Carbon Dioxide Removal Methodology, U.S. Cropland Agriculture, V1.3

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1.0 Summary of the methodology

The historic cultivation of croplands has left soils depleted of carbon. Around the world, soils have lost an average of 26 percent of the carbon in the top 30 cm of soil.[1] However, a 2019 report by the National Academy of Sciences identified multiple conservation practices that can "increase carbon stocks in soils and are successfully practiced by progressive farmers and ranchers."[2] These practices are not limited to their greenhouse gas (GHG) benefits; they provide "additional ecosystem service benefits, including watershed protection, increased biodiversity, and improved soil health and fertility."[3] Implementing these practices can generate new income streams and valuable agronomic benefits for producers.

This methodology was developed as the requirements and approach for the Truterra Carbon Project. It provides the criteria and requirements to quantify changes in soil organic carbon (SOC) stocks through the adoption of two agricultural practices: reduced tillage (including no-tillage) and cover crops. The Truterra Carbon Project was launched on February 4, 2021 by Truterra, LLC ("Truterra") a sustainability-focused subsidiary of Land O'Lakes, Inc., one of America's largest farmer-owned cooperatives. It is a transformational new carbon credit project that helps arable farmers quantify increases in the SOC pool through the adoption of certain agriculture management practices that have been demonstrated to increase soil carbon levels.

This methodology provides a biogeochemical modeling approach to quantification. It is applicable to agricultural producers of corn, soybeans, wheat, and cotton in the U.S. It utilizes an innovative approach to retaining carbon dioxide removal. Rather than focusing on a permanence period, it uses the approach of maintaining the durability of the carbon in the soil for a minimum of 5 years after the crediting period. The methodology details the:

- Eligible project activities that are credited,
- Crediting period for credits,
- GHG emission sources included in the project,
- Quantification approach,
- Monitoring requirements, and
- Conditions that could potentially lead to a reversal of SOC sequestration.

[1] Sanderman, J., Hengl, T., Fiske, G.J. Soil carbon debt of 12,000 years of human land use. *Proceedings of the National Academy of Sciences of the United States of America* 114 (36) 9575-9580 (2017). https://doi.org/10.1073/pnas.1706103114

[2] National Academies of Sciences, Engineering, and Medicine 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Washington, DC: The National Academies Press. https://doi.org/10.17226/25259

[3] ibid.

2.0 Project ownership structures and terminology

This section outlines key participants and the ownership structures allowed.

Table 1 – Summary of project ownership categories

Term	Definition	Required Participant
Landowner	The entity with title to the physical property that contains one or more fields within the project area.	No
Farm Operator	The entity with management control over agricultural management activities for a given field(s) in the project area during the relevant reporting period, and with the right to market carbon sequestered on a given field(s). The farm operator may or may not have title to the physical property.	Yes
Project Developer	An entity which manages the monitoring, reporting, and verification of a carbon credit project.	Yes
Project Owner	An entity with legal ownership of the GHG reduction rights for the entire project area.	Yes

There is no requirement for direct participation of the landowner or for production of land title documentation. Every project will involve at least one farm operator. A project is defined in relation to row crop management practices of a specific area of land, and thus the project activities are attributed to the farm operator for that field. Unless there exists a legal instrument transferring the ownership rights to the GHG emission reductions to an entity other than the farm operator, the farm operator is assumed to be the project owner for the relevant field(s).

The project owner will contract directly with each farm operator. The farm operator takes full responsibility for any operations performed by subcontractors or other agents on the eligible field(s). Upon enrollment, the farm operator is asked to attest that they have the exclusive right to operate on the land, they are the only party eligible to receive payment for any carbon assets generated from project activity, and that they have the authority to perform project activities.

The project owner shall have clear ownership of the project's GHG reductions during the crediting period. The project owner shall have a signed contract with the farm operator conveying title to the GHG reduction rights related to the relevant field(s). Through the contracting process, the project owner should confirm that the farm operator has not entered other agreements or marketed carbon rights elsewhere. In this way, the project mitigates against double counting of impacts at design and performance levels.

