

Cumberland Piedmont Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure 10

Soil Measurements—Version 1.1

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Overview

This standard operating procedure (SOP) serves to characterize forest soil nutrients, micronutrients, texture, and other standard soil testing information and their changes over time. Development of this SOP benefitted from reviews of similar protocols (Tierney and Faber-Langendoen 2007; Lee et al. 2008; Perles et al. 2010). This SOP may best capture effects of atmospheric deposition on soil chemistry and provide insight into the soils ability to sustain its current physiognomic structure into the future. This SOP includes a rapid assessment of forest floor condition as well.

Three soil samples approximately $10 \times 10 \times 10$ centimeters ($3.9 \times 3.9 \times 3.9$ inches [in]) in size will be collected every eight years. Soil samples from different horizons are collected separately.

Regulations Governing Sample Collection

The National Historic Preservation Act of 1966 (as amended) provides for the protection of historical and cultural artifacts. Due to the random placement of the vegetation monitoring plots, a plot may be located on a site of prehistoric or historical significance. Field crews are required to obtain permission to collect soil samples from the park archeologists or cultural resource specialists prior to field visits. If cultural artifacts are encountered at a plot where permission to sample has been granted, do not take a soil sample. Record why a soil sample was not taken.

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Definitions

Horizons are layers which develop in soil under the influence of climate, living organisms, and other soil forming factors. Major horizons from top to bottom include the O (organic), A, E (eluviated), B, and C horizons.

Litter is intact or partially decomposed organic material that is easily identified (e.g., leaves, stem, twigs, etc.). Other names for the litter layer include the Oe horizon or the L horizon.

Mineral soil consists predominantly of products derived from the weathering of rocks (i.e., sands, silts, and clays). As soil develops under the influence of climate, living organisms, and other soil forming factors, it typically develops layers or horizons. Typical mineral soil horizons include the A, E, and B horizons.

Step by Step Instructions

Step 1. The soil sampling frames are hypothetical 2-meter (6.6 feet [ft]) radius circles that occur above modules 3 and 4. Locate the soil sampling frames just outside the plot adjacent to modules 3 and 4 (Figure 1). To determine the location of the middle soil sampling frame, extend the line delineating the boundary between modules 3 and 4 another 2 meters slope distance beyond the end of the plot (2 meters beyond the module corner). Place a chaining pin at this point. This is the center of Soil Sampling Frame 2 (Figure 1). If you have already laid out the 40 meter (131.2 ft) coarse woody debris plot, then use that to measure the diameter of the first circle.

