

METHODOLOGY FOR THE QUANTIFICATION,  
MONITORING, REPORTING AND VERIFICATION  
OF GREENHOUSE GAS EMISSIONS  
REDUCTIONS AND REMOVALS FROM

**AVOIDED CONVERSION OF  
GRASSLANDS AND SHRUBLANDS  
TO CROP PRODUCTION**

VERSION 2.0

October 2019

# METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

VERSION 2.0

October 2019

American Carbon Registry®

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A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

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# 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
CO <sub>2</sub> e	Carbon dioxide equivalent
CH <sub>4</sub>	Methane
CDM A/R	Clean Development Mechanism Afforestation/Reforestation
CRP	Conservation Reserve Program
DAYCENT	Daily Time Step Version of the CENTURY Biogeochemical Model
d.u.	Dimensionless unit
EF	Emission Factor
EPA	Environmental Protection Agency
ERS	Economic Research Service
ERT	Emission Reduction Ton
GHG	Greenhouse Gas
IA	Identified Agent
IPCC	Intergovernmental Panel on Climate Change
LU/LC	Land Use/Land Cover
LCA	Land Conservation Agreement
LCC	Land Capability Class

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MLRA	Major Land Resource Areas
NH <sub>3</sub>	Ammonia
N <sub>2</sub> O	Nitrous Oxide
NLCD	National Cropland Data Layer
NO <sub>x</sub>	Nitrogen Oxides
PDA	Programmatic Development Approach
REDD	Reduced Emissions from Deforestation and Degradation
SOC	Soil Organic Carbon
SSR	Sources, Sinks and Reservoir
UA	Unidentified Agent
VVB	Validation/Verification Body

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# 1 BACKGROUND AND APPLICABILITY

## 1.1 SUMMARY DESCRIPTION OF METHODOLOGY

This methodology estimates the emissions avoided by preventing the conversion of Grasslands and Shrublands to annual crop production.<sup>1</sup> Conversion of Grassland and Shrubland to uses other than annual Cropland is not an eligible activity under this methodology. Conversion to orchards and vineyards 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 with GHG implications, such as fertilizer applications, may also be avoided through the project activity. Livestock, primarily cattle, are anticipated to be common in the project scenario and their associated emissions from enteric fermentation and manure deposition are accounted.

This methodology accounts for two Avoided Conversion baseline scenarios: 1) where the conversion agent is identified and 2) where the conversion agent is 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 historical rates of conversion of existing grasslands and shrublands within a county, in addition to the various land capability classes suitable for agriculture at the field level.

The removal of project lands from the supply of potential Cropland is expected to create leakage effects, all in the form of market leakage.<sup>2</sup> A default market leakage estimate is offered to account for these effects. Standardized values for leakage and baseline determination are specific to the United States.

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<sup>1</sup> 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) that have been in grassland cover for a minimum of 10 years.

<sup>2</sup> Leakage and market leakage are defined in the ACR Standard. Leakage is a decrease in sequestration or increase in emissions outside project boundaries resulting from project implementation. Leakage may

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Unless specified otherwise in this document, projects are subject to all requirements and specifications in the most current version the American Carbon Registry Standard. Definitions specific to this methodology can be found at the end of the document.

### 1.2 APPLICABILITY CONDITIONS

In addition to satisfying the latest ACR program requirements, project activities must satisfy the following conditions for this methodology to apply:

- All Participant Fields avoid the complete conversion<sup>3</sup> 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.
- 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<sup>4</sup>, 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.
- All Participant Fields enrolled in the Project Area must be subject to a qualified Land Conservation Agreement (LCA) entered into by the Project Participant prohibiting the conversion of the land from Grassland or Shrubland for the duration of the minimum Project Term or longer. The area bound by the LCA does not have to match the Project Area nor Participant Field enrolled; however, the entire area of the Participant Field must be included in the area covered by the LCA. The LCA must also explicitly prohibit grassland conversion to another land use—often referred to as a “sod-buster” clause—such that avoidable reversals are sufficiently precluded as long as the LCA is enforced.<sup>5</sup> If the easement allows for alternative land use other than grassland preservation, such as building envelopes, gravel sites, road development, etc., those areas must be delineated and removed from the eligible portion of the Participant Field. The LCA must be recorded on the deed of the property encompassing all Participant Fields to ensure transferability among ownership.

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be caused by shifting of the activities present in the project area or by market effects whereby emission reductions are countered by emissions created by shifts in supply of and demand for the products and services affected by the project. See Section 6.3 for discussion of leakage as pertains to this project type.

<sup>3</sup> 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.

<sup>4</sup> 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.

<sup>5</sup> ERTs will not be issued for any period of non-conformance with the LCA.

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- In the case of an unidentified agent of conversion, the Project Area is located entirely in a county or counties listed in Appendix B.<sup>6</sup> In the case of an identified agent of conversion, written offers to lease or buy property must specify cropland as the intended/highest and best use, including reference to available water rights and infrastructure if irrigation is required; in the absence of written offers to lease or buy the property, landowner attestations or other documentation demonstrating threat to conversion must reference the highest and best use as cropland and other comparable conversion events in the region.
- 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 the provisions of the relevant qualified LCA are met. In the project scenario, detrimental 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 under this methodology.
- At least 50% of the project area is in Land Capability Class (LCC) I-IV and no more than 25% of the project area is LCC VII and VIII as assessed using the SSURGO non-irrigated lands database.
- When the landowner will hold title to the carbon rights, a statement of intent<sup>7</sup> to develop a carbon offset project is submitted to ACR no sooner than 12 months before and not longer than 12 months after the date that the qualified LCA is recorded.
- When the landowner will not hold title to the carbon rights, the date of any agreement (e.g. a carbon options agreement) transferring carbon rights from the landowner to the project developer must be enacted no sooner than 12 months before and not longer than 12 months after the date that the qualified LCA is recorded.
- The Project Area includes either one contiguous 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.
- Project Areas do not include Grasslands or Shrublands on organic soils or peatlands, nor include wetland acres within Grassland/Shrubland tracts. Additional information on how to appropriately identify and remove wetland acres and organic soils from GHG modeling and ERT calculation is provided in Section 2.1.2.
- An irrigated cropland scenario in the baseline and an irrigated project scenario are allowed. In the baseline scenario, a strong justification must be made for the likelihood of the irrigated cropland scenario that is ultimately subject to the verifier's professional judgement. The justification shall include, at a minimum, an assessment of irrigation water access—both legal and physical—to the Project Field(s) at the Project Start Date and evidence of ongoing irrigation practices on like parcels in the same county. Any biogeochemical models used for GHG

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<sup>6</sup> Eligibility maps are updated at minimum every 5 years.

<sup>7</sup> Contact ACR administrator for a Statement of Intent template document or basic requirements.

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modelling must have proven capabilities to account for GHG influences from specific irrigation practices.

- Where livestock are present in the project scenario, manure is not managed, stored, or dispersed in liquid form. Livestock are 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.
- The Project Area is located in the United States.

### 1.3 PERIODIC REVIEWS AND REVISIONS

ACR may require revisions to this Methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes to project activities. This Methodology may also be periodically updated to reflect regulatory changes, emission factor revisions, or expanded applicability criteria. Before beginning a project, the project proponent should ensure that they are using the latest version of the methodology.

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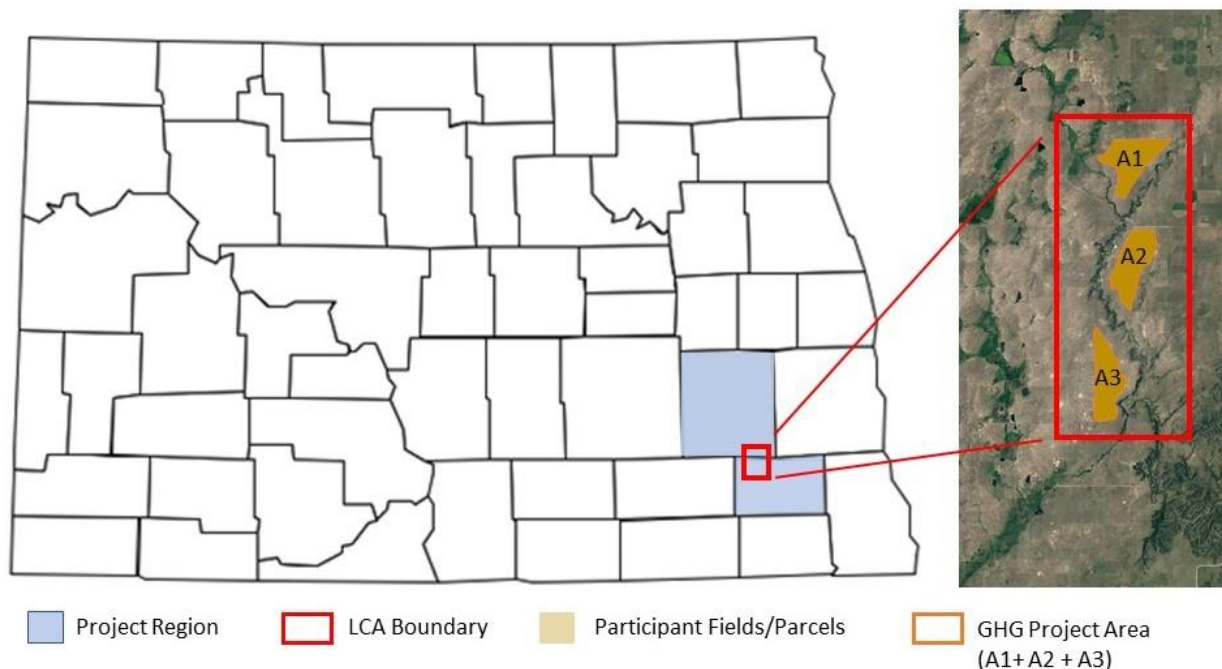
# 2 PROJECT BOUNDARIES

## 2.1 SPATIAL BOUNDARY

### 2.1.1 Field, Area, Region Boundary Terms

#### Figure 1: Spatial Boundaries

Three spatial boundaries are relevant to this methodology: Participant Fields, Project Area and Project Region.



Participant Fields are the discrete parcels where project activities are implemented, when referred to individually.

All Participant Fields must be covered in full by the qualified LCA and an agreement specifying ownership of any ERTs issued, if not specified in the qualified LCA. The GHG project area (e.g. area within Participant Field boundaries) may be smaller than but must be completely within the qualified LCA boundary.



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The Project Area is the collection of Participant Fields. Other areas that may fall within relevant property boundaries but for which Grassland-Shrubland to Cropland conversion is not applicable (e.g., non-Grassland or Shrubland 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 identification of baseline management practices and the quantification of greenhouse gas emission reductions and avoidance, i.e., to define the applicability of models and emission factors. The Project Region shall be further stratified to account for heterogeneity within the Project Region according to the procedures in Section 4 Stratification.

In situations where the Project Proponent (e.g., an aggregator or developer) is not the Project Participant (e.g., an owner of a Participant Field), the Project Proponent must demonstrate that a qualified LCA 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 GHG 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.

### 2.1.2 Recording the Project Area and Project Region

Spatially explicit data files (e.g. shapefiles for GIS) recording the following boundaries must be provided in the GHG Project Plan:

1. Project Region
2. Project Area
3. Participant Fields
4. Wetlands, building envelopes, cultivated areas, streams, roads, gravel pits or other areas not covered by a sod-buster clause and/or excluded from but within the Project boundary
5. LCA Boundary<sup>8</sup>
6. ERT ownership boundary (if different than 3 or 5)

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<sup>8</sup> LCA boundary as recorded on the deed; if the LCA is not a recorded easement, adequate evidence, subject to verifier professional judgement, of due diligence in determining spatially accurate boundaries, must be provided.

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See Section 7 Monitoring and Data Collection for additional details.

The Project Area is the collection of shape file polygons for all individual Participant Fields boundaries and is not necessarily contiguous.

The Project Region(s) must include the entirety of the Project Area within its (their) boundaries. The Project Region(s) may be comprised of non-contiguous areas so long as all Participant Fields are contained within a Project Region (i.e. the Project Area must be fully contained within the boundaries of the Project Region(s)) and all Participant Fields are within the qualified LCA boundary.

All required shapefiles shall be made available in the GHG Project Plan at time of validation. Wetland acreage delineation can often be subjective given the influence of yearly precipitation and associated variability. Where wetland acres are explicitly accounted in the language of the qualified LCA or otherwise legally encumbered, Project Proponents are to rely on the qualified LCA language or other legal protections for identifying total wetland acreage that is ineligible. Spatially explicit boundary shapefiles must be provided that delineate the total wetland acres in the qualified LCA. These shapefiles can then be either directly uploaded into a GHG accounting platform, or overlaid with the soils maps provided through NRCS's Web Soil Survey (<http://web-soilsurvey.sc.egov.usda.gov/App/HomePage.htm>) as required by biogeochemical models.

If wetland acres are not explicitly identified in the qualified LCA, Project Proponents must demonstrate at the time of project validation that no portion of the project area requires exclusion due to classification as a wetland, either permanent, emergent, seasonal or otherwise. Project Proponents must demonstrate to the satisfaction of the verifier that the project area is limited to the area that would reasonably be plowed under as part of conversion i.e. roads, building envelopes, infrastructure or wet areas are excluded.<sup>9</sup> These boundaries remain constant for the length of the project. The shapefiles delineating wetland acres must be provided and overlaid with the boundaries of the Participant Field(s).

## 2.2 GHG ASSESSMENT BOUNDARY

The GHG assessment boundary delineates the sources, sinks and reservoirs (SSRs) that must be included or excluded when quantifying the net changes in emissions associated with the avoided conversion of Grassland or Shrubland to Cropland.

All SSRs that are likely to result in a significant increase in GHG emissions or decreased carbon storage in the project scenario relative to the baseline must be accounted for, for each Participant Field.

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<sup>9</sup> Verifiers may use SSURGO or other databases to inform the presence of soils that would be too wet or otherwise unsuitable for cultivation.



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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.

### 2.2.1 Carbon Pools (Reservoirs)

**Table 1: Carbon Pools**

CARBON POOL	INCLUDED/ EXCLUDED	JUSTIFICATION
Tree biomass (above-ground, below ground)	Excluded	Tree biomass is conservatively excluded in both the baseline and project scenario. <sup>10</sup>
Above-ground non-tree, 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.
Above-ground non-tree, 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	Excluded	Not a major pool in baseline or project scenarios.
Below-ground, non-tree biomass	Optional	Likely to be a significant source of carbon loss in baseline scenario. Projects may elect to account for below-ground biomass. Where Project Proponents

<sup>10</sup> All references to above-ground or below-ground biomass in this methodology are in reference to grassland, shrubland or cropland vegetation that does not meet the definition of a tree according to the U.S. Forest Service <https://www.nrs.fs.fed.us/fia/data-tools/state-reports/glossary/default.asp>

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CARBON POOL	INCLUDED/ EXCLUDED	JUSTIFICATION
		nents elect to include this pool in the project scenario, it must also be included in the baseline scenario.
Soil organic carbon	Included	Major carbon pool subject to project activity.
Dead wood	Excluded	Not a major carbon pool in the baseline or project scenario.
Wood products	Excluded	Not a major carbon pool in the baseline or project scenario.

### 2.2.2 GHG Sources and Sinks

**Table 2: Greenhouse Gas Sources**

SOURCE	GAS	INCLUDED/ EXCLUDED	JUSTIFICATION
Soil Management	CO <sub>2</sub>	Included	Accounted for in soil organic carbon pool.
	CH <sub>4</sub>	Excluded	Not a significant gas for this source.
	N <sub>2</sub> O	Included	Covers direct emissions from synthetic and organic N amendment sources. Indirect emissions from synthetic and organic N amendments are excluded. <sup>11</sup>
Fossil Fuel Combustion	CO <sub>2</sub>	Optional	Baseline emissions from fossil fuel are likely larger than in the project scenario and may be conservatively excluded. Where Project Proponents elect to include this pool in the project scenario, it must also be included in the baseline scenario.

<sup>11</sup> This methodology assumes that baseline emissions of N<sub>2</sub>O (direct or indirect) due to N amendments are always larger than project emissions of N<sub>2</sub>O.

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SOURCE	GAS	INCLUDED/ EXCLUDED	JUSTIFICATION
	CH <sub>4</sub>	Excluded	Not a significant gas for this source.
	N <sub>2</sub> O	Excluded	Not a significant gas for this source.
Biomass Burning	CO <sub>2</sub>	Excluded	Accounted for in biomass pools.
	CH <sub>4</sub>	Excluded	Not a significant gas for this source.
	N <sub>2</sub> O	Excluded	Not a significant gas for this source.
Livestock Emissions	CO <sub>2</sub>	Excluded	Not a significant gas for this source.
	CH <sub>4</sub>	Optional	When livestock are present in the baseline and/or project scenario, this is a major source of emissions and must be included.
	N <sub>2</sub> O	Excluded	Emissions of N <sub>2</sub> O from livestock waste are captured under Soil Management emissions.

## 2.3 TEMPORAL BOUNDARY

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

- Project Start Date for each Participant Field enrolled
- Project Crediting Period start and end dates
- Date of submittal of Project listing with ACR (date when GHG Project Plan was initially submitted) for initial Participant Fields if a PDA Project
- Date of signature of the agreement specifying ownership of ERTs (if project proponent is not participant field(s) landowner)
- Date of submittal of Statement of Intent to ACR (if project proponent is participant field(s) landowner)
- Projected dates and intervals of revaluation of baseline inputs (at minimum once every 5 years)

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- Projected dates of enrollment<sup>12</sup> and validation for new Participant Fields included in the project, if applicable<sup>13</sup> and actual dates as Participant Fields are enrolled.
- Demonstration that each Participant Field was in a Grassland or Shrubland land cover at least 10 years prior to time of executing the qualified Land Conservation Agreement.

