National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Eastern Rivers and Mountains Network

# Vegetation and Soil Monitoring Program

# Standard Operating Procedures

## Version 8.0 (May 2017)

# List of Standard Operating Procedures

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# Protocol Revision History

The Vegetation and Soil Monitoring Protocol consists of a narrative (Perles et al. 2013, available at http://science.nature.nps.gov/im/units/ermn/monitor/vegetation.cfm) and the Standard Operating Procedures (SOPs) contained in this document. The SOPs outline specific data collection details of the monitoring protocol. Each SOP includes a revision history log to document changes in the protocol.

Version numbers will be incremented by a whole number (e.g., Version 1.3 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.3 to Version 1.4) when there are minor modifications that do not affect requirements or procedures included in the protocol. For simplicity, all SOPs have the same version number at the same time so that the set of SOPs used in a particular field season can be referenced as a group. As a result, the revision log for each SOP may not include notes for every version since changes may not have made to that SOP during that revision. Some SOPs that have not been changed substantially since the monitoring program began have no notes in their revision history.

**Field Season Preparation**
**Version 8.0 (April 2017)**

## Overview

This SOP describes preparations for the summer field season and includes a list of necessary field equipment. Preparations should be completed by the start of the field season in early May.

## Staff

Achieving the goal of accurate, reliable, and consistent data begins with the hiring process followed by a rigorous training program. This forest monitoring protocol involves the forest crew leader plus one or two crew members. Much of the vegetation monitoring protocol is most accurately and efficiently completed when working in pairs. One person on the crew (most likely the forest crew leader) should have good identification skills for woody, herbaceous, and graminoid plants in Pennsylvania and West Virginia and have some experience in forest sampling methods. Other crew members should have good woody plant identification skills and enjoy working outdoors. Between the crew leader and the two crew members, the crew should ideally have knowledge or expertise in the following areas: forest pests and pathogens; forest soils; and herbaceous and graminoid plant identification. The protocol will also require some knowledge of databases, as well as GIS mapping in ArcGIS or ArcView. The ERMN Data Manager can provide support for these tasks.

Locating skilled crew members takes time. Consider contacting universities and colleges in the ERMN area for qualified students. List the job announcements on websites such as the Society for Conservation biology job database (http://www.conbio.org/jobs) or listserves such as the Ecological Society of America's ecolog listserve (ecolog-l@listserv.umd.edu). Identify professors and professionals (such as those at the state Heritage Programs, the Morris Arboretum, etc) in the region who can refer potential seasonal staff.

## Planning and Coordination

A current NPS research permit is required for each park scheduled for vegetation monitoring. The status of vegetation monitoring research permits and applications for new permits are available at the NPS Research Permit and Reporting System website (http://science.nature.nps.gov/research). ERMN personnel or the field crew leader should ensure that each ERMN park natural resource manager has the current Vegetation Monitoring Protocol including all SOPs, as well as an up-to-date map of sampling locations. A map clearly showing the locations of all plots must be provided to the cultural resource specialist in each park at least one month prior to any soil sampling. The cultural resource manager will assess the presence of cultural artifacts potentially compromised by soil sampling. All plot markers and tree scribing procedures must be cleared with each park natural resource manager prior to plot establishment. These procedures may vary by park.

ERMN should select an experienced forest soils chemistry laboratory, and have a purchase order or other contract in place for soil sample analysis. Several soil laboratories have sufficient capabilities, including the Analytical Lab at the University of Maine (http://anlab.umesci.maine.edu, contact Sue Ehrich erich@maine.edu).

## Maps

Prior to each field season, a predetermined number of plots will be assign to that year's sampling panel using the GRTS sampling algorithm. The ERMN Ecologist should screen each plot in GIS to determine that: a) the plot does not fall on private land, non-vegetated land uses, managed cultural landscapes, or steep slopes; b) the plot falls in a vegetated area at least 40 m by 40 m in size; and c) the plot can be safely accessed in a reasonable amount of time (i.e., completed in one day including travel time). If a plot is rejected based on these criteria, enter the plot and its coordinates into the Vegetation Monitoring Database, check "Rejected", and explain the rationale in "Plot Notes". Park resource managers can be very helpful in determining the best access for some plots. Be sure to discuss any questionable access issues with park managers.

Prior to each field season, prepare maps showing the year's sampling locations at each park. One map should show the plot locations overlaid on the USGS topographical maps, with roads, trails, and park boundaries included. A second map should show the plot locations overlaid on the most current aerial photography, with roads, trails, and park boundaries included. Line and point symbols for roads, streams, plots, and other features should be clearly visible but not large enough to obscure other features. Include a scale on all maps showing distances in meters or kilometers. If necessary, prepare a smaller park-wide location map inset to show where in the park the plot is located. Print all field maps on waterproof marine paper using a color LaserJet printer (inkjet printing does not adhere well to Rite-in-Rain paper).

Supply the crew with Gazetteers for Pennsylvania and West Virginia, as well as the Emergency Response map for the Gauley River (available at the Cathedral Café, 134 S. Court Street, Fayetteville, WV, 25840, 304-574-0202), and the National Geographic map of New River Gorge National River (also includes Gauley and Bluestone Rivers).

Download plot coordinates into the ERMN GPS unit (see the Using the Global Positioning System SOP). Immediately after downloading the plot coordinates, it is critical to check the GPS map page to ensure that the plot locations are shown correctly on the GPS, ensuring that the coordinates were downloaded in the correct projection.

## Schedule

Begin field crew training in May as soon as all crew members are available. Training will last one week and is discussed in more detail below.

To reduce seasonal variation between sampling visits, the following order must remain consistent from year to year. The growing season is longer in West Virginia, therefore, sample the West Virginia parks at the beginning and the end of the field season. Although this schedule may be altered by unforeseen events, strive to sample the parks according to the following schedule:

Late May–Early June: NERI
June–Early July: DEWA
July: ALPO, JOFL, FONE and FRHI
August: GARI, BLUE and the remainder of NERI

The field crew leader should carefully consider logistics and the crew's capabilities and motivation levels when setting a weekly work schedule. Flex-time (e.g. four 10-hour days/week, and/or eight days working 10-hour days followed by six days off) may be more efficient to accommodate long travel times to parks and plot locations.

## Logistics

ERMN personnel or the field crew leader should reserve or acquire a field vehicle for transport to and within parks. Depending on employees and projects contracts, a Pennsylvania State University fleet vehicle can be rented (contact Fleet Operations, 814-865-7571) or vehicle owned or leased by the ERMN can be used for all or part of the field season. Vehicles are also available from rental companies (e.g. Enterprise, National, etc). For all Pennsylvania parks, most plots can be accessed via a regular car and reasonable hiking. In DEWA, a few plots may require a four wheel drive vehicle or a canoe. Resource managers at DEWA may provide a 4WD vehicle and/or canoe to the field crew on a day-by-day basis during the field season. In BLUE, a regular car should be sufficient. Since the Bluestone River is shallow enough to wade at most riffles, a canoe should not be necessary. In GARI and NERI, a four wheel drive vehicle with high clearance and a scrape plate is necessary to access several large sections of the parks. Wading across the Gauley and New Rivers is impossible and dangerous in almost all river stretches in the parks. Guided raft access may be necessary in NERI.

ERMN personnel or the field crew leader should contact the natural resource manager and/or research coordinator at each park to discuss the timing of field visits and reserve park lodging, if available. If no park lodging is available, make alternative lodging reservations. Wherever possible, lodging should include kitchen facilities and the internet.

## Training

Prior to commencing each field season, ERMN must ensure all field personnel fully understand the field protocols by conducting in-situ training sessions. Field crew preparation should involve careful review and discussion of all SOPs, as well as field sessions using training plots. Crew members must read the entire protocol and all SOPs thoroughly. It may be useful to divide the training into discrete phases, so that a particular SOP or set of SOPs can be read, learned, and practiced.

Training should cover:

- job hazards and safety procedures;
- introduction to ERMN forest ecosystems;
- review common tree and shrub species of Pennsylvania and West Virginia;
- proper use of all equipment, including GPS, field computer, compass, clinometer, measuring tape, dbh tape, digital camera, laser hypsometer, and NPS radio;
- declination settings on compasses;
- using a clinometer to measure slope as percent and in degrees;
- reading plot locations maps;
- plot layout and installation;
- rules for rejecting or shifting pre-selected plot locations;
- measuring horizontal vs. slope distance;

- estimating slope distance using slope conversion table;
- determining terrain position, stand structure, stand disturbance, and crown closure;
- proper tree scribing technique;
- accurate diameter-at-breast-height measurement;
- determining of tree crown class;
- identifying specific tree conditions and foliage problems;
- accurately assessing tree vigor and dieback categories for different tree species;
- identifying high priority exotic pests and pathogens for the ERMN;
- assessing snag and coarse woody debris decay classes;
- measuring seedling height;
- estimating percent cover classes;
- inspecting the forest floor for earthworm casts and burrows;
- collecting soil samples and separating by soil horizon;
- labeling, drying and storing soil samples;
- labeling unknown plant specimens;
- procedures for careful data collection and quality control;
- minimizing plot trampling;
- how the data are used and what information is gained from each type of data collected (i.e. why each type of data is important);
- expectations of field crew behavior;
- use of PSU fleet vehicles and NPS field vehicles;
- completing and submitting timesheets and expenses reports.

Training should include demonstration and practice of all measurement procedures. The critical importance of careful, accurate, and steady data collection to this long-term monitoring program must be emphasized. Trainers must stress the importance of exact adherence to SOP instructions to prevent bias in measurements among years, which will inhibit ERMN's ability to detect long-term trends. Encourage trainees to discuss with their supervisors any concerns that arise over field procedures, the datasheets, or the database during training or later during the field season. The crew should never deviate from established protocols or alter the datasheet or database without first consulting with their supervisor. Any changes in procedures must be clearly documented in the SOP revision history, and the project database.

Training must emphasize the critical importance of careful plot behavior to minimize plot trampling. On steep slopes, in wetlands, or on plots with thick herbaceous or moss cover, place and unload packs outside the plot boundary, not within. Crew members should plan ahead and retrieve all gear for a particular set of measurements at one time, rather than taking extra trips across the plot. Crew members should minimize steps on the transects and within the microplots and quadrats. Extra-care must be taken to avoid trampling the regeneration microplots, the herb quadrats, and any coarse woody debris on or near a transect.

During training, designate one crew member as the field computer lead, and another as the GPS lead. The field computer lead should receive extra training in all aspects of the use and care of the field computer and the use of the ERMN vegetation monitoring database. Likewise, the GPS

lead should receive extra training in the use of the GPS unit, and should carefully study the Using the Global Positioning System SOP, and the Garmin manual.

The ERMN Plant Ecologist should spend at least the first week of data collection after training in the field with the crew, to answer additional questions about the protocols and assure that the protocols are being implemented correctly.

## Communication and Crew Oversight

The crew should carry a National Park Service radio at all times. Program the radio to the appropriate frequencies in each park. Crew members should know which frequencies work in which sections of each park, how to contact park radio dispatch, and be familiar with proper radio etiquette. In parks with cell phone coverage, crew members should carry a cell phone in the field for safety and to call their supervisor concerning protocol questions.

It is essential for the crew to maintain regular contact with ERMN staff throughout the field season. Establish a regular weekly telephone call time between crew leader and supervisors to review the week's work. The update should cover questions or problems related to plots, protocol, logistics, and scheduling.

Division of labor for the crew must allow the crew leader to remain aware of crew activity on the plot during the regular course of data collection.

ERMN coordinators and any other supervisors should endeavor to join the crew in the field at least twice during the field season to directly observe data collection procedures.

## Equipment

Required equipment and supplies for vegetation monitoring are listed below. Equipment should be organized and maintained in good working condition. At the end of each season the crew leader will inventory the condition of all equipment and prepare a list of required repaired or replacements. Mark each piece of equipment with a piece of brightly colored flagging to assist with locating it on the forest floor during data collection.

Handle the field computer carefully and protect the screen from injury at all times. During hard rain, store the field computer in a waterproof bag and use datasheets. Protect all electronic equipment, including the GPS unit, the digital camera, the laser, and the Sonin distance measures from water damage.