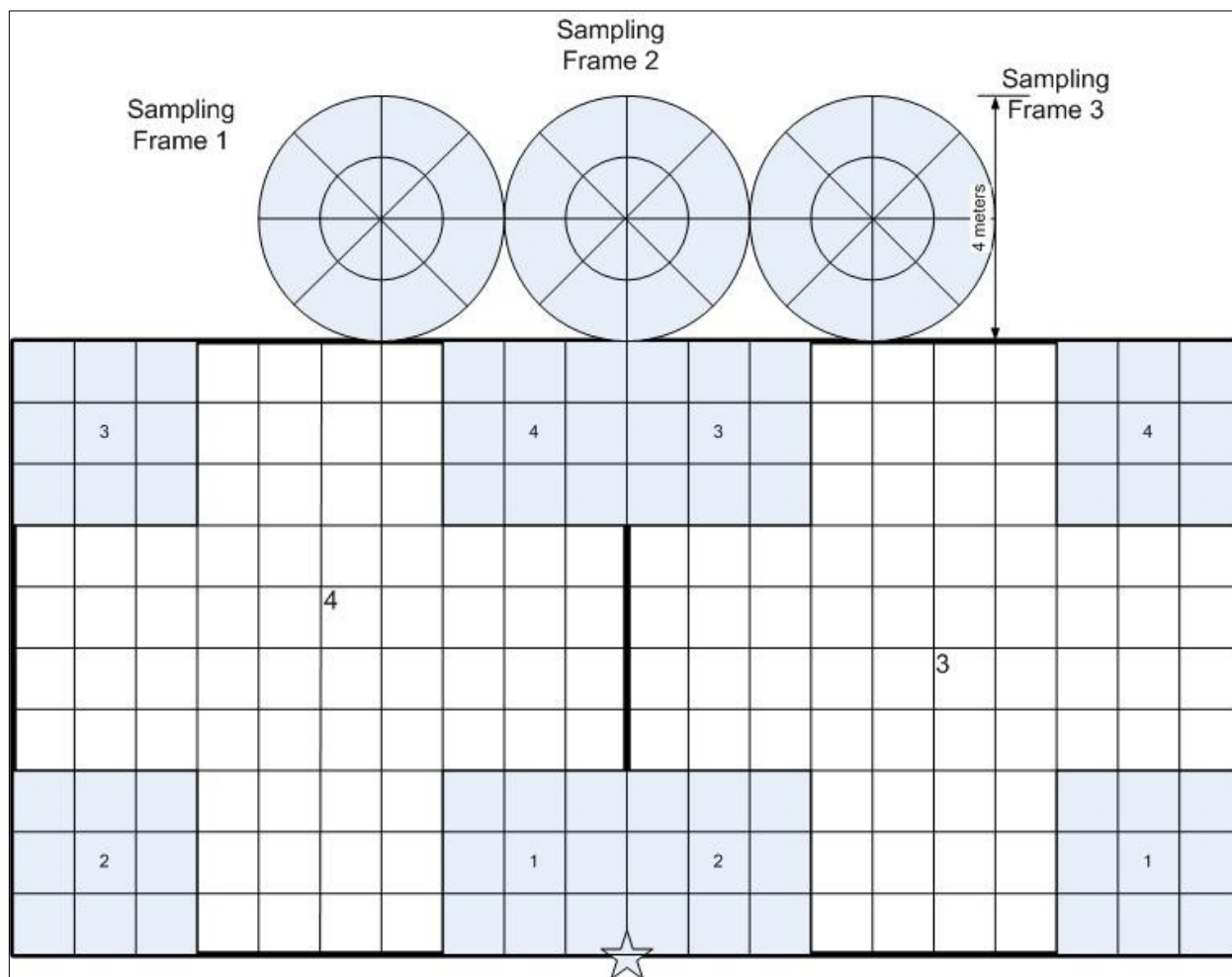


Figure 1. Soil sampling frame placement in relation to the northern half of the sampling plot.

Step 2. From the first chaining pin, measure 4-meter (13.1 ft) slope distance parallel to the length of the plot in both directions. This is the center of Soil Sampling Frame 1 and 3 (Figure 1). The three chaining pins should be in a straight line.

The soil sampling frames should be free from obstructions (e.g., boulderfields, cliffs, standing water) and generally representative of the forest floor through the plot. Soil sampling frames should not include tree tip-ups, large animal burrows, historic house foundations, and fire rings, unless these features are widespread throughout the plot and generally representative of the site conditions. If soil cannot be sampled at this location due to obstructions or site anomalies, abandon these samples and instead choose the area just outside of the plot between modules 1 and 2 and repeat the process above to establish the plots (Figure 2). If soil cannot be sampled in that location either, then pick a different location either between modules 2 and 3 or between modules 1 and 4. In these cases, note the location of the sampling frames in “Frame Location” field on the datasheet.