The GHG Project Plan shall also include anticipated timeline for monitoring, reporting, and/or verification activities.

### 2.3.1 Start Date

The earliest Project Start Date for AFOLU projects is specified in the most recent version of the ACR Standard.

The Project Start Date for this project type is the date on which the qualified LCA is recorded. The project shall be submitted for listing with ACR no more than 3 years after the date upon which the qualified LCA is recorded.<sup>14</sup>

### 2.3.2 Crediting Period

The Project Crediting Period must begin no earlier than the project start date.<sup>15</sup> The Project Crediting Period is the timeframe in which changes are conservatively estimated to occur in a Participant Field's terrestrial carbon pools, i.e. the time as predicted by a biogeochemical model or field measurements<sup>16</sup> that soil carbon loss would continue to occur in the baseline scenario of

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<sup>12</sup> The enrollment date is the date where a landowner entered into an agreement with the Project Proponent if not the landowner or the date where a new parcel was added to an existing GHG project plan where the landowner is the Project Proponent.

<sup>13</sup> Projects expecting to add new Participant fields over time must follow the requirements for Programmatic Design Approach in the ACR Standard.

<sup>14</sup> See ACR Standard Section 6A for Project Development Process, requirements for the step Project Listing. The Statement of Intent to develop or participate in a carbon project on the part of the land owner is separate from Project Listing and is required within 12 months of the LCA being recorded. Please contact ACR Administrator for a Statement of Intent template document or requirements.

<sup>15</sup> The start of the first reporting period may be after the project start date such that a project may forego credit issuance for a period of time in order to delay verification provided the validation occurs within 3 years of the start date.

<sup>16</sup> When changes in the soil carbon pool are not modeled and a default value 20 years is used for the parameter D, the transition period between soil organic carbon equilibrium states, the crediting period is also 20 years and cannot be renewed (See Appendix A).

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conversion to Cropland. The Crediting Period must be at least 5 years but no more than 40 years and cannot be renewed.

The establishment of the baseline scenario as conversion to Cropland is valid for the duration of the Project Term following a successful initial validation. Updates to the project's baseline land management scenarios shall occur at least once every five years from the project start date.<sup>17</sup>

### 2.3.3 Project Term

The Minimum Project Term refers to the required duration of crediting, monitoring and reporting of Project Activities. The minimum Project Term for AFOLU projects with a risk of reversal is defined in the latest ACR Standard.

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<sup>17</sup> Verifications are required at the same minimum frequency (5 years) but updates to the baseline cropland management scenario not required at every verification necessarily.

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# 3 BASELINE DETERMINATION AND ADDITIONALITY

## 3.1 BASELINE DETERMINATION

The baseline scenario is the conversion of Grassland or Shrubland to Cropland. Baseline determination requires: 1) demonstration of the land-use scenario of cropland in the absence of the project activity and 2) description of the avoided cropland management practices. Baseline determination should be performed in conjunction with Section 3.2 Additionality Assessment. The baseline land use scenario of conversion to cropland, once determined, is static and made ex ante, with no adjustments during the Project Term. The baseline management scenario must be updated every 5 years, as outlined below in 3.1.2.

### 3.1.1 Determine Baseline Land-Use Scenario

All Participant Fields must demonstrate that Cropland is the likely land use scenario in the absence of the project activity with conversion of Grassland or Shrubland to Cropland occurring via either an identified or unidentified agent.

#### 3.1.1.1 CONVERSION VIA AN UNIDENTIFIED AGENT

The baseline land use scenario is Cropland for all Participant Fields located in counties shown in the map below, listed in Appendix B and meeting all criteria in Section 1.2.

#### 3.1.1.2 CONVERSION VIA AN IDENTIFIED AGENT

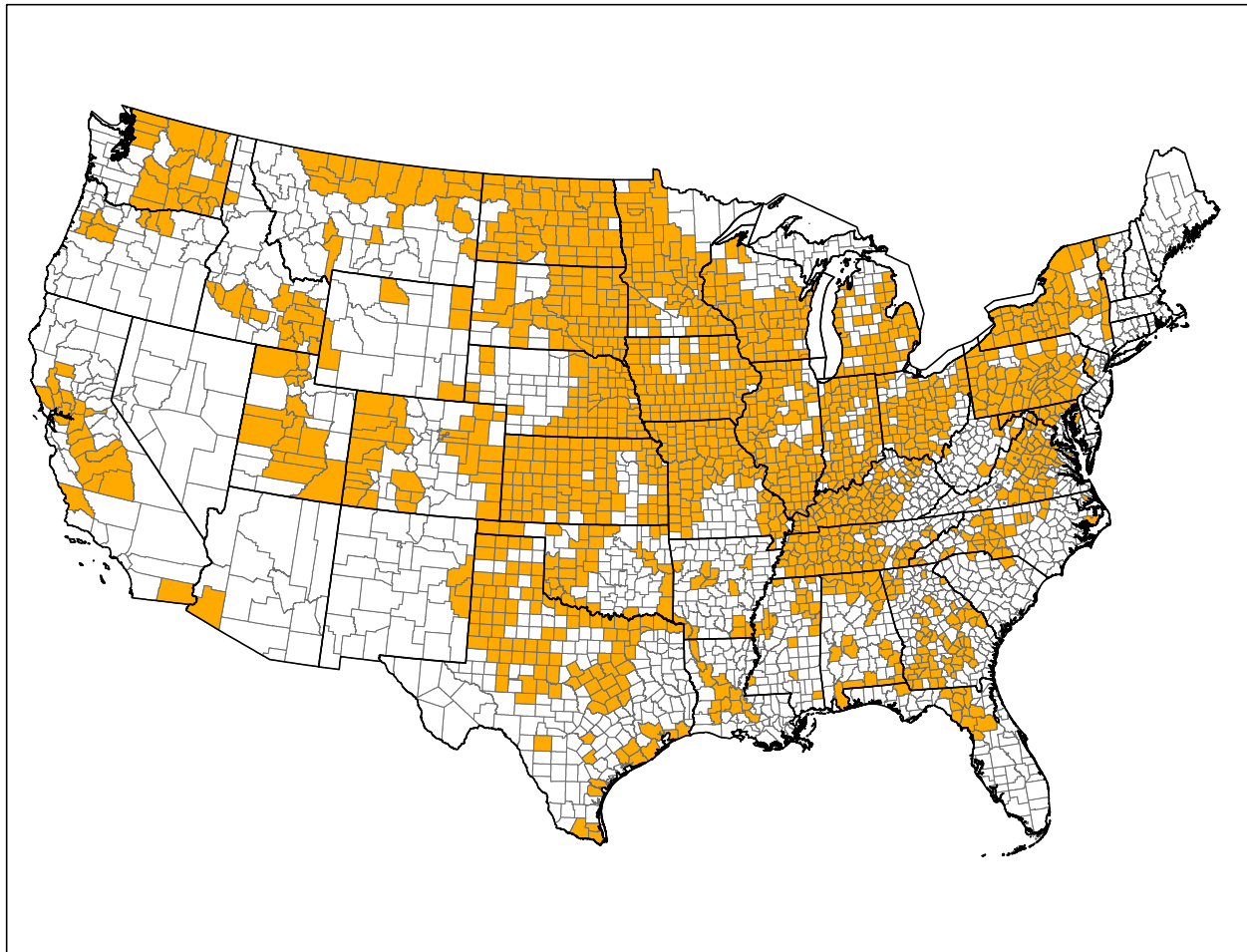
The baseline land use scenario is Cropland for all Participant Fields not located in counties shown in the map below and listed in Appendix B but: 1) meet all criteria in Section 1.2 and 2) are unambiguously identified in written rental or purchase offers with Cropland named as the intended use OR unambiguously identified in other documentation, subject to verifier and ACR review, including landowner affidavits, that can demonstrate a threat to conversion to cropland.

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### Figure 2: County Map for Unidentified Agents of Conversion, Baseline Land Use Scenario and Practice-Based Performance Standard

Project fields/parcels located in the counties highlighted in orange have a baseline scenario of cropland for unidentified agents of conversion and surpass the practice-based performance standard for demonstrating additionality. Project fields/parcels in white counties must determine the baseline land-use scenario and demonstrate additionality according to sections 3.1.1.2 and 3.2.2.2 respectively.





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### 3.1.2 Determine Baseline Cropland Management Scenario

The baseline crop management scenario is determined ex ante and must be updated at minimum every 5 years from the project start date for the duration of the project term. This re-assessment updates the avoided crop management practices (i.e. the baseline) for the subsequent 5-year period. 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.<sup>18</sup>

Required projected baseline management practices are listed below. Management practices (including as inputs to approved biogeochemical models) shall be informed from producer surveys conducted by government agricultural agencies or university extension offices<sup>19</sup>; 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.

The following baseline data should be defined:

- Field preparation techniques
- Tillage practices and intensity
- Typical cropping sequence (including fallow)
- Timing of planting and harvest of all crops
- Average applied N rates per identified crop
- Type of applied N and application methods employed
- Average application rates of other nutrients, or inputs, if applicable
- Irrigation practice and frequency
- Presence and type of cover crop
- Residue management practice
- Fire practice and frequency

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<sup>18</sup> Verifications are required at the same minimum frequency (5 years) but updates to the baseline cropland management scenario not required at every verification necessarily.

<sup>19</sup> 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.



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- Other necessary inputs for modeling relevant biogeochemical processes
- Stocking rates, season dates for grazing, livestock type
- Equipment types and usage or volumes of fossil fuels by type

### 3.2 ADDITIONALITY ASSESSMENT

Avoided emissions from the project must be additional. Assessment of the additionality of a project will be made based on passing the tests cited below. These tests require the project proponent to demonstrate that the project activity is surplus to regulations and reduces emissions below “business-as-usual” for rates of conversion of grassland to cropland in the U.S.

- Regulatory Surplus Test (all participant fields)
- Practice Based Performance Standard (participant fields in counties in Appendix B) OR Implementation Barrier (participant fields in all other U.S. locations)

#### 3.2.1 Regulatory Surplus Test

The project activity must meet the requirements of regulatory surplus set out in the latest ACR Standard. The project activity shall not be mandated by any law, statute or other regulatory framework. Specifically, there must not be any federal, state, or local regulations for the project region/area (pre-existing or subsequent), nor other pre-existing legally binding contracts, deed restrictions or encumbrances that require the project fields to be maintained as grassland other than the LCA that is recorded for the project (assessed at Project Start Date and upon initial verification). Furthermore, there must be no federal, state, or local regulation which would prohibit ongoing management of the project area as cropland in the baseline scenario (assessed at Project Start Date and initial verification).

Voluntary agreements that can be rescinded, such as rental contracts, are not considered legal requirements. Non-perpetual payment programs administered by government entities (e.g. Conservation Reserve Program) are not considered legal barriers to participation in a carbon offset program, given that the recordation of a new perpetual 99-year easement would disqualify the lands from continued participation in any such program. Enhancement payments administered by government entities (e.g. Environmental Quality Incentives Program or Conservation Stewardship Program) do not purport to pay for the preservation of grasslands, and thus, are considered compliant with this methodology’s regulatory surplus requirements.

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### 3.2.2 Practice-Based Performance Standard (if applicable)

#### 3.2.2.1 UNIDENTIFIED AGENT

Participant Fields located in counties listed in Appendix B pass the Practice Based Performance Standard Test. Participant Fields which meet the eligibility criteria for this methodology can use the performance standard to demonstrate additionality without providing additional implementation barrier analysis.

An assessment of the rate at which unencumbered (available for conversion) Grassland and Shrubland acres as defined by the NCDL on a per county basis were converted to the Cropland land use type over a 10-year period, shows that the counties listed in Appendix B experience a high rate of loss of Grassland and Shrubland to Cropland.<sup>20</sup> Conversion of Grassland and Shrubland to Cropland is considered common practice in these areas, therefore the activity of encumbering fields within a qualified LCA in these counties is considered beyond business as usual.

#### 3.2.2.2 IDENTIFIED AGENT

Participant Fields not located in counties listed in Appendix B may also pass the Practice Based Performance Standard Test when a specific agent of conversion has been identified. Participant Fields which meet the eligibility criteria for this methodology and can document likelihood to conversion via an identified agent and can use the performance standard to demonstrate additionality without providing additional implementation barrier analysis.

The county level analysis conducted to produce the maps in Appendix B may not reflect recent hot spots of conversion, real threats at a smaller scale than county level or where data is incorrect or lacking in the underlying databases. In instances where the Project Participants have received an offer to rent or purchase the Participant Fields for the purposes of cultivation or can

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<sup>20</sup> Counties listed in Appendix B represent the top 50% of U.S. counties in terms of loss of available Grassland and Shrubland to Cropland. Loss rates in these counties represent areas where grassland loss in the United States is most extreme, relative to current conditions in the U.S. This calculation produced a county list of grassland conversion rates, normalized by the unique number of grassland/shrubland acres available for conversion in each county in each time step. It would be inaccurate to assume that one county is more at-risk just because more cumulative grassland acres were converted compared to another. By deriving the proportion of converted acres in relation to the grassland base acreage, the analysis avoids this potential bias. A brief description of the analysis to determine counties with high rates of conversion where Grasslands and Shrublands are most under threat can be found in Appendix B. The analysis will be updated every 5 years to reflect the current areas of highest conversion in the United States.

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otherwise document such an offer, conversion of grassland and shrubland to cropland is considered common practice in this area (as it is a demonstrable threat), therefore the activity of encumbering fields within a qualified LCA is considered beyond business as usual.

Projects do not need to reassess additionality with each verification during their crediting period. However, ACR will re-assess the performance standard every 5 years.

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# 4 STRATIFICATION

The objective of stratification is to reduce uncertainty of pool and emission estimates at the Project Area level.

When the DAYCENT model (or other approved process based biogeochemical models) are used for quantification of carbon pools, spatial heterogeneity must be accounted for in both baseline and project scenarios via stratification, for example, soil type, climate, cropping scenario and/or previous land use history. For modeling efforts, this requires parameterizing and running the model for each stratum and estimating parameter values separately for each category. The stratification approach must be included in the GHG Project Plan and is subject to verifier review during project validation.

When soil sampling is conducted in the Project Area and this area is not homogeneous, stratification may be used to improve the precision of carbon stock estimates. For estimation of baseline carbon stocks, strata may be defined by parameters that are key variables for estimating changes in baseline and project carbon stocks, for example: soil type, climate, cropping scenario and/or previous land use history.

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 (see Chapter 5) that will be applied for the methodology, where each stratum can be represented by a unique model parameterization. It is not necessary to use the same stratification categories for each pool or for baseline and project scenarios.

## 5 USE OF MODELS FOR QUANTIFICATION OF GHG EMISSIONS

Under this methodology, the following classes of models shall be used to quantify carbon pools and GHG emissions:

1. Process based biogeochemical models (e.g. DAYCENT)
2. Empirical models based on time series measurements and proxy sites

The DAYCENT model is approved for use with this methodology throughout the continental United States, excluding Alaska. Additional process based biogeochemical models may be approved by ACR<sup>21</sup>, according to the criteria specified in the ACR Standard, Section A.6.

Empirical models may be approved on a case by case basis where available. Please contact ACR for approval of new empirical models for use with this methodology. Proposed models shall, at a minimum, meet the following criteria:

- Be published in peer-reviewed, scientific literature;
- Be empirically based;
- Be able to account for changes to soil organic matter and nutrient dynamics that occur following the conversion of Grassland or Shrubland to Cropland;
- Be able to estimate size of relevant carbon pools on an annual basis (mass of carbon/year);
- Be able to make predictions at the scale of a Stratum or Project Area, whichever is smallest;

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<sup>21</sup> Proposed biogeochemical or empirical models will be reviewed by ACR and/or Winrock staff as well as ACR's AFOLU Technical Committee. ACR's AFOLU Technical Committee supports the objective of bringing to market high-quality AFOLU carbon offsets based on scientifically sound methodologies. The AFOLU Technical Committee will provide ACR independent advice on a range of agriculture, forestry, grassland, rangeland, wetland and other land-use topics needed for greenhouse gas (GHG) methodologies being brought to ACR and/or developed by Winrock. ACR approves new methodologies, tools and significant methodology modifications through a process of public consultation and expert peer review. The AFOLU Technical Committee will not replace that process, but rather complement it. This is a standing committee with a subset of Committee members, serving on two-year terms, consulted for specific issues that match their expertise.

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- A baseline site must be identified and accessible on which one or more parameters are monitored in the baseline scenario; baseline and project site must have similar soil types, climate, and management history<sup>22</sup>.
- Directly measure soil carbon (soil carbon loss) in baseline and project sites OR dependent variable is soil carbon (soil carbon loss) and relationship between proxy variable and emissions must be significant at  $P < 0.1$  and unbiased (i.e. with minimal trend in residuals)
- Uncertainty in predicted soil carbon loss (emissions - dependent variable) is known and calculated as the root mean squared error (RMSE);
- Be validated for the Project Region to demonstrate that the model can accurately estimate each carbon pool and GHG source in the Project Region including the management systems identified in both the project and baseline scenario and regional weather and climate conditions (average annual precipitation and temperature) applicable to the Project Area. Model validation shall use 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. For an example see Ahlering et al. (2016) or Chamberlain et al. (2011).
- Be based on a time series experimental design that includes cropped and grassland sites and  $t=0$  is the conversion event

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. See Section 6.5 Uncertainty Assessment and Conservativeness.

