Conservation Evaluation and Monitoring Activity

Soil Organic Carbon Stock Monitoring

CEMA 221

Definition

Quantitative measurement of soil organic carbon stocks.

Used to quantify the levels of organic carbon stored in the soil and monitor the change in soil carbon stocks before and after the implementation of a conservation practice or conservation plan.

Applicable Land Uses

All land uses where a change in management or vegetation may change soil organic carbon stocks.

REQUIREMENTS

Qualified Individual Requirements

The Natural Resources Conservation Service (NRCS) strongly encourages participants to know the following Qualified Individual (QI) Requirements to ensure the person they hire is a good match for their needs and objectives.

A QI for this CEMA must meet one of the following:

- Certified Crop Advisor (CCA), Certified Professional Agronomist (CPAg) through the American Society of Agronomy or a Certified Professional Soil Scientist (CPSS) through the Soil Science Society of America.
- Technical Service Providers (TSP) certified for Conservation Practice Standard (CPS) Nutrient Management (Code 590) or Soil Health Management Design and Implementation Activity (162).
- Associates degree or higher in an agricultural or soil science with at least 2 years of experience collecting soil for laboratory analysis.

Individuals under the guidance or management of a QI are allowed to collect soil samples for this CEMA.

General Requirements

1) This CEMA includes the performance of work and documentation of the tasks, results, interpretations, and other activities described herein by a QI.
2) Prior to initiation of the CEMA, the QI must arrange a pre-work conference to ensure all parties understand the participant's objectives, required deliverables, and characteristics of the CEMA tasks.

a) The parties in the pre-work conference must include the participant, the QI, and the NRCS field office staff. The parties should agree whether they will join in-person or join via phone, web-meeting, etc.

b) If the participant will employ a TSP to implement a Conservation Planning Activity (CPA) or Design and Implementation Activity (DIA) that will be supported by results of this CEMA, it is recommended to invite them to the pre-work conference too.

3) A QI may use any reference information, resource concerns, conservation practice standards and related documents served in the NRCS Field Office Technical Guide (FOTG) for the state where this CEMA is performed. The FOTG home page hyperlink is: https://efotg.sc.egov.usda.gov/#/

Technical Requirements

Follow the criteria in this CEMA to complete the work and document the tasks, results, and other interpretations related to soil organic carbon (SOC) stock measurement.

Use the following sampling protocol to ensure accurate SOC and bulk density measurements:

1) Site Selection

Select a representative management unit or field to sample soil.

Identify and digitize an area of interest (AOI) of the footprint of the planned or applied conservation practice(s) where soil samples will be collected, as well as the required minimum land management information. Locate the AOI in a region that has been managed uniformly and is representative of the larger management unit. Do not exceed 20 acres when creating the AOI. Ensure the AOI is not on a histosol (muck or peat soil) since these are soils formed in mostly organic material.

Web Soil Survey provides soil data and information that can be used to identify an AOI. Other resources such as recent aerial imagery, normalized difference vegetation index (NDVI), Landsat, soil adjusted vegetation index (SAVI), elevation data, slope, aspect, yield maps, producer knowledge can also be used to determine if the soil and vegetation within the AOI is uniform, or if there are distinct variations that can be clustered together (stratification).

Contact all applicable utilities in the project area, or a coordinated entity, such as 811, State One Call system, MISS UTILITY, DIG SAFE, etc., to check for any buried utilities. The landowner and/or the QI are responsible for locating all buried structural measures in the AOI, including drainage tiles and other structural measures. Contact the local soil and water conservation district for assistance in locating any buried conservation measures.

2) Soil Sampling Strategy

Identify locations within the AOI polygon to collect soil. Mark each sampling point on a map and record the coordinates. This is important for repeatability of soil sampling. Use either of the following sampling strategies:

a) Uniform Sampling.

If there is generally only one dominant soil type and no reason to believe that there is significant variability in factors affecting carbon amount or response to management in the AOI, identify 6 random locations to collect soil.

b) Stratified Sampling.