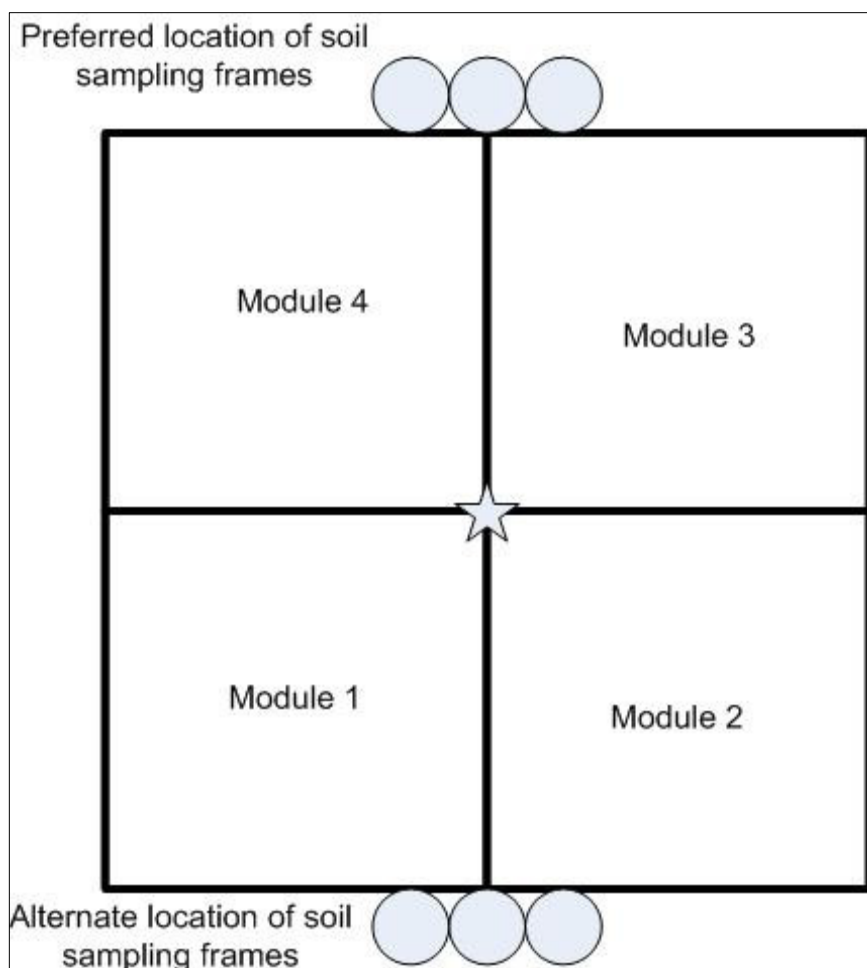


Figure 2. Preferred location of soil sampling frames and alternative location, assuming preferred is not feasible.

Step 3. First, select a 10×10 centimeters (3.9×3.9 in) area within Sampling Frame 1 to place the sampling quadrat. The objective is to collect a soil sample, so select a location for the quadrat that is relatively free of rocks, roots, or other obstructions that prevent soil sampling. Do not toss the quadrat into the sampling frame to “randomly” decide the quadrat location.

Visually divide the sampling frame into 16 sections as shown on the datasheet (Figure 3). Determine which sector of the sampling frame contains the selected quadrat sampling area. Use the 2-meter (6.6 ft) rope to help determine the sample area sector. Place an “X” on the datasheet in the appropriate sector to indicate the location of the soil sample. Write the last two digits of the current year (e.g. “11”) adjacent to the “X.” Do not place an “X” on any of the lines in the frame diagram; the “X” must be inside one of the sectors.

