Soil Sampling Methodology

This methodology is used for determining soil organic carbon in the Project Area during sampling events - the baseline determination and subsequent monitoring.

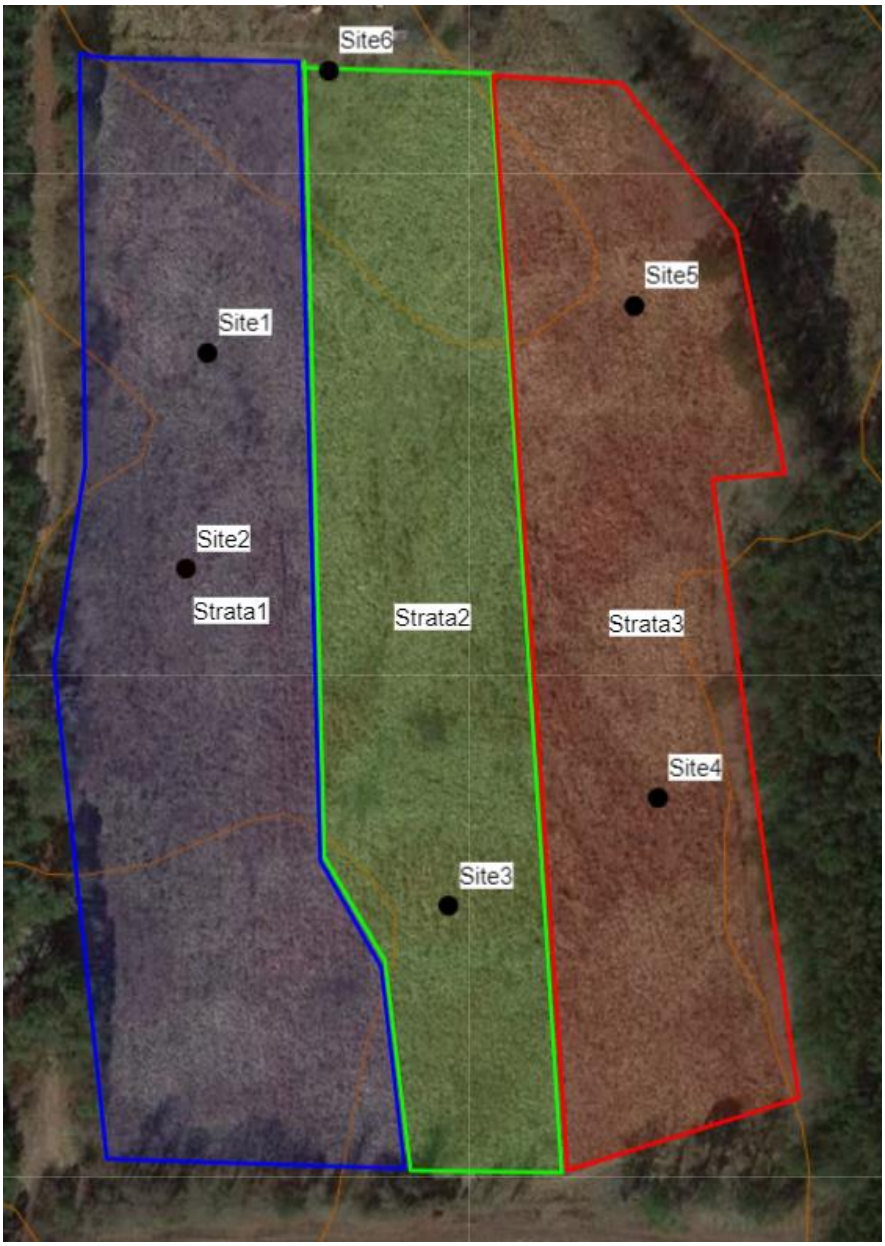
Equipment

- Coring Device (e.g., soil probe) capable of taking soil cores to 30 cm of depth - hinge style recommended
- Compass
- Transect measuring tape or 3-meter measuring tape
- Ruler or measuring tape with centimeter markings
- Offset spatula for removing soil from coring device
- Metal file to create depth markers on coring device
- Log for recording soil cores
- One-gallon Ziploc or paper bags for storing composite samples
- Permanent marker
- 3 buckets for mixing composite samples
- GPS device, phone or handheld
- Bent rebar and flagging tape
- Bulk density equipment

Stratification

Stratification is a tool for increasing the accuracy of soil carbon measurements and decreasing the intensity of sampling required. The Project Area will be subdivided into different strata based on factors such as management history, slope, aspect, soil type, erosion, compaction, and vegetation type. The idea is to determine strata that maximize variation between strata and minimize variation within strata.