ERMN Vegetation Monitoring Equipment List:

*General:*

Park topo and aerial photo maps showing plot locations in protective plastic folders
Gazetteers for Pennsylvania and West Virginia
Smartphone or tablet with satellite or aerial imagery and GPS capabilites
Binder containing protocol and all Standard Operating Procedures
Slope conversion table
Park permits
Flagging

Pencils (1 – 2 boxes, with extra lead and erasers)
Black Industrial Sharpies – regular size
Black Sharpies – wide point
Dry erase markers
Daypacks (3)
First aid kit
Insect repellant (2 bottles)
Poison ivy soap (2 large bottles)
Snake chaps (3 pair)
Field vests – optional

*Plot Establishment:*

GPS unit and spare AA batteries
GPS antennae and battery
Compass (3)
30-m tape (3)
Chaining pins (4 for field + 8 spare) with leather sheath
18" long ¾" diameter rebar (1 per plot)
Aluminum cap with plastic insert (for Pennsylvania parks, 1 per plot)
Brass cap with plastic insert (for West Virginia parks, 1 per plot)
Rubber mallet
Small metal sledge hammer
Galvanized metal spikes, 10" or 12" long (10 per plot)
Bounty Hunter metal detector (1 for field + 1 spare)
Hand held metal detector

*Plot Measurement:*

Field computer
Harness table for field computer
Data sheets (on regular and Rite-in-Rain paper)
Enclosed clipboard (2)
Clinometer
Laser hypsometer (1 for field + 1 spare)
Sonin Electronic Distance Measures Combo Pro
10 m DBH tape
2 m DBH tape
Loggers Tape, retractable with distance and DBH measurements (2 for field + 1 spare)
Finley pole (1 for field + 2 spares)
Finley wedge for measuring sapling DBH
Steiner stick, marked at sapling height cut-offs (2 for field + several spares)
Microplot chains – thin chain or non-stretch rope, 2 m in length (2)
Tree scribe with guard, sharpened (2)
Peterson's Eastern Trees field guide
Compact, waterproof binoculars
Ruler (24", sturdy)

Ruler (10”, clear plastic)
Laminated index cards (for photo documentation)
PVC Quadrat frame - 1 x 1 m, w/ purple 10cm sections spray painted on to aid % cover estimates
10x hand lens (2)
Plastic bags for plant samples
Newcombs Wildflower Guide
PVC soil sampling quadrat – 10 cm x 10 cm (1 for field + 1 spare)
Sturdy trowel
Bunny soil knife or keyhole saw
Clippers
Sealable ½ gallon-sized plastic bags for soil samples (~9 per plot)
Digital camera
Charged AA rechargeable batteries (8)
9V batteries (4)

*In Field House:*

Full-size plant press
Newspaper for pressing plant samples
Box of Rite in the Rain paper
AA Battery recharger
Plenty of spare AA and 9V batteries
Replacement reels for loggers tapes (2)
Spare screws and stays for loggers tape (2 sets)
Replacement tapes for 30-m tapes (3)
Extra connector pieces for cable that connects GPS to antennae (2 of each)
Power cords for Field computer and GPS antennae batteries
Leatherman
Gorilla Glue
Dry Bags (2)
Flora of the Northeast - Gleason & Cronquist
Illustrated Guide to the Flora of the Northeast - Gleason & Cronquist
Flora of Pennsylvania - Rhoads and Block
Flora of West Virigina - Strausbaugh and Core
The Shrub Identification Book - Symonds
The Tree Identification Book – Symonds
Peterson Field Guide to the Ferns of NE & Central N. America – Cobb, Farnsworth, and Lowe

*For Limiting Invasive Species Spread:*

Wire brush with teeth (2)
Coarse bristled brush (2)
5 gallon bucket (2)

*First Aid Kit:*

5 Bandage, Adhesive, Fabric, 1" x 3"
2 Dressing, Gauze, Sterile, 4" x 4", Pkg./2
2 Dressing, Gauze, Sterile, 2" x 2", Pkg./2
2 Bandage, Conforming Gauze, 3"
2 Dressing, Non-Adherent, Sterile, 3" x 4"
5 Bandage, Adhesive, Fabric, Knuckle
1 Trauma Pad, 5" x 9"
1 Instructions, Easy Care Bleeding
1 Gloves, Nitrile (Pair), Hand Wipe
1 GlacierGel (Large Oval)
11 Moleskin, Pre-Cut & Shaped (11 pieces)
1 CPR Face Shield, Laerdal
1 Duct Tape, 2" x 5 Yards
1 Instructions, Easy Care Fracture & Sprain
1 Bandage, Elastic with Velcro, 3"
1 Bandage, Triangular
1 EMT Shears, 4"
1 Splinter Picker/Tick Remover Forceps
3 Safety Pins
1 Pencil
3 Thermometer, Disposable
1 Patient Assessment Form
1 Comp. Guide to Wilderness & Travel Medicine
2 Acetaminophen (500 mg), Pkg./2
2 Ibuprofen (200 mg), Pkg./2
1 Instructions, Easy Care Medications
2 Antihistamine (Diphenhydramine 25 mg)
1 Aspirin (325 mg), Pkg./2
1 Instructions, Easy Care Wound
1 Tape, 1" x 10 Yards
1 Syringe, Irrigation, 20 cc, 18 Gauge Tip
2 Tincture of Benzoin Topical Adhesive
6 After Cuts & Scrapes Antiseptic Wipe
1 Povidone Iodine, 3/4 oz
1 Wound Closure Strips, 1/4" x 4", Pkg./10
1 Cotton Tip Applicator, Pkg./2
1 Sam Splint
1 Quick Clot Bandage

## Revision History

<u>From Version 3.0 to Version 4.0</u>
*May 2010* – Added materials lists for Limiting Invasive Species Spread and First Aid Kit

**Using the Global Positioning System (GPS)**
**Version 8.0 (April 2017)**

## Overview

This SOP delineates the proper use of the ERMN Garmin GPSmap 60CSx unit.

## Getting Started

Install two fully charged AA rechargeable batteries in the back of the unit. Always carry two additional fully charged AA batteries as back up.

Turn on the Garmin GPS by depressing the small power button near the antennae for 2 seconds. Check SETUP options by pressing the menu button twice, then scroll down to the SETUP selection and press ENTER. Scroll through the sub-menus (using the Rocker keypad) to following menus:

System: GPS = Battery Saver
    WAAS / EGNOS = Enabled
Units: Position Format = UTM UPS
    Map Datum = NAD 83
    Distance / Speed = Metric
    Elevation = Metric
Heading: Display = Degrees
    North Reference = True

Set other settings as desired by user. These settings will be saved on the GPS unit. It should not be necessary to re-enter them each time the unit is turned on.

Use the PAGE button to page through Satellite, Map, Compass, Altimeter, and Trip screens. Press the MENU button once to get a local menu, or twice to view the main menu showing setup and other options. Use the center ROCKER keypad to scroll up, down, left, or right through selections. Use the QUIT button to cancel a selection, or backup one step. When scrolling through fields in a menu, press the ENTER button to view all available options in a field. Also press ENTER to make a selection. To access the list of waypoints or navigate to a waypoint, press the FIND button.

To turn off the Garmin GPS unit, press and hold the small power button near the antennae for 2 seconds.

## Uploading Plot Locations

GPS coordinates for pre-selected plot centers should be loaded into the unit before field sampling. The datum for all coordinate values is NAD 83 and the coordinate system is Universal Transverse Mercator (UTM). The zone is 17 for BLUE, NERI, GARI, FONE, FRHI, ALPO, and JOFL. The zone is 18 for DEWA and UPDE.

Use the Minnesota DNR Garmin extension in Arcview 3.x or ArcGIS 9.x to upload plot locations from the shapefile to the GPS unit. Immediately after uploading the plot coordinates, it

is critical to check the GPS map page to ensure that the plot locations are shown correctly on the GPS, thus ensuring that the coordinates were uploaded in the correct projection.

### Additional Antenna

In BLUE, GARI, and NERI, connect an external antenna to the GPS unit to capture sufficient signals. The external antenna requires its own battery, which also powers the GPS unit when connected to the antenna. Charge the antenna battery overnight, and carry a charged backup battery in the field. During plot work, disconnect the antenna from the battery to prolong battery life.

The antenna connects to the back of the GPS unit via two cables: a power cable and a "signal" cable. Place a rubber band around the GPS unit and cable connections to secure the cables in place. Do not connect the signal cable to the GPS unit when the power cable is not connected. Doing so will draw on and quickly deplete the GPS's AA batteries.

### Navigating

Check the Satellite page. When sufficient satellites (4 for 3D navigation, 3 for 2D navigation) have been located, the satellite page will display your location coordinates and the estimated accuracy. If 3D navigation is active, "3D" will appear in the satellite on the top of the screen. The GPS is most accurate when it has at least four satellites and a 3D position. Satellite reception will vary with interference from trees, topography, structures, weather, and satellite positions. The antenna should point skyward when navigating or collecting points.

You can navigate using the Map or Compass screens. Select a location (waypoint) to navigate toward by pressing the FIND button, and select WAYPOINTS. Select the Waypoint you would like to navigate to by Name or by Location and press 'Enter'. Press 'Menu' to switch between 'Find by Name' or 'Find by Nearest' to find the appropriate waypoint name. On the 'Waypoint' screen select 'Go To'. Now the Map or Compass screens will show the direction to travel to the waypoint.

When navigating using the GPS, remember that directional signals you receive from the GPS are only valid while you are moving. Unlike a compass, if you stop and turn to face a different direction, the GPS will not reposition until you move again. Also, the arrow that represents your position on the Map page is not necessarily pointing in the direction that you are moving. A compass may be used to determine the correct direction, and care must be taken to hold the compass sufficiently far from the GPS unit to avoid influencing the compass needle.

### Recording a New Location

1) To record a new location (waypoint), press the MARK button from any of the main screens.
2) On this screen, scroll to the waypoint name adjacent to the blue flag. Hit ENTER and type the name of the plot using the rocker bar and ENTER to select letters and numbers.
3) Name the plot using the four letter park code, three digit unique number, plus the capital letter F to represent that this point was taken in the field. (e.g. NERI.031F) To find the "." and the numbers, highlight the "↑" and hit ENTER. A number pad will appear on the right side of the screen. After entering the name, Highlight OK, and hit ENTER.
4) Scroll to AVE at the bottom right of the screen. Hit ENTER. Let the Measurement Count reach at least 100–150 points. Watch the Estimated Accuracy—good estimated accuracy is

under 10 m; excellent estimated accuracy is under 5 m. If estimated accuracy is not less than 10 m after 150 points have been averaged, stop collecting points. Record the plot center location again 1 – 2 hours later when satellite configuration has shifted.

5) When the desired number of points or estimated accuracy has been reached, hit ENTER to save the location. Note the estimated accuracy displayed before you hit ENTER. Record this on the datasheet.
6) Make sure that the name of the plot now shows at the top of the screen. Record the coordinates shown on the screen onto the datasheet. Scroll to OK and hit ENTER.

## Downloading Recorded Location to ArcGIS

Each week, use the Minnesota DNR Garmin extension in Arcview 3.x or ArcGIS 9.x to download the recorded field plot locations from the GPS unit to a shapefile. Save this shapefile with a descriptive name and date (e.g. DEWA_field_plot_locations_20070715.shp)

## Suggested Reading

Garmin GPSMAP 60CSx Owner's Manual
Garmin GPSMAP 60CSx Quick Start Guide

**Site Selection and Plot Establishment**
**Version 8.0 (April 2017)**

## Overview

This SOP provides instruction for locating and establishing plots and for collecting site information. ERMN must ensure that plot marking procedures have been approved by the natural resource manager at each park prior to plot establishment. These procedures may vary by park in response to individual park requirements.

## Definitions

Horizontal distance is the level, straight line distance between two points. This contrasts with slope distance which is measured parallel to the ground surface. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

True north is the direction of the North Pole relative to your position. This contrasts with magnetic north—the direction a compass needle points when in the northern hemisphere. Magnetic north varies across the landscape and over time. To locate true north, it is necessary to adjust a compass to account for the differences between true north and magnetic north using a magnetic declination chart or table (e.g., http://www.ngdc.noaa.gov/geomag-web/#declination or http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp). Adjust your compass by dialing the declination into the faceplate to the nearest degree. Set the compasses of all field crew members for the same declination. For 2017, the declination for ERMN parks is as follows:

| Park | Declination | Compass Adjustment |
|---|---|---|
| BLUE | 8.15° West | 8° West |
| NERI | 7.94° West | 8° West |
| GARI | 8.27° West | 8° West |
| FRHI | 9.21° West | 9° West |
| FONE | 9.42° West | 9° West |
| ALPO | 10.22° West | 10° West |
| JOFL | 10.07° West | 10° West |
| DEWA | 12.49° West | 13° West |

## Preparation for Field Work

Before leaving the field house and again before leaving the vehicle near the plot site, check to see if you have all of the needed equipment. Ensure that all consumable items (data sheets on plain and rite-in-the-rain paper, charged batteries, soil bags, rebar, caps, and spikes) have been restocked to sufficient quantities for the number of plots that will be visited during the day. If you are revisiting previously established plots, read the Plot Notes for the plots you will be visiting that day. Check to see if you need to bring extra rebar, caps, or spikes to the plot to replace ones that were not installed or were improperly installed during the last visit. Make sure that you have the correct Plot Sheets and Tree Sheets that contain information from prior visits for the plots that will be visited that day.

## Locating and Establishing a New Plot Center

Examine park maps, topographic maps, and aerial photography to determine the best route to a preselected plot location. Using GPS and compass, travel to the plot location. Remember that the GPS unit may affect compass readings—keep them sufficiently far apart. Do not take safety risks while traveling to plots. If off-trail topography becomes too steep or difficult, find an alternative route. If a safe route does not exist, discard the location and record the reason for abandoning the location.

To avoid plot location bias, it is very important to establish plot center as close to the pre-defined coordinates as possible. Doing otherwise can lead to serious data bias. As you near the pre-selected location, use the following protocol to locate plot center. The GPS unit will likely not have sufficient precision to navigate exactly to the pre-selected location. Therefore, as soon as the GPS indicates you are within 15 m of the pre-selected location, continue exactly 10 paces (20 steps) in the direction of the pre-selected location and stop. Do not veer off course to avoid obstacles. This is plot center.

At plot center, ensure that the area is not a managed grassland (i.e., mowed periodically), cropland, or developed land, and that plot center is ≥15 m from the park boundary, agricultural fields, roads, developed land, or large perennial streams (without canopy closure over the stream). Small trails, ephemeral streams, or streams under closed canopy can be included in the plot. If the plot center is <15 m from any of the features listed above, move the plot center 20 m horizontal distance perpendicular to the feature. This is the new plot center. If multiple features (roads, fields, streams) are present and there is insufficient space (<40 m between features) to establish a plot, discard the plot and record the reason. Proceed to the next location on the list of plot locations.

If the plot presents a safety hazard such as steep slopes or unstable snags, discard the plot and record the reason. Proceed to the next location on the list of plot locations.