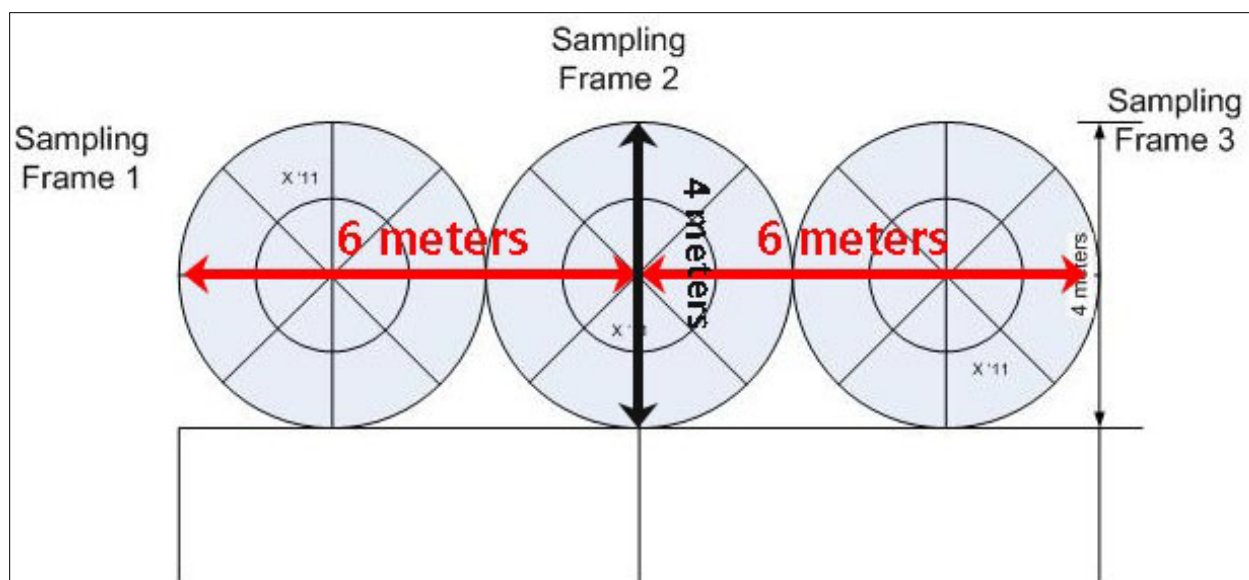


Figure 3. Soil sampling frames with X and year marking each (hypothetical) sample taken in 2011.

In the selected area, place the 10×10 centimeters (3.9×3.9 in) sampling quadrat carefully on the ground to avoid compacting the forest floor. If the ground is level, select two opposite sides of the quadrat on which to measure litter depth, using a clear ruler. If the ground is sloped, measure the litter depth on the up-slope side and the down-slope side of the quadrat, using a clear ruler. The bottom of the litter layer is distinguished as the boundary where plant parts (e.g., leaves or needles) are no longer recognizable as such because of decomposition. Record the litter layer depth on the data sheet to the nearest 0.5 centimeters (0.2 in).

Using a pair of clippers, carefully remove all live vegetation from the sample area. Clip living mosses at the base of the green, photosynthetic material. Next, use a sharp knife or keyhole saw to carefully cut through the unconsolidated litter and the forest floor along the inner surface of the quadrat. Then collect all unconsolidated litter (e.g., leaves, bark, wood fragments) within the quadrat. Place the unconsolidated litter in a plastic bag labeled with Collection Date (YYYY-MMM-DD), Park (four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Litter, as shown in the following example: GUCO052, Frame 1, Litter, 2011-JUN-03. If possible, mark both sides of the bag with this information just in case ink on one side runs. Do not remove consolidated litter which has begun to compress and decompose. Do not include any animal scat in the litter sample. Deer droppings can be common and should not be collected.

Once the unconsolidated litter is removed, visually examine the quadrat to assess and record the presence (1) or absence (0) of earthworm casts and burrows. If the examination is inconclusive, record 9.

Next, use a sharp knife or keyhole saw to carefully cut through the consolidated litter along the inner surface of the quadrat to separate it from the surrounding soil. Using inward scooping motions, carefully collect and bag the consolidated organic horizon to expose the top of the mineral soil. Place the organic material in a plastic bag labeled with Collection Date (YYYY-MMM-DD), Park (four

letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (O), as shown in the following example: GUCO052, Frame 1, O Horizon, 2010-JUN-02. Discard all recognizable woody debris and rocks greater than 2 millimeters (0.08 in) in diameter. This includes pine cones, large pieces of bark, partially decomposed wood, rocks, or pebbles. Soil samples will be sieved in the lab to remove all particles greater than 2 millimeters in diameter, thus crew members need not spend a lot of time removing all particles from the soil sample in the field. If a trowel was used to collect the O horizon sample, wipe the trowel clean on a rag before collecting the next sample.

Measure to the nearest 0.5 centimeters (0.2 in) the thickness of the O horizon. The O horizon thickness is the distance from the top of the consolidated litter to the top of the mineral soil. The boundary between the O horizon and the underlying mineral soil is detected by soil texture and weight. The O horizon is light in weight and has a greasy feel. The underlying mineral soil may vary in color or have a dark color like the O horizon and contain a mix of organic and mineral particles which is heavier in weight and may feel gritty. Record the color of the O horizon (e.g., “dark brown,” “grayish brown”). If there is no consolidated leaf litter, do not collect an O horizon sample, and make a note in Soil Notes.