The determination of strata is highly dependent on the specific Project Area. Land may be relatively homogenous and consist of only one strata. Strata do not need to be contiguous. See map below for an example of stratification on a 10-acre field. Once strata have been determined, the RGP Practitioner must develop a map of the strata that are located in the Project Area.



Strata Number	Acreage	Description
1	4	Western aspect with 1 to 4-degree slope, primarily soil type Wedowee sandy loam, main drainage pathway - wetter
2	3	Central portion of land, soil type Wedowee sandy loam, drier
3	3	Eastern aspect with 1 to 3-degree slope, primarily soil type Wedowee sandy loam, bordering pine forest and increased acidity of soil

Sampling Intensity: Number of Sampling Sites per Strata

This methodology sets a lower bound on the number of sampling sites in order to minimize the risk that the change in SOC is due to spatial variation rather than management practices. In each strata there must be at least three sampling sites established. If any one strata accounts for more than 50% of the Project Area, then that strata must have at least five sampling sites.

Sampling

Determining Sampling Location and Season

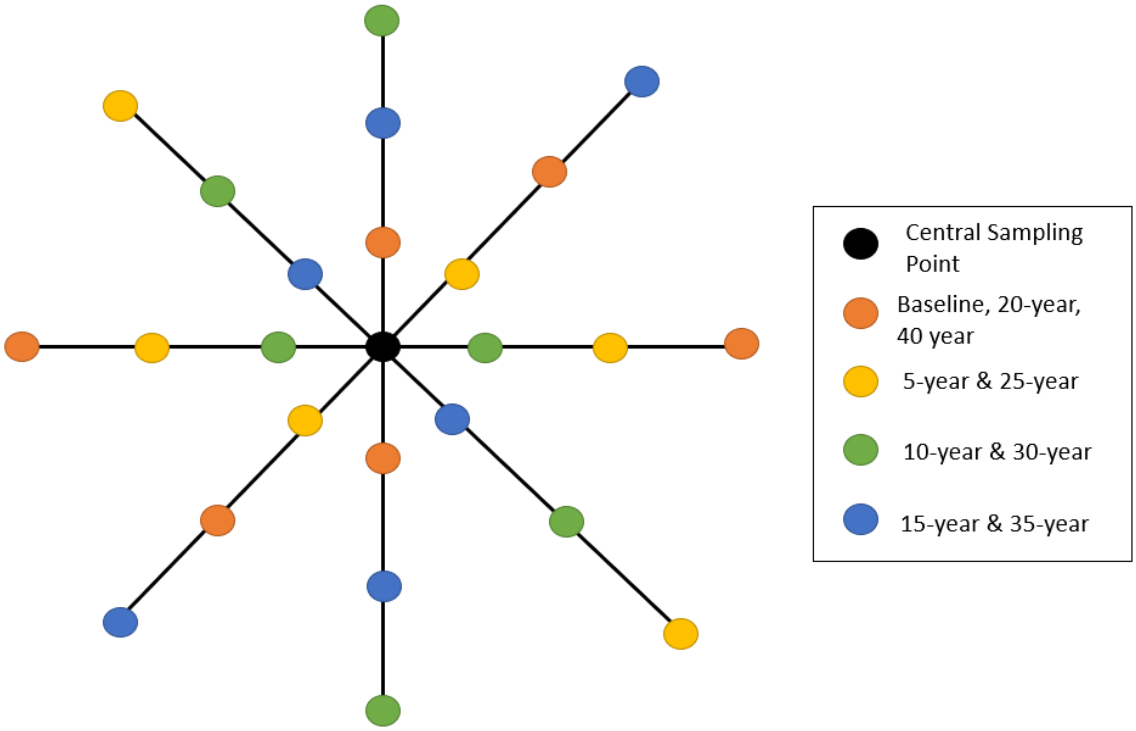
Once the strata and sampling intensity have been determined, the RGP Practitioner must establish sampling sites. Sites should be representative of the strata. RGP Practitioners should avoid sampling in irregular locations such as low points, areas near fences, or areas subject to increased compaction. Sampling at each site will cover a 3-meter radius from the central sampling point and the entire area must be contained within a strata. Future sampling events should occur at roughly the same time of year to ensure comparability. The ideal time of year for soil sampling can vary by soil type, but sampling during the summer or winter can be difficult due to very dry or frozen soil.