3.0 Applicability conditions

This methodology is applicable under the following conditions:

3.1 Geographical applicability

- The methodology is only applicable to United States.
- The methodology is only applicable for actively farmed croplands that are owned/managed by private individuals and/or farmers cooperatives.
- The methodology is not applicable on U.S. Tribal lands.

3.2 Regulatory compliance

- The methodology is only applicable where project activities do not cause material violations of applicable laws (e.g., air, water quality, safety).

3.3 Eligible activities and criteria

- The eligible activities under the methodology include the implementation of reduced tillage (including no tillage) and/or cover crops.
- It is only applicable to mineral soils.
- It is only applicable to agricultural producers of the following functional crop groups: corn, soybeans, wheat, and cotton.

3.4 Ineligible activities and criteria

- Histosols or organic soils, such as peat, are prohibited from inclusion in projects. The boundary of any project under this methodology shall be drawn to exclude areas containing Histosol soils.

3.5 Start date

The project start date is the earliest first day of a cultivation year when reduced tillage and/or cover crops practices were first implemented on an eligible field, but cannot be earlier than October 1, 2015. All fields in the project shall have a start date after the project start date. The crediting period for projects under this methodology is 10 years.

The rationale for the retroactive start date is to identify farm operators who have sufficient experience with reduced tillage and/or cover crops to be able to commit to long-term maintenance of the practice. It takes farm operators several years to gain the necessary experience to transition to and successfully maintain reduced till or cover crop practices. Truterra is working with farm operators to gain the necessary experience with the practices before enrolling them in a project and collecting the necessary data required by this methodology. Waiting until the farm operator has experience with practices dramatically increases the durability of the SOC and reduces the risk of these farm operators reversing the implemented practices. Additional detail on the Durability period is addressed in Section 4 of this methodology.

3.6 Additionality

Soil carbon sequestration requires specific management practices tailored to the unique conditions of each farm, which can vary based on geography, crop rotations, growing year and environmental conditions. The highest quality credits come from farm operators with multiple years of experience with

these practices, including multiple years of benchmarking/experimenting to determine and refine the ideal practices for each field.

The activities credited by this methodology shall be implemented by the farm operator at the time the field joins the project. The baseline management scenario should not include eligible activities that are part of the project unless an eligible practice is part of the baseline and the farm operator implements an additional eligible practice at the time of joining the project. The credited SOC practices are the implementation of reduced tillage and/or cover crops. Farm operators shall implement at least one of the activities on at least one of their fields to participate in the project. The project activity is considered additional if the net carbon dioxide removals are over and above the counterfactual/business as usual (BAU) scenario. The project shall demonstrate additionality using the following criteria:

- **Regulatory Surplus:** The project shall demonstrate that there are no local, state or federal regulations requiring the farm operator to implement the eligible activities.

4.0 Crediting, reporting and durability periods

4.1 Crediting period

The crediting period for projects under this methodology is ten years, and begins at the project start date regardless of whether sufficient monitoring data are available to verify GHG reductions.

4.2 Reporting period

The reporting period is the period of time over which GHG emission reductions from project activities are quantified. The typical reporting period under this methodology is one complete cropping season, or generally the period between the first day after harvest of the last crop on a field and the last day of harvest of the last crop on a field during the reporting period (typically October 1 through Sept 30 of the following year).

4.3 Durability period

The implemented practices shall be maintained for a minimum of 5 years after the final crediting year. Any fields that do not maintain the implemented practices for 5 years post crediting shall be considered a reversal (see Section 8).

Once a practice change has been made and maintained for over a 5-year durability period, that practice is effectively permanent, as the risk of practice reversal at that point is very low.

During the durability period, farm operators shall provide Truterra with annual reports, which confirm that they have maintained the implemented practices. Where applicable, these reports shall be submitted to Truterra with support of Truterra network providers who have a personal relationship with the farm operator and routinely visit their operations.

Monitoring of tillage and cover practices via remote sensing provides an additional datapoint for checking eligibility during the durability period.

5.0 Selected emission pools and sources

The table below includes the carbon pools and emission sources included or excluded from the project boundary.

