass of manure and urine N deposited by grazing animals on pasture, range and paddock	Producer records, or a university extension or other production report containing grazing animal population multiplied by per animal manure and urine N deposition.	0.27
$FC_{p,t,y}$	d.u.	The cumulative proportion of Participant Field *p* that has been converted to Cropland in year *t*, time of conversion, as of year *y* in the baseline scenario, determined based on rates and extents of conversion	Section F.1.2	0.5; 0.9
$FSOC_{LU}$	d.u.	Fraction of soil organic carbon pool remaining after transition period, accounting for land use factors	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL 2006	0.12
$FSOC_{MG}$	d.u.	Fraction of soil organic carbon pool remaining after transition period, accounting for management factors	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL 2006	0.12
$FSOC_{IN}$	d.u.	Fraction of soil organic carbon pool remaining after transition period, accounting for input of organic matter	Literature, model, measured, or IPCC defaults Table 5.5 AFOLU GL 2006	0.12
$FF_{BL/PR_{p,v,j,y}}$	litres	Volume of fossil fuel consumed in the baseline/project scenario on Participant Field *p* in vehicle/equipment type *v* with	Expert opinion or extension/agency report (baseline) or producer report	0.20; 0.37

		fuel type *j* during year *y*	(project) that contains vehicle/equipment hours and fuel needed per unit of use.	
$GD_{p,l,y}$	days	Grazing days per livestock type *l* on Participant Field *p* in year *y*	University extension, producer, or other production report containing average grazing days per livestock type *l* in the project region.	0.31 0.35
GE	MJ head^{-1} day^{-1}	Gross energy intake	Literature, government reports, or expert opinion.	0.36
$M_{BL/PR,SN_{p,j,y}}$	tonnes	Mass of synthetic fertilizer type *j* applied to Participant Field *p* in year *y*	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	0.15; 0.28

			management plans approved by a lending agency.	
$M_{BL/PR,ON_{p,k,y}}$	tonnes	Mass of organic N amendment type *k* applied to Participant Field *p* in year *y*	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.	0.16; 0.29
$N_{BL/PR,ON_k}$	t-N (tonne input)$^{-1}$	Nitrogen content of organic N amendment type k	Producer of nitrogen if a commercially produced product. Otherwise IPCC defaults or values from the literature.	0.16; 0.29
$N_{BL/PR,SN_j}$	t-N (tonne input)$^{-1}$	Nitrogen content of synthetic fertilizer type j	Producer of fertilizer	0.15; 0.28

$N_{rate(l)}$	kg N (1000 kg animal mass)$^{-1}$ day^{-1}	N excretion rate	Default values may be found in Table 10.19, Chapter 10 IPCC 2006 AFOLU GL	0.31
$P_{p,l}$	number of head	Population of livestock type l	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.	0.30; 0.35
TAM_l	kg animal^{-1}	Typical animal mass for livestock category *l*	Literature, government reports, or expert opinion.	0.31
L		Total number of livestock types in project scenario	Project Proponent	0.30
J		Total number of synthetic N inputs, j	Project Proponent	0.28
K		Total number of organic N	Project Proponent	0.29

		amendments, k		
V		Total number of vehicles, v	Project Proponent	0.20
F		Total number of fossil fuels, f	Project Proponent	0.20