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<sup>22</sup> Suitability of the project and baseline sites ultimately to the discretion of the verifier and ACR validation review

# 6 QUANTIFICATION OF GHG EMISSIONS REDUCTIONS

## 6.1 QUANTIFICATION OF BASELINE GHG EMISSIONS

Baseline GHG emissions for all Participant Fields in the project area in a single year are calculated according to Equation 1. Baseline emissions for a single Participant Field are calculated according to Equation 2.

### Equation 1: Baseline Emissions

$$BE_y = \sum_p^P BE_{p,y}$$

#### WHERE

$BE_y$	Baseline emissions in year $y$ , $y = 0$ at project start date; MTCO <sub>2e</sub>
$BE_{p,y}$	Baseline emissions from Participant Field $p$ in year $y$ ; MTCO <sub>2e</sub>
$P$	Total number of Participant Fields in the Project Area
$p$	Participant Field
$y$	Year

### Equation 2: Baseline Emissions from Each Participant Field

$$BE_{p,y} = (C_{AGB,BL,p,y-1} - C_{AGB,BL,p,y} + C_{BGB,BL,p,y-1} - C_{BGB,BL,p,y} + C_{SOC,BL,p,y-1} - C_{SOC,BL,p,y}) + E_{N_2O,BL,p,y} + E_{FERM,BL,p,y} + E_{FF,p,y}$$

#### WHERE

$BE_{p,y}$	Baseline emissions from Participant Field $p$ in year $y$ ; MTCO <sub>2e</sub>
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$C_{AGB,BL_{p,y}}$	Carbon stock of above-ground biomass for Participant Field <b>p</b> , in year <b>y</b> , in the baseline scenario; MTCO <sub>2</sub> e (optional)
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field <b>p</b> , in year <b>y</b> , in the baseline scenario; MTCO <sub>2</sub> e (optional)
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field <b>p</b> , in year <b>y</b> , in the baseline scenario; MTCO <sub>2</sub> e
$E_{N_2O,BL_{p,y}}$	N <sub>2</sub> O emissions from Participant Field <b>p</b> , in year <b>y</b> in the baseline scenario for; MTCO <sub>2</sub> e
$E_{FERM,BL_{p,y}}$	CH <sub>4</sub> emissions from livestock – enteric fermentation in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e
$E_{FF,p,y}$	Emissions due to the use of fossil fuels in agricultural management in field <b>p</b> and year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e (optional)

### 6.1.1 Accounting Baseline Emissions from Aboveground Biomass (Woody and Non-woody)

Accounting for this pool is optional. If included, woody biomass is non-tree. If included, in the baseline scenario, projects must account for remaining 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 according to Equation 3.

#### Equation 3: Baseline Above Ground Biomass

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

#### WHERE

$C_{AGB,BL_{p,y}}$	Carbon stock of aboveground biomass in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e
$C_{AGB_{grass},BL_{p,y}}$	Remaining carbon stock of pre-existing aboveground biomass for Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e



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$C_{AGB_{crop, BL_{p,y}}}$

Carbon stock of aboveground crop biomass in Participant Field **p** in year **y** in the baseline scenario, as calculated from Section 6.1.1.2;  $MTCO_2e$

### 6.1.1.1 CARBON STOCKS OF WOODY AND NON-WOODY, NON-CROP ABOVEGROUND BIOMASS ( $C_{AGB, GRASS, BL, P, Y}$ )

In the conversion of Grassland to Cropland, this methodology treats carbon in aboveground biomass<sup>23</sup> 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 6.2.1). That is, for projects accounting for the loss of above-ground biomass due to 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 biomass.

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. The most conservative scenario is that biomass would decompose as slow as litter in an untilled Cropland.<sup>24</sup> 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, for biomass from the project scenario, shall be the annual peak biomass, i.e. maximum annual growth prior to grazing, harvest or other disturbance.

#### Equation 4: Baseline Carbon Stocks of Woody and Non-Woody, Non-Crop Above Ground Biomass Loss

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

#### WHERE

<sup>23</sup> 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 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.

<sup>24</sup> 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.

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$C_{AGB_{grass,BL,p,y}}$	Carbon stock of aboveground woody and non-woody biomass from Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MT CO <sub>2</sub> .
$C_{AGB,PR,p,y}$	Carbon stock of aboveground non-woody biomass for Participant Field <b>p</b> , in the project scenario, as determined from Section 6.2.1; MTCO <sub>2</sub> e
$FC_{p,t,y}$	The proportion of Participant Field <b>p</b> that is converted to Cropland in year <b>t</b> , time of conversion, in year <b>y</b> of the baseline scenario. If the entire field will be converted in year 1, $FC_{p,t,y} = 1$ , d.u.
$e^{(-0.77 \times (y-t))}$	Decay rate 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)
<b>t</b>	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 40 years

### 6.1.1.2 CARBON STOCKS OF ABOVEGROUND CROP BIOMASS ( $C_{AGB,CROP,BL,P,Y}$ )

In the baseline scenario, the aboveground biomass each year is assumed equal to biomass losses from harvest and mortality in that same year. There is no carryover of aboveground crop biomass between years. 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). After 100% conversion for a Participant Field,  $C_{AGB_{crop,BL,p,y}}$  will remain static, except in rotational cropping systems where aboveground biomass values will conform to each crop year.

$C_{AGB_{crop,BL,p,y}}$  can be estimated by either:

- Approved models (see Section 5)<sup>25</sup>
- Field measurements for crop or forage productivity and Project Region published in peer reviewed literature
- Agricultural statistics for crop or forage productivity and Project Region, including State Agricultural Extension Offices

<sup>25</sup> 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  $C_{AGB_{crop,BL,p,y}}$ .

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- Values for the annualized average dry matter ( $DM_{BL,p,y}$ ) and carbon fraction ( $CF_b$ ) for each crop type (Equation 6). Values for  $DM_{BL,p,y}$  can be obtained from fixed ratio of crop yield to plant biomass, the Harvest Index ratio, available from peer reviewed literature, or government or University extension for crop and region of interest. 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). 5-year average crop yields must be used, and yield data 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 crop biomass in the baseline scenario should be calculated for each Participant Field in the Project Area, each year according to Equations 5 and 6.

### Equation 5: Baseline Above Ground Crop Biomass

$$C_{AGB_{crop,BL_{p,y}}} = \sum_b^B C_{AGB_{crop,BL_{b,y}}}$$

#### WHERE

$C_{AGB_{crop,BL_{p,y}}}$	Carbon stock of aboveground crop biomass for Participant Field <b>p</b> in the baseline scenario in year <b>y</b> ; $MTCO_2e$
$C_{AGB_{crop,BL_{b,y}}}$	Carbon stock of aboveground crop biomass in the baseline for crop type <b>b</b> in year <b>y</b> ; $MTCO_2e$
<b>B</b>	Total number of crop types

### Equation 6: Baseline Above Ground Crop Biomass for Crop Type b

$$C_{AGB_{crop,BL_{b,y}}} = DM_{BL,b,y} \times CF_b \times \frac{44}{12} \times A_b$$

#### WHERE

$C_{AGB_{crop,BL_{b,y}}}$	Baseline above ground crop biomass for crop type <b>b</b>
$DM_{BL,b,y}$	Annualized average dry matter in the baseline for crop type <b>b</b> in year <b>y</b> ; MT dry matter per ha
$CF_b$	Carbon fraction of dry matter for biomass type <b>b</b> ; $MT-C (MT \text{ dry matter})^{-1}$

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$A_b$	Area of crop type <b>b</b> ; hectares
$\frac{44}{12}$	Ratio of molar mass of CO <sub>2</sub> to <b>C</b>

### 6.1.2 Accounting Baseline Emissions from Belowground Biomass

Accounting for this pool is optional. If included, woody biomass is non-tree (i.e. shrubs). The conversion of Grassland to Cropland is expected to result in the removal or rapid decomposition of belowground biomass.

$C_{BGB,BL,p,y}$  can be estimated by either:

- Approved models (see Section 5)<sup>26</sup>
- $C_{AGB,BL,p,y}$  (Equation 3) and appropriate root-to-shoot ratios for crop and woody and non-woody components

Below-ground biomass carbon stocks are assumed to decompose at a rate specified in Equation 8 upon conversion to Cropland in the baseline scenario.

#### Equation 7: Baseline Belowground Biomass

Carbon stocks in belowground biomass in the baseline shall be calculated for each Participant Field in the Project Area according to Equation 7.

$$C_{BGB,BL,p,y} = C_{BGB_{grass},BL,p,y} + C_{BGB_{crop},BL,p,y}$$

#### WHERE

$C_{BGB,BL,p,y}$	Carbon stock of belowground biomass in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e
$C_{BGB_{grass},BL,p,y}$	Carbon stock of woody and non-woody belowground biomass for Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; MTCO <sub>2</sub> e

<sup>26</sup> 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  $C_{BGB,BL,p,y}$ .

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$C_{BGB_{crop,BL_{p,y}}}$

Carbon stock of belowground crop biomass in Participant Field **p** in year **y** in the baseline scenario;  $MTCO_2e$

### 6.1.2.1 ACCOUNTING CARBON STOCKS OF WOODY AND NON-WOODY, NON-CROP BELOWGROUND BIOMASS ( $C_{BGB,GRASS,P,Y}$ )

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 woody and non-woody biomass in the project scenario (see Section 6.2.2 Below-Ground Biomass). That is, for projects accounting for the loss of belowground biomass due to 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 biomass.

The loss of carbon from belowground biomass due to conversion shall be based upon the proportion of that field that has been converted ( $FC_{p,t,y}$ ) and the decomposition of biomass in the portion of the field that was converted. The decomposition rate is specified in Equation 8.

#### Equation 8: Baseline Pre-existing Belowground Grass Biomass

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

#### WHERE

$C_{BGB_{grass,BL_{p,y}}}$	Carbon stock of belowground woody and non-woody biomass from Participant Field <b>p</b> in year <b>y</b> in the baseline scenario; $MTCO_2e$
$C_{BGB,PR_{p,y}}$	Carbon stock of belowground biomass for Participant Field <b>p</b> , in year <b>y</b> , in the project scenario, as determined from Section 6.2.2; $MTCO_2e$
$FC_{p,t,y}$	The cumulative proportion of Participant Field <b>p</b> that has been converted to Cropland in year <b>t</b> , time of conversion, as of year <b>y</b> in the baseline scenario. If the entire field will be converted in year 1, $FC_{p,t,y} = 1$ , d.u.
$e^{(-1.41 \times (y-t))}$	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 Equation 8. 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

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	should be used for broadleaved species and a decay rate of 0.30 should be used for conifer species (Silver and Miya 2001) <sup>27</sup>
t	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 40 years

### 6.1.2.2 ACCOUNTING CARBON STOCKS OF BELOWGROUND CROP BIOMASS

$C_{BGB_{crop, BL_{b,y}}}$  can be estimated by:

- Approved models (see Section 5)<sup>28</sup>
- Field measurements for crop or forage productivity and Project Region published in peer reviewed literature
- Agricultural statistics for crop or forage productivity and Project Region, including State Agricultural Extension Offices
- $C_{AGB_{crop, BL_{b,y}}}$  and suitable root-to-shoot ratio for crop and region (Equation 9). For maize a default value of 0.07 should be used.<sup>29</sup>

If using a root-to-shoot ratio, carbon stocks in belowground crop biomass in the baseline scenario should be calculated for each Participant Field in the Project Area, each year, and for each crop according to Equation 9.

#### Equation 9: Baseline Belowground Crop Biomass Using Root to Shoot

$$C_{BGB_{crop, BL_{p,y}}} = \sum_b^B R_b \times C_{AGB_{crop, BL_{b,y}}}$$

<sup>27</sup> Project Proponents may replace the default decomposition rate with a site-specific value based on peer reviewed literature.

<sup>28</sup> 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  $C_{BGB_{crop, BL_{b,y}}}$ .

<sup>29</sup> 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).

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### WHERE

$C_{BGB_{crop,BL_{p,y}}}$	Carbon stock of belowground crop biomass for Participant Field <b>p</b> in the baseline scenario in year <b>y</b> ; MTCO <sub>2e</sub>
$R_b$	Root carbon-to-shoot carbon ratio of (crop) biomass type <b>b</b> ; d.u.
$C_{AGB_{crop,BL_{b,y}}}$	Carbon stock of aboveground crop biomass of crop type <b>b</b> and year <b>y</b> of the baseline scenario, as calculated in 6.1.1; MTCO <sub>2e</sub>
<b>B</b>	Total number of crop types

### 6.1.3 Accounting Baseline Emissions from Soil Organic Carbon

Accounting for this pool is required. The soil carbon pool is expected to be the primary source of emissions for the project activity, as soil carbon accounts for approximately 90% of ecosystem carbon in Grassland and rangeland systems (Schuman et al. 2001).

$C_{SOC,BL_{p,y}}$  can be estimated by:

- Approved models (see Section 5).<sup>30</sup> This method assumes emissions from SOC following conversion proceed according to the best fit decay curve to the model SOC and for the time up until when SOC levels in the model are changing by no more than  $\pm 3\%$ , not to exceed 40 years.
- Direct measurement of SOC according to requirements in ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques.<sup>31</sup> This method assumes the emissions from SOC 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).<sup>32,33</sup>

<sup>30</sup> 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  $C_{BGB_{crop,BL_{b,y}}}$ .

<sup>31</sup> Please see Section B.1.1 Stratification.

<sup>32</sup> [http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4\\_Volume4/V4\\_02\\_Ch2\\_Generic.pdf](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf)

<sup>33</sup> Determination of the equilibrium SOC value resulting after a linear decay of 20 years requires the selection of an appropriate proxy site or chronosequence study. Site similarity or appropriateness must be



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- Direct measurement of SOC according to requirements in ACR Tool for Estimation of Stocks in Carbon Pools and Emissions from Emission Sources.<sup>34</sup> This method assumes the emissions from SOC 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).<sup>35</sup>

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.<sup>36</sup> The affected depth chosen for sampling or modeling shall be justified to the validator using peer-reviewed scientific data and/or professional expert opinion. 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.

### Equation 10: Total Soil Organic Carbon in the Baseline Scenario

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 according to Equation 10.

$$C_{SOC,BL_{p,y}} = \sum_i^{p,i} C_{SOC_{i,y=0}} \times A_{p,i} \times (1 - EF_{t,y}) \times FC_{p,y}$$

#### WHERE

$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field <b>p</b> in the baseline scenario in year <b>y</b> ; MTCO <sub>2</sub> e
$C_{SOC_{i,y=0}}$	Total initial (year <b>y=0</b> ) soil organic carbon stock for soil stratum <b>i</b> , fixed for project duration; MTCO <sub>2</sub> e (ha) <sup>-1</sup>
$A_{p,i}$	Area of participant field <b>p</b> in soil strata <b>i</b> ; hectares
$EF_{t,y}$	Emission factor for the fraction of soil organic carbon pool remaining <b>t</b> years since conversion to Cropland in year <b>y</b> ; d.u.

demonstrated satisfactorily at the time of validation or a literature study used which meets the standards of best practice for soil chronosequence studies by the USGS e.g.

<https://pubs.usgs.gov/bul/1648/report.pdf>.

<sup>34</sup> Please see Section B.1.1 Stratification.

<sup>35</sup> [http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4\\_Volume4/V4\\_02\\_Ch2\\_Generic.pdf](http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf)

<sup>36</sup> Recent syntheses commonly find losses of soil carbon down to 1 meter (Sanderman et al. 2017).



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$FC_{p,y}$	Proportion of Participant Field <b>p</b> that has been converted to Cropland in the baseline scenario for year <b>y</b> . If the entire field will be converted in year 1, $FC_{p,y}=1$ , d.u.
$t$	Time since conversion of Grassland to Cropland in the baseline scenario, maximum value of 40; years

When direct measurement approaches are used to estimate  $C_{SOC,BL,p,y}$ ,  $EF_{t,y}$  for each soil organic carbon stratum may be determined by:

- Equation 11
- A peer-reviewed study of soils and a region similar to the Project Area or Project Region that examines long-term changes in soil carbon, with samples from sites that have a minimum of 20 years since conversion to cropland.
- 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 5.2.3.5 of IPCC GL AFOLU 2006.
- Approved process based biogeochemical models (see Section 5), e.g., DAYCENT.