Table 2 – Carbon pools, Emission sources, sinks and reservoirs included in projects

Source/Sink	GHGs	Status	Justification
Soil organic carbon stock(s)	CO_2	Included	Soil organic carbon can be impacted both positively and negatively by the regenerative farming practices incentivized by this project. Mineral soils are included in the project scope, but organic soils, such as peat, are not.
	CH_4	Excluded	Regenerative farming practices are not expected to generate methane emissions (soil methanogeneis) and are therefore excluded.
	N_2O	Excluded	N_2O is not a material GHG targeted in this emission source.
Emissions from fuel use (fossil fuels and electricity)	CO_2	Included	Fuel use emissions may increase or decrease depending on management activities.
	CH_4	Excluded	CH_4 is not a material GHG targeted in this emission source.
	N_2O	Excluded	N_2O is not a material GHG targeted in this emission source.
Emissions from irrigation energy use	CO_2	Excluded	Emissions associated with energy use for in-field irrigation are expected to be the same year-over-year.
	CH_4	Excluded	
	N_2O	Excluded	
Emissions from the use of synthetic fertilizers	CO_2	Excluded	Emissions associated with the production of synthetic fertilizers are typically excluded from carbon projects because they are upstream emissions out of the scope of the project boundary (on-farm Scope 1 emissions).
	CH_4	Excluded	CH_4 is not a material GHG targeted in this emission source.
	N_2O	Included	Emissions associated with the use of synthetic fertilizers are known to be a material source of farm emissions and may increase or decrease depending on management activities.
Emissions from crop residue management	CO_2	Excluded	CO_2 is not a material GHG targeted in this emission source.

	CH_4	Excluded	CH_4 is not a material GHG targeted in this emission source.
	N_2O	Included	Emissions associated with the use of nitrogen fixing species are known to be a material source of farm emissions, both positive and negative.
Emissions from livestock	CO_2	Excluded	CO_2 is not a material GHG targeted in this emission source.
	CH_4	Excluded	Emissions from enteric fermentation or manure management are excluded as livestock management practices are outside the scope of this program
	N_2O	Included	Emissions from livestock manure applied to the land are impacted by management practices.
Biomass burning	CO_2	Excluded	Biomass burning is highly uncommon in the U.S. Corn Belt and often occurs on a limited area basis, if at all. Since little to no biomass burning is anticipated in the project, emissions from this source are likely to be insignificant and below a *de minimis* threshold.
	CH_4	Excluded	
	N_2O	Excluded	
Aboveground biomass	C	Excluded	This carbon pool is not included because it is not subject to significant changes, or potential changes are transient in nature.
Belowground biomass	C	Excluded	This carbon pool is not included because it is not subject to significant changes, or potential changes are transient in nature.

Dead wood	C	Excluded	This carbon pool is not included because it is not subject to significant changes, or potential changes are transient in nature.
Litter	C	Excluded	This carbon pool is not included because it is not subject to significant changes, or potential changes are transient in nature.

6.0 Quantification of carbon dioxide removals

This methodology uses biogeochemical process modeling to support the quantification of GHG fluxes in soil organic carbon stocks. The complex fluctuation of GHGs in agricultural systems makes direct measurement of SOC stocks and corresponding emissions extraordinarily difficult. To directly measure them would require complex, expensive monitoring equipment in every field with continuous monitoring conducted by specialized experts. This level of monitoring is not yet cost effective. Therefore, to quantify these emissions, sophisticated biogeochemical models have been developed by the scientific community. Once parameterized, calibrated, and validated, these models can accurately estimate the GHG fluxes in agricultural systems.

The table below provides a summary of what SSRs may be modeled or calculated.

Table 3 - Quantification approaches for GHG sources

GHG	Source	Modeled	Calculated
CO_2	Soil organic carbon stock(s)	X	
	Emissions from fuel use (fossil fuels and electricity)		X
N_2O	Emissions from the use of synthetic fertilizers	X	X
	Emissions from livestock	X	X
	Emissions from crop residue management	X	X

6.1 Baseline

The baseline GHG emissions and SOC are quantified for each field. The baseline for each enrolled field is calculated using a full crop rotation or at least three years of historical field-level data from prior to the start of the project activities.