At plot center, set the 18 inch piece of rebar with appropriately labeled survey cap into the ground as close as possible to that location. If the rebar cannot be set exactly where you are standing, locate a place in the general vicinity (~2 m radius) where the rebar can be set. The survey cap should be flush with ground. The rebar marks the plot center from which all plot measurements are taken.

## Locating a Previously Established Plot Center

When revisiting a plot, navigate to the site location using directions from previous years, park roads, trails, map and compass, and GPS unit. Do not take safety risks while traveling to plots. Be sure to pay attention to the accuracy of previously written directions. Make note of directions that need to be corrected or altered. If you do not find the previous directions particularly useful, take careful notes in order to provide better directions to the next crew. Road conditions in the West Virginia parks can change dramatically (for better or worse) within one to four years. In some cases, you will not be able to take the same roads as the previous crew; or previously impassable roads will now be well graded and will provide easy access. Update the plot directions as needed to reflect changes in road conditions.

Navigate as close as possible to plot center using the GPS unit. Once you arrive in the general area of plot center, look for scribe marks on trees (see photo below). In most cases, the scribe marks are facing plot center. If necessary, look at the Tree Sheet and identify trees that are closest to plot center. Find likely trees to those noted on the data sheet and backsight the likely location of plot center using the distances and azimuths listed on the data sheet. The metal detector can also be used to locate the capped rebar marking plot center. To the extent possible, limit the disturbance to the forest floor, leaf litter, and understory vegetation when searching for plot center. See photo below of the different kinds of rebar caps used to mark plot center. In general, brass caps are used in the West Virginia parks and aluminum caps are used in the Pennsylvania parks.

## Establishing Transects

From the rebar at plot center, establish six (6) transects at 0, 60, 120, 180, 240, 300 degrees using a compass and measuring tape. The length of each transect is 15 m, **slope distance**. Be exact about sighting each transect since the transect will be relocated on the next sampling visit. Measure distances within 0.1 m error, and sight bearings within 4 degrees error.

When sighting compass bearings, crew members must take care that metal objects do not affect the compass needle, and that the compass is held level (flat) at all times. The compass needle will not show small shifts in azimuth when the compass is tilted. When sighting up or down slope, remember to hold the compass level—do not tilt it relative to the slope.

To measure slope distance, pull the tape taught parallel to the ground surface, ensuring that it is not caught on vegetation. Both ends of the tape must be held at the same height above the ground to keep it parallel to the ground. In areas with minimal groundstory vegetation, place both ends of the tape on the ground to measure 15 meters slope distance from plot center, also ensuring that it is not caught on vegetation. It is important to measure slope distance accurately so that the end of the transect can be located on subsequent revisits.

*When establishing a new plot*, set a galvanized 12 inch spike flush to the ground at the end of each transect. If the spike cannot be placed exactly at the end of the transect due to rocks or trees, place the spike along the transect as close to the end as possible. It is important that the spike is on the same azimuth as the transect, even if the spike is not exactly 15 m from the plot center. Note the location of the spike in Plot Notes on the datasheet (e.g., spike for 180 transect placed 10 cm closer to plot center than standard). The transect is always 15 m in length even if the spike

had to be placed at a distance shorter or longer than 15 m. If there are significant obstacles along the transect (large downed trees, boulders, large tree boles), record where the transect was run in relation to the obstacles.

*When revisiting an established plot*, read the Plot Notes to determine if the spike at the end of any transect is different than standard. Remember that the transect is always 15 m in length even if the spike is placed at a distance shorter or longer than 15 m. For each transect, run a measuring tape 15 m along the appropriate azimuth. Then use a metal detector to search for the spike marking the transect end. Once the spike is located, the tape may need to be run again from plot center in order to lay straight. If the spike cannot be located after a reasonable amount of searching, place a new spike at the transect end, following the guidelines in the preceeding paragraph. For each transect, record whether the spike was located. If the spike falls in a depositional, erosional, or otherwise disturbed location (e.g. stream channel, drainageway, evidence of human visitation), such that it is likely that the old spike is no longer present, leave the new spike at the transect end when sampling is completed. Mark on the datasheet that the spike was replaced. If the location of the new spike is not standard, note the location of the new spike in Plot Notes on the datasheet. In normal undisturbed forest settings in which there is no clear reason why the spike cannot be located, remove the new spike when sampling is completed. Mark on the datasheet that the spike was not replaced.

If there are significant new obstacles along the transect (large downed trees, boulders, large tree boles), record where the transect was run in relation to the obstacles. Using the pin and plot center as guides, attempt to locate the previous quadrat positions as accurately as possible, despite the new obstacles. Once the transect is established, make sure that the 15 m mark of the tape is on plot center so that the other transect established with that tape is not also affected by the obstacles.

At the ends of three transects, attach the claw of the measuring tape to the spike to keep the tape in place during plot work. At the ends of the other three transects, place the handle of the measuring tape over the spike and wind the tape tight, locking the winding handle in place to keep the tape taut.

## Establishing Microplots

Establish four (4) microplots at 30, 150, 210, and 330 degrees using a compass and measuring tape. The center of the microplot should be 7.5 m **slope distance** from plot center. Be exact about sighting and distance measurements since the plots are permanent. Distances should be measured to within 0.1 m error, and bearings should be sighted to within 4 degrees error.

To measure slope distance, pull the tape taught parallel to the ground surface, ensuring that it is not caught on vegetation. Both ends of the tape must be held at the same height above the ground to keep it parallel to the ground.

When sighting compass bearings, crew members must take care that metal objects do not affect the compass needle, and that the compass is held level (flat) at all times. The compass needle will not show small shifts in azimuth when the compass is tilted. When sighting up or down slope, remember to hold the compass level—do not tilt it relative to the slope.

*When establishing a new plot*, set a galvanized 12 inch spike flush to the ground at the center of the microplot. If the spike cannot be placed exactly at the center of the microplot due to rocks or trees, place the spike along the same azimuth as close as possible to 7.5 m from plot center. It is important that the spike is on the correct azimuth, even if the spike is not exactly 7.5 m from the plot center. Note the location of the spike in Plot Notes on the datasheet (e.g., spike marking the center of Microplot 150 was placed 10 cm closer to plot center on the correct azimuth). The location of the spike marks the center point of the microplot, the point from which the 2-m radius is measured, even if the spike is not exactly 7.5 m from plot center. If a spike cannot be placed within 0.5 m of the actual microplot center (7.5 m from plot center) due to large rocks or trees, mark the center with a rock painted with tree paint. Record in the plot notes why the microplot center was not marked with a spike and what kind of marker was used.

*When revisiting an established plot*, read the Plot Notes to determine if the spike at the center of any microplot is different than standard. The location of the spike marks the center point of the microplot, the point from which the 2-m radius is measured, even if the spike is not exactly 7.5 m from plot center. For each microplot, run a measuring tape 7.5 m along the appropriate azimuth. Then use a metal detector to search for the spike marking the microplot center. To the extent possible, limit the disturbance to the forest floor, leaf litter, and understory vegetation when searching for microplot centers. For each microplot, record whether the spike was located on them microplot datasheet. If the spike cannot be located after a reasonable amount of searching, place a new spike at the microplot center, following the guidelines in the preceeding paragraph. If the spike falls in a depositional, erosional, or otherwise disturbed location (e.g. stream channel, drainageway, evidence of human visitation), such that it is likely that the old spike is no longer present, leave the new spike at the microplot center when sampling is completed. Mark on the datasheet that the spike was replaced. If the location of the new spike is not standard, note the location of the new spike in Plot Notes on the datasheet. If a spike cannot be placed within 0.5 m of the actual microplot center (7.5 m from plot center) due to large rocks or trees, mark the center with a rock painted with tree paint. Record in the plot notes why the microplot center was not marked with a spike and what kind of marker was used. In normal undisturbed forest settings in which there is no clear reason why the spike cannot be located, remove the new spike when sampling is completed. Mark on the datasheet that the spike was not replaced.

## Data Collection

PARK. 4-letter park code (BLUE, NERI, GARI, FRHI, FONE, ALPO, JOFL, DEWA, or UPDE).

PLOT. Plot identification number, unique within each park.

OBSERVERS. First initial and last name of each crew member present.

DATE: Month/day/year that data was collected (e.g., 08/17/2007)

GRTS ORDER. *For new plots only.* Order that this plot fell in the GRTS-determined sampling order.

UTME. *For new plots only.* East Universal Transverse Mercator value of the plot center from the GPS unit once the location of plot center has been determined using the average position function.

UTMN. *For new plots only.* North Universal Transverse Mercator value of the plot center from the GPS unit once the location of plot center has been determined using the average position function.

DATUM. *For new plots only.* Use UTM NAD 83. For ALPO, JOFL, FONE, FRHI, BLUE, NERI, and GARI, the zone will be 17. For UPDE and DEWA, the zone will be 18.

GPS ACCURACY. *For new plots only.* Positional accuracy of the UTMN and UTME coordinates, in meters, as determined by the GPS unit when the average position function stopped.

ELEVATION. *For new plots only.* Elevation above mean sea level of the plot center, in meters, as determined by the GPS unit.

ASPECT. *For new plots only.* The direction the ground surface of the plot faces. Aspect is measured downslope using a compass. Record aspect to the nearest 1°. If the plot is flat and has no aspect, record "Flat".

SLOPE. *For new plots only*. The predominant down slope angle across plot to the nearest percent. Occasionally, there will be multiple aspects within a plot (in a valley or on a narrow ridge), choose the predominant slope to measure by considering what direction water would eventually flow if poured onto the plot. Slope is determined with a clinometer by sighting parallel to the average incline or decline of the plot. To measure average slope, Observer 1 stands at the upper plot boundary and sights Observer 2 standing at the lower plot boundary. Observer 1 must sight Observer 2 at a height equivalent to the eye-level of Observer 1. Read slope directly as percent (<u>not degrees</u>) from the clinometer.

PLOT SLOPE REMEASURED? *For plot revisits only*, check the plot slope listed on the Plot Sheet and assess whether the plot slope has changed since the last revisit. If the slope has changed significantly, remeasure the plot slope using the guidelines in the preceding paragraph, record it on the datasheet under Slope, and circle "Y" under Slope Remeasured. If the slope has not changed significantly, circle "N".

DIRECTIONS. Directions for driving and walking to the plot, including trails, landmarks, distances, and bearings from identifiable landmarks or reference points. Include parking recommendations where applicable. Be very specific, so that future crews can successfully follow your directions.

PLOT NOTES. Record any unusual plot features or problems encountered during plot setup, including reasons for discarding any pre-selected plot locations. Note any problems or irregularities inserting plot markers. Note any features which indicate plot history, including evidence of past agricultural, silvicultural, or recreational use regardless of how long ago it may have been.

TRANSECT SPIKE FOUND? *For plot revisits only*, record whether the spike at the end of each of the six transects was located.

TRANSECT SPIKE REPLACED? *For plot revisits only*, record whether the spike at the end of each of the six transects was replaced, following the guidelines discussed above.

MICROPLOT SPIKE FOUND? *For plot revisits only*, record whether the spike at the center of each of the four microplots was located.

MICROPLOT SPIKE REPLACED? *For plot revisits only*, record whether the spike at the center of each of the four microplots was replaced, following the guidelines discussed above.

## Revision History

Note: The declinations are updated every year, even if the version number is not changed.

From Version 1.0 to Version 2.0
*December 2007* – distance to microplot centers from plot center should be measured as slope distance instead of horizontal distance.

From Version 4.0 to Version 5.0
*April 2011* – Added directions for locating plots and plot markers during revisits. Specified which data should be recorded at new plots and which data should be recorded during plot revisits. Added directions for recording whether plot markers were located and/or replaced.

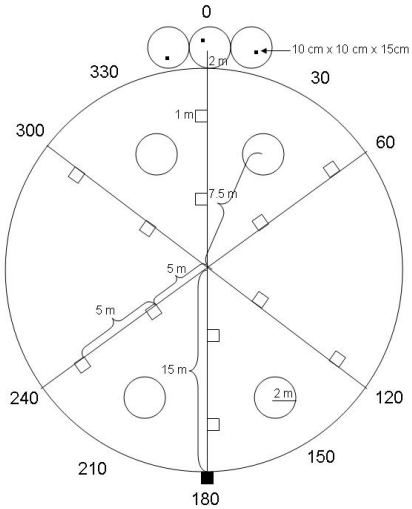
**Photopoint**
**Version 8.0 (April 2017)**

## Overview

This SOP documents the procedure for photographing plots. Photographs will be archived and used as a visual reference for documenting changes in appearance of plots over time. Take photographs shortly after plot setup to record plot conditions before trampling occurs.

## Data Collection

Photograph the plot from the end of one of the plot's transects, facing in towards plot center (designated the "plot photo"). The default location for the plot photo is the end of the 180° transect (shown as black square in figure to right). Six additional photographs ("transect photos") are taken from plot center with the center of each photograph aimed at the pin marking the end of each transect.




*When establishing a new plot*, select the end of the transect that will provide the best representative and unobstructed view of the plot for the plot photo. Choose a location where the view of the plot is not blocked by a large tree, dense vegetation or other obstructions. Note the photo location on the data sheet.

The plot photo should be taken from the end of a transect facing towards plot center. If necessary (in very thick vegetation), the plot photo can also be taken from plot center facing the direction of one of the transects. In this case, clearly explain on the data sheet where the photo was taken and which direction the camera was facing.

To capture the transect photos, stand in plot center and aim the center of each photograph at the pin marking the end of each transect, regardless of obstructions. These photographs are meant to document the location of the transects and prominent disturbances to the plot for reference during future visits.