### Equation 11: Emission Factor for Decay Rate of SOC Following Conversion

$$EF_{t,y} = \frac{1 - (FSOC_{LU} \times FSOC_{MG} \times FSOC_{IN})}{D} \times t$$

#### WHERE

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

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$FSOC_{IN}$	Fraction of soil organic carbon pool remaining after transition period, accounting for input of organic matter; d.u.
$D$	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

### 6.1.4 Accounting Baseline Emissions from Soil $N_2O$

Accounting for this pool is required. Direct and indirect soil  $N_2O$  emissions in the baseline scenario result from nitrogen fertilizer application, both synthetic and organic, as well as the presence of N-fixing plant species such as legumes. Quantification of indirect  $N_2O$  emissions from nitrogen fertilizer application is highly uncertain. GHG benefits from this pool cannot be assured to be real and are therefore conservatively excluded from both the baseline and project scenario.<sup>37</sup>

$E_{BL,N_2O_{p,y}}$  may be determined by:

- Approved models (see Section 5).<sup>38</sup>
- Equations 12, 13 and 14.<sup>39</sup>

#### Equation 12: Baseline $N_2O$ Emissions

Baseline emissions of  $N_2O$  from the application of nitrogen fertilizer can be calculated for each Participant Field in the Project Area according to Equation 12.

$$E_{BL,N_2O_{p,y}} = E_{BL,N_2O,direct_{p,y}} = (F_{BL,SN_{p,y}} + F_{BL,ON_{p,y}}) \times EF_N \times \frac{44}{28} \times GWP_{N_2O}$$

#### WHERE

<sup>37</sup> Nitrogen application is assumed to be higher in the baseline scenario, crop cultivation, relative to the project scenario, grassland with or without grazing.

<sup>38</sup> 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  $C_{BGB_{crop,BL_{b,y}}}$ .

<sup>39</sup> CDM A/R Methodological Tool, Estimation of direct nitrous oxide emission from nitrogen fertilization. <https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-07-v1.pdf>

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$E_{BL,N_2O_{p,y}}$	Total N <sub>2</sub> O emissions from Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2e</sub>
$E_{BL,N_2O,direct_{p,y}}$	Direct N <sub>2</sub> O emissions from the addition of <b>N</b> to Participant Field <b>p</b> in the baseline scenario for year <b>y</b> ; MTCO <sub>2e</sub>
$F_{BL,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field <b>p</b> in the baseline scenario in year <b>y</b> adjusted for volatilization as NH <sub>3</sub> and NO <sub>x</sub> ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$F_{BL,ON_{p,y}}$	Mass of organic <b>N</b> amendments applied to Participant Field <b>p</b> in the baseline scenario in year <b>y</b> adjusted for volatilization as NH <sub>3</sub> and NO <sub>x</sub> ; See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$EF_N$	Emission Factor for emission from <b>N</b> inputs; MT N <sub>2</sub> O-N (MT N input) <sup>-1</sup> . A default emission factor of 0.0254 (2.54%) of applied synthetic fertilizer N and 0.02 (2%) of applied organic fertilizer <b>N</b> can be assumed to be emitted (Davidson 2009).
$\frac{44}{28}$	Ratio of molecular weights of N <sub>2</sub> O to <b>N</b> ; MT N <sub>2</sub> O (MT N) <sup>-1</sup>
$GWP_{N_2O}$	Global Warming Potential for N <sub>2</sub> O <sup>40</sup>

### Equation 13: Baseline Mass of Synthetic Fertilizer Nitrogen

$$F_{BL,SN_{p,y}} = \sum_j M_{BL,SN_{p,j,y}} \times N_{BL,SN_j} \times (1 - \text{Frac}_{SN})$$

#### WHERE

$F_{BL,SN_{p,y}}$	Mass of synthetic fertilizer nitrogen applied to Participant Field <b>p</b> in the baseline scenario in year <b>y</b> adjusted for volatilization as NH <sub>3</sub> and NO <sub>x</sub> ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$M_{BL,SN_{p,j,y}}$	Mass of synthetic fertilizer type <b>j</b> applied to Participant Field <b>p</b> in year <b>y</b> ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT fertilizer

<sup>40</sup> Project proponents shall refer to the ACR Program Standard for the approved IPCC GWP for nitrous oxide value, which will be updated periodically as new information becomes available.

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$N_{BL,SN_j}$	Nitrogen content of synthetic fertilizer type <b>j</b> ; MT N (MT input) <sup>-1</sup>
$Frac_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> ;
<b>J</b>	Total number of synthetic <b>N</b> inputs of type <b>j</b>

### Equation 14: Baseline Mass of Organic Fertilizer Nitrogen

$$F_{BL,ON_{p,y}} = \sum_k^K M_{BL,ON_{p,k,y}} \times N_{BL,ON_k} \times (1 - Frac_{ON})$$

#### WHERE

$F_{BL,ON_{p,y}}$	Mass of organic <b>N</b> amendments applied to Participant Field <b>p</b> in the baseline scenario in year <b>y</b> adjusted for volatilization as NH <sub>3</sub> and NO <sub>x</sub> ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$M_{BL,ON_{p,k,y}}$	Mass of organic <b>N</b> amendment type <b>k</b> applied to Participant Field <b>p</b> in year <b>y</b> ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT fertilizer
$N_{BL,ON_k}$	Nitrogen content of organic <b>N</b> amendment type <b>k</b> ; MT-N (MT inputs) <sup>-1</sup>
$Frac_{ON}$	Fraction of organic amendment nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> ;
<b>K</b>	Total number of organic <b>N</b> amendments types

## 6.1.5 Accounting Baseline Emissions from Enteric Fermentation

Livestock, such as cattle, bison and sheep, produce CH<sub>4</sub> due to 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 CH<sub>4</sub> emissions as their diet will be primarily milk (US EPA 2013).

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Accounting for GHG emissions from livestock enteric fermentation is required when livestock would be present in the baseline scenario. In some areas, it is common practice for livestock to graze cultivated fields in the winter or to graze stover following harvest. It must be shown at time of validation that: 1) winter grazing is common practice in the region as part of the baseline crop management scenario, per the requirements in section 3.1.2, and 2) winter grazing is feasible and likely at the specific project location because cattle are already present or have been present in the project area<sup>41</sup> or LCA area.

Estimates of enteric CH<sub>4</sub> emissions are restricted to rangeland/pasture manure systems where manure is left unmanaged once deposited by livestock per the Applicability Conditions in Section 1.2. It is recognized that in Grassland ecosystems, the net contribution of livestock in the system may be net GHG sequestration (Liebig et al. 2010). Any stimulation to vegetation growth from soil nutrient amendments, grazing and/or natural manure management, present from pre-project conditions/practices, are assumed to be captured through the model parameterization 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 6.1.4 Soil Nitrogen Emissions. Baseline emissions from livestock due to enteric fermentation shall be calculated for each Participant Field in the Project Area according to Equation 15 and 16.

### Equation 15: Baseline Enteric Fermentation

$$E_{\text{Ferm},p,y} = \sum_{l=1}^L P_{p,l} \times EF_l \times GD_{p,l,y} \times GWP_{\text{CH}_4} \div 1,000$$

#### WHERE

$E_{\text{Ferm},p,y}$	CH <sub>4</sub> emission from enteric fermentation due to livestock on Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2</sub> e
<b>L</b>	Total number of livestock types in project scenario
$P_{p,l}$	Population of livestock type <b>l</b> on Participant Field <b>p</b> ; head
$GD_{p,l,y}$	Grazing days per livestock type <b>l</b> on Participant Field <b>p</b> in year <b>y</b> ; grazing days

<sup>41</sup> These emissions are conservatively excluded in the baseline scenario if the project scenario does not also include grazing. These emissions are conservatively excluded if it cannot be demonstrated that grazing was already occurring within the project boundary or by the land manager. These emissions are conservatively excluded if it cannot be demonstrated that grazing is both feasible and likely for the project area in addition to common practice in the region.

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$EF_1$	Enteric CH <sub>4</sub> emission factor for livestock type <b>I</b> ; kgCH <sub>4</sub> (head <sup>-1</sup> ) (grazing day <sup>-1</sup> )
$GWP_{CH_4}$	Global warming potential for CH <sub>4</sub> (See ACR Standard)
1,000	Conversion kg to MT

### Equation 16: Enteric Emission Factor per Head of Livestock

$$EF_1 = \frac{GE \times \left(\frac{Y_m}{100}\right)}{55.65}$$

#### WHERE

$EF_1$	Enteric methane emission factor per head of livestock
GE	Gross energy intake MJ head <sup>-1</sup> day <sup>-1</sup>
$Y_m$	Methane conversion factor, per cent of gross energy in feed converted to methane
55.65	Energy content of methane; MJ/kg CH <sub>4</sub>

## 6.1.6 Accounting Baseline Emissions from Fossil Fuels

Accounting for GHG emissions from fossil fuels is optional. The combustion of fossil fuels used in farm machinery, and potentially construction equipment, to assist with the conversion and ongoing crop management process produces emissions that may optionally be accounted for with Equation 17 and included in Equation 2.

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### Equation 17: Baseline Fossil Fuel Emissions

Projects that elect to account for fossil fuel emissions in the baseline scenario shall be calculated according to Equation 17.

$$E_{BL,FFp,y} = \sum_v \sum_f (FF_{BL,p,v,f,y} \times EF_{f,y})$$

#### WHERE

$E_{BL,FFp,y}$	Emissions due to the use of fossil fuels in agricultural management in the baseline scenario on Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2e</sub>
$FF_{BL,p,v,f,y}$	Volume of fossil fuel consumed in the baseline scenario on Participant Field <b>p</b> in vehicle/equipment type <b>v</b> with fuel type <b>j</b> during year <b>y</b> ; (See Section 3.1.2. Baseline Cropland Management Scenario); liters
$EF_f$	Emission factor for the type of fossil fuel combusted in vehicle or equipment, <b>j</b> . (See U.S. Energy Information Agency, EIA) <sup>42</sup>
<b>v</b>	Type of vehicle/equipment
<b>V</b>	Total number of types of vehicle/equipment used in the project activity
<b>f</b>	Type of fossil fuel
<b>F</b>	Total number of fuel types

## 6.2 QUANTIFICATION OF PROJECT GHG EMISSIONS

The greatest net GHG benefit from the project activity 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

<sup>42</sup> [https://www.eia.gov/environment/emissions/co2\\_vol\\_mass.php](https://www.eia.gov/environment/emissions/co2_vol_mass.php)

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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.

Project GHG emissions for all Participant Fields in the project area in a single year are calculated according to Equation 18. Project GHG emissions for a single Participant Field are calculated according to Equation 19.

### Equation 18: Total Project Emissions

$$PE_y = \sum_p^P PE_{p,y}$$

#### WHERE

$PE_y$	Total project emissions in year <b>y</b> ; MTCO <sub>2</sub> e
$PE_{p,y}$	Total project emissions for Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2</sub> e
<b>P</b>	Total Project Participant Fields

### Equation 19: Project Emissions

$$PE_{p,y} = C_{AGB,PR,p,y-1} - C_{AGB,PR,p,y} + C_{BGB,PR,p,y-1} - C_{BGB,PR,p,y} + E_{PR,N_2O,p,y} + E_{FERM,p,y} + E_{FF,PR,y,p}$$

#### WHERE

$PE_{p,y}$	Project emissions per participating field <b>p</b> in year <b>y</b>
$C_{AGB,PR,p,y}$	Carbon stock of above-ground crop biomass for Participant Field <b>p</b> in the project scenario in year <b>y</b> ; MTCO <sub>2</sub> e (optional)
$C_{BGB,PR,p,y}$	Carbon stock of below-ground crop biomass for Participant Field <b>p</b> in the project scenario in year <b>y</b> ; MTCO <sub>2</sub> e (optional)
$E_{PR,N_2O,p,y}$	Emissions due to the use of fossil fuels in agricultural management in the project scenario on Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2</sub> e
$E_{FERM,p,y}$	Project emissions from livestock – enteric fermentation in Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2</sub> e



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$E_{FF,PR,y,p}$

Emissions due to the use of fossil fuels in project management, fermentation in Participant Field  $p$  in year  $y$ ; MTCO<sub>2</sub>e (optional)

### 6.2.1 Accounting Project Emissions from Aboveground Biomass (Woody and Non-woody)

This pool is optional. If included, woody biomass is non-tree. If included, projects must account for these emissions by determining initial above ground carbon stocks for each biomass type using one of the following methods:

- Models meeting the criteria in Section 5 Use of Models for GHG Estimation.<sup>43</sup>
- Direct field measurements of  $C_{AGB_{b,y=0}}$  or  $DM_{b,y=0}$  and  $CF_b$  (Equation 21) for each biomass type,  $b$ , in a year where growing season precipitation is within 30% of average annual growing season precipitation or averaged over three years.<sup>44</sup>
- Remote sensing of  $C_{AGB_{b,y=0}}$  or  $DM_{b,y=0}$  and  $CF_b$  (Equation 21) for each biomass type,  $b$ , 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.<sup>45</sup>
- Data as available from government agency or University extension office for  $DM_{b,y=0}$  and  $CF_b$

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 (excluding trees) shall therefore be assumed to remain at a steady state for the duration of the Project Crediting Period.

#### Equation 20: Project Aboveground Biomass

$$C_{AGB,PR_{p,y}} = \sum_b^B C_{AGB_{b,y=0}}$$

<sup>43</sup> 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  $C_{BGB_{crop,BL_{b,y}}}$ .

<sup>44</sup> Conducted for project or available in peer reviewed literature.

<sup>45</sup> Conducted for project or available in peer reviewed literature.

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### WHERE

$C_{AGB,PR,p,y}$	Carbon stock of above-ground biomass for Participant Field <b>p</b> in the project scenario in year <b>y</b>
$C_{AGB,b,y=0}$	Initial (year <b>y=0</b> ) carbon stock of above-ground biomass for biomass type <b>b</b> ; MTCO <sub>2</sub> e

### Equation 21: Initial Project Aboveground Biomass

$$C_{AGB,b,y=0} = DM_{b,y=0} \times CF_b \times \frac{44}{12} \times A_b$$

### WHERE

$C_{AGB,b,y=0}$	Initial (year <b>y=0</b> ) carbon stock of above-ground biomass for biomass type <b>b</b> ; MTCO <sub>2</sub> e
$DM_{b,y=0}$	Dry matter for biomass type <b>b</b> at project initiation (year <b>y=0</b> ); MT dry matter ha <sup>-1</sup>
$CF_b$	Carbon fraction of dry matter for biomass type <b>b</b> ; MT C (MT dry matter) <sup>-1</sup>
$A_b$	Area of biomass type <b>b</b> ; hectares
$\frac{44}{12}$	Ratio of molar mass of CO <sub>2</sub> to C

## 6.2.2 Accounting Project Emissions from Belowground Biomass

This pool is optional. If included, projects must account for these emissions by determining initial below ground carbon stocks for each biomass type using one of the following methods:

- Models meeting the criteria in Section 5 Use of Models for GHG Estimation<sup>46</sup>

<sup>46</sup> 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  $C_{BGB,BL,p,y}$ .

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- $C_{AGB,PR,p,y}$  (Equation 22) and appropriate root-to-shoot ratios for crop and woody and non-woody components

### Equation 22: Project Belowground Biomass

$$C_{BGB,PR,p,y} = \sum_b^B R_b \times C_{AGB,b,y=0}$$

#### WHERE

$C_{BGB,PR,p,y}$	Carbon stock of below-ground biomass for Participant Field <b>p</b> in the project scenario in year <b>y</b> ; MTCO <sub>2e</sub>
<b>B</b>	Total number of biomass types
$R_b$	Root carbon-to-shoot carbon ratio of biomass type <b>b</b> ; default value 4.2 for temperate Grassland, 4.5 for cool temperate Grassland, and 1.8 for Shrubland (Mokany et al. 2006); d.u. <sup>47,48</sup>
$C_{AGB,b,y=0}$	Initial (year <b>y=0</b> ) carbon stock in above-ground biomass of biomass type <b>b</b> ; MTCO <sub>2e</sub>

As stated in Section 6.2.1, above-ground biomass stocks are assumed to remain in steady-state throughout the project duration; the corresponding carbon stock change in below-ground biomass pools is therefore also assumed to be zero over the project life. 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.

<sup>47</sup> Project Proponents can replace the default rate with a site-specific value or more recent value from peer reviewed literature.

<sup>48</sup> 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.

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### 6.2.3 Accounting Project Emissions from Soil Organic Carbon

SOC stocks are conservatively assumed to be in a steady state from the date of recording of the easement, such that soil organic carbon stocks in the project scenario are fixed over the project life i.e. do not increase. Because there is no change in SOC during year  $y$  in the project scenario, this term is not included in the total project emissions for year  $y$ , Equation 19.

### 6.2.4 Accounting Project Emissions from Soil N<sub>2</sub>O

Direct soil N<sub>2</sub>O emissions in the project scenario result from nitrogen fertilizer application, both synthetic and organic. Quantification of indirect N<sub>2</sub>O emissions from nitrogen fertilizer application is highly uncertain. GHG benefits from this pool cannot be assured to be real and are therefore conservatively excluded from both the baseline and project scenario.<sup>49</sup>

$E_{PR,N_2O,p,y}$  may be determined by:

- Models meeting the criteria in Section 5 Use of Models for GHG Estimation.<sup>50</sup>
- Equations 23- 27.<sup>51</sup>

#### Equation 23: Project N<sub>2</sub>O Emissions

$$E_{PR,N_2O,p,y} = E_{PR,N_2O,direct,p,y} = [(F_{PR,SN,p,y} + F_{PR,ON,p,y}) \times EF_N + F_{PRP,p,y} \times EF_{MNR}] \times \frac{44}{28} \times GWP_{N_2O}$$

#### WHERE

$E_{PR,N_2O,p,y}$	Total N <sub>2</sub> O emissions from Participant Field $p$ in year $y$ ; MTCO <sub>2e</sub>
$E_{PR,N_2O,direct,p,y}$	Direct N <sub>2</sub> O emissions from the addition of $N$ to Participant Field $p$ in the project scenario for year $y$ ; MTCO <sub>2e</sub>

<sup>49</sup> Nitrogen application is assumed to be higher in the baseline scenario, crop cultivation, relative to the project scenario, grassland with or without grazing.