6.1.1 Baseline scenario

The baseline scenario for each participating field represents a business-as-usual approach for that specific field, based on field-specific management data from before the adoption of the eligible project activity. The baseline shall be modeled for each cultivation cycle for each field included in the project. The model shall use the corresponding, regionally-appropriate weather data associated with the agronomic data. For example, a 2021 cropping cycle shall use weather data from 2021.

This methodology applies a blended baseline approach. A blended baseline indicates that the baseline scenario represents all possible cultivation options represented in the historical baseline period averaged together. A blended baseline means that in the current reporting period, the model will be used to individually simulate every year from the historical baseline period, regardless of crop. The outputs from the model are averaged together to determine the baseline SOC stock change and emissions. The baseline simulations are continuous, meaning in the next cultivation cycle the individual baseline simulations will continue with whatever is the next cultivation cycle from the historical baseline period. The number of simulations corresponds to the number of cultivation cycles in the historical baseline period, with the pattern staggered such that each simulation covers one complete baseline cultivation cycle in every year of the project.

This blended baseline approach mitigates the impact of arbitrary crop sequencing on the modeled results. For example, simply repeating the pre-practice change management through the baseline scenario could result in crop seasons where a high biomass crop in the practice change scenario is compared to a low biomass crop in the baseline scenario, resulting in SOC gains that are significantly driven by the crop biomass difference. The blended baseline approach reduces the influence of the cropping pattern in the baseline scenario when it does not match the practice change scenario.

6.2 Project activities

SOC stocks from eligible project activities shall be quantified using modeling. Modeling shall be conducted for each cropping season to quantify the credits generated by changing tillage practices and/or implementing cover crops. Weather information for the specific year shall be used to calculate the SOC stocks in each year of the project.

6.2.1 Project activities scenarios

The project activities for this methodology are a change to tillage practices and/or implementation of cover crops.

6.2.2 Quantification of SOC stock changes and GHG emissions

SOC stock changes are modeled for each project field and project year. The modeled output for the project scenario (SOC change year-to-year) is reduced by the modeled output for the blended baseline scenario (SOC change year-to-year, average across all baseline scenarios) to determine the additional SOC change that is enabled by the eligible project activities.

$$\Delta SOC_y = \Delta SOC_{PC,y} - \Delta SOC_{B,y}$$

Where

ΔSOC_y	=	change in SOC stocks during crop year y
$\Delta SOC_{PC,y}$	=	modeled change in SOC stocks during project scenario crop year y
$\Delta SOC_{B,y}$	=	modeled change in SOC stocks during baseline thread crop year y

Modeled or calculated N_2O emissions from the project scenario are subtracted from modeled or calculated N_2O emissions from the blended baseline scenario (average across all baseline scenarios).

$$N_2O_y = N_2O_{PC,y} - N_2O_{B,y}$$

Where

N_2O_y	=	N_2O emissions during crop year y
$N_2O_{PC,y}$	=	N_2O emissions during project scenario crop year y
$N_2O_{B,y}$	=	N_2O emissions during baseline thread crop year y

Calculated CO_2 emissions from the project scenario are subtracted from calculated CO_2 emissions from the blended baseline scenario (average across all baseline scenarios).

$$CO_{2y} = CO_{2PC,y} - CO_{2B,y}$$

Where

CO_{2y}	=	CO_2 emissions during crop year y
$CO_{2PC,y}$	=	CO_2 emissions during project scenario crop year y
$CO_{2B,y}$	=	CO_2 emissions during baseline thread crop year y

Total GHG emissions for each field and each year are then determined by summing the GHG emissions across all included sources and sinks.

$$\Delta CO_2_proj_y = \Delta SOC_y + N_2O_y + CO_{2y}$$

Where

$\Delta CO_2_proj_y$	=	carbon dioxide emission reductions from the project field during crop year y

6.3 Model parameterization and calibration

Biogeochemical models are extensively used to predict SOC changes and GHG emissions due to agricultural practices. Their ability to represent different agricultural systems depends on different factors including both the appropriateness of their use for the agricultural system but also the model parameterization, calibration, and validation procedures implemented. This methodology employs the use of a process-based model that has a robust history of use in simulation efforts to quantify ecosystem level responses to changes in agricultural practices in croplands in the U.S. and has demonstrated its ability to confidently represent the dynamics of SOC stocks and GHG emissions. The modeling approach shall be informed by methods and processes from peer reviewed literature.