Establishing Central Sampling Point

The sampling sites determined in the baseline will be revisited during monitoring, so the locations of each site need to be recorded. The preferred method is to drive a length of bent rebar into the ground, mark with flagging tape, and record the GPS coordinates to facilitate relocating the point. In areas where this method is not possible, the GPS coordinates of the central point must be recorded and the RGP Practitioner must take detailed notes of nearby landmarks, measuring distance from landmarks when possible to facilitate relocation of the central sampling point. Name each central point and label on the map.

Sampling Plan

At each sampling site, the RGP Practitioner will take 6 cores. Multiple cores reduce the chance that the SOC measurement is due to an irregularity in the soil. From the central sampling point, use a compass to determine magnetic north. The baseline cores will be taken one meter north and south of the central point, 2 meters northeast and southwest, and three meters east and west as represented in the image below. This method will allow for subsequent sampling to occur without resampling the same locations disturbed by the baseline coring.



Preparing a Log

Prepare a log before going into the field and note the following for each core:

- Core name (will correspond to the name given to the central sampling point and the appropriate cardinal direction, i.e. A-Northwest)
- Date of core
- Strata
- Nominated sampling depth
- Actual sampling depth
- GPS coordinates of central point
- Notes
    - If taking a bulk density sample, note the diameter of the sampling device.
    - Note reasons for any disparities between actual sampling depth and nominated sampling depth.