*When revisiting an established plot*, refer to the previous visit's plot and transect photos shown on the Plot Sheet while positioning the camera to ensure the same portion of the plot is documented from year to year. Position yourself along the appropriate transect (or in plot center) as indicated by the Photo Location listed on the Plot Sheet. Next, move forward, backward, side to side, and adjust the camera tilt and height to match the previous visit's photo. Pay close attention to the following when matching photos:

- trees located at the edge of the photo
- how a tree in the forefront lines up with a tree in the background
- the angle and location of the transect tape
- the location of plot center if it can be seen in the photograph
- the position and size of the photo sign
- how other key features in the plot are aligned

An identification sign must be visible in each photograph. Using a dry erase marker, label a laminated index card as shown below. Hold the laminated card at arm's length in the lower left hand corner of the photograph frame.

| |
|---|
| PARK. ### (3 digit plot number)<br><br>Date<br><br>Subject of Photo (Transect Azimuth or "Plot Center") |

For example:

| |
|---|
| NERI.264<br><br>05/21/2016<br><br>120º |

During rain or other circumstances prevent the use of a laminated card, write the identification sign on the back of the rite-in-the-rain paper. Have a crew member hold the piece of paper 2–5 m in front of the camera location where it is easily seen in the photograph but does not obstruct the view of the plot.

Capture one digital photograph of the plot. Use the landscape mode to get maximum coverage of all vegetation layers. Do not zoom-in on the scene. Focus the camera on the end of the transect or the center of the plot. Allow the camera to automatically select the appropriate aperture for the given light conditions. **Check photo quality on the camera's LCD screen, specifically that the identification sign is legible and the entire photograph is not too dark or blurry.** Take additional photographs if the quality is questionable. If lighting is questionable, take multiple photos using different exposure settings and with / without flash. If the camera has a date stamp function, make sure the date and time are set correctly and turn this function on.

For the Canon PowerShot S3IS camera, set the picture size to M2 Normal to achieve a good balance between quality picture resolution and manageable file size.

At the end of each week, the plot photos taken that week should be downloaded from the camera onto the field computer and backed up on an external thumb drive. Download the photos into clearly labeled folders on the field computer.

## Data Collection

LOCATION FROM WHICH PHOTOGRAPH WAS TAKEN. *For new plot only*, record the location in the plot from which the photograph was taken. This location will typically be from the end of the 180° transect.

LOCATION SAME AS PREVIOUS? *For plot revisits only*, record whether the photo location was the same as used during the previous visit.

PHOTO NUMBERS. Record the photo numbers assigned to each photograph by the camera

PHOTO NOTES. Record any other important information about the photographs or their location.

## Revision History

From Version 2.0 to Version 3.0
*April 2009* – Changed the photo location to the end of the transect that will provide the best representative and unobstructed view of the plot. Previously, the photo location was the end of the 180 degree transect, or the best transect to the counter-clockwise position from 180 transect.

From Version 4.0 to Version 5.0
*April 2011* – Clarified instructions used during plot revisits.

From Version 5.0 to Version 6.0
*September 2013* – Added instructions for six transect photos to be taken from plot center focused down each of the six transects.

From Version 6.0 to Version 7.0
*April 2016* – Changed photo identification system from aluminum holder with paper signs to laminated index card with dry ease markers.

**Stand Measurements**
**Version 8.0 (April 2017)**

## Overview

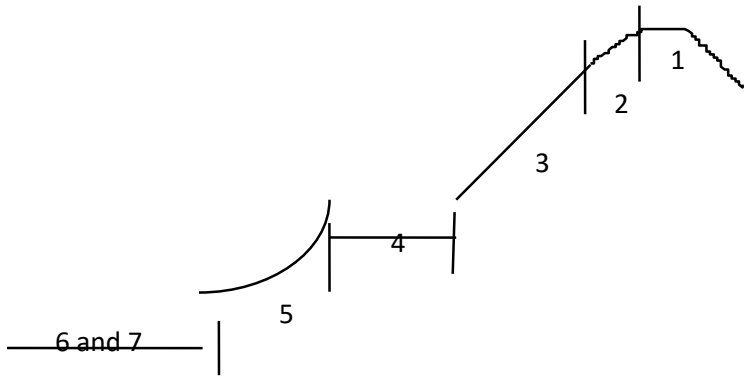
This SOP collects stand-level measurements within the plot to allow interpretation of other measures, and to assess stand structure and disturbance. This SOP is designed for use only during the summer leaf-on period (approximately May 15 to September 15).

Canopy closure and cover classes do not contain exact breakpoints (e.g., 25%). Classes are either above or below each breakpoint. This encourages the crew to assess and recorded cover classes rapidly, without compromising accuracy.

## Data Collection

TERRAIN POSITION. In relation to the entire park, record the terrain position of the plot. Refer to a topographic map to determine the plot's terrain position. Use following codes:

1 Top of slope - convex region, or flat ground on top of a plateau
2 Upper slope - convex region near top of slope
3 Mid-slope - uniform, fairly straight sloping region
4 Bench - level land with slopes above and below
5 Lower slope - concave region near bottom of slope
6 Bottomland - flat and low-lying; associated with drainage and flooding
7 Flatland - low elevation, but unrelated to drainage and flooding; may have minimal elevation change




CROWN CLOSURE. Estimate the perentage of plot area covered by live tree crowns directly overhead and record appropriate code. If foliage is not present due to seasonal variation or temporary defoliation, visualize the amount of live crown normally present. Do not visualize foliage that formerly existed on dead branches.

1 0 to 10 %
2 10 to 25 %
3 25 to 50 %
4 50 to 75 %
5 75 to 100 %

DENSIOMETER LOCATION. To assess canopy closure with the densiometer, stand on plot center and face the 0 transect. The lowest branch over the densiometer should be part of the subcanopy or canopy. If branches from tall shrubs or overtopped trees block the view of the canopy in the densitometer mirror, find the location closest to plot center with an unencumbered view of the canopy. Record that location on the datasheet. For example: "10 m away from plot center along the 60 degree transect."

DENSIOMETER READINGS. Hold the densiometer level, approximately 12 – 18 inches in front of your body, at elbow height, so that your head is just outside the grid area. Imagine four equi-spaced dots in each of the 24 grid squares. Systematically count the number of dots that are *NOT* covered by canopy (e.g., open sky or bare thin twigs). Record the total number of dots on the "North (0º)" line.

Foliage, large branches, and trunks are considered part of the canopy. Bare or defoliated fine twigs thinner than the densiometer grid lines are not considered as part of the canopy, therefore dots falling on bare fine twigs should be counted. Assess canopy closure in its current state, even if the trees are defoliated.

From plot center, face east (90º), south (180º), and then west (270º), repeating the above instructions in each direction and recording the number of dots *NOT* covered by canopy on the corresponding line on the data sheet.

In the database, calculate canopy closure for the plot as: $\sum$ [ (96 - Number of dots) * 1.04 ] / 4

STAND STRUCTURE. Record the basic stand structure in the plot using the following codes:

1 Even-sized: A succeeding stand dominated by a single cohort of closely competing trees of relatively uniform size and height with a closed tree canopy (>= 60% tree canopy cover). Smaller trees are typically stressed or overtopped and have fallen behind their associates. Regeneration and/or tall relics from a previous stand may be present. However, at least 66% of the trees in the plot have similar diameter and height.

3 Multi-sized: A later-successional or mature stand characterized by a distinct canopy with typical regeneration below including trees of may sizes and heights. Canopy trees vary in age and diameter such that <66% of the trees have similar diameter and height. Typically has a closed tree canopy (>= 60% tree canopy) but gap dynamics may be evident.

4 Mosaic: Plot contains at least two distinct structural classes or size classes of trees, each covering at least 25% of the stand.

5 Early-successional: A succeeding stand without a closed tree canopy (<60% canopy cover). May be dominated by a mix of trees, saplings, shrubs and herbaceous vegetation.

6 Woodland: A stand with at least 25% but less than 60% canopy tree cover, giving the area an open appearance. Trees are open-grown, or growing in small groups interspersed with shrub or herbaceous cover or bare rock. Do not use this code for early-successional plots apparently succeeding to forest, or a forested plot that currently has < 60% canopy cover due to gap dynamics.

DEER IMPACT. Visually inspect the plot and record the level of deer impact observed (adapted from Brose et al 2008). The browse preference of many common tree and shrub species is listed in Table 1. The browse preference of some common herbaceous species is listed in Table 2. Record this assessment after the quadrats and microplots have been sampled. Remnants of browsed plants may not be obvious without detailed examination of the forest floor. Record the deer impact level using the following codes and criteria:

1 Very low impact. No browse observed. Found only inside well maintained, woven-wire, deer-exclosure fences.

2 Low impact. Browse is absent or scarce. Browse-preferred regeneration is abundant and of varying heights. Browse-preferred plants are present and able to flower and fruit. Stump sprouts, if present, have minimal evidence of browse.

3 Moderate impact. Browse evidence is observed but not common. Browse-preferred regeneration is present but with little variability in height. Stump sprouts, if present, are browsed. Nonpreferred browse and browse-resistant species are common and widespread.

4 High impact. Browse evidence is common, or browse-preferred regeneration is rare to absent. Nonpreferred and browse-resilient vegetation is limited in height growth by deer browsing.

5 Very high impact. Browse evidence is omnipresent, or browse-preferred regeneration is absent. The abundance of nonpreferred vegetation is reduced by browsing. Browse-resilient plants show signs of heavy repeated browsing and a browse line is evident.

Table 1. Browse preferences for tree regeneration and shrubs (adapted from Latham et al 2005).

| **Browse preference** | **Scientific name** | **Common name** |
|---|---|---|
| **High – moderate preference** | *Acer rubrum* | red maple |
| | *Cornus* spp. | dogwoods |
| | *Fraxinus* spp. | ashs |
| | *Liriodendron tulipifera* | Tulip-poplar |
| | *Nyssa sylvatica* | blackgum |
| | *Prunus pensylvanica* | pin cherry |
| | *Quercus* spp. | oaks |
| | *Rubus allegheniensis* | Allegheny blackberry |
| | *Sassafras albidum* | sassafras |
| | *Tilia americana* | basswood |
| | *Viburnum* spp. | viburnums |
| **High preference in autumn and winter** | *Betula* spp. (*lenta, alleghaniensis*) | birches |
| | *Fagus grandifolia* | American beech |
| | *Tsuga canadensis* | eastern hemlock |
| **Low preference** | *Acer pensylvanicum* | striped maple |
| | *Carya* spp. | hickories |
| | *Liquidambar sytraciflua* | sweetgum |
| | *Hamamelis virginiana* | witch-hazel |
| | *Ostrya virginiana* | eastern hophornbeam |
| | *Populus* spp. | aspen |
| | *Prunus serotina* | black cherry |
| | *Robinia pseudoacacia* | black locust |

Table 2. Browse preference for herbaceous species.

| Scientific name | Common name |
|---|---|
| **Preferred browse species** | |
| *Actaea* spp. (*A. pachypoda, A. podocarpa, A. rubra*) | baneberries |
| *Arisaema triphyllum* | Jack-in-the-pulpit |
| *Maianthemum canadense* | Canada mayflower |
| *Maianthemum* spp. (*M. racemosum, M. stellatum*) | false lily of the valleys |
| *Medeola virginiana* | Indian cucumber root |
| *Osmorhiza* spp. (*O. claytonia, O. longistylis*) | sweetroot |
| *Polygonatum* spp. (*P. biflorum, P. pubescens*) | Solomon's seal |
| *Prosartes* spp. (*P. lanuginosa, P. maculata*) | yellow fairy bells, mandarin |
| *Smilax* spp. (*S. rotundifolia, S. glauca, S. taminoides*) | catbriers |
| *Trillium* spp. (*numerous)* | trilliums |
| *Uvularia* spp. (*U. grandiflora, U. perfoliata, U. puberula, U. sessilifolia*) | bellworts |
| **Browse preference is debated** | |
| *Podophyllum peltatum* | mayapple |
| *Actaea racemosa (formerly Cimicifuga racemosa)* | black bugbane |
| **Species that are avoided** | |
| *Ageratina altissima* | white snake root |
| *Dennsteadtia punctilobula* | hay-scented fern |
| *Thelypteris noveboracensis* | New York fern |

MICROTOPOGRAPHY. Microtopography is small-scale variation in the land surface caused by tree tip-ups that create a pit and mound undulation. Microtopography is eliminated when a site is plowed, and recovers over time once an area is reforested. Record presence (1) if: a) more than 1 canopy or subcanopy tree (co-dominant or intermediate canopy class as defined in the Tree SOP) has recently created a tip-up in the plot ("recent" includes fallen trees that are still clearly visible as CWD or partially living trees), OR b) the stand contains old-growth structure and more than 1 pit-and-mound microtopography exists within the plot even if the fallen trees are no longer visible. If pit and mound topography is suggested but not clear, record 9.

% COVER BY STRATA. Estimate the total cover of plant foliage by strata within the plot. A rapid cover estimate is made, ignoring overlap among species. It may help to visualize cover by collapsing each layer into a 2-dimensional space, ignoring normal spaces occurring between leaves. Estimate total cover for each strata listed below. Use the following cover classes: <1%, 1–2%, 2–5%, 5–10%, 10–25%, 25–50%, 50–75%, 75–95%, 95–100%

Groundstory: <0.5 m above ground
Mid-understory: 0.5–2 m above ground
High-understory: 2–5 m above ground.
Subcanopy: Height defined for each plot. Must be >5 m.
Canopy: Height defined for each plot.