The calibration procedure shall be based on the identification of the parameters that govern different processes within the model (such as, crop productivity and initial SOC stocks) and their estimation will reduce model prediction error. These parameters, for example, crop productivity or carbon and nitrogen values of roots, leaves and stems of a particular crop shall be selected from publicly available peer-reviewed, published literature sources from the region in which the practices are implemented. Model parameters may be updated with directly measured values where they exist for the practices and regions as long as SOC and related GHG measurements have been conducted in conjunction with the measured values.

Model calibration, which is the process of tuning these model parameters, to the peer-reviewed literature data enables a comparison to published data so a determination of the acceptable level of model fit and bias specific to the geographic region targeted prior to use by project proponents is ascertained. The model shall be calibrated for each combination of crop, geography and project activities before it can be used in a project and the same model parameters shall be used across the project domain. The calibration procedure, approach, and results shall be maintained by the project proponent and provided to the verifier upon request. Model calibration shall be run with independent values from model validation.

6.4 Leakage

Leakage corresponds to an increase in GHG emissions outside the project boundary due to the proposed and implemented project activity. Leakage refers to activities that occur on lands outside of the project areas, but in direct response to project activities. Leakage risk can be managed through do-no-significant-harm assessments.

Leakage results from an overall decrease in crop yield from fields participating in the project being offset by increased cultivation by other producers in the market using conventional management practices. If crop yields decrease because of project activities, the project is considered to have resulted in leakage. Leakage occurs when the annual yield of the primary (cash) crop is more than 10% less than the 10-year average state yield for that crop, according to USDA NASS statistics.

Emissions caused by reductions in yield of more than 10% shall be accounted for as leakage, unless the project owner provides evidence that yield reductions were caused by factors unrelated to the project activity, e.g., regional yield reduction due to force majeure events such as fire, flood, or civil war; crop failure or prevent plant due to extreme weather.

7.0 Monitoring parameters and frequency

Farm operators use the Truterra Sustainability Tool (TST) to assist in the collection and management of the data required for the project. The information in the table below is collected using the TST, with the support of Truterra network providers and a team of Truterra data coordinators. All data categories, even if the collection frequency is once, are reviewed on an annual basis to confirm if any changes occurred during the project year. An example of a potential change to data collected at project initiation is the installation of a tile drainage system.

Table 4 - Data collected for projects

Data Category	Data Field	Collection Frequency
Field characteristics	Climate Zone	Once
	Slope	Once
	Soil type and texture	Once
	Hydrology	Once
Winter Crop	Crop Type	Crop Year
	Plant Date	Crop Year
	Harvest/Termination date	Crop Year
	Yield/Termination method	Crop Year
	Was crop residue removed? If so, how was it removed from the field?	Crop Year
Summer Crop	Crop Type	Crop Year
	Plant Date	Crop Year
	Harvest/Termination date	Crop Year
	Yield/Termination method	Crop Year
	Was crop residue removed? If so, how was it removed from the field?	Crop Year
Tillage	Tillage pass date	Each event
	Tillage pass type	Each event
Irrigation	Is this field irrigated?	Crop Year
	If so, what irrigation method do you use?	Crop Year
	If so, what water source do you use?	Crop Year
Drainage	Does your field have a tile drainage system?	Crop Year
Fertilizer	Type of fertilizer applied	Each event
	Type of product applied	Each event
	Fertilizer application date	Each event
	Fertilizer application timing	Each event
	Fertilizer application method/placement	Each event
	Amount of Product Applied (lbs./ac)	Each event
	N Applied (lbs./ac)	Each event
	P Applied (lbs./ac)	Each event
	K Applied (lbs./ac)	Each event
	Is fertilizer additive used?	Each event

8.0 Reversal events

A reversal occurs if stored carbon is deemed to be released through a disturbance of the project area or when any portion of the project area leaves the project during the durability period (i.e., it is no longer included in monitoring).