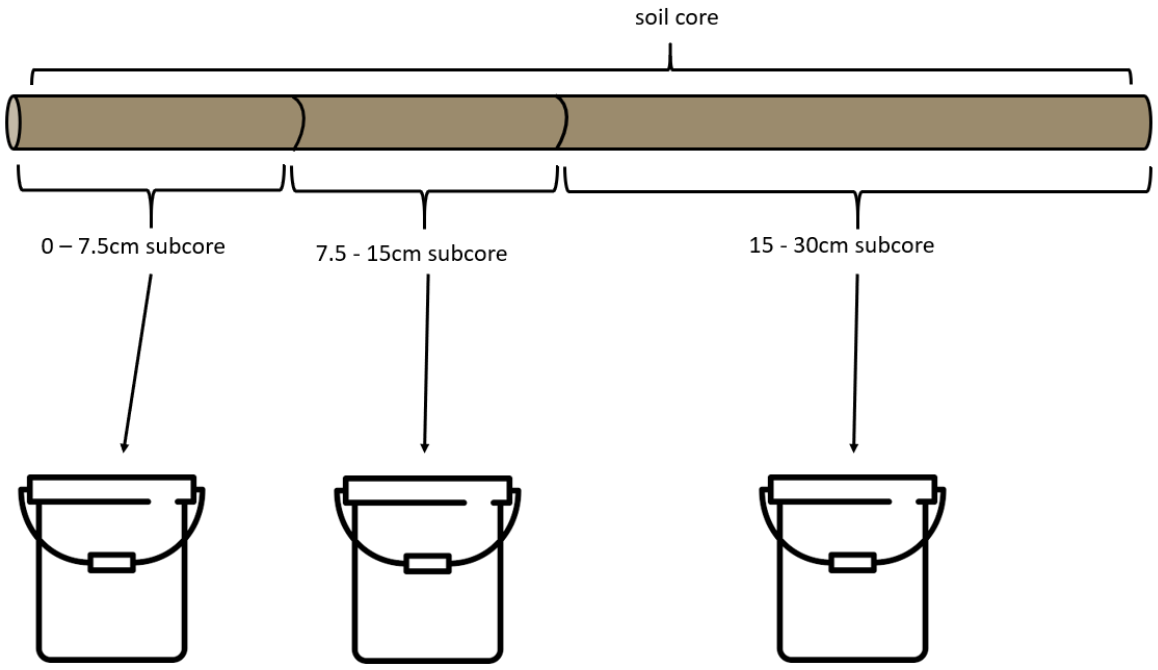
Taking Samples

To reduce lab analysis costs, this methodology relies on composite sampling. Subcores from the 6 cores will be aggregated based on soil depth; ultimately each sampling site will yield 3 composite samples.

Clear away any grass, pats, or debris to get to the topsoil level. Carefully sink the coring device (e.g., soil probe) into the ground and pull up the core. If the full 30 cm cannot be extracted, attempt to resample in the immediate vicinity of the first location. If the soil cannot be adequately sampled due to bedrock, hard pan, or soil composition, you can choose another central sampling point or log the actual sampling depth that you were able to reach.

Divide the core into three subcores based on the nominated sampling depth - from 0-7.5 cm, from 7.5-15 cm, and from 15-30 cm. Using a metal file to mark these depths on the probe can speed the process of determining where to divide core into subcores. The offset spatula is a useful tool for dividing the core into subcores and removing subcores from the coring device. Discard any soil beyond 30 cm.

Place each subcores into a different container labelled with the appropriate depth range.



Repeat for the remaining 5 cores, until you have 6 subcores in each container. Then bag the contents of each container in a 1-gallon Ziploc bag and label with date, central sampling point name, and nominated sampling depth. Each sampling site will result in three composite samples, one for each depth range. Log each core taken to capture any differences between the actual sampling depth and nominated sampling depth. Repeat this process at each sampling site.

Taking Bulk Density

Bulk density is the dry weight per unit of volume of undisturbed soil. The soil cores determine the mass of carbon per mass of soil, but it is not well suited for measuring the volume of soil, because probes compact the soil, disturbing the measurement. Bulk density allows you to extrapolate the SOC measurements from the core samples to calculate the SOC measurements for the Project Area.

This methodology recognizes the validity of several different ways of taking bulk density samples. Cores for bulk density must be at least 5 cm in diameter but can be obtained in a variety of ways. Bulk density sampling kits are available for purchase, sharpened pipes can be hammered into the soil, or custom probes can be machined for this purpose. Resources for taking bulk density are listed at the end of this appendix.

During each sampling event, one bulk density sample must be taken for each strata. Bulk density should be sampled within a 3-meter radius of one of the central sampling points in each strata. The bulk density sample should not be taken in a location that will interfere with the cores that will be taken in future sampling events, as described in the Sampling Plan. Bulk density samples must be taken for nominated sampling depths of 0-7.5cm, 7.5-15cm, and 15-30cm. If the soil cannot be adequately sampled due to bedrock, hard pan, or soil composition, you can choose another central sampling point or log the actual sampling depth that you were able to reach. Each sample must be bagged separately and labeled with the central sampling point and the nominated depth. Log each sample, noting the diameter of the sampling device.

Lab Analysis

Samples measuring SOC and bulk density must be analyzed by a lab. Many land grant universities will prepare the samples and perform the required tests at a reasonable price. See the resource section for more information about labs in the Southeastern US. Labs may have different requirements for receiving samples. The RGP Practitioner should contact the lab before taking samples to get specific instructions for drying or packaging samples. Generally, the RGP Practitioner should air-dry soil as soon as possible.

This methodology recommends analyzing SOC using a dry combustion test, reporting the mass of carbon per the mass of soil. Labs will also measure the mass of the bulk density samples.