DOMINANT VEG. For each of the strata listed above, record the type of vegetation dominant in that stratum. The type of vegetation with the most percent cover is the dominant vegetation. The possible types of vegetation are: Nonvascular, Fern, Graminoid, Herb, Deciduous Shrub, Evergreen Shrub, Deciduous Tree, Evergreen Tree, and Vine.

SECONDARY VEG. If there is a second type of vegetation which covers greater than 25% of the plot, record that type of vegetation in the secondary vegetation column. Do this for each stratum that has a second type of vegetation covering greater than 25% of the plot. Not every stratum will have a secondary vegetation type. The types of vegetation are: Nonvascular, Fern, Graminoid, Herb, Deciduous Shrub, Evergreen Shrub, Deciduous Tree, Evergreen Tree, and Vine.

DISTURBANCE CODE. Record up to three (3) disturbance codes from most to least important based on visual inspection of the plot. A disturbance must cause "significant threshold" damage, equivalent to either: 1) 25% of all trees in a plot, 2) 50% of the individual trees of a species (must include at least two trees in or near the plot), or 3) disturbance to at least 25% of the soil surface, understory vegetation, and canopy. Only record disturbances which appear to have occurred since the previous inventory or within the last four (4) years. If you record an unknown disturbance, attempt to capture a picture illustrating the disturbance.

- 00 None - no observable disturbance
- 10 Insect damage
  - 11 insect damage to understory vegetation
  - 12 insect damage to trees, including seedlings and saplings
- 20 Disease damage
  - 21 disease damage to understory vegetation
  - 22 disease damage to trees, including seedlings and saplings
- 30 Fire - prescribed or natural
- 40 Animal damage
  - 41 beaver damage to vegetation
  - 42 porcupine
  - 43 deer/ungulate
  - 44 bear
  - 45 rabbit
  - 46 domestic animal/livestock including grazing
  - 47 flooding caused by beaver
- 50 Weather damage
  - 51 ice/snow
  - 52 wind including hurricane, tornado
  - 53 flooding caused by weather
  - 54 drought
  - 55 earth movement/avalanches
- 60 Vegetation - severe competition (>75% cover) from vines and/or invasive plant species
- 70 Unknown/not sure/other. Describe in Notes and take photo.
- 80 Human-caused damage - other than described in these codes. Describe in Notes and take a photograph.
- 90 Silvicultural treatment
  - 91 Overstory removal - removal of all or most of the canopy trees
  - 92 Selective cutting - removal of one or more trees from a stand (but see 91)
  - 93 Site preparation - clearing, slash burning, chopping, disking, bedding, or other practice to prepare site for regeneration.

94 Artificial regeneration
95 Other silvicultural treatment - use of fertilizers, herbicides, girdling, pruning, or other activities to improve the commercial value of the stand. Describe in Notes and take a photograph.

DISTURBANCE THRESHOLD. For each disturbance recorded above, record which threshold was triggered: 1) damage to 25% of all trees in a plot, 2) damage to 50% of the individual trees of a species (must include at least 2 trees in or near the plot), or 3) disturbance to at least 25% of the plot's soil surface, understory vegetation, or canopy.

DISTURBANCE % COVER. For each disturbance recorded above, record an approximate disturbance percentage using the following cover classes: 25–50, 50–75, 75–95, or 95–100 %. If the recorded disturbance was triggered by Threshold 1, record the approximate percentage of all trees in the plot damaged by that disturbance. If triggered by Threshold 2, record the approximate percentage of the individual trees of that species damaged by that disturbance. If triggered by Threshold 3, record the percentage of the soil surface, understory, or canopy affected by that disturbance.

FOREST FLOOR: Examine the ground within the plot and estimate the percent cover of each of the categories listed below. Use the following cover classes: <1, 1–2, 2–5, 5-10, 10–25, 25–50, 50–75, 75–95, or 95–100 %. For reference, a 2.6 m by 2.6 m square is equal to 1% cover of the plot area.

BARE SOIL. Record the percentage of the plot covered by bare soil (mineral or organic). Do not include soil covered by leaf litter.

ROCK. Record the percentage of the plot covered by exposed bedrock or surface rocks (>10 cm).

WATER. Record the percentage of the plot covered by water.

OTHER. Record the percentage of other things that have significant cover (>1% of the plot area; e.g. trash, etc).

TRAMPLED. Record the percentage of the plot showing evidence of trampling by humans, wildlife, or livestock. Trampling is assessed relative to the conditions of adjacent undisturbed soil. Include area occupied by established or unofficial trails traversing the plot, and record type of trail in plot notes.

SUBCANOPY HEIGHT. After the tree data are collected, measure the height of three live subcanopy trees. *For newly established plots,* select three live intermediate trees (crown class = 4) with crowns visible from the ground that have heights typical of most intermediate trees in the subcanopy of the stand. Do not measure the heights of snags.

To measure the height of each tree, move to a position as far from the base of the tree as possible along minimal slope while still allowing sufficient view of the tree crown. Determine height to

the top of the intermediate tree either using the laser hypsometer or an analog clinometer. Record the height in meters and the tree number from the tree data sheet for each measured tree.

To use the laser hypsometer:
- Set the laser to Height Routine, so that "HT" is visible in the bottom of the viewfinder.
- Hold the laser horizontal and sight the bole of the target tree through the viewfinder. Press the fire button.
- Then, sight the base of the target tree through the viewfinder. Press the fire button.
- Next, sight the top of the target tree through the viewfinder. Press the fire button.
Note: It is not necessary that the laser actually hit the foliage at the top of the target tree. When measuring the base and the top of the tree, the laser hypsometer is actually measuring angle from horizontal, not distance. Therefore, your line of sight to the top of the tree does not need to be unobstructed as when measuring distance.
- The height of the tree should appear in the viewfinder.

To use an analog clinometer and simple triangulation:
- Use the clinometer to read the angles to the top of the tree and to its base. Grasp the clinometer with the right hand and sight through the optics with the right eye, keeping the left eye open and looking at the tree top. A movable scale with angle measurements in percent should be visible and should rotate as the clinometer is tilted. An optical illusion extends the hair-line crosshair outside of the clinometer frame. Aim the clinometer so that the extended hair-line coincides with the top of the tree. Hold the clinometer steady, close your left eye and read the percent on the right side of the rotating scale. This is Percent 1; include whether the percent is positive or negative.
- Repeat the previous step, this time aiming the extended hair-line at the base of the trunk. This is Percent 2; include whether the percent is positive or negative.
- Next, aim the extended hair-line of the clinometer above the base of the trunk to the point where the angle measurement is 0 degrees. This point on the trunk represents eye level of the observer. Run a measuring tape from the level of the observer's eye to this point on the trunk. Check to make sure that your tape is measuring horizontal distance. Note this distance measurement in meters.
- Convert the percentages to decimals and complete the following equation:
Calculate tree height = (Percent 1 − Percent 2) × Distance

Subcanopy tree height cannot exceed 20.0 m. If the height of the tree you are measuring exceeds 20.0 m, check to make sure you are hitting the correct spots on the bottom and top of the tree. The top of the tree is the tallest branch directly over the trunk, not the branches that extend towards you over your head. Remeasure the tree height. If the second reading of the tree height exceeds 20.0 m, find a different subcanopy tree to measure.

*For revisits to previously established plots,* check the Plot Sheet to identify which three intermediate trees were measured for subcanopy height at the last visit. Visually inspect these

trees to ensure that no unusual changes to tree height have occurred (e.g., broken top due to storm damage, etc.). If any unusual changes have occurred or the tree has died, select a different intermediate tree, record the new tree number on the data sheet, and record in the Plot Notes why a new tree was selected. Otherwise, measure the height of the three trees measured at last visit. Current height should be within 3 meters of the previously measured height, shown on the Photo Sheet. If the current height deviates more than 3 meters from the previously measured height, measure the height two more times. If the height is consistently deviates > 3 m, record the measured height and write "checked 2x" on the datasheet in the space next to the height table.

CANOPY HEIGHT. After the tree data are collected, repeat the instructions above to measure the height of three live co-dominant trees (crown class = 3). *For newly established plots,* select three live co-dominant trees (crown class = 3) with crowns visible from the ground that have heights typical of most co-dominant trees in the canopy of the stand. Do not measure the heights of snags. *For revisits to previously established plots,* check the Plot Sheet to identify which three co-dominant trees were measured for canopy height at the last visit. Visually inspect these trees to ensure that no unusual changes to tree height have occurred (e.g., broken top due to storm damage, etc.). If any unusual changes have occurred or the tree has died, select a different co-dominant tree, record the new tree number on the data sheet, and record in the Plot Notes why a new tree was selected. Otherwise, measure the height of the three trees measured at last visit. Current height should be within 3 meters of the previously measured height, shown on the Photo Sheet. If the current height deviates more than 3 meters from the previously measured height, measure the height two more times. If the height is consistently deviates > 3 m, record the measured height and write "checked 2x" on the datasheet in the space next to the height table.

Canopy tree height cannot exceed 45.0 m. If the height of the tree you are measuring exceeds 45.0 m, check to make sure you are hitting the correct spots on the bottom and top of the tree. The top of the tree is the tallest branch directly over the trunk, not the branches that extend towards you over your head. Remeasure the tree height. If the second reading of the tree height exceeds 45.0 m, find a different canopy tree to measure.

## Literature Cited

Brose, P. H., K. W. Gottschalk, S. B. Horsley, P. D. Knopp, J. N. Kochenderfer, B. J. McGuinness, G. W. Miller, T. E. Ristau, S. H. Stoleson, and S. L. Stout. 2008. Prescribing regeneration treatments for mixed-oak forests in the Mid-Atlantic region. General Technical Report NRS-33. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Latham, R. E., J. Beyea, M. Benner, C. A. Dunn, M. A. Fajvan, R. R. Freed, M. Grund, S. B. Horsley, A. F. Rhoads and B. P. Shissler. 2005. Managing White-tailed Deer in Forest Habitat From an Ecosystem Perspective: Pennsylvania Case Study. Report by the Deer Management Forum for Audubon Pennsylvania and Pennsylvania Habitat Alliance, Harrisburg.

## Revision History

From Version 2.0 to Version 3.0

*February 2009* – Replaced Deer Browse Line which recorded presence/absence/unclear with Deer Impact from Brose et al 2008. The 5 levels of deer impact have clearer definitions for each

level and will provide a more sensitive and repeatable measure. Added tables of browse preferred/avoided species for reference.

– Changed protocol for Subcanopy Height and Canopy Height from measuring the height of one tree in the subcanopy and canopy to measuring three trees in each layer. Using the average of three measurements will hopefully reduce the large variation in measurements between observers and years.

– Changed Disturbance threshold #3 to read: "3) disturbance to at least 25% of the soil surface, understory vegetation, and **canopy**." so that the creation of large canopy gaps can be recorded. For example, if a few of the largest trees in the plot fall or were harvested (but they were <25% of the trees and, <50% of any species), resulting in a third of the canopy is opening, this disturbance can now be recorded.

*April 2009* – For Stand Structure, changed "Even-aged" to "Even-sized" and "Multi-aged" to "Multi-sized" in response to reviewer comments that we were collecting no information on tree age. Also added more definite, quantitative definitions of those categories in response to field crew confusion over the distinction between the two categories.

<u>From Version 3.0 to Version 4.0</u>

*April 2010* – For canopy and subcanopy height, added that the tree number of the trees that were measured should be recorded so that the same trees can be measured again during the revisit.

<u>From Version 7.0 to Version 8.0</u>

*April 2017* – Added densiometer readings to obtain finer scale and quantitative assessment of canopy closure.

**Coarse Woody Debris**
**Version 8.0 (April 2017)**

## Overview

This SOP quantifies coarse woody debris using line intercept transect sampling along six 15-m transects at each plot. These data yield information on forest structural diversity and habitat for wildlife and fungi.

## Definitions

Coarse woody debris (CWD) includes down, dead tree and shrub boles, large limbs, and other woody pieces. To be tallied in this protocol, the CWD piece must be ≥7.5 cm diameter and ≥1 m long. CWD includes dead trees leaning >45 degrees from vertical, measured along the bole. CWD does not include:

a. Woody pieces <7.5 cm in diameter at the point of transect intersection.
b. Woody pieces <1 m in length.
c. Dead trees leaning 0 to 45 degrees from vertical.
d. Trees showing any sign of life.
e. Stumps that are rooted in the ground (i.e., not uprooted).
f. Bark that is no longer attached to a bole or limb. (Bark attached to a piece is counted.)
g. Roots or main bole below the root collar.
h. Very decomposed logs reduced to slightly elevated 'humps' on the ground without structural integrity

Horizontal distance is the level, straight line distance between two points. This contrasts with slope distance which is measured parallel to the ground surface. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

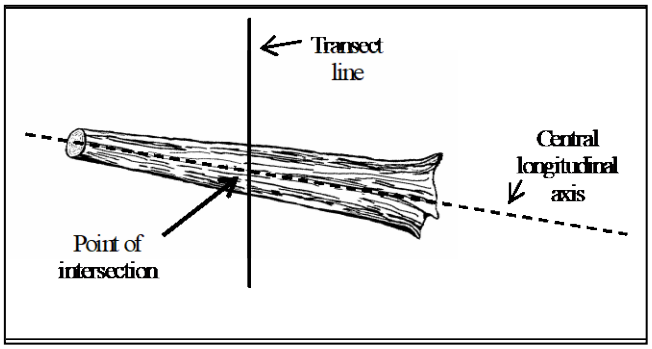
## Transect Set Up

The six CWD transects extend 15 m slope distance from plot center in the following directions: 0°, 60°, 120°, 180°, 240°, and 300°. Transects are laid out along a straight line to avoid biasing piece selection. Detailed directions for establishing these transects are provided in the Site Selection and Plot Establishment SOP. To tally CWD, walk along the right side of the 0° transect, starting at plot center and working towards the plot edge. Repeat with the remaining transects working clockwise. This pattern ensures that second intersects and second transects (see following section) are tallied consistently between sampling.