<sup>50</sup> 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  $C_{BGB_{crop,BL,y}}$ .

<sup>51</sup> CDM A/R Methodological Tool, Estimation of direct nitrous oxide emission from nitrogen fertilization. <https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-07-v1.pdf>

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$F_{PRP,p,y}$	Mass of manure and urine <b>N</b> deposited by grazing animals on pasture, range and paddock on participant field <b>p</b> , in year <b>y</b>
$F_{PR,SN,p,y}$	Mass of synthetic fertilizer nitrogen applied to Participant Field <b>p</b> in the project scenario in year <b>y</b> adjusted for volatilization as $NH_3$ and $NO_x$ ; MT N
$F_{PR,ON,p,y}$	Mass of organic <b>N</b> amendments applied to Participant Field <b>p</b> in the project scenario in year <b>y</b> adjusted for volatilization as $NH_3$ and $NO_x$ ; MT N
$EF_N$	Emission factor for emission from <b>N</b> inputs; MT $N_2O$ -N (MT N input) <sup>-1</sup>
$EF_{MNR}$	Emission factor for emissions from manure inputs MT $N_2O$ -N (MT N input) <sup>-1</sup>
$\frac{44}{28}$	Ratio of molecular weights of $N_2O$ to N; MT $N_2O$ (MT N) <sup>-1</sup>
$GWP_{N_2O}$	Global Warming Potential for $N_2O$ <sup>52</sup>

### Equation 24: Project Mass of Synthetic Fertilizer Nitrogen

$$F_{PR,SN,p,y} = \sum_j M_{PR,SN,p,j,y} \times N_{PR,SN_j} \times (1 - \text{Frac}_{SN})$$

#### WHERE

$F_{PR,SN,p,y}$	Mass of synthetic <b>N</b> amendments applied to Participant Field <b>p</b> in the project scenario in year <b>y</b> adjusted for volatilization as $NH_3$ and $NO_x$ ; See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$M_{PR,SN,p,j,y}$	Mass of synthetic fertilizer type <b>j</b> applied to Participant Field <b>p</b> in year <b>y</b> ; MT
$N_{PR,SN_j}$	Nitrogen content of synthetic fertilizer type <b>j</b> ; MT-N (MT input) <sup>-1</sup>
$\text{Frac}_{SN}$	Fraction of synthetic fertilizer nitrogen that volatilizes as $NH_3$ and $NO_x$ ;
<b>J</b>	Number of synthetic fertilizer types

<sup>52</sup> Project proponents shall refer to the ACR Program Standard for the approved IPCC GWP for nitrous oxide value, which will be updated periodically as new information becomes available.

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j Synthetic fertilizer type

### Equation 25: Project Mass of Organic Fertilizer Nitrogen

$$F_{PR,ON,p,y} = \sum_k^K M_{PR,ON,p,k,y} \times N_{PR,ON,k} \times (1 - \text{Frac}_{ON})$$

#### WHERE

$F_{PR,ON,p,y}$	Mass of organic N amendments applied to Participant Field <b>p</b> in the project scenario in year <b>y</b> adjusted for volatilization as $\text{NH}_3$ and $\text{NO}_x$ ; (See Section 3.1.2. Baseline Cropland Management Scenario); MT N
$M_{PR,ON,p,k,y}$	Mass of organic fertilizer type <b>k</b> applied to Participant Field <b>p</b> in year <b>y</b> ; MT
$N_{PR,ON,k}$	Nitrogen content of organic fertilizer type <b>k</b> ; MT-N (MT input) <sup>-1</sup>
$\text{Frac}_{ON}$	Fraction of organic fertilizer nitrogen that volatilizes as $\text{NH}_3$ and $\text{NO}_x$ ;
K	Number of organic fertilizer types
k	Organic fertilizer type

### Equation 26: Percent Excreta Nitrogen

$$F_{PRP,p,y} = \sum_l^L (P_{p,l} \times \text{Nex}_{l,p,y})$$

#### WHERE

$F_{PRP,p,y}$	Percent excreta nitrogen
L	Number of livestock types
l	livestock type
$P_{p,l}$	Population of livestock type <b>l</b> , on participant field <b>p</b> ; number of head

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$N_{ex_{l,p,y}}$

Annual average **N** excretion per head of species/category, kg N (animal)<sup>-1</sup> of livestock type **l**

### Equation 27: Nitrogen Excreta Per Head of Livestock

$$N_{ex_{l,p,y}} = \frac{N_{rate(l)} \times \frac{TAM_l}{1,000} \times GD_{p,l,y}}{1,000}$$

#### WHERE

$N_{ex_{l,p,y}}$

Nitrogen excreta per head of livestock on participant field **p** in year **y** (kg N (animal)<sup>-1</sup> (year)<sup>-1</sup>)

$N_{rate(l)}$

**N** excretion rate; kg **N** (1,000 kg animal mass)<sup>-1</sup> day<sup>-1</sup>

$TAM_l$

Typical animal mass for livestock category **l**; kg animal<sup>-1</sup>

$GD_{p,l,y}$

Grazing days per livestock type **l** on Participant Field **p** in year **y**; grazing days

## 6.2.5 Accounting Livestock Emissions from Enteric Fermentation

Livestock, such as cattle, bison and sheep, produce CH<sub>4</sub> 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 of 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 CH<sub>4</sub> emissions as their diet will be primarily milk (US EPA 2013).

Estimates of enteric CH<sub>4</sub> emissions are restricted to rangeland/pasture manure systems where manure is left unmanaged once deposited by livestock per the Applicability Conditions in Section 1.2. 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

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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 6.2.4 Soil Nitrogen Emissions. Project emissions from livestock due to enteric fermentation shall be calculated for each Participant Field in the Project Area according to Equation 28 and 29.

### Equation 28: Project Enteric Fermentation

$$E_{Ferm,p,y} = \sum_{li}^L P_{p,l} \times EF_1 \times GD_{p,l,y} \times GWP_{CH_4} \div 1,000$$

#### WHERE

$E_{Ferm,p,y}$	CH <sub>4</sub> emission from enteric fermentation due to livestock on Participant Field <b>p</b> in year <b>y</b> ; MTCO <sub>2</sub> e
$L$	Total number of livestock types in project scenario
$P_{p,l}$	Population of livestock type <b>l</b> on Participant Field <b>p</b> ; head
$GD_{p,l,y}$	Grazing days per livestock type <b>l</b> on Participant Field <b>p</b> in year <b>y</b> ; grazing days
$EF_1$	Enteric CH <sub>4</sub> emission factor for livestock type <b>l</b> ; kgCH <sub>4</sub> (head <sup>-1</sup> ) (grazing day <sup>-1</sup> )
$GWP_{CH_4}$	Global warming potential for CH <sub>4</sub> (See ACR Standard)
1,000	Conversion kg to MT

### Equation 29: Enteric Emission Factor per Head of Livestock

$$EF_1 = \frac{GE \times \left(\frac{Y_m}{100}\right)}{55.65}$$

#### WHERE

$EF_1$	Enteric CH <sub>4</sub> emission factor for livestock type <b>l</b> ; kgCH <sub>4</sub> (head <sup>-1</sup> ) (grazing day <sup>-1</sup> )
$GE$	Gross energy intake MJ head <sup>-1</sup> day <sup>-1</sup>



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$Y_m$	Methane conversion factor, per cent of gross energy in feed converted to methane. 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
55.65	Energy content of methane; MJ/kg CH <sub>4</sub>

### 6.2.6 Accounting Project Emissions from Fossil Fuels

Accounting for GHG emissions from fossil fuels is optional. Where fossil fuel emissions are accounted for in the baseline, project fossil fuel emissions must also be estimated.

#### Equation 30: Project Fossil Fuel Emissions

$$E_{FF,PR,p,y} = \sum_v \sum_f (FF_{PR,p,v,f,y} \times EF_f)$$

#### WHERE

$E_{FF,PR,p,y}$	Emissions due to the use of fossil fuels in project management, on participant field p in year y; MTCO <sub>2e</sub>
$FF_{PR,p,v,f,y}$	Consumption of fossil fuel in vehicle/equipment type v during year y per fuel type f; Liters (yr.) <sup>-1</sup> on participant field p
$EF_f$	Emission factor for the type of fossil fuel combusted in vehicle or equipment, v. See U.S. Energy Information Agency. <sup>53</sup>
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

<sup>53</sup> [https://www.eia.gov/environment/emissions/co2\\_vol\\_mass.php](https://www.eia.gov/environment/emissions/co2_vol_mass.php)

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Unlike the baseline scenario, Project Proponents can 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.

### 6.3 LEAKAGE

Market leakage is the primary source of potential leakage from the avoided conversion of Grassland and Shrubland. Conversion is most likely driven by commodity crops, rather than food crops which would be consumed locally and potentially induce activity shifting leakage. For commodity crops, attempts to estimate activity shifting leakage will double count market leakage. For food crops, the default values provided in this section for market shifting leakage will provide a conservative estimate of activity shifting leakage where it occurs.

#### Equation 31: Leakage Emissions

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

##### WHERE

$LE_y$	Leakage factor in year $y$
$LE_{M,y}$	Market Leakage in year $y$

#### 6.3.1 Description of Leakage

##### 6.3.1.1 COMMODITY AND FOOD CROP

The crops identified in the baseline analysis shall be assessed for leakage type 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. The ability to estimate activity shifting leakage in scenarios

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where conversion is driven by non-commodity crops is extremely poor with available data. 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.

### 6.3.1.2 MARKET LEAKAGE

Avoiding the conversion of Grassland and Shrubland will directly remove arable Cropland that would otherwise enter 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 analyses 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 all else being equal, 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 project.

The default leakage value is derived from Equation 32, which is derived from Murray, McCarl and Lee (2004).

#### Equation 32: Market Leakage

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$$LE_{M,y} = \frac{E_S}{E_S - E_D}$$

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### WHERE

$LE_{M,y}$	Market leakage in year $y$ ; (0-1.0)
$E_S$	Price elasticity of supply
$E_D$	Price elasticity of demand

Note that Price elasticity of demand ( $E_D$ ) is generally a negative number (demand goes down as price goes up) and Price elasticity of supply ( $E_S$ ) is generally a positive number (supply goes up as price goes up), so market leakage will be a percentage that ranges from 0 to 100.

Elasticities may be obtained from the Food and Agriculture Policy Research Institute (FAPRI) Elasticity Database<sup>54,55</sup> as well as peer reviewed literature and state government reports.

To obtain a default value that can be reliably used in the United States, we considered a range of approaches to estimating leakage and used the most conservative result. Several researchers have used estimates of leakage associated with the USDA Conservation Reserve Program (CRP). The retirement of land from crop production as in the Conservation Reserve Program should have similar or larger leakage effects as an avoided conversion project that keeps land out of crop production. Both approaches preclude marginal Cropland from entering crop production. One might expect CRP to have greater leakage because of both the large scale of land retirement and because CRP typically removes land entirely from all productive uses, although some emergency haying and grazing is allowed, whereas, conservation through a carbon offset program such as this one still allow grazing and livestock production.

<sup>54</sup> The USDA Commodity and Food Elasticity Database is no longer being updated (<https://www.ers.usda.gov/data-products/commodity-and-food-elasticities/>).

<sup>55</sup> <http://www.fapri.iastate.edu/tools/elasticity.aspx>

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**Table 3: Literature Values for Leakage Associated with the USDA CRP**

SOURCE	ESTIMATE OF MARKET EFFECTS LEAKAGE	APPROACH
Taheripour, (2006)	≤20%	General equilibrium model of CRP leakage.
Wu (2000)	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. Any estimate of the price elasticity of demand that is less than -0.116 would result in leakage of 20% or lower. In drafting of version 1.0 of this methodology, 241 estimates were obtained from the USDA ERS database on own-price demand elasticities for commodities relevant to the United States (corn, soy, legume, grain, cereal, oil, food) for the period prior to 2014. The mean demand elasticity was -0.44, and more than 90% of all values were less than -0.116.

Therefore, a conservative default value of 20% market leakage may be used for avoided conversion of Grasslands or Shrublands to commodity crops in the United States.

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### 6.3.2 Quantification of Leakage Deduction

#### Equation 33: Leakage Deduction

$$LD_y = LE_y \times \sum_p^P (C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}})$$

#### WHERE

$LD_y$	Leakage deduction in year $y$
$LE_y$	Leakage in year $y$ , MTCO <sub>2e</sub> (Equation 31)
$C_{AGB,BL_{p,y}}$	Carbon stock of aboveground biomass in Participant Field $p$ in year $y$ in the baseline scenario; MTCO <sub>2e</sub> . (Equation 3, optional pool)
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field $p$ in the baseline scenario in year $y$ ; MTCO <sub>2e</sub> . (Equation 7, optional pool)
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field $p$ in the baseline scenario in year $y$ ; MTCO <sub>2e</sub> . (Equation 10)

## 6.4 NET GHG EMISSIONS

#### Equation 34: Net Emission Reductions

$$ER_y = BE_y - PE_y - NP_y - LD_y$$

#### WHERE

$ER_y$	Net GHG emissions reductions and/or removals in year $y$ , MTCO <sub>2e</sub>
$BE_y$	Baseline emissions in year $y$ , (Equation 1) MTCO <sub>2e</sub>
$PE_y$	Project emissions in year $y$ , (Equation 16) MTCO <sub>2e</sub>
$NP_y$	Non-Permanence deduction in year $y$ , (Equation 35) MTCO <sub>2e</sub>
$LD_y$	Leakage deduction for year $y$ , (Equation 31) MTCO <sub>2e</sub>

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

### Equation 35: Non-Permanence Deduction

$$NP_y = BF_y \times \sum_p^P (C_{AGB,BL_{p,y-1}} - C_{AGB,BL_{p,y}} + C_{BGB,BL_{p,y-1}} - C_{BGB,BL_{p,y}} + C_{SOC,BL_{p,y-1}} - C_{SOC,BL_{p,y}})$$

#### WHERE

$NP_y$	Non-Permanence deduction for year $y$
$BF_y$	Non-Permanence buffer in year $y$ , result of project analysis using the latest version of the ACR Tool for Risk Analysis and Buffer Determination to determine the overall project risk rating, applied as $BF_y$ . <sup>56</sup>
$C_{AGB,BL_{p,y}}$	Carbon stock of aboveground biomass in Participant Field $p$ in year $y$ in the baseline scenario; MTCO <sub>2e</sub> (Equation 3, optional pool)
$C_{BGB,BL_{p,y}}$	Carbon stock of below-ground crop biomass for Participant Field $p$ in the baseline scenario in year $y$ ; MTCO <sub>2e</sub> (Equation 7, optional pool)
$C_{SOC,BL_{p,y}}$	Carbon stock of soil organic carbon for Participant Field $p$ in the baseline scenario in year $y$ ; MTCO <sub>2e</sub> (Equation 10)

## 6.5 UNCERTAINTY

Estimation of uncertainty is required for each baseline and project carbon pool and GHG sources. When sampling is conducted, and the 90% confidence limit (high or low) is greater than 10% of the mean value, the confidence limit (resulting in the lowest ERT value) shall be used rather than the sampled mean to ensure conservativeness. Uncertainty estimates or lower bounds are required for default values (such as those by the IPCC), estimates from peer-reviewed literature, and direct measurements or empirical relationships based on measurements. They should be directly estimated per general requirements in the ACR Standard. Where process models are used to estimate pools and sources, key sources of uncertainty in model parameters and inputs should be used to model uncertainty.<sup>57</sup> Models approved for use by ACR

<sup>56</sup> As described in the most recent version of the ACR Standard, the Project Proponent shall use the ACR Tool for Risk Analysis and Buffer Determination.

<sup>57</sup> 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.

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with this methodology must meet all criteria for process based biogeochemical models in the ACR Standard. When the DAYCENT model is used, an uncertainty deduction factor of 10% must be subtracted from the difference between baseline and project SOC.<sup>58</sup>

## 6.6 PERMANENCE AND REVERSALS

Carbon offsets generated through the sequestration of carbon in soil or biomass are inherently at some risk of reversal or termination. Reversals can be unintentional or intentional. Internal risk factors include project management, financial viability, opportunity costs and project longevity. External risk factors include factors related to easement violations and natural risks including fire, flood, and extreme weather events. See specific instructions for agriculture/grassland projects within the ACR Risk Assessment Tool. The risk assessment, overall risk rating, and proposed mitigation or buffer contribution shall be included in the GHG Project Plan.

Per the Buffer Pool Terms and Conditions (see the ACR Standard) sequestration projects will terminate automatically if a Reversal causes project stocks to decrease below baseline levels prior to the end of the Minimum Project Term.

### 6.6.1 Assessment of Risk

To assess the risk of reversal or termination, the Project Proponents shall conduct a risk assessment addressing internal, external and natural risks using the most recently approved ACR Risk Assessment Tool.<sup>59</sup>

### 6.6.2 Mitigation of Risk

While prescribed burns are allowed under this Methodology, fire could have negative ecological impacts and reduce aboveground biomass in shrublands in addition to potentially reversing carbon storage resulting from the project when best practices for prescribed burns are not followed. Project Proponents shall know and follow best management practices for use of fire for the vegetation type and region.

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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.