If there is soil stratification in the AOI, identify random sampling locations in each of the strata. If there are 2 strata, identify 3 random locations per strata. If there are 3 strata, identify 2 random locations per strata. If there are more than 3 strata, select another AOI.

3) Sample Collection

Navigate to each sampling location using a GPS (WGS84). Record the actual location if it is different than the predetermined location.

Ensure equipment is relatively clean prior to collection. Remove all plant/organic matter (e.g., crop residue, moss) and ensure the surface of the mineral soil is bare.

When allowable, collect soil either before tillage/planting operations or after harvest operations. Ensure soil is not saturated or frozen. If soil is collected during other times of the year:

- Wait at least 8 weeks after tillage, additions of soil amendments or fertilizers, or other disturbances, or
- Collect soil at the same time of year under similar management conditions when production system or climate do not allow a waiting period of 8 weeks.

Do not collect soil from:

- Wheel tracks or drive lanes, field borders, depressions, within 25 ft. of a gravel road, or any other odd areas within the field.
- Different landscape positions (*i.e.,* summit, shoulder, backslope, foot-slope, or toe-slope).
- Eroded versus non-eroded areas.

Soil samples can be collected using either a soil probe (hydraulic or mechanized) or with a shovel (excavation).

If using a soil probe, ensure it has a minimum length of 100 cm and minimum diameter of 5 cm to collect soil for organic carbon and bulk density measurements from each of the following 4 depths:

Sampling Increment	**1**	**2**	**3**	**4**
Sampling Depth (cm)	0 to 15	15 to 30	30 to 60	60 to 100

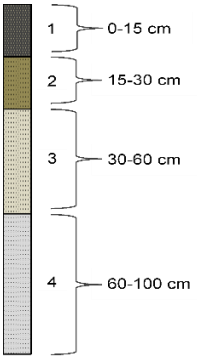

Figure 1. Soil Core Depth Increments

The probe must be free of rust, have a steel corer, and should be used without lubrication. In situations where lubrication is needed, use a sampling sleeve made of plastic or acrylic.

Collect the following number of cores:

- 6 cores for a uniform AOI
- 6 cores for a stratified AOI
    - 3 cores per strata when there are 2 strata
    - 2 cores per strata when there are 3 strata

If sample collection is not possible due to a restrictive layer or a municipal ordinance, collect soil from the maximum depth possible and record the depth.

When coarse fragments prohibit the use of a hydraulic probe for sampling, use the excavation method to sample to depth.

Take georeferenced digital images during soil collection. Images should include:

- 1 image of the entire AOI (landscape photo from sampling site).
- 1 image of each sampling location (include soil probe and bare soil surface).
- 1 of each core after extraction and prior to processing with a measuring tape.

4) Sample Processing

Create a sample ID, and label re-closable, plastic, freezer-grade bags prior to going to the field. Use a name system such as field name or Farm Name, Farm Number, or Tract number. Include type of sample (bulk density or carbon), depth of sampling, soil name, and date collected. It is recommended the labeling guidance found in the 2022 Dynamic Soil Properties Guide be followed.

Record sample ID, GPS data and other required information.

Measure and remove soil from one depth increment and place in the appropriately labeled bag. Keep collected samples cool and out of sunlight while in the field.

After returning from the field, place samples in a cool dark place until shipping. Do not oven dry or freeze. Ship soils within 2 weeks of sampling. Follow all USDA-APHIS regulations for

prohibited, regulated, or quarantined soils.

5) Soil Analysis

Soils samples will be shipped to laboratories that measure soil carbon by dry combustion. See Soil Health Technical Note 450-03 for more information on measuring soil organic carbon.

Ensure laboratories maintain current certification for one of the following:

- The Performance Assessment Program (PAP) from The North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America, or
- The American National Standards Institute (ANSI) National Accreditation Board (ANAB), or
- The International Organization for Standardization (ISO/IEC 17043:2010) for ISO 10694:1995

Measure bulk density and organic carbon on each core increment without compositing. Six cores x 4 depths = 24 measurements.