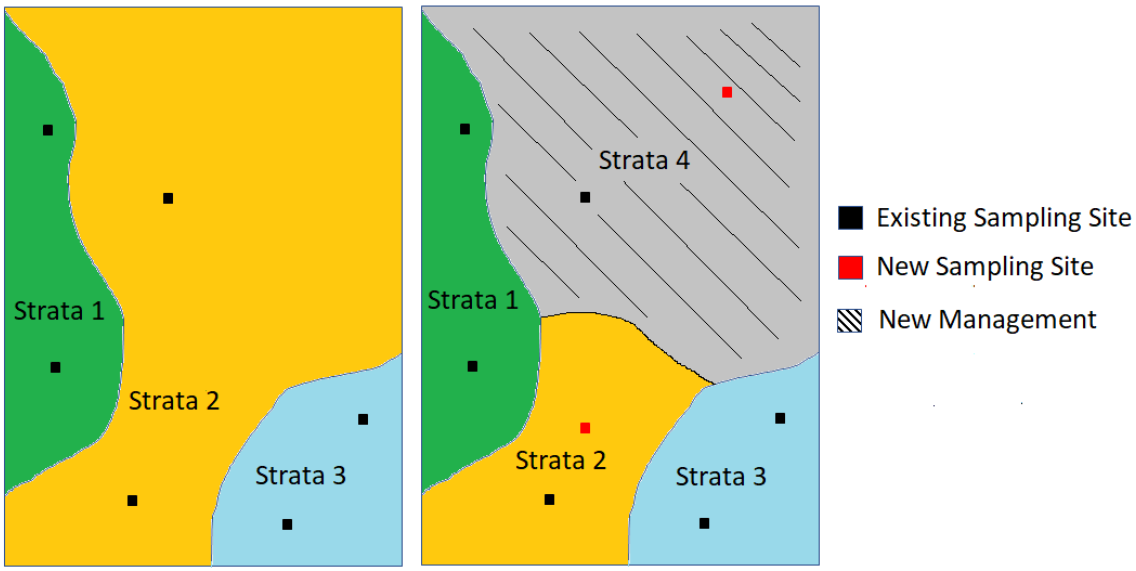
Documentation

An electronic file must be made available which identifies the Project Area, strata, and central sampling locations. The bounds of strata within the Project Area must be recorded using a GPS cellular application (e.g., GPX Tracker for iPhone or Android) or a GPS device. The recorded strata must be included in the electronic file containing the boundaries of the Project Area.

Flexibility Mechanisms

Changes to Strata

This methodology allows for changes to the strata between sampling events due to changes in land management or sampling data showing negligible variation between strata. If a strata established in a previous sampling event becomes subdivided and subject to different land management practices which could lead to different levels of SOC accumulation, then new strata and sampling sites must be established in accordance with the required sampling intensity.



Multiple strata established in a previous sampling event may also be combined in later sampling events if there is negligible variation between the strata. This mechanism is meant to encourage more intensive sampling in baseline measurements, ensuring a more accurate accounting of initial variability within the pasture. Based on the bulk density and SOC measurements, the RGP Practitioner may document a case for combining multiple strata into one for future sampling events. The RGP Developer will ultimately decide if

there is negligible variation between the bulk density and SOC measurements and approve the combination of strata. Future sampling events may reduce the number of sample locations in compliance with the sampling intensity requirements of this methodology. The sampling locations that are retained must represent the upper and lower bounds of SOC as measured in previous sampling events of the newly combined strata.

Resources

Bulk Density Sampling Methods

Sharpened pipe and hammer

- Measuring Soil Carbon Change, pg. 27

Sampling Kit

- Bulk Density Test

Labs

North Carolina State University

- Email: eats-laboratory@ncsu.edu
- Telephone: 919-513-1297
- Cost for total organic carbon analysis: $7.60 per sample
- Fees:
    - Grinding Room Usage Fee – $5.30 per hour
    - Instrument Usage Fee – $12.00 per hour
    - Sample Handling Fee – $0.20 per sample
- Submission form: https://eats.wordpress.ncsu.edu/files/2020/04/2020-EATS-Request-Form-Locked.pdf

University of Georgia

- Telephone: 706-542-5350
- Cost for total organic carbon analysis: $15 per sample
- Submission form: http://aesl.ces.uga.edu/forms/soil.pdf?18-0430