### Tally Rules for CWD

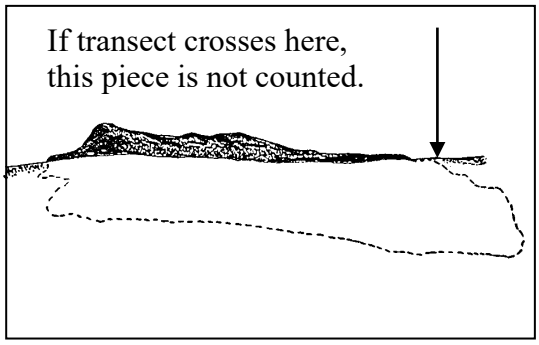
Most CWD will be lying on the ground. To be tallied by this protocol, the transect must intersect the central longitudinal axis of the piece of CWD (see diagram below left). The point of intersection between the transect and the central longitudinal axis of the piece must occur above the ground (see diagram below right). The CWD piece must meet the minimum diameter criteria (≥ 7.5 cm) at the point of intersection, as well as the minimum length criteria (≥1 m).

VIEW FROM ABOVE




(adapted from USFS 2005)

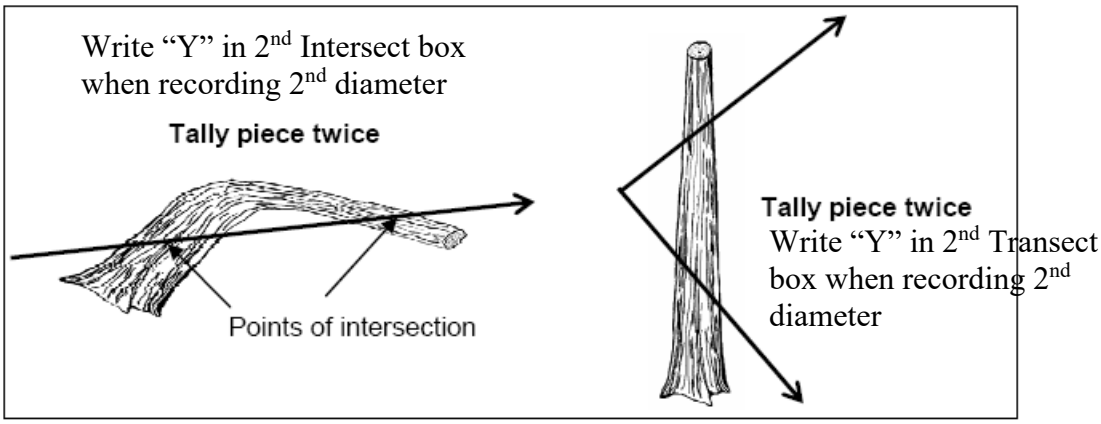
VIEW FROM SIDE




(adapted from Jenkins et al. 2004)

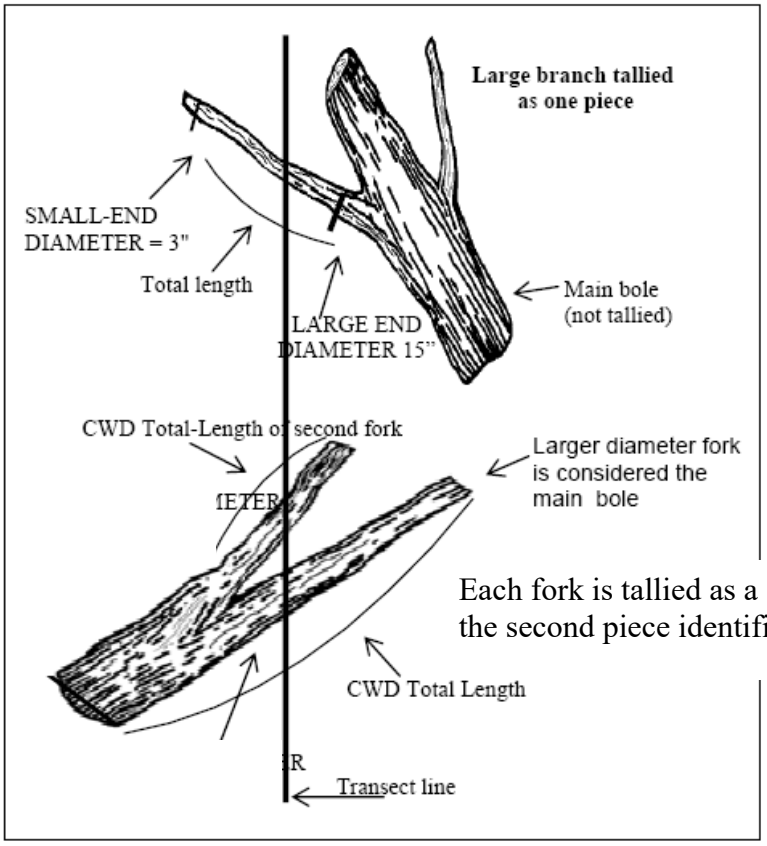
All snags leaning >45º from vertical should be tallied regardless of height off the ground. If a snag is too high to reach, record this fact in the Notes and estimate its diameter.

If a piece intersects a transect line more than once or intersects more than one transect, measure and record the diameter of the piece each time it intersects (see diagram below). When recording the diameter of a CWD piece the second time it intersects on a single transect, put a "Y" in "2nd Intersect" box on the data sheet. When recording the diameter of a CWD piece on a second or third transect, put a "Y" in "2nd Transect" box or "3rd Transect" box on the data sheet. If the plot center falls directly on a CWD piece, tally that piece only once on the 0° transect. This case will be uncommon.




(adapted from USFS 2005)

When the transect crosses a forked downed tree bole or large branch connected to a downed tree, tally each qualifying piece separately (see diagram below). To be tallied, each individual piece must meet the minimum diameter and length requirements. Write "Y" in the 2nd Intersect box when recording to second diameter of the forked piece.




(adapted from USFS 2005)

If a piece is fractured across its diameter or length, and would pull apart at the fracture when pulled from either end or sides, treat it as two separate pieces. If judged that it would not pull apart, tally as one piece. Tally only the piece intersected by the transect line.

Do not tally a piece if it intersects the transect on the root side of the root collar. Do not tally roots.

## Data Collection

TRANSECT SLOPE. *For new plots only*. Measure and record the average slope of the transect to the nearest 1% using a clinometer. The observer with a clinometer should stand over the plot center at transect origin and sight a known height on a second person located at the transect end. The known height is the approximate height of the observer's eye on the second person.

TRANSECT SLOPE REMEASURED? *For plot revisits only*, check the transect slope listed on the Plot Sheet for each transect and assess whether the transect slope has changed since last visit. If the slope has changed significantly, remeasure the transect slope using the guidelines in the

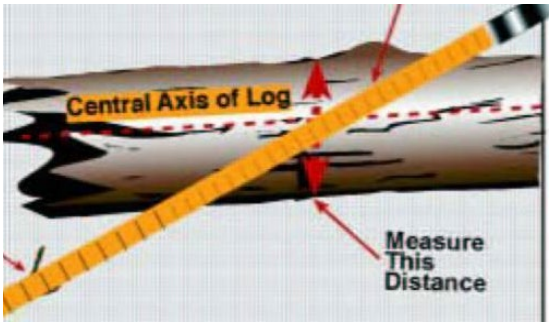
preceding paragraph and record it on the datasheet. Circle "Y" under Slope Remeasured. If none of the transect slopes have changed significantly, circle "N".

TRANSECT. Record the number indicating the azimuth of the transect: 0°, 60°, 120°, 180°, 240°, or 300°. Sample the 0° transect first and work clockwise around the plot. If no pieces of CWD cross the transect, record the transect azimuth and put a horizontal line through the Diameter and Decay Class boxes. All transects must be recorded for each plot.

To tally CWD, walk along the right side of the 0° transect, starting at plot center and working towards the plot edge. Repeat with the remaining transects working clockwise. This pattern ensures that second intersects and second transects (see following section) are tallied consistently between sampling. For each piece of CWD tallied, record the following:

DIAMETER AT INTERSECTION. Record the diameter of the CWD piece, to the nearest 0.5 cm, at the point where the transect intersects the central longitudinal axis of the piece of CWD. Take care to measure diameter perpendicular to the piece's central axis (not perpendicular to the transect) as shown below. Diameter of CWD is measured with calipers. Do not squeeze soft logs with the calipers; this will produce a smaller diameter reading and may affect future measurements of the log. If calipers are unavailable, diameter can be measured by holding a metal tape or ruler above the log. To avoid parallax error, position your eyes directly over each end of the ruler in sequence. First position your eyes above one side of the CWD piece. Align the 0 end of the ruler with that side of the CWD piece. Then, without moving the ruler, position your eyes above the other side of the CWD piece. Read the diameter at the distance that appears aligned with that side of the CWD piece.

For pieces that are severely flattened or oval in cross-section, take two diameter measurements perpendicular to each other at the point where the central axis crosses the transect. Record the average of these to measurements if the average is ≥ 7.5 cm.




(from Coulston 2003)

DECAY CLASS. Record the code indicating the predominant decay class (>50% of the piece) along the length of the entire CWD piece. If no single class dominates, average the decay classes present. See the figure and tables on the following pages for illustrations and descriptions of decay classes.

HOLLOW. Record whether piece is hollow (Y) or not (N). A piece is considered hollow if a cavity extends at least 0.5 m along the central longitudinal axis of the piece, and the cavity entrance is at least 1/4 the diameter of the piece.

2ND INTERSECT. If a piece of CWD intersects the same transect more than once or two pieces of CWD are connected, record an "Y" in the "2nd Intersect" box on the lines that record the second, third, etc diameters recorded from the same piece of CWD. Indicate in the Notes which pieces are connected, as shown in the example below.

2ND TRANSECT. If a piece of CWD intersects with a second transect, record an "Y" in the"2nd Transect" box on the line that records the second diameter measured from the same piece of CWD. Indicate in the Notes which diameters were measured from the same piece of CWD, as shown in the example below.

3RD TRANSECT. If a piece of CWD intersects with a third transect, record an "Y" in the"3rd Transect" box on the line that records the third diameter measured from the same piece of CWD. Indicate in the Notes which diameters were measured from the same piece of CWD.

NOTES. Record anything unusual about the transect placement or the pieces of CWD. If the species of the CWD can be easily identified, record that information in this space. Use this space to identify which pieces of CWD are connected to each other, or which diameters were measured from the same piece of CWD, as shown in the example below.

Example of Completed CWD Transect Data Sheet

| Transect | Diameter | Decay class | Hollow | 2nd intersect | 2nd transect | 3rd transect | Notes |
|---|---|---|---|---|---|---|---|
| 0 | ----- | ----- | | | | | |
| 60 | 8.5 | 2 | N | N | N | N | #1 |
| 60 | 10.0 | 2 | N | Y | N | N | Forked piece, connected to #1 |
| 120 | ----- | ----- | | | | | |
| 180 | 26.5 | 3 | N | N | N | N | #2 |
| 180 | 13.5 | 4 | Y | N | N | N | |
| 240 | 19.0 | 3 | N | N | Y | N | Same piece as #2 |
| 300 | 8.0 | 1 | N | N | N | N | Pinus strobus |
| | | | | | | | |
| | | | | | | | |

## References

Coulston, John W. et. al. 2003. Forest Health Monitoring 2003 National Technical Report. U.S. Department of Agriculture, Forest Service, Southern Research Station.

Jenkins, M. A., Webster, C.R., Parker, G.R., and M.A. Spetich. 2004. Coarse woody debris in managed Central Hardwood forests of Indiana, USA. Forest Science 50:781–792.

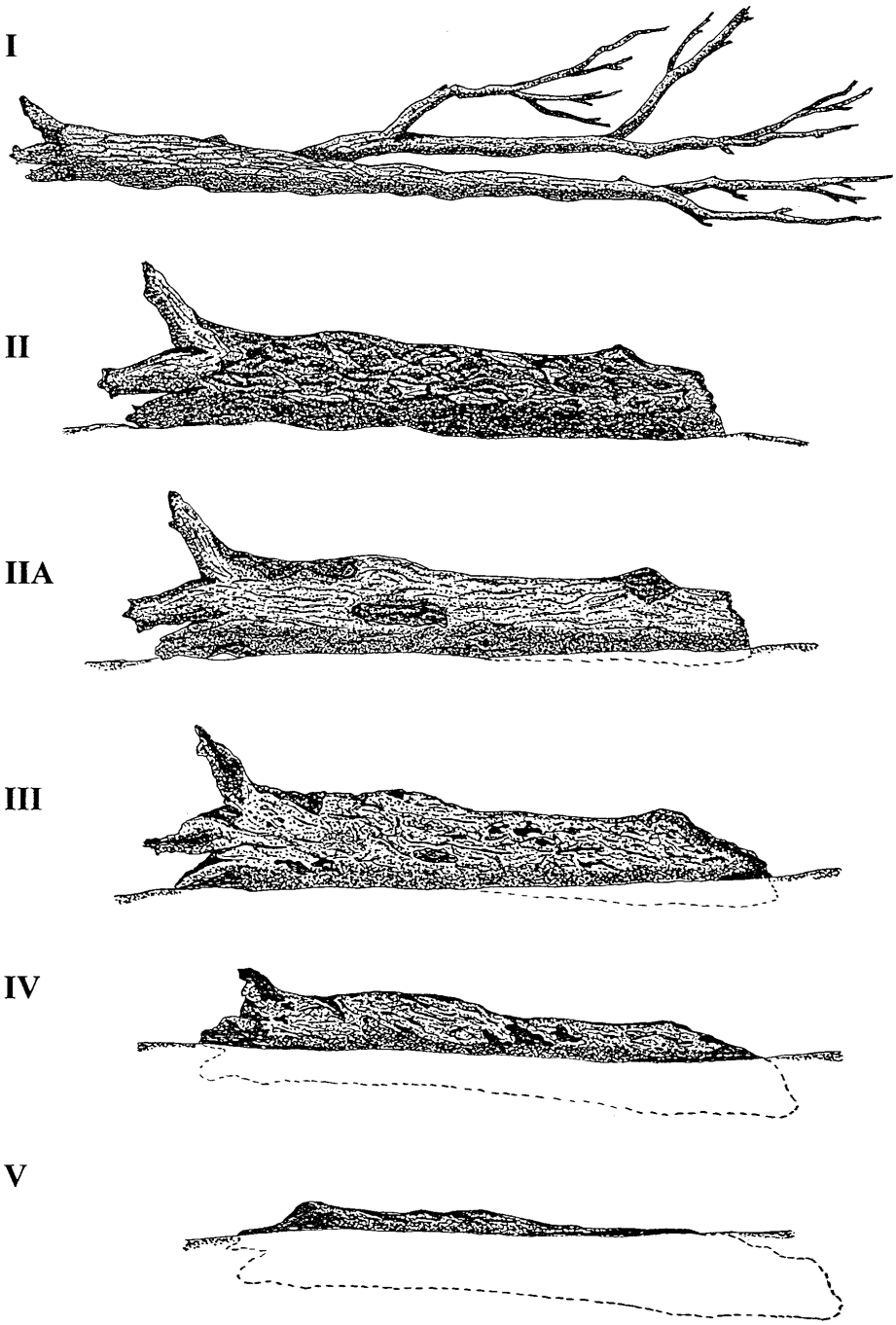
Pyle, C., and M. M. Brown. 1998. A rapid system of decay classification for hardwood logs of the eastern deciduous forest floor. Journal of the Torrey Botanical Society 125:237–245.

United States Forest Service. 2005. Forest Inventory and Analysis National Core Field Guide Phase 3 – Downed Woody Materials. Version 3.0. United States Forest Service.

**Revision History**

From Version 4.0 to Version 5.0

*April 2011* – Added instructions for transect slope remeasurement during plot revisits.




Decay stages of down deadwood in eastern deciduous forests. Classes are based upon Pyle and Brown (1998). Figure is adapted from Jenkins et al. (2004). We will not use Decay Class IIA.

| Class | Bark | Log shape and integrity | Color of exposed wood | Texture of Rotten Portions | Primary surface substrate | Branches and twigs |
|---|---|---|---|---|---|---|
| 1 | Firmly attached | Round and solid. Freshly fallen, intact logs | Fresh color, not stained by weathering | Intact, no rot or conks. Stem decay absent. | Sound, tight bark | Branches retain many small twigs |
| 2 | If present, decayed, faded and not firmly attached | Round and solid | May be bleached and relatively smooth (like driftwood) | Mostly intact, sapwood partly soft and starting to decay, but can't be pulled apart by hand | Decayed bark and hard wood - impenetrable with fingernail or pen point, may be case hardened with power wood beneath | Branches retain some small twigs, often with peeling bark |
| 3 | Generally absent, except in Betula and Prunus | Round and firm, piece supports its own weight | Reddish-brown, or original color | Hard, large pieces of sapwood can be pulled apart by hand. | Soft wood - will spring back if compressed, easily penetrated with fingernail or pen point | No small twigs, but branch stubs will not pull out |
| 4 | Absent | Oval or flattened, no longer a solid piece, though some hard chunks remain. Piece does not support its own weight, but maintains its shape | Reddish or light brown | Soft, small blocky pieces, a metal pin can be pushed into heartwood | Very spongy wood - responds to finger pressure and may exude moisture. Powder wood flows through fingers like coarse sawdust | No small twigs, branch stubs pull out |
| 5 | Absent | Quite flat or flat with some rounding. Piece longer maintains its shape, but spreads out on the ground | Red-brown to dark brown | Soft, powdery when dry | Loosely aggregated powder wood | No small twigs. Branch stubs and pitch pockets have usually rotted down |

(adapted from Pyle and Brown 1998 and USFS 2005)

**Groundstory Diversity**
**Version 8.0 (April 2017)**

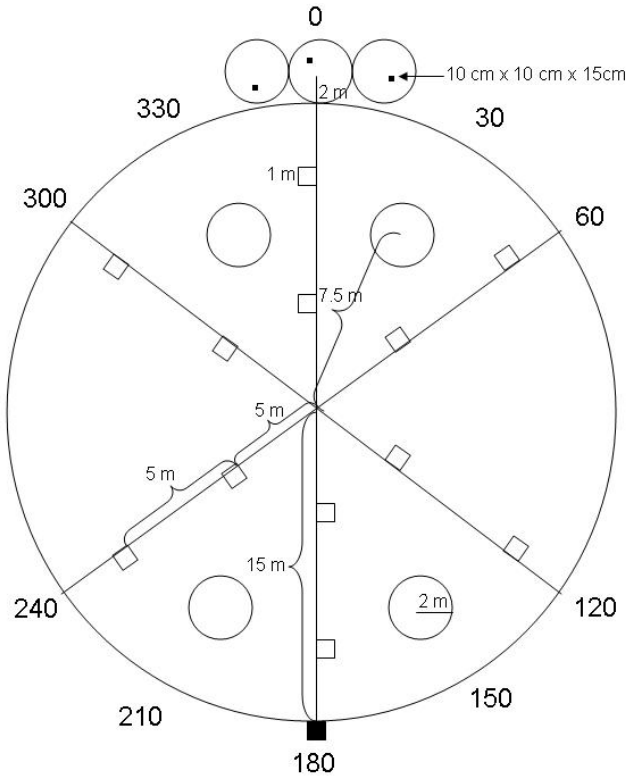
## Overview

This SOP measures the composition and abundance of groundstory vascular plants. Species percent cover data are collected in twelve 1-$m^2$ quadrats nested within each 15-m radius plot. This SOP should be conducted by a person (botanist or vegetation crew leader) familiar with flora of the region, especially herbaceous, graminoid, and fern species. This protocol should be conducted only during the summer months (approximately May 15 to September 15).

## Quadrat Set Up

The quadrat frame is made from ½ inch PVC pipe, with four pieces cut to be 1 m long when inserted into right angle corner pipe joints. One side of each corner joints should be detachable to improve maneuverability. The quadrat poles should be painted with 10-cm lengths of purple PVC primer, alternating with 10-cm lengths of unpainted white area. Thus, when the quadrat is assembled, each 10-cm x 10-cm purple or white square section illustrates 1% of the quadrat, facilitating accurate estimation of percent cover.

The location of the twelve quadrats is determined by the six transects used to measure coarse woody debris. These six transects extend 15 m slope distance from plot center in the following directions: 0°, 60°, 120°, 180°, 240°, and 300°. Transects are laid out along a straight line to avoid biasing the data collection. Two quadrats are placed along each transect. Quadrats are always placed to the LEFT of the transect meter tape, as one looks down the transect from plot center (i.e., the quadrats are placed on the counter clockwise side of the transect tape, as shown in the adjacent figure). The lower corners of the quadrats are placed at 5 and 10 meters from plot center, respectively, such that the quadrats cover 5–6 m from plot center and 10–11 m from plot center. The quadrats are placed so that the outer edge of the quadrat frame touches the outside edge of the meter tape. The quadrats are laid on the ground so that it is measuring 1 m slope distance along the transect. Do not prop up the edges to make the quadrat level.




When a quadrat is located on a steep slope the observer should be positioned next to or downhill from the quadrat to prevent sliding or falling into the quadrat. In areas of thick vegetation, the quadrat poles should be slid through the vegetation.

To avoid trampling the vegetation in the quadrats, all crew members must be aware of quadrat locations and avoid these areas. Always walk on the RIGHT side of the transect when heading away from plot center, and walk on the LEFT side of the transect when heading towards plot center. In other words, stay on the clockwise side of the transects and avoid the area on the counterclockwise side of the transects.

## Data Collection

Percent cover class: Within a quadrat, percent cover will be recorded using the following cover classes:

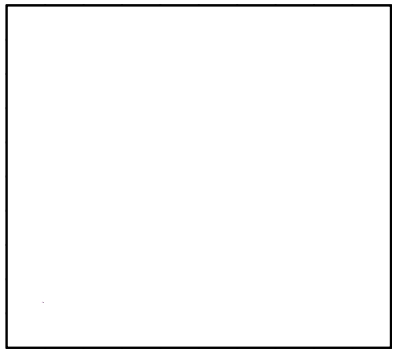
| Percent Cover Range | Cover Class | Class Midpoint |
|---|---|---|
| Absent | 0 | 0 |
| 0–1% | 1 | 0.5 |
| 1–2% | 2 | 1.5 |
| 2–5% | 3 | 3.5 |
| 5–10% | 4 | 7.5 |
| 10–25% | 5 | 17.5 |
| 25–50% | 6 | 37.5 |
| 50–75% | 7 | 62.5 |
| 75–95% | 8 | 85.0 |
| 95–100% | 9 | 97.5 |

(from Peet et al. 1998)

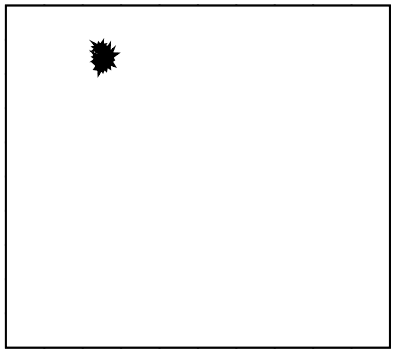
Graphic representations of these cover classes and their midpoints are provided on the following page. Imagine the percent cover of each plant as its shadow on the ground if the sun were directly overhead. Moss or vines growing on a vertical surface (tree or rock) have little percent cover.

Use the 10×10-cm purple and white square sections painted on the quadrat poles to help determine percent cover. Each purple or white square illustrates 1% of the quadrat.

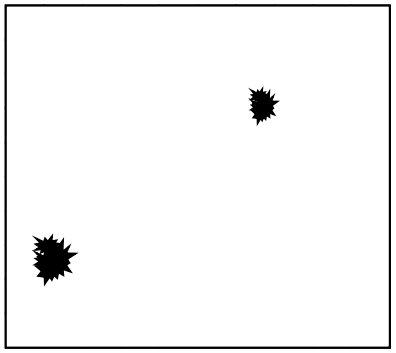
Notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake. The most suitable class should be assessed and recorded as rapidly as possible while maintaining accuracy.



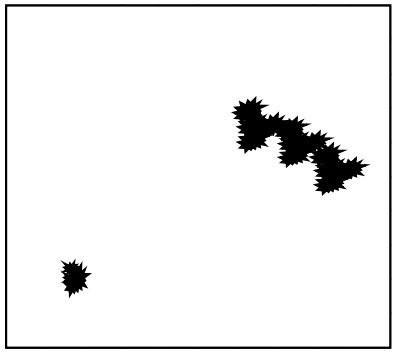
Class 0: Absent



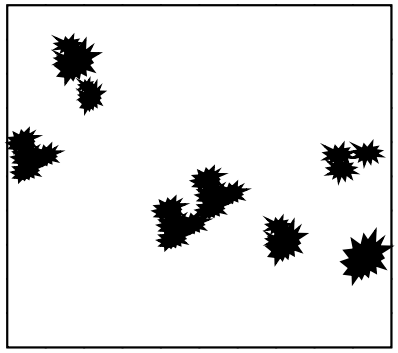
Class 1: 0 – 1 %



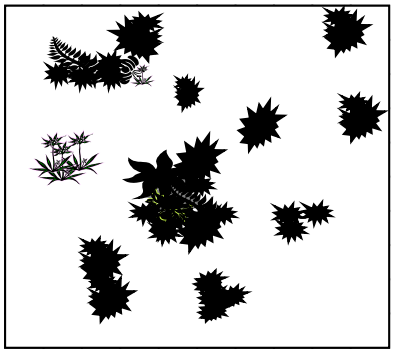
Class 2: 1 – 2 %



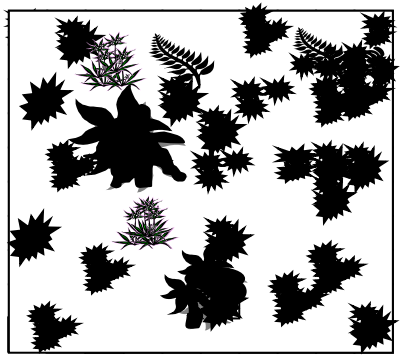
Class 3: 2 – 5 %



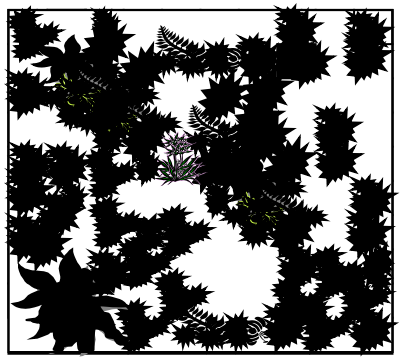
Class 4: 5 – 10 %



Class 5: 10 – 25 %



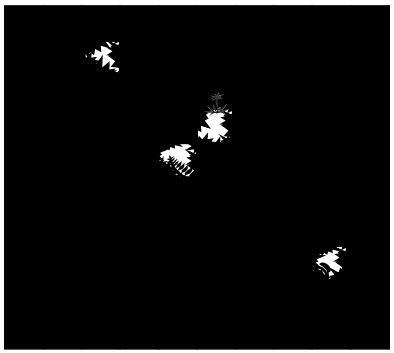
Class 6: 25 – 50 %



Class 7: 50 – 75 %

(modified from Peet et al. 1998)

Class 8: 75 – 95 %



Class 9: 95 – 100 %

***Quadrat Characterization***

Quadrat Substrate Characterization: Examine the quadrat. If the vascular and nonvascular plants were removed (or it was winter), what does the surface of the quadrat look like? Record the appropriate percent cover class for each of the following categories within the quadrat. The first four categories (Rock, Wood, Trunk, Trash) provide information on how much space in the quadrat is unavailable for plant growth. The second three categories (Soil, Litter, Water) provide information on the conditions available for plant growth. The total cover of these seven categories should add up to approximately 100% (the total will not be exact due to the range of values included in the larger percent cover classes). The percent cover of nonvascular plants in the section below can contribute to the total of 100% in the substrate characterization if there is significant nonvascular cover and it cannot be determined on what substrate the nonvascular plants are growing.

% ROCK. Record the cover class of exposed rock greater than 1 cm in length by 1 cm in width. Moss- or lichen-covered rock are included. Rocks covered by leaf litter are NOT included.

% WOOD. Record the cover class of downed coarse and fine woody debris >1 cm in diameter. Moss- or lichen-covered wood is counted as wood cover. Pieces of fallen bark >1 cm in width and length are counted as wood cover. Woody debris that is not touching the ground is not included in the percent cover.

% TRUNK. Record the cover class that best represents the basal area of live woody trunks and stems > 1 cm in diameter at the root collar. Include exposed roots (>1 cm in diameter) of living trees in this category. Woody vines (>1 cm in diameter) laying on the ground are also considered "trunk".

% TRASH. Record the cover class of human-discarded objects (tires, bottles, metal, etc) visible on the ground. Lightweight items (plastic bags/wrappers) that have blown into the quadrat and will likely blow or roll out of the quadrat should not be included in the percent cover. The cover of trash buried below the soil surface should not be included.

% SOIL. Record the cover class of exposed bare soil or sand. Large areas of moss that are not on rock or wood are counted as soil percent cover.

% LITTER. Record the cover class of leaf, graminoid, forb and other vegetative litter.

% WATER. Record the cover class of standing, ponded, or flowing water on the surface of the quadrat.

Quadrat Vegetation Characterization: Examine the vegetation < 2m in height in the quadrat. Record the appropriate percent cover class for each of the following within the quadrat. The total of these five categories can be less than 100%, if portions of the quadrat are unvegetated. The total can exceed 100% if vegetation is dense and overlapping. Refer to the Master Plant List to determine which species are woody, herbaceous, graminoid, fern, or vine.

% BRYOPHYTE. Record the cover class of all bryophytes plants, including mosses, and liverworts. Bryophyte plants on coarse woody debris that is suspended above the ground are included. Bryophyte plants on tree trunks are also included, though often have negligible cover since the trunk is vertical.

% LICHEN. Record the cover class of all lichens. Lichens on coarse woody debris that is suspended above the ground are included. Lichens on tree trunks are also included, though often have negligible cover since the trunk is vertical.

% WOODY. Record the cover class of all woody species (i.e., trees seedlings, saplings, and shrubs). Refer to the Master Plant List to determine which species are trees and shrubs.

% VINE. Record the cover class of all woody and herbaceous vine species. Refer to the Master Plant List to determine which species are vines.

% GRAM. Record the cover class for all graminoid species, including grasses, rushes, and sedges.

% FERN. Record the cover class for all fern species and fern allies such as *Lycopodium* spp..

% HERB. Record the cover class for all herbaceous species (i.e., vascular plants that are not woody, vines, graminoid, or fern).

### *Species Data*

SPECIES. Each quadrat is examined by an observer (vegetation crew leader or contract botanist) familiar with flora of that park. Record the list of all vascular plant species that are rooted in or overhanging the quadrat within 2 m of the ground. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. Refer to the Master Plant List for proper nomenclature.

CONFIDENCE. Record your level of confidence in the species identification for each plant. Your confidence in the identification is independent of the level of taxonomic specificity. You could be very confident in a plant identified only to family, (e.g. Species = Orchidacea; Confidence = 1) because you are sure that it is in that family, but have no idea which genus it is. Similarly, you could be not very confident in a genus- or species-level identification (e.g. Species = Dryopteris sp.; Confidence = 3) for obscure, small, or un-collectable individuals. Use the following codes:

1 = confident
2 = somewhat confident
3 = not very confident

PERCENT COVER CLASS. The percent cover class for each species is estimated and recorded, using the cover classes discussed above. Use the following guidelines to estimate cover:

- For each species, cover is based on a vertically projected polygon described by the outline of the foliage, including any normal spaces occurring between leaves.
- Estimate only foliar cover on plants or portions of plants that fall inside the quadrat frame and are less than 2 m above the ground. Bare twigs or branches without foliage and woody vines without foliage do not count towards cover (e.g. low growing pine or hemlock branches that support no foliage within the quadrat due to shading from the branches above; also large grapevines without foliage in the quadrat).
- For deciduous plants, base percent cover estimates on the current years' growth, by including living, damaged, and dead material only from the current year. For evergreen plants, base percent cover estimates on all green foliage, excluding dead foliage.
- Record the percent cover present at the time of the plot visit. Do not adjust the percent for the time of year during which the visit was made (i.e., for immature or wilted plants).
- Overlap of plants of the same species is ignored. There will often be overlap of plants of different species. Therefore, <u>the total cover for a quadrat may exceed 100%</u>.

### *Unknown Plants*

If a plant cannot be identified to species quickly and confidently, assign the species a specimen number, record genus or family, if possible, and include a short descriptive name. Follow these guidelines to determine whether and how to collect a specimen for subsequent identification:

- Do not collect any plants represented by 5 or fewer individuals (i.e., locally sparse) in the general vicinity of the plot. If an unknown plant is not locally sparse, it can be collected from the plot, outside the quadrats.
- Remove as little as possible from the plant to obtain characteristics necessary for identification. Do no remove entire plants (including roots) from within the quadrats. If the plant occupies greater than 2 % cover and is sufficiently robust, a portion of the plant may be removed from within the quadrat such that the overall cover of the plant within the quadrat is not significantly affected.
- Anytime it is not possible to collect a specimen, collect a photograph. Place a ruler in the photograph for scale, and allow the camera to automatically select the appropriate aperture for the given light conditions. Use the Macro setting or Super Macro setting to take detailed close up photographs of smaller plants.

Plant material and photographs of plants collected for identification purposes are not retained for future reference since they were not collected in a manner to serve as herbarium voucher specimens or photovouchers.

### *Deer Browse Indicators*

If any of the target species listed in the table below occur in the quadrat, the data described below will be recorded.

| Scientific Name | Common Name |
|---|---|
| *Actaea* spp. (*A. pachypoda*, *A. podocarpa*, *A. rubra*, *A. racemosa* - formerly *Cimicifuga racemosa*) | baneberries |

| | |
|---|---|
| *Arisaema triphyllum* | Jack in the pulpit |
| *Maianthemum canadense* | Canada mayflower |
| *Maianthemum* spp. (*M. racemosum*, *M. stellatum*) | false lily of the valleys |
| *Medeola virginiana* | Indian cucumber root |
| *Osmorhiza* spp. (*O. claytonia*, *O. longistylis*) | sweetroot |
| *Podophyllum peltatum* | mayapple |
| *Polygonatum* spp. (*P. biflorum*, *P. pubescens*) | solomon's seals |
| *Prosartes* spp. (*P. lanuginosa*, *P. maculata*) | yellow fairy bells, mandarin |
| *Trillium* spp. (numerous) | trilliums |
| *Uvularia* spp. (*U. grandiflora*, *U. perfoliata*, *U. Puberula*, *U. sessilifolia*) | bellworts |

QUADRAT. Record the code corresponding to each quadrat. Use the transect azimuth and the distance from plot center. Appropriate codes are: 0-5, 0-10, 60-5, 60-10, 120-5, 120-10, 180-5, 180-10, 240-5, 240-10, 300-5 and 300-10.

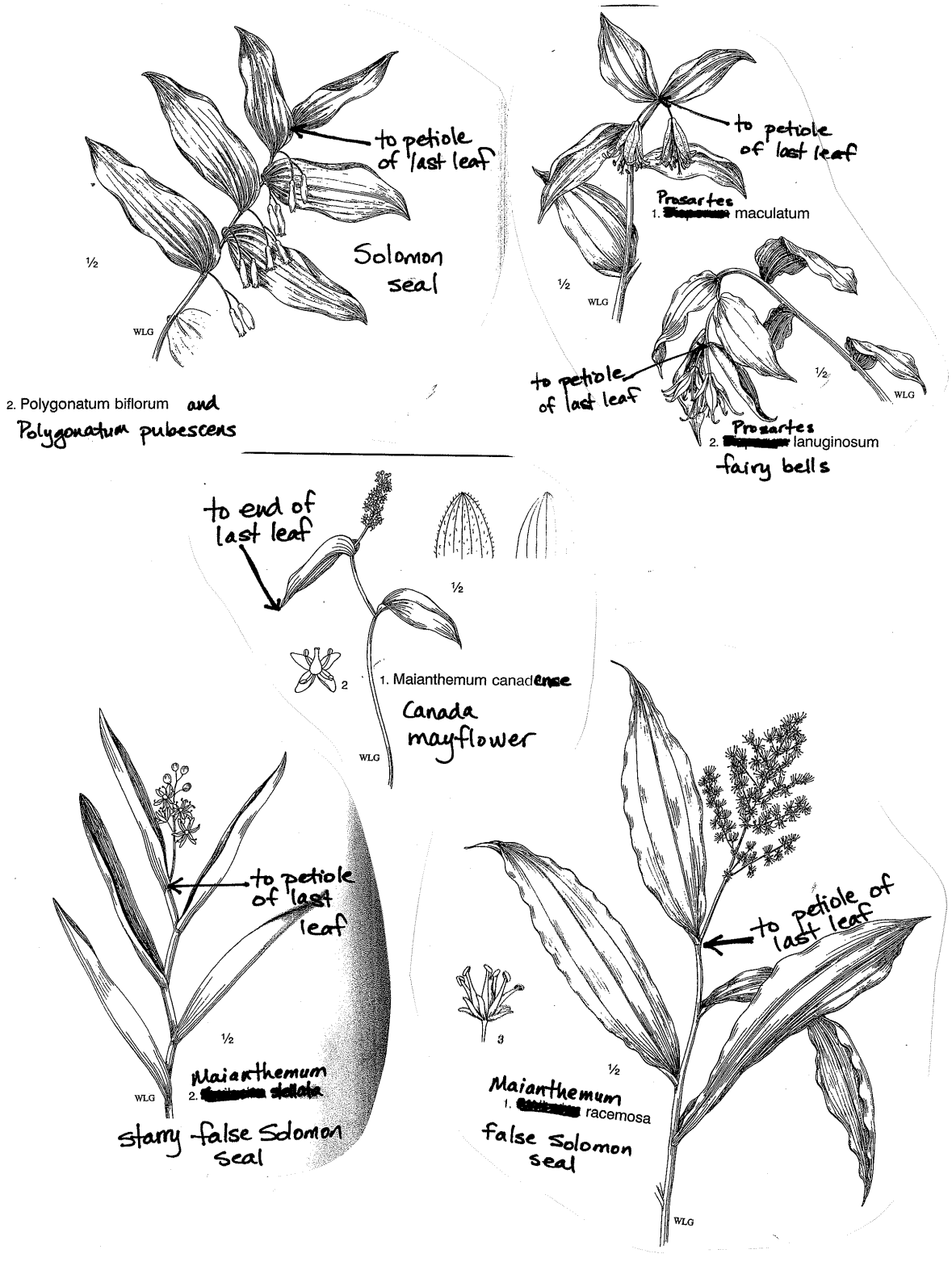
SPECIES. Record the species name only if the species is rooted in the quadrat. Plants that are overhanging into the quadrat but that are not rooted inside are not counted in this section of the protocol.

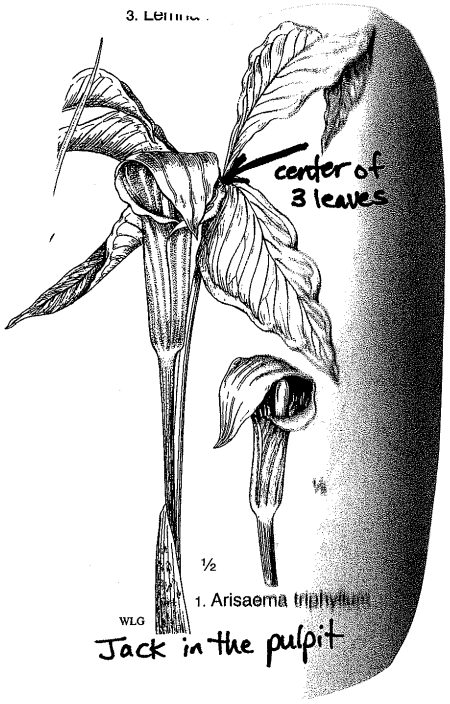
NUMBER OF REPRODUCING PLANTS. For each target species, tally number of plants with evidence of flowering or fruiting using the dot tally system. If a plant has been browsed, but evidence of reproduction present, record that individual in this field.