Reversal events can be either avoidable or unavoidable. Avoidable reversals are intentional actions that result in the release of SOC from the project by activities under the control of project participants. Examples of avoidable reversals are returning a field to conventional tillage. Portions of the project area

leaving the project before the completion of the durability period are also treated as avoidable reversals. Unavoidable reversals are events outside the control of project participants. Potential unavoidable reversals include drought, fire, and flood.

If a reversal occurs during the durability period, the reversal is recorded in project monitoring documentation and TST. Reversal documentation requirements do not apply to emission reductions unrelated to carbon stored in the project area soils (e.g., CH_4 and N_2O).

In the event of a reversal event on a field, the total carbon dioxide emission reductions from the soil organic carbon pool during the crediting period of that field shall be calculated, and the amount of the reversal recorded in project monitoring documentation.

9.0 Definitions and terms specific to the methodology

Additionality: Additionality is a fundamental principle of project-level carbon accounting that ensures that any intervention – in this case, SOC enhancements -- is not required by any law, regulation or statutes, and that the creditable activity or technology results in less GHG emissions (or more carbon removals) than the business-as-usual counterfactual.

Avoidable Reversal: Intentional **r**eleases of CO_2 resulting from a planned activity, such as a field leaving the project and reverting to conventional tillage practice.

Baseline: Conventional agricultural practices (e.g., tillage practices, fertilization, residue management) that generate a counterfactual/business as usual GHG emission assessment and against which GHG emission reductions/removals from a specific conservation agricultural practice are measured.

Carbon Asset: A unit representing one metric ton of GHG reduced/sequestered as a result of the project and intended to be permanently stored or otherwise sequestered in the soil.

Durability Period: The 5-year term after the crediting period that the carbon assets delivered under this project are required to retain the carbon sequestered in the soil.

Farm Operator: The entity with management control over agricultural management activities for a given field(s) in the project area during the relevant reporting period, and with the right to market carbon sequestered on a given field(s). The farm operator may or may not have title to the physical property.

Greenhouse Gas: Any of the potent atmospheric gases identified in the Kyoto Protocol including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).

Leakage: A decrease in ecosystem services outside the boundaries of the project as a result of implementation of the project. Leakage may be caused by the shifting activities of people present in the project area or by market effects beyond the project area. For example, a decrease in yield resulting from cover crops results in more acreage being farmed outside the project area.

Mineral Soils: Non-histosol soils as identified via the SSURGO soils database.

Model Calibration: The process of running a biogeochemical model with publicly available peer-reviewed, published literature parameters to determine the accuracy of the model prior to use by project proponents.

Model Parameterization: The selection of data parameters to calibrate a model.

N-fixing species: Plant species that associate with nitrogen-fixing microbes found within nodules formed on the roots.

Permanence: The durability period for which a C-sequestering practice is carried out. The term "permanence" references the market standard definition that permanence is a necessary condition for creditable CO_2 emission reductions and removals.

Project Developer: An entity which manages the monitoring, reporting, and verification of a carbon credit project.

Project Owner: An entity with legal ownership of the GHG reduction rights for the entire project area.

Project Participant: An individual or entity that is contributing to the generation of the Carbon Removal Units. Project participants include farm operators, project developers and the project owner.

Reduced Tillage: The reduction of tillage from the baseline condition to the project scenario. This includes changes from conventional tillage to strip till or no till.

Reversal: An escape or release into the atmosphere during the Durability Period, as a result of a Reversal Event, of any stored or otherwise sequestered CO_2 represented by project carbon assets.

Reversal Event: Any event or circumstance occurring after delivery of any project carbon assets and during the Durability Period, whether intentional or unintentional, that results in a Reversal. Soil may be subject to weather force majeure events, including flooding, land hurricanes and tornadoes that are outside the control of the Project Owner and Project Participants.

Soil Organic Carbon: According to the United Nations Food and Agriculture Organization, soil organic carbon (SOC) sequestration is “the process by which carbon is fixed from the atmosphere via plants or organic residues and stored in the soil.”

Unavoidable Reversal: Releases of SOC resulting from natural disasters, such as drought, fire, or flood.