After collecting the O horizon, use a trowel to carefully remove the mineral soil and place it in a plastic bag labeled with Collection Date (YYY-MM-DD), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (A), as shown in the following example: GUCO052, Frame 1, A Horizon, 2011-JUN-02. Continue carefully removing soil until a color change is observed in the soil. If a color change is observed, expose the soil profile along the edge of the sample area. Examine the exposed profile for distinct color changes that identify the boundary between the A horizon and underlying soil. The E horizon, if present, will be a band of markedly lighter colored soil between the overlying A and underlying B horizons. If no E horizon is present, it may still be possible to note a distinct color change between the dark brown A horizon and the lighter brown or pale B horizon underneath.

If the lower boundary of the A horizon is distinct and apparent, carefully measure and record the depth of the A horizon to the nearest 0.5 cm as the distance from the bottom of the O horizon to the top of the B horizon. Record the color of the A horizon (e.g. “light brown,” “dark gray”).

Circle “Y” next to “Observed Bottom of A Horizon.” Record the color of the underlying B horizon (e.g. “light brown,” “grayish brown”).

If the lower boundary of the A horizon is not observed, do not collect more than 15 centimeters (5.9 in) in depth of A horizon soil. Measure the depth of the exposed A horizon to the nearest 0.5 centimeters (0.08 in) as the distance from the bottom of the O horizon to the bottom of the soil pit. Under “A Horizon Thickness” on the datasheet, write a “>” symbol before the observed thickness. For example, record “>11.5 cm” if the observed depth of exposed A horizon soil was 11.5 centimeters (4.5 in). Record the color of the A horizon (e.g. “light brown,” “dark gray”). Circle “N” next to “Observed Bottom of A Horizon.”

If the A horizon is less than 5 centimeters (2 in) in depth, carefully measure and record the depth of the A horizon to the nearest 0.5 centimeters. Record the color of the A Horizon (e.g. “light brown,” “dark gray”). Circle “Y” next to “Observed Bottom of A Horizon.” Wipe the trowel clean on a rag before collecting the next sample. Then, carefully remove the B horizon soil and place it in a plastic bag labeled with Collection Date (YYYY-MMM-DD), Park (four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (B), as shown in the following example: GUCO052, Frame 1, B Horizon, 2011-June-08. Continue carefully removing soil until a maximum depth of 15 centimeters (5.9 in) from the bottom of the B horizon. Record the color of the underlying B horizon (e.g. “light brown,” “grayish brown”). Carefully measure and record the depth of the B horizon to the nearest 0.5 centimeters. Circle “Y” next to “Collected B Horizon.” Wipe the trowel clean on a rag before collecting the next sample.

Repeat this entire procedure in the remaining two soil sample plots (Figure 4). For each vegetation monitoring plot, take only one set of soil samples in each soil sampling frame (i.e., in each 2-meter [6.6 ft] radius circle).

Note: If a crew member smokes cigarettes or chews tobacco, they must wear gloves while handling the soil samples. Soils handled directly by smokers will report artificially high nitrogen levels.

Soil sample 1:	Soil sample 1	Soil sample 2	Soil sample 3
Litter sample collected:	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Litter thickness up-slope			
Litter thickness downslope			
*Earthworms present?:	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
O horizon collected?:	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
O horizon thickness			
O horizon color			
A horizon collected	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
A horizon thickness			
A horizon color			
Observed the bottom of A horizon?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
B horizon collected:	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
B horizon thickness:			
B horizon color			
Observed the bottom of B horizon?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Soil notes (Note which, if any, horizons are absent. If soil was not collected from certain horizons, note why. If it was difficult to find a suitable soil location, record the reason. Record any unusual soil)			

Figure 4. Example of data fields used in soil data collection

Soil Sampling Procedure on Remeasurement Plots

Soil samples will be measured every eight years. On subsequent remeasurements, use the same soil sampling frames. Read the Frame Location notes from the previous visit's datasheet.