Use the same laboratory to measure bulk density or measure the volume and oven dry weight of fine earth soil material, and coarse fragments separately to calculate the bulk density. The same method for estimating coarse fragments must be applied for repeat sampling.

When soil is collected by excavation:

- Measure bulk density at each depth using compliant cavity (water or polyurethane foam), clod paraffin, or coring. However, the same method must be applied for repeat sampling.
- See “Procedures and Protocols for Field Data and Sample Collection” located in the reference section for details.
- Calculate or visually estimate the coarse fragment content.

6) Calculations and Reporting

Calculate the soil organic carbon stock for each layer using the corresponding bulk density results and the following formula:

Bulk Density (grams/cubic cm) x Soil Organic Carbon (%) x Thickness (cm) x Volume of Soil (1 – coarse fragment%)

Measure the internal diameter of the soil core cutting tip and record the height in cm. Calculate the volume of the bulk density sample in cubic cm. Average the bulk density values obtained from each depth increment.

Calculate cylinder volume using $V = \pi r^2 h$. (π = Pi or 3.14, r = radius, h = height)

7) Monitoring and Resampling

It is recommended to schedule this CEMA at least 2 times. Take the first test prior to practice implementation and the second test 3-5 years after the first test.

Use the same georeferenced locations and sampling strategy under similar soil conditions, and the same time of year for the second test to monitor practice effects.

Send soil for analysis to the same laboratory.

DELIVERABLES

The QI must provide documentation showing all the tasks indicated in the **General Requirements** section, the **Technical Requirements** section, and the following sections:

Cover Page

Cover page reporting the technical services provided by the QI. Cover page(s) must include the following:

1) CEMA name and number.
2) Participant information: Name, farm bill program name, contract number (QI obtains contract number from participant), land identification (e.g., state, county, farm, and tract number).
3) QI name, address, phone number, email.
4) A statement by the QI explaining how they currently meet the Qualified Individual Requirements for this CEMA. Attaching or enclosing a copy of documentation for how the QI requirements are met is encouraged. Examples include:
    - Certification Name and Number,
    - License Name and Number,
    - Agricultural Retailer Business Name, or
    - Other brief written statement indicating how the requirements of a QI for this CEMA are met.
5) A statement by the QI that services provided meet NRCS requirements, such as:

    I certify the work completed and delivered for this CEMA:

    - *Complies with all applicable Federal, State, Tribal, and local laws and regulations.*
    - *Meets the general requirements, technical requirements and deliverables for this CEMA.*
    - *Is consistent with and meets the conservation objectives for which the program contract was entered into by the participant.*
    - *Addresses the participant's conservation objectives for this CEMA.*

    QI Signature: _____ Date: _____
6) A Participant's acceptance statement, such as:

    I accept the completed CEMA deliverables as thorough and satisfying my

objectives.

Participant Signature: _____ *Date:* _____

7) A space for an NRCS reviewer to certify the agency's acceptance of the completed CEMA and, such as:

NRCS administrative review completion by:

Signature: _____ *Title:* _____ *Date:* _____

Notes and Correspondence

1) Document each site visit, its participants, the activity completed in the field, and results of each site visit.
2) Copies of correspondence between the QI and the participant relating to decision-making and completion of this CEMA.
3) Copies of observations, data, technology tool output, or test results prepared during completion of this CEMA.

Deliver Completed Work

1) The QI must prepare and provide the participant two sets of all of the items listed in the **General Requirements**, the **Technical Requirements** and the **Deliverables** sections of this document.
2) One set is for the participant to keep.
3) The other set is for the local NRCS Office.
4) The QI may transmit a set of the completed work to the local NRCS Office, if their participant has authorized it.

It is recommended to provide the NRCS field office an opportunity to review the CEMA deliverables, prior to asking for their acceptance.

References

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