<sup>58</sup> Based on Ogle et al. 2007 for CRP lands

<sup>59</sup> <http://americancarbonregistry.org/carbon-accounting/tools-templates/acr-risk-tool-v1-0.pdf>



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### 6.6.3 Buffer Pool Contributions

ACR's Risk Assessment Tool produces a total risk rating for the project which equals the percentage of offsets that must be deposited in the ACR buffer pool to compensate for reversal or termination (unless another ACR approved risk mitigation mechanism is used in lieu of buffer contribution). The risk assessment, overall risk rating, and proposed mitigation or buffer contribution shall be included in the GHG Project Plan.

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# 7 MONITORING AND DATA COLLECTION

Each project shall include a GHG project plan sufficiently meeting the requirements of the ACR Standard. The plan shall describe the collection of all data required to be monitored and, in a manner, which meets the requirements for accuracy and precision of this Methodology. Project Proponents shall use the template for GHG project plans available at [www.americancarbonregistry.org](http://www.americancarbonregistry.org). Additionally, projects are required to submit a GHG monitoring report for each reporting period. Project Proponents shall use the template for GHG monitoring reports available at <http://americancarbonregistry.org/carbon-accounting/tools-templates>.

## 7.1 THE GHG PROJECT PLAN

Requirements for GHG Project Plans for all ACR projects are listed in the ACR Standard. See sections 7.2 and 7.3 for additional GHG Project Plan requirements, specific to this methodology.

## 7.2 DATA COLLECTION AND PARAMETERS MONITORED

See Appendix A for a list of parameters available at validation, parameters monitored, and parameters determined from equations. Project Proponents are strongly encouraged to maintain area-based parameters in per Hectare (or per acre) units as well per field p, to assist validation and verification events.

### 7.2.1 Description of the Monitoring Plan

The Monitoring Plan is developed at time of validation, contained in the GHG Project Plan and submitted at each verification event. In addition to the parameters listed in Appendix A the monitoring plan must also include:

- Baseline Crop Management Scenario (Section 3.1.2); updated at minimum every 5 years
- Spatially explicit shapefiles for project boundaries (Section 2.1.2)
- Conversion Agents

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- Livestock presence, average annual AUMs of grazing and average annual forage availability in AUMs within the Project Area and the dates of grazing activity<sup>60</sup>
- Cover of Grassland versus Shrubland in Project Area
- Any effects of disturbance, especially of burning (wildfire or prescribed), on aboveground shrub biomass.

The Monitoring Report shall further describe the following:

- Monitoring tasks included or required as part of the LCA and responsible party
- Frequency of monitoring tasks and reporting
- Measurement procedures and frequency of collection (if applicable)
- Biogeochemical model parameter definitions<sup>61</sup>
- Quality Assurance/Quality Control measures
- Archiving measures
- Responsibilities, roles and qualifications of monitoring team
- Any due diligence for boundaries in the LCA

### 7.2.2 Sampling Design

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 locations. All sampling must be carried out such that a 90% Confidence Interval does not exceed 10% of the mean. Where uncertainty exceeds 10% of the mean, estimated GHG benefits or values must be discounted by using the boundary of the confidence interval. All measurements will be conducted according to approved sampling standards and subject to Quality Assurance/Quality Control measures, as specified in the Monitoring Plan.

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<sup>60</sup> A Grazing Management Plan, when available, meets this monitoring requirement. Grazing practices, including intensity, shall be consistent with the conservation goals set forth in the easement.

<sup>61</sup> 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.

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### 7.3 DATA ARCHIVING

The VVB shall retain reports, measurements and other project related documents, including documentation of LU/LC conversion, per requirements in the ACR Standard. Where soil samples are collected, these shall be maintained by the project developer 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.

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# 8 VALIDATION AND VERIFICATION

## 8.1 ACR VV STANDARD AND DEVIATIONS

Aspects of the avoided conversion project type are unique such that certain validation and verification procedures are allowed that supersede the ACR Verification and Validation Standard.<sup>62</sup> Specific instances where this methodology supersedes requirements in the ACR Validation and Verification Standard are described below. Unless otherwise stated, the requirements in the most recent version of the ACR Validation and Verification Standard apply to all projects.

### 8.1.1 Listing Requirements

Submittal of a full GHG Project Plan is not required at listing for this project type. Project Proponents can submit basic project information and the Statement of Intent or GHG ownership agreement and estimated future properties (if PDA) within  $\pm 12$  months of date of recording of the LCA. A complete GHG Project Plan can be submitted up until the time of validation.<sup>63</sup>

### 8.1.2 Site Visits

Site-visits are not required at validation nor at subsequent verifications for this project type, provided the verifier can reach a reasonable level of assurance via review of required documents and supplemental material (e.g. images, on-going monitoring reports as required as part of the LCA, telephone interviews, including those with the responsible entity for the LCA, remote sensing, third party datasets etc.). The verifier has discretion to request a site-visit at the following times in the project life cycle IF he/she determines that a reasonable level of assurance is unattainable without a site visit: at validation, if a reversal occurs, if LCA or regulatory infraction occurs, or change in VVB.

At a minimum, the following must be included in a remote verification:

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<sup>62</sup> These include: 1) the baseline scenario is a counterfactual scenario and cannot be monitored, rather the baseline assumptions are justified ex ante 2) the project activity requires a qualified LCA be recorded, which in and of itself includes due diligence prior to recording and on-going monitoring and reporting and 3) LCAs are complex legal agreements that vary geographically and upon the nature of the organizations entering into the agreement; it is difficult to predict with accuracy when an LCA will be completed and recorded and thus to know in advance the official project start date.

<sup>63</sup> Per the ACR Standard, AFOLU projects must COMPLETE validation within 3 years of the start date of the project; i.e. the date of qualified LCA recording.

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- Spatially-explicit boundary shape file of Project Region, Project Area, and Participant Fields, including delineation of any wetlands, building envelopes, cultivated areas, gravel pits, or other acres not governed by a sod-busting/no-conversion clause. Participant Field boundaries will not be made public.
- Spatially-explicit boundary shapefiles of the area covered by the qualified LCA.
- Copy of the recorded Land Conservation Agreement(s)/Easement(s) that encompass all Participant Fields.
- Record of due diligence for accurate boundary definition prior to LCA recording.
- Links to recent LANDSAT imagery of the project area or time stamped LANDSAT image files.
- Record or image of the Participant Fields being Grassland or Shrubland at 10 years prior to start date.
- Monitoring Plan for the qualified LCA.
- Evidence of ownership/right-to the GHG offsets for Project Participant on all Participant Fields for the crediting period being verified.
- GHG Project Plan and associated components. This includes documentation on how any models were parameterized and a detailed Monitoring Plan.
- GHG Quantification documents with modeling output, assumptions, and net GHG calculations.
- If applicable, an electronic copy of the appraisal and valid appraiser's license.

Annual easement monitoring reports are sufficient for demonstrating that the land has not been converted or undergone significant changes and is being managed in a way consistent with the protected conservation values. If an easement violation occurs, the registry must be informed in accordance with ACR's Standard, and it must be referenced in the project plan being verified, including any remediation steps taken.

### 8.1.3 Requirements for PDA Projects

Requirements for PDA projects as defined in the ACR Standard apply. Regarding site visits, this methodology supersedes requirements in the ACR Standard (See Section 8.1.2).

### 8.1.4 Significant Changes to a Project

If a significant or a substantial change occurs to the project after validation and/or initial verification, a site visit may be required either by the verifier or ACR, before the next issuance of ERTs. Examples of significant changes include:

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- Partial reversal of credits issued to date for a specific parcel and it intends to continue to participate in the project.
- Unintentional reversals resulting from extreme weather events that cause a change to the baseline soil carbon stocks.
- If a parcel is considered a full reversal and it's intentional.
- Material regulatory violations that exclude parcels from future inclusion.

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# DEFINITIONS

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

- Cropland** 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.<sup>64</sup>
- Grassland and Shrubland** 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 managed with agroforestry practices such as silvipasture and windbreaks, assuming the stand or woodlot does not meet the criteria for Forest Land.<sup>65</sup>
- Forest Land** 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.<sup>66</sup>

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<sup>64</sup> Adapted from: [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=nrcs143\\_014127](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=nrcs143_014127)

<sup>65</sup> Adapted from: [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=nrcs143\\_014127](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=nrcs143_014127) Spatial analysis uses the unique definitions of Grassland and Shrubland, respectively, in the NLCD.

<sup>66</sup> <https://americancarbonregistry.org/carbon-accounting/standards-methodologies/american-carbon-registry-standard>



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Identified Agent	The known entity that is planning to convert a particular parcel of Grassland or Shrubland to Cropland (e.g., a particular local landowner).
Indirect N <sub>2</sub> O Emissions	N <sub>2</sub> O emissions that result from microbial nitrification and denitrification of Nitrogen that has first been removed from agricultural soils and animal waste management systems within the project boundary via volatilization, leaching, runoff, or harvest of crop biomass. <sup>67, 68</sup>
Land Conservation Agreement	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	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.
Price Elasticity of Demand	A measure used in economics to show the responsiveness, or elasticity, of the quantity demanded of a good or service to a change in its price, ceteris paribus.
Price Elasticity of Supply	A measure used in economics to show the responsiveness, or elasticity, of the quantity supplied of a good or service to a change in its price.
Project Area	The collection of all participant fields where project activities are implemented.
Project Crediting Period	The length for which project activities are eligible to earn ERTs and the baseline determination remains valid.
Project Participant	A landowner or the manager of a Participant Field.
Project Proponent	An individual or entity that undertakes, develops, and/or owns a project. This may include the project investor, designer, and/or owner of the lands/facilities on which project activities are conducted. The Project

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<sup>67</sup> IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories; [https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4\\_6\\_Indirect\\_N2O\\_Agriculture.pdf](https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/4_6_Indirect_N2O_Agriculture.pdf)

<sup>68</sup> American Carbon Registry Standard, <https://americancarbonregistry.org/carbon-accounting/standards-methodologies/american-carbon-registry-standard/acr-standard-v5-1-july-2018.pdf>

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	<p>Proponent and landowner/facility owner may be different entities. The Project Proponent is the ACR account holder.</p>
<b>Project Region</b>	<p>The larger region including and encompassing the entire Project Area. The Project Region may be an eco-region or geographic administrative unit.</p>
<b>Soil texture</b>	<p>The proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil. It is a classification instrument used both in the field and laboratory to determine soil classes based on their physical texture.</p>
<b>Stratum</b>	<p>An area of land within which the value of a variable, and the processes leading to change in that variable, are relatively homogenous.</p>
<b>Succession</b>	<p>The process of change in the species structure of an ecological community over time.</p>
<b>Tree</b>	<p>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. For FIA, any plant on the tree list in the current field manual is measured as a tree.<sup>69</sup></p>
<b>Unidentified Agent</b>	<p>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.</p>

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<sup>69</sup> <https://www.nrs.fs.fed.us/fia/data-tools/state-reports/glossary/default.asp>

# APPENDIX A: PARAMETERS

## A.1 PARAMETERS DEFINED BY METHODOLOGY EQUATIONS

All parameters in A.1 can also be obtained as outputs from approved biogeochemical models.

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$BE_y$	MTCO <sub>2</sub> e	Baseline emissions in year $y$ , all field. $y=0$ at project start date		1
$BE_{p,y}$	MTCO <sub>2</sub> e	Baseline emissions from participant field $p$ , in year $y$		1,2
$C_{AGB,BL_{p,y}}$	MTCO <sub>2</sub> e	Carbon stock of above-ground biomass for Participant Field $p$ in the baseline scenario in year $y$		2,3
$C_{AGB_{b,y=0}}$	MTCO <sub>2</sub> e	Initial (year $y=0$ ) carbon stock of above-ground biomass for biomass type $b$		20, 22
$C_{AGB,PR_{p,y}}$	MTCO <sub>2</sub> e	Carbon stock of above-ground biomass for Participant Field $p$ in the project scenario in year $y$		4, 19, 21
$C_{AGB_{grass,BL_{p,y}}}$	MTCO <sub>2</sub> e	Carbon stock of (remaining, pre-existing) above ground for Participant Field $p$ in year $y$ in the baseline scenario, as calculated from Section 6.2.1		3

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$C_{AGB_{crop, BL_{p,y}}}$	MTCO <sub>2</sub> e	Carbon stock of aboveground crop biomass in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario		5
$C_{AGB_{crop, BL_{b,y}}}$	MTCO <sub>2</sub> e	Carbon stock of aboveground crop biomass in Participant Field <b>p</b> , for crop type <b>b</b> , in year <b>y</b> in the baseline scenario		5, 6
$C_{BGB, BL_{p,y}}$	MTCO <sub>2</sub> e	Carbon stock of belowground biomass in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario		2,7
$C_{BGB_{crop, BL_{p,y}}}$	MTCO <sub>2</sub> e	Carbon stock of belowground crop biomass in Participant Field <b>p</b> in year <b>y</b> in the baseline scenario		7, 9
$C_{BGB_{grass, BL_{p,y}}}$	MTCO <sub>2</sub> e	Carbon stock of (remaining, pre-existing) belowground biomass from Participant Field <b>p</b> in year <b>y</b> in the baseline scenario		7, 8
$C_{BGB, PR_{p,y}}$	MTCO <sub>2</sub> e	Carbon stock of below-ground biomass for Participant Field <b>p</b> in the project scenario in year <b>y</b>		8, 19, 22
$C_{SOC, BL_{p,y}}$	MTCO <sub>2</sub> e	Carbon stock of soil organic carbon for Participant Field <b>p</b> in the baseline scenario in year <b>y</b>		2,10
$F_{BL/PR, ON_{p,y}}$	MT-N	Mass of organic <b>N</b> amendments applied to Participant Field <b>p</b> in the baseline/project scenario in year <b>y</b> adjusted for volatilization as NH <sub>3</sub> and NO <sub>x</sub>		12, 14, 23, 25

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$F_{BL/PR,SN_{p,y}}$	MT-N	Mass of synthetic fertilizer nitrogen applied to Participant Field <b>p</b> in the baseline/project scenario in year <b>y</b> adjusted for volatilization as $NH_3$ and $NO_x$		12, 13, 23, 24
$E_{BL/PR,N_2O_{p,y}} = E_{BL/PR,N_2O_{direct_{p,y}}}$	MTCO <sub>2</sub> e	Total N <sub>2</sub> O emissions from Participant Field <b>p</b> in the baseline/project scenario in year <b>y</b> . Indirect emissions are conservatively excluded		2, 12, 19, 23
$E_{(BL/PR),FF_{p,y}}$	MTCO <sub>2</sub> e	Emissions due to the use of fossil fuels in agricultural management in the baseline/project scenario on Participant Field <b>p</b> in year <b>y</b>		2, 17, 19, 30
$EF_{t,y}$	d.u.	Emission factor for the fraction of soil organic carbon pool remaining <b>t</b> years since conversion to Cropland in year <b>y</b>		10, 11
$Ne_{X_{l,p,y}}$	kg N (animal) <sup>-1</sup> (yr.) <sup>-1</sup>	Annual average <b>N</b> excretion per head of species/category <b>l</b> , Participant Field <b>p</b> in year <b>y</b>		26, 27
$E_{FERM_{p,y}}$	MTCO <sub>2</sub> e	CH <sub>4</sub> emission from enteric fermentation due to livestock on Participant Field <b>p</b> in year <b>y</b>		28
$PE_y$	MTCO <sub>2</sub> e	Total project emissions in year <b>y</b>		18
$PE_{p,y}$	MTCO <sub>2</sub> e	Total project emissions from participant field <b>p</b> in year <b>y</b>		18, 19

## A.2 PARAMETERS AVAILABLE AT VALIDATION

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$A_b$	ha	Area of biomass/crop type <b>b</b>	Project Proponent	6, 21
$A_{p,i}$	ha	Area of Participant Field in soil strata <b>i</b>	Project Proponent	10
$C_{AGB_{b,y=0}}$	MTCO <sub>2</sub> e	Initial (year <b>y=0</b> ) carbon stock of aboveground biomass for Participant Field <b>p</b>	Measured, Modeled, values from literature	20, 22
$C_{SOC_{i,y=0}}$	MTCO <sub>2</sub> e (ha) <sup>-1</sup>	Total initial (year <b>y=0</b> ) soil organic carbon stock in soil strata <b>i</b> , fixed for project duration	Measured, modeled, or literature. Where unavailable, default values from IPCC 2006 AFOLU GL, Table 2.3 may be used.	10
$CF_b$	MT C (MT dry matter) <sup>-1</sup>	Carbon fraction of dry matter for biomass type <b>b</b>	Literature, Table 11.2 IPCC 2006 GL AFOLU	6, 21
<b>D</b>	years	Transition period for soil organic carbon, time period for transition between equilibrium SOC values, default value of 20	Measured, Modeled, literature, or default value of 20 years (IPCC 2006 AFOLU GL, Ch. 2).	11

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$DM_{b,y=0}$	MTCO <sub>2</sub> e	Average, annual, dry matter for biomass type <b>b</b> at project initiation (year <b>y</b> =0)	Measured, Modeled, literature	6, 21
$e^{(-0.77 \times (y-t))}$	d.u.	The decay function for aboveground biomass following conversion	Kochsiek et al. 2009	4
$e^{(-1.41 \times (y-t))}$	d.u.	The decay function for belowground biomass following conversion	Silver and Miya 2001	8
$EF_f$	MTCO <sub>2</sub> e (liter of fuel) <sup>-1</sup>	Emission factor for the type of fossil fuel combusted in vehicle or equipment	For gasoline EF CO <sub>2</sub> e = 8.89 kg CO <sub>2</sub> e/gallon. For diesel EF CO <sub>2</sub> e = 10.16 kg CO <sub>2</sub> e/gallon. Source: EIA	17, 30
$EF_l$	kg-CH <sub>4</sub> head <sup>-1</sup> grazing day <sup>-1</sup>	Enteric CH <sub>4</sub> emission factor for livestock type <b>l</b>	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 GL	28, 29
$EF_N$	MT-N <sub>2</sub> O-N (MT-N input) <sup>-1</sup>	Emission Factor for emission from <b>N</b> inputs	0.0254 (2.54%) of applied synthetic fertilizer <b>N</b> and 0.02 (2%) of applied organic fertilizer <b>N</b> (Davidson, 2009)	12, 23

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$EF_{MNR}$	MT-N <sub>2</sub> O-N (MT-N input) <sup>-1</sup>	Emission Factor for emission from manure inputs	Literature, Default values may be found Table 11.1, Chapter 11 IPCC 2006 AFOLU GL	23
$FC_{p,y}$	d.u.	Proportion of Participant Field <b>p</b> that has been converted to Cropland in the baseline scenario for year <b>y</b> , d.u.	Project Proponent	10
$FC_{p,t,y}$	d.u.	The cumulative proportion of Participant Field <b>p</b> that has been converted to Cropland in year <b>t</b> , time of conversion, as of year <b>y</b> in the baseline scenario, determined based on rates and extents of conversion	Project Proponent	4, 8
$Frac_{ON}$	kg N volatilized (kg of N applied or deposited) <sup>-1</sup>	Fraction of organic <b>N</b> applied to soils that volatilizes as NH <sub>3</sub> and NO <sub>x</sub>	Default value of 0.20 Source: Chapter 11, Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	14, 25
$Frac_{SN}$	kg N volatilized (kg of N applied or deposited) <sup>-1</sup>	Fraction of synthetic <b>N</b> applied to soils that volatilizes as NH <sub>3</sub> and NO <sub>x</sub>	Default value of 0.10 Source: Chapter 11, Table 11.3, p. 11.24, IPCC 2006 AFOLU GL	13, 24



PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$GWP_{CH_4}$	MTCO <sub>2</sub> e	Global warming potential for CH <sub>4</sub>	See ACR Standard	28
$GWP_{N_2O}$	MTCO <sub>2</sub> e	Global warming potential for N <sub>2</sub> O	See ACR Standard	12, 23
$Y_m$	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	29
$P$		Total number of participant fields, $p$	Project Proponent	
$t$	years	Time since conversion of Grassland to Cropland in the baseline scenario	Project Proponent	
$R_b$	d.u.	Root carbon-to-shoot carbon ratio of (crop) biomass type $b$ ; default value 4.2 for temperate grassland, 4.5 for cool temperate grassland and 1.8 for shrubland	Literature, Craine et al. 2005, Mokany et al 2006; or IPCC 2006 AFOLU GL	9, 22

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$\frac{44}{12}$		Ratio of molar mass of CO <sub>2</sub> to <b>C</b>	NA	6, 21
$\frac{44}{28}$		Ratio of molar mass of N <sub>2</sub> O to <b>N</b>	NA	12

### A.3 PARAMETERS MONITORED

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
B		Total number of crop/bio-mass types <b>b</b>		
DM <sub>BL,b,y</sub>	MT dry matter (ha) <sup>-1</sup>	Annualized average dry matter in the baseline for crop type <b>b</b> in year <b>y</b>	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 MT C (ha) <sup>-1</sup> for annual crops following one year after conversion (IPCC 2006 AFOLU GL, Table 5.9)	6

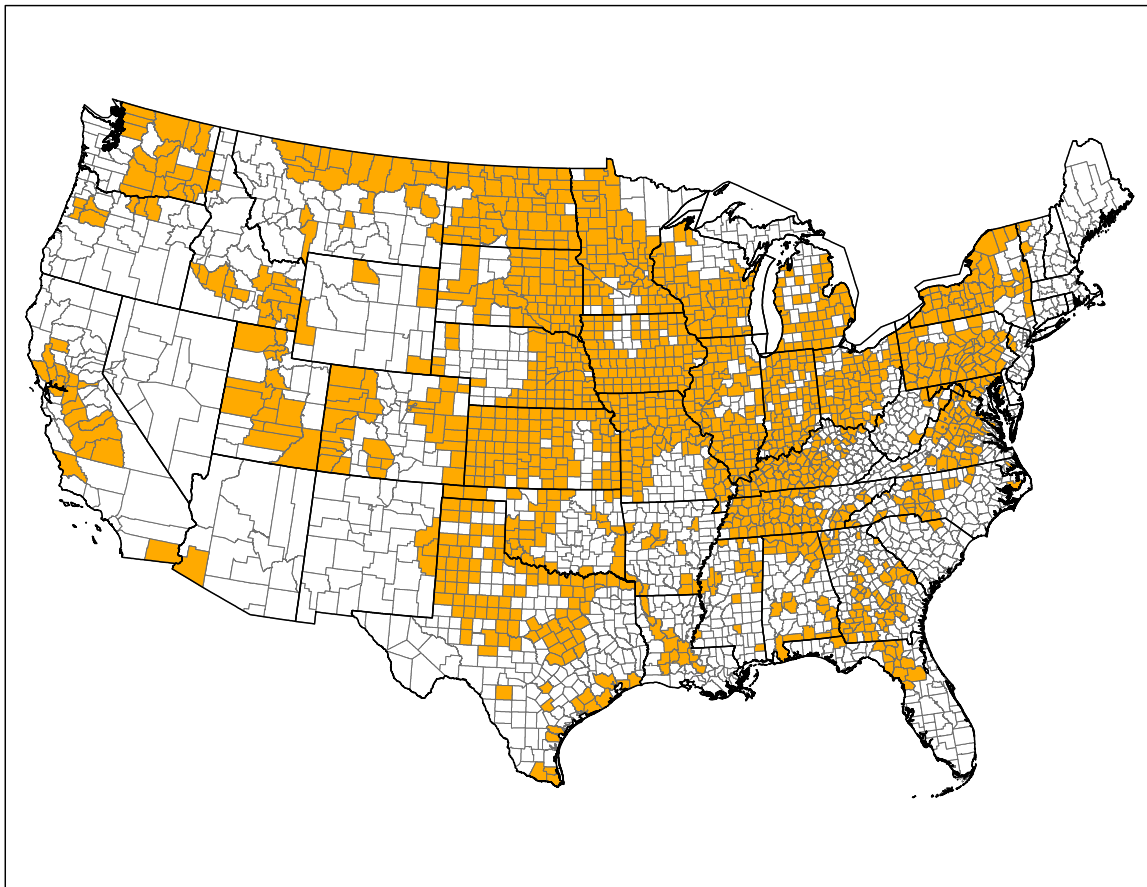
PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$F_{PRP_{p,y}}$	MT-N	Mass of manure and urine <b>N</b> deposited by grazing animals on pasture, range and paddock	Producer records, or a university extension or other production report containing grazing animal population multiplied by per animal manure and urine <b>N</b> deposition.	23
$FSOC_{LU}$	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	11
$FSOC_{MG}$	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	11
$FSOC_{IN}$	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	11
$FF_{BL/PR_{p,v,j,y}}$	liters	Volume of fossil fuel consumed in the baseline/project scenario on Participant Field <b>p</b> in vehicle/equipment type <b>v</b> with fuel type <b>j</b> during year <b>y</b>	Expert opinion or extension/agency report (baseline) or producer report (project) that contains vehicle/equipment hours and fuel needed per unit of use.	17, 30

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
$GD_{p,l,y}$	days	Grazing days per livestock type <b>l</b> on Participant Field <b>p</b> in year <b>y</b>	University extension, producer, or other production report containing average grazing days per livestock type <b>l</b> in the project region.	27, 28
GE	MJ head <sup>-1</sup> day <sup>-1</sup>	Gross energy intake	Literature, government reports, or expert opinion.	29
$M_{BL/PR,SN,p,j,y}$	MT	Mass of synthetic fertilizer type <b>j</b> applied to Participant Field <b>p</b> in year <b>y</b>	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.	13, 24
$M_{BL/PR,ON,p,k,y}$	MT	Mass of organic <b>N</b> amendment type <b>k</b> applied to Participant Field <b>p</b> in year <b>y</b>	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,	14, 25

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
			NRCS) with jurisdiction in the Project Region, or Cropland management plans approved by a lending agency.	
$N_{BL/PR,ON_k}$	MT-N (MT input) <sup>-1</sup>	Nitrogen content of organic N amendment type <b>k</b>	Producer of nitrogen if a commercially produced product. Otherwise IPCC defaults or values from the literature.	14, 25
$N_{BL/PR,SN_j}$	MT-N (MT input) <sup>-1</sup>	Nitrogen content of synthetic fertilizer type <b>j</b>	Producer of fertilizer	13, 24
$N_{rate_l}$	kg N (1,000 kg animal mass) <sup>-1</sup> day <sup>-1</sup>	N excretion rate	Default values may be found in Table 10.19, Chapter 10 IPCC 2006 AFOLU GL	27
$P_{p,l}$	number of head	Population of livestock type <b>l</b>	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 must 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.	26, 28

PARAMETER	UNIT	DESCRIPTION	SOURCE	USED IN EQ.
TAM <sub>l</sub>	kg animal <sup>-1</sup>	Typical animal mass for livestock category <b>l</b>	Literature, government reports, or expert opinion.	27
L		Total number of livestock types in project scenario	Project Proponent	26, 28
J		Total number of synthetic <b>N</b> inputs, <b>j</b>	Project Proponent	13, 24
K		Total number of organic <b>N</b> amendments, <b>k</b>	Project Proponent	14, 25
V		Total number of vehicles, <b>v</b>	Project Proponent	17, 30
F		Total number of fossil fuels, <b>f</b>	Project Proponent	17, 30

## APPENDIX B: COUNTY MAP FOR UNIDENTIFIED AGENT OF CONVERSION



Project fields/parcels located in the counties highlighted in orange have a baseline scenario of cropland for unidentified agents of conversion and surpass the practice-based performance standard for demonstrating additionality. Project fields/parcels in white counties must determine the baseline land-use scenario and demonstrate additionality according to sections 3.1.1.2 and 3.2.2.2 respectively.

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
AL	Baldwin County		Lonoke County		Garfield County
	Barbour County		Miller County		Kiowa County
	Bullock County		Perry County		Kit Carson County
	Calhoun County		Pope County		La Plata County
	Cherokee County		Yell County		Lincoln County
	Colbert County	AZ	Yuma County		Logan County
	Covington County	CA	Amador County		Mesa County
	Cullman County		Contra Costa County		Moffat County
	Dallas County		Fresno County		Montezuma County
	DeKalb County		Glenn County		Montrose County
	Escambia County		Imperial County		Morgan County
	Etowah County		Kings County		Phillips County
	Franklin County		Lake County		Pitkin County
	Geneva County		Madera County		Prowers County
	Henry County		Merced County		Rio Blanco County
	Houston County		Napa County		Rio Grande County
	Jackson County	Sacramento County	Routt County		
	Lauderdale County	San Joaquin County	Saguache County		
	Lawrence County	San Luis Obispo County	San Miguel County		
	Limestone County	Solano County	Washington County		
Macon County	Sonoma County	FL	Alachua County		
Madison County	Stanislaus County		Citrus County		
Marengo County	Tulare County		Columbia County		
Marshall County	Yolo County		Dixie County		
Morgan County	CO		Gilchrist County		
Perry County			Adams County	Hamilton County	
Talladega County			Alamosa County	Jackson County	
AR	Ashley County	Arapahoe County	Lafayette County		
	Chicot County	Baca County	Levy County		
	Conway County	Cheyenne County	Madison County		
	Crawford County	Conejos County	Marion County		
	Drew County	Delta County	Suwannee County		
	Jackson County	Denver County	GA	Appling County	
	Lafayette County	Dolores County		Atkinson County	
	Little River County	Eagle County		Bacon County	
		Elbert County			



## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Baker County		Pierce County		Clayton County
	Bartow County		Polk County		Clinton County
	Berrien County		Putnam County		Crawford County
	Bleckley County		Richmond County		Dallas County
	Brooks County		Screven County		Davis County
	Burke County		Seminole County		Decatur County
	Calhoun County		Spalding County		Delaware County
	Chattooga County		Sumter County		Des Moines County
	Coffee County		Taylor County		Dickinson County
	Colquitt County		Telfair County		Dubuque County
	Crawford County		Terrell County		Emmet County
	Crisp County		Thomas County		Fayette County
	Decatur County		Toombs County		Floyd County
	Dodge County		Treutlen County		Franklin County
	Dougherty County		Walker County		Fremont County
	Early County		Walton County		Greene County
	Floyd County		Warren County		Grundy County
	Gordon County		Washington County		Guthrie County
	Hart County		Wheeler County		Hancock County
	Houston County		White County		Hardin County
	Irwin County		Worth County		Harrison County
	Jeff Davis County				Henry County
	Jefferson County				Howard County
	Jenkins County				Ida County
	Johnson County				Iowa County
	Lamar County				Jackson County
	Lanier County				Jasper County
	Lee County				Jefferson County
	Macon County				Johnson County
	Miller County				Jones County
	Mitchell County				Keokuk County
	Monroe County				Lee County
	Montgomery County				Linn County
	Morgan County				Louisa County
	Murray County				Lucas County
	Peach County				Lyon County
		IA	Adair County		
			Adams County		
			Allamakee County		
			Appanoose County		
			Audubon County		
			Benton County		
			Black Hawk County		
			Butler County		
			Carroll County		
			Cass County		
			Cedar County		
			Cherokee County		
			Chickasaw County		
			Clarke County		
			Clay County		

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Madison County		Bear Lake County		Ford County
	Mahaska County		Bingham County		Franklin County
	Marion County		Bonneville County		Fulton County
	Marshall County		Butte County		Gallatin County
	Mills County		Camas County		Greene County
	Mitchell County		Canyon County		Hamilton County
	Monona County		Caribou County		Hancock County
	Monroe County		Elmore County		Hardin County
	Montgomery County		Gooding County		Henderson County
	Muscatine County		Jefferson County		Henry County
	O'Brien County		Latah County		Jackson County
	Osceola County		Lincoln County		Jasper County
	Page County		Madison County		Jefferson County
	Plymouth County		Oneida County		Jersey County
	Polk County		Power County		Jo Daviess County
	Pottawattamie County				Johnson County
	Poweshiek County	IL	Adams County		Kane County
	Ringgold County		Alexander County		Kankakee County
	Sac County		Bond County		Kendall County
	Shelby County		Boone County		Knox County
	Sioux County		Brown County		Lawrence County
	Story County		Bureau County		Lee County
	Tama County		Calhoun County		Livingston County
	Taylor County		Carroll County		Macoupin County
	Union County		Cass County		Madison County
	Van Buren County		Christian County		Marion County
	Wapello County		Clay County		Marshall County
	Warren County		Clinton County		Mason County
	Washington County		Coles County		Massac County
	Wayne County		Crawford County		McDonough County
	Winnebago County		Cumberland County		McHenry County
	Winneshiek County		DeKalb County		McLean County
	Woodbury County		Douglas County		Menard County
	Wright County		Edgar County		Mercer County
ID	Ada County		Edwards County		Monroe County
	Bannock County		Effingham County		Montgomery County
			Fayette County		

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Morgan County		Carroll County		Miami County
	Ogle County		Cass County		Monroe County
	Peoria County		Clark County		Montgomery County
	Perry County		Clay County		Morgan County
	Pike County		Crawford County		Newton County
	Pope County		Daviess County		Noble County
	Pulaski County		Decatur County		Orange County
	Putnam County		DeKalb County		Owen County
	Randolph County		Delaware County		Perry County
	Richland County		Dubois County		Pike County
	Rock Island County		Elkhart County		Porter County
	Saint Clair County		Fayette County		Pulaski County
	Saline County		Floyd County		Putnam County
	Schuyler County		Fountain County		Randolph County
	Scott County		Franklin County		Ripley County
	Shelby County		Fulton County		Rush County
	Stark County		Gibson County		Saint Joseph County
	Stephenson County		Greene County		Scott County
	Tazewell County		Hamilton County		Spencer County
	Union County		Harrison County		Starke County
	Vermilion County		Hendricks County		Steuben County
	Wabash County		Henry County		Tippecanoe County
	Warren County		Huntington County		Union County
	Washington County		Jackson County		Vermillion County
	Wayne County		Jasper County		Vigo County
	White County		Jay County		Warren County
	Whiteside County		Jefferson County		Warrick County
	Will County		Jennings County		Washington County
	Williamson County		Knox County		Wayne County
	Winnebago County		Kosciusko County		White County
			LaGrange County		Whitley County
			LaPorte County		
			Lawrence County	KS	Allen County
			Madison County		Atchison County
			Marshall County		Barton County
			Martin County		Bourbon County
					Brown County
IN	Adams County				
	Allen County				
	Benton County				
	Blackford County				
	Boone County				
	Brown County				

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Butler County		Lincoln County		Stafford County
	Cherokee County		Linn County		Stanton County
	Cheyenne County		Logan County		Stevens County
	Clay County		Marion County		Sumner County
	Cloud County		Marshall County		Thomas County
	Comanche County		McPherson County		Trego County
	Crawford County		Meade County		Wallace County
	Decatur County		Miami County		Washington County
	Dickinson County		Mitchell County		Wichita County
	Doniphan County		Montgomery County		Wilson County
	Douglas County		Morton County		
	Edwards County		Nemaha County	KY	Adair County
	Ellis County		Neosho County		Allen County
	Finney County		Ness County		Ballard County
	Ford County		Norton County		Barren County
	Franklin County		Osage County		Bath County
	Gove County		Osborne County		Bourbon County
	Graham County		Ottawa County		Boyle County
	Grant County		Pawnee County		Breckinridge County
	Gray County		Phillips County		Bullitt County
	Greeley County		Pratt County		Butler County
	Hamilton County		Rawlins County		Caldwell County
	Harper County		Reno County		Calloway County
	Harvey County		Republic County		Carlisle County
	Haskell County		Rice County		Carroll County
	Hodgeman County		Rooks County		Casey County
	Jackson County		Rush County		Christian County
	Jefferson County		Russell County		Clark County
	Jewell County		Saline County		Clinton County
	Johnson County		Scott County		Crittenden County
	Kearny County		Sedgwick County		Cumberland County
	Kingman County		Seward County		Daviess County
	Kiowa County		Shawnee County		Edmonson County
	Labette County		Sheridan County		Estill County
	Lane County		Sherman County		Fleming County
	Leavenworth County		Smith County		Franklin County
					Fulton County

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

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STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Graves County		Simpson County		Allegan County
	Grayson County		Spencer County		Alpena County
	Green County		Taylor County		Arenac County
	Greenup County		Todd County		Barry County
	Hancock County		Trigg County		Bay County
	Hardin County		Trimble County		Berrien County
	Hart County		Union County		Branch County
	Henderson County		Warren County		Calhoun County
	Henry County		Washington County		Cass County
	Hickman County		Wayne County		Clinton County
	Hopkins County		Webster County		Eaton County
	Larue County				Genesee County
	Lewis County	LA	Allen Parish		Gladwin County
	Lincoln County		Avoyelles Parish		Grand Traverse County
	Livingston County		Bossier Parish		Hillsdale County
	Logan County		Evangeline Parish		Huron County
	Lyon County		Grant Parish		Ingham County
	Marion County		Iberville Parish		Ionia County
	Marshall County		Jefferson Davis Parish		Iosco County
	Mason County		Natchitoches Parish		Isabella County
	McCracken County		Pointe Coupee Parish		Jackson County
	McLean County		Rapides Parish		Lapeer County
	Meade County		Red River Parish		Leelanau County
	Mercer County		Saint Landry Parish		Lenawee County
	Metcalfe County	MD	Allegany County		Livingston County
	Monroe County		Baltimore County		Macomb County
	Muhlenberg County		Carroll County		Manistee County
	Nelson County		Cecil County		Mason County
	Ohio County		Frederick County		Mecosta County
	Powell County		Garrett County		Missaukee County
	Pulaski County		Harford County		Muskegon County
	Rockcastle County		Howard County		Oceana County
	Rowan County		Montgomery County		Ogemaw County
	Russell County		Queen Anne's County		Oscoda County
	Scott County		Washington County		Ottawa County
	Shelby County	MI	Alcona County		Saginaw County

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Saint Clair County Saint Joseph County Sanilac County Shiawassee County Tuscola County Washtenaw County Wayne County		Lake of the Woods County Le Sueur County Lincoln County Lyon County Mahnommen County Marshall County McLeod County Meeker County Mille Lacs County Morrison County Mower County Murray County Norman County Olmsted County Otter Tail County Pennington County Pine County Pipestone County Polk County Pope County Red Lake County Redwood County Rice County Roseau County Scott County Sherburne County Sibley County Stearns County Steele County Stevens County Swift County Todd County Traverse County Wabasha County Wadena County Washington County		Wilkin County Winona County Wright County Yellow Medicine County
MN	Aitkin County Anoka County Becker County Beltrami County Benton County Big Stone County Carver County Cass County Chippewa County Chisago County Clay County Clearwater County Cottonwood County Crow Wing County Dakota County Dodge County Douglas County Fillmore County Freeborn County Goodhue County Grant County Hennepin County Houston County Hubbard County Isanti County Jackson County Kanabec County Kandiyohi County Lac qui Parle County			MO	Adair County Andrew County Atchison County Audrain County Barry County Barton County Bates County Benton County Bollinger County Boone County Buchanan County Butler County Caldwell County Callaway County Cape Girardeau County Carroll County Cass County Cedar County Chariton County Clark County Clay County Clinton County Cole County Cooper County Dade County Davies County DeKalb County Dunklin County Franklin County Gasconade County Gentry County Greene County

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Grundy County		Saint Charles County	MT	Blaine County
	Harrison County		Saint Clair County		Broadwater County
	Henry County		Saint Francois County		Chouteau County
	Hickory County		Saint Louis County		Daniels County
	Holt County		Sainte Genevieve County		Dawson County
	Howard County		Saline County		Fallon County
	Jackson County		Schuyler County		Gallatin County
	Jasper County		Scotland County		Glacier County
	Johnson County		Scott County		Golden Valley County
	Knox County		Shelby County		Hill County
	Lafayette County		Stoddard County		Liberty County
	Lawrence County		Sullivan County		McCone County
	Lewis County		Vernon County		Petroleum County
	Lincoln County		Warren County		Phillips County
	Linn County		Wayne County		Pondera County
	Livingston County		Worth County		Roosevelt County
	Macon County	MS	Adams County		Sheridan County
	Madison County		Alcorn County		Teton County
	Marion County		Benton County		Toole County
	Mercer County		Calhoun County		Valley County
	Moniteau County		Chickasaw County		
	Monroe County		Clay County	NC	Alamance County
	Montgomery County		Covington County		Anson County
	Morgan County		DeSoto County		Burke County
	New Madrid County		George County		Cabarrus County
	Newton County		Humphreys County		Catawba County
	Nodaway County		Leake County		Cherokee County
	Perry County		Lee County		Clay County
	Pettis County		Leflore County		Cleveland County
	Pike County		Lowndes County		Davidson County
	Platte County		Monroe County		Davie County
	Polk County		Noxubee County		Durham County
	Putnam County		Pontotoc County		Franklin County
	Ralls County		Sunflower County		Gaston County
	Randolph County		Union County		Henderson County
	Ray County		Washington County		Hyde County

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Iredell County		LaMoure County		Butler County
	Lincoln County		Logan County		Cass County
	Mecklenburg County		McHenry County		Cedar County
	Mitchell County		McIntosh County		Clay County
	Orange County		McLean County		Colfax County
	Pasquotank County		Mercer County		Cuming County
	Randolph County		Morton County		Dakota County
	Rowan County		Mountrail County		Dawes County
	Stanly County		Nelson County		Dixon County
	Surry County		Oliver County		Dodge County
	Transylvania County		Pembina County		Fillmore County
	Union County		Pierce County		Franklin County
	Warren County		Ramsey County		Furnas County
	Wilkes County		Ransom County		Gage County
	Yadkin County		Renville County		Gosper County
			Richland County		Greeley County
			Rolette County		Hall County
			Sargent County		Hamilton County
			Sheridan County		Harlan County
			Slope County		Holt County
			Stark County		Howard County
			Steele County		Jefferson County
			Stutsman County		Johnson County
			Towner County		Kearney County
			Walsh County		Kimball County
			Ward County		Knox County
			Wells County		Lancaster County
			Williams County		Madison County
					Merrick County
					Nance County
					Nemaha County
					Nuckolls County
					Otoe County
					Pawnee County
					Perkins County
					Phelps County
ND	Adams County				
	Barnes County				
	Benson County				
	Billings County				
	Bottineau County				
	Bowman County				
	Burke County				
	Burleigh County				
	Cass County				
	Cavalier County				
	Dickey County				
	Divide County				
	Dunn County				
	Eddy County				
	Emmons County				
	Foster County				
	Grand Forks County				
	Grant County				
	Griggs County				
	Hettinger County				
	Kidder County				
		NE	Adams County		
			Antelope County		
			Banner County		
			Boone County		
			Box Butte County		
			Boyd County		
			Buffalo County		
			Burt County		



## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Pierce County		Dutchess County		Auglaize County
	Platte County		Erie County		Brown County
	Polk County		Franklin County		Butler County
	Red Willow County		Genesee County		Champaign County
	Richardson County		Herkimer County		Clark County
	Saline County		Jefferson County		Clermont County
	Sarpy County		Lewis County		Clinton County
	Saunders County		Livingston County		Columbiana County
	Seward County		Madison County		Coshocton County
	Sherman County		Monroe County		Crawford County
	Stanton County		Montgomery County		Darke County
	Thayer County		Niagara County		Defiance County
	Thurston County		Oneida County		Delaware County
	Valley County		Onondaga County		Fairfield County
	Washington County		Ontario County		Fayette County
	Wayne County		Orleans County		Franklin County
	Webster County		Oswego County		Fulton County
	Wheeler County		Otsego County		Gallia County
	York County		Rensselaer County		Greene County
			Saint Lawrence County		Hardin County
NJ	Hunterdon County		Saratoga County		Highland County
	Warren County		Schoharie County		Hocking County
NM	Curry County		Schuyler County		Holmes County
	Quay County		Seneca County		Huron County
	Roosevelt County		Steuben County		Jackson County
			Tioga County		Knox County
NY	Albany County		Tompkins County		Licking County
	Allegany County		Washington County		Logan County
	Broome County		Wayne County		Lorain County
	Cattaraugus County		Wyoming County		Madison County
	Cayuga County		Yates County		Mahoning County
	Chautauqua County				Marion County
	Chemung County	OH	Adams County		Medina County
	Chenango County		Allen County		Mercer County
	Clinton County		Ashland County		Montgomery County
	Columbia County		Ashtabula County		Morgan County
	Cortland County		Athens County		

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Morrow County		Jackson County		Centre County
	Muskingum County		Jefferson County		Chester County
	Perry County		Kay County		Clarion County
	Pickaway County		Kingfisher County		Clearfield County
	Pike County		Kiowa County		Clinton County
	Portage County		Le Flore County		Columbia County
	Preble County		Major County		Crawford County
	Richland County		McCurtain County		Cumberland County
	Ross County		Muskogee County		Dauphin County
	Sandusky County		Ottawa County		Erie County
	Scioto County		Roger Mills County		Fayette County
	Seneca County		Sequoyah County		Franklin County
	Shelby County		Texas County		Fulton County
	Stark County		Tillman County		Greene County
	Trumbull County		Tulsa County		Huntingdon County
	Tuscarawas County		Wagoner County		Indiana County
	Union County		Washita County		Jefferson County
	Warren County				Juniata County
	Wayne County	OR	Benton County		Lancaster County
	Williams County		Gilliam County		Lawrence County
	Wyandot County		Linn County		Lebanon County
			Marion County		Lehigh County
			Morrow County		Luzerne County
			Polk County		Lycoming County
			Sherman County		Mercer County
					Mifflin County
					Monroe County
					Montour County
					Northumberland County
					Perry County
					Potter County
					Schuylkill County
					Snyder County
					Somerset County
					Sullivan County
					Union County
OK	Alfalfa County				
	Beckham County				
	Blaine County				
	Bryan County				
	Caddo County				
	Canadian County				
	Cimarron County				
	Cotton County				
	Craig County				
	Custer County				
	Garfield County				
	Grant County				
	Greer County				
	Harmon County				
	Harper County				
		PA	Adams County		
			Allegheny County		
			Armstrong County		
			Beaver County		
			Bedford County		
			Berks County		
			Blair County		
			Bradford County		
			Butler County		
			Cambria County		
			Carbon County		

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Venango County Warren County Washington County Westmoreland County York County		Jackson County Jerauld County Jones County Kingsbury County Lake County Lincoln County Lyman County Marshall County McCook County McPherson County Meade County Miner County Minnehaha County Moody County Pennington County Perkins County Potter County Roberts County Sanborn County Spink County Stanley County Sully County Tripp County Turner County Union County Walworth County Yankton County		Clay County Cocke County Coffee County Crockett County Davidson County Decatur County DeKalb County Dickson County Dyer County Fayette County Franklin County Gibson County Giles County Grundy County Hamblen County Hardeman County Hardin County Haywood County Henderson County Henry County Hickman County Houston County Humphreys County Jackson County Jefferson County Lauderdale County Lawrence County Lewis County Lincoln County Loudon County Macon County Madison County Marion County Marshall County Maury County McMinn County
SC	Cherokee County Chesterfield County				
SD	Aurora County Beadle County Bennett County Bon Homme County Brookings County Brown County Brule County Buffalo County Campbell County Charles Mix County Clark County Clay County Codington County Davison County Day County Deuel County Douglas County Edmunds County Faulk County Grant County Gregory County Haakon County Hamlin County Hand County Hanson County Hughes County Hutchinson County Hyde County	TN	Bedford County Benton County Bledsoe County Blount County Bradley County Cannon County Carroll County Cheatham County Chester County		

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	McNairy County		Coleman County		Howard County
	Meigs County		Collin County		Hunt County
	Monroe County		Collingsworth County		Jackson County
	Montgomery County		Comanche County		Jefferson County
	Obion County		Concho County		Johnson County
	Perry County		Cooke County		Jones County
	Polk County		Coryell County		Karnes County
	Robertson County		Cottle County		Kaufman County
	Rutherford County		Crosby County		Lamar County
	Sequatchie County		Dallam County		Lamb County
	Smith County		Dallas County		Limestone County
	Stewart County		Dawson County		Lubbock County
	Sumner County		Deaf Smith County		Lynn County
	Tipton County		Delta County		Martin County
	Trousdale County		Denton County		Matagorda County
	Warren County		Ellis County		McCulloch County
	Wayne County		Falls County		McLennan County
	Weakley County		Fannin County		Milam County
	White County		Fisher County		Mills County
	Williamson County		Floyd County		Mitchell County
			Gaines County		Montague County
			Glasscock County		Moore County
			Gray County		Navarro County
			Grayson County		Nolan County
			Guadalupe County		Nueces County
			Hale County		Ochiltree County
			Hall County		Parmer County
			Hamilton County		Randall County
			Hansford County		Reagan County
			Hardeman County		Red River County
			Harris County		Robertson County
			Hartley County		Rockwall County
			Haskell County		Runnels County
			Hidalgo County		San Patricio County
			Hill County		Schleicher County
			Hockley County		Scurry County
TX	Archer County				
	Armstrong County				
	Bailey County				
	Bell County				
	Borden County				
	Bosque County				
	Bowie County				
	Brazoria County				
	Callahan County				
	Cameron County				
	Carson County				
	Castro County				
	Chambers County				
	Childress County				
	Clay County				
	Cochran County				

## AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY	STATE	COUNTY
	Sherman County		Buckingham County		Wythe County
	Swisher County		Campbell County		
	Taylor County		Caroline County	VT	Addison County
	Terry County		Charlotte County		Franklin County
	Throckmorton County		Clarke County		Grand Isle County
	Tom Green County		Culpeper County		
	Uvalde County		Cumberland County	WA	Adams County
	Wharton County		Dinwiddie County		Benton County
	Wheeler County		Fauquier County		Columbia County
	Wichita County		Fluvanna County		Douglas County
	Wilbarger County		Franklin County		Ferry County
	Willacy County		Frederick County		Franklin County
	Williamson County		Goochland County		Garfield County
	Yoakum County		Greene County		Grant County
			Halifax County		Kittitas County
UT	Box Elder County		Hanover County		Klickitat County
	Cache County		King George County		Okanogan County
	Davis County		King William County		Skagit County
	Emery County		Loudoun County		Snohomish County
	Garfield County		Louisa County		Spokane County
	Juab County		Lunenburg County		Stevens County
	Millard County		Madison County		Walla Walla County
	Morgan County		Mecklenburg County		Whatcom County
	Piute County		Nelson County		Whitman County
	San Juan County		Nottoway County		Yakima County
	Sanpete County		Orange County	WI	Adams County
	Sevier County		Page County		Ashland County
	Utah County		Pittsylvania County		Barron County
	Wayne County		Powhatan County		Bayfield County
	Weber County		Rappahannock County		Brown County
			Richmond County		Buffalo County
VA	Albemarle County		Rockbridge County		Burnett County
	Amelia County		Rockingham County		Calumet County
	Appomattox County		Shenandoah County		Chippewa County
	Augusta County		Spotsylvania County		Clark County
	Bath County		Stafford County		Columbia County
	Brunswick County				Crawford County

AVOIDED CONVERSION OF GRASSLANDS AND SHRUBLANDS TO CROP PRODUCTION

Version 2.0

STATE	COUNTY	STATE	COUNTY
	Dane County		Vernon County
	Dodge County		Walworth County
	Door County		Washburn County
	Dunn County		Washington County
	Eau Claire County		Waupaca County
	Fond du Lac County		Waushara County
	Grant County		Winnebago County
	Green County		Wood County
	Green Lake County		
	Iowa County	WV	Berkeley County
	Jackson County		Greenbrier County
	Jefferson County		Hardy County
	Juneau County		Jefferson County
	Kenosha County		Mason County
	Kewaunee County		Mineral County
	La Crosse County		Preston County
	Lafayette County		Tucker County
	Manitowoc County		
	Marquette County	WY	Big Horn County
	Monroe County		Crook County
	Oconto County		Laramie County
	Outagamie County		Lincoln County
	Ozaukee County		Weston County
	Pepin County		
	Pierce County		
	Polk County		
	Portage County		
	Racine County		
	Richland County		
	Rock County		
	Rusk County		
	Saint Croix County		
	Sauk County		
	Shawano County		
	Sheboygan County		
	Trempealeau County		

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