Re-establish the center points of the three sampling frames at the appropriate location using the instructions from above.

Using the previous visit's datasheet, determine which sampling frame sectors were previously sampled. Select a sector not previously sampled and follow the soil sampling procedure outlined above. Place an "X" on the datasheet in the appropriate section of the soil sampling frame to show the sampling location. Write the last two digits of the current year (e.g. "11") adjacent to the "X." Do not place an X on any of the lines in the frame diagram; the X must be inside one of the sectors.

Sample Drying

Upon return from the field, leave soil sample bags open in a safe location to air-dry until the soil no longer appears moist. Bags should not be sealed until they are dry or else anaerobic activity may bias the sample. To test dryness, gently squeeze the soil through the bag to break clumps and arrange the sample so it has maximum exposure to the air (fold back the bag lip, move soil out of bag corners, and let the sample lay as flat as possible). For this to work properly, use flexible plastic soil sampling bags that are wider at the opening than they are long. As the soil dries, check and mix the sample by gently squeezing from outside the bag.

Some soil samples may contain considerable moisture from ground water or recent rain. These wet soils will not dry properly in plastic bags. Wet soil samples should be spread out on wax paper or a metal pan to dry completely before being returned to plastic bags. If there is access to a soil drying oven for soils, this would speed the process up and keep from contaminating the soil with mildew and other organisms that might alter the final analysis.

Prior to sending samples to the lab, prepare a master list of sample information. Assign each sample a unique number from 1 to n , and mark this number prominently on the bag (using a different color ink than other info on the bag and circling this number). Create a list identifying which sample number corresponds to which park, plot number, frame number, soil horizon, and date collected. Print a copy of this list for the Cumberland Piedmont Network, and include a copy with the samples when shipped or delivered to the testing lab. Also send a digital copy to CUPN staff.

Sample Analysis

Soil tests will include a determination of soil nutrients, micronutrients, texture, percent carbon, and other standard soil testing information. Brookside Laboratories does soil analysis on samples collected by the Carolina Vegetation Survey and may be a good choice for the work here. Brookside Laboratories provides some guidance in [Brookside Laboratories Soil Sample Requirements](https://www.blinc.com/node/29) (<https://www.blinc.com/node/29>).

The lab should prepare samples by passing each through a 2 millimeters (0.08 in) sieve to remove larger particles. Analysis should include (list is still undergoing additions and changes): Total carbon and total nitrogen by dry combustion NH_4Cl extractable ions including Ca and Al.

Sample Archives

When samples are sent to the laboratory, coordinate with the contractor's lab staff to ensure that all unused portions of the samples are retained. Request that all leftover soil be returned in the original bags. Each sample that is returned from the lab should be archived for later analysis. Each soil sample should be placed in a clean, new, pint-sized cardboard ice cream container. The sample label should be written clearly on the container and the lid. Archived samples can be stored at room temperature in a safe location.

Equipment List

- Chaining pins
- Rag for cleaning trowel
- Meter stick
- Trowel
- Spade with heavy handle
- Key saw
- Plastic bags with wide tops

Literature Cited

- Lee, M. T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2008. CVS-EEP Protocol for Recording Vegetation, All Levels of Plot Sampling. Version 4.2. Carolina Vegetation Survey. <http://cvs.bio.unc.edu/protocol/cvs-EEP-protocol-v4.2-lev1-5.pdf> (last accessed September 2023).
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- Tierney, G. and D. Faber-Langendoen. 2007. NETN Forest Vital Sign Protocol, Soil Measurements and Sampling, Version 2.1 in NPS Northeast Temperate Network Long-term Forest Monitoring Protocol. SUNY College of Environmental Science & Forestry and NatureServe. Syracuse, NY.

Revision Log

Revision History Log.

Version #	Date	Revised by	Changes
1.1	8/28/23	B. Moore	Minor format changes, such as moving revision history to end of SOP, to match format of other protocol SOPs. Formatted by editor to regional I&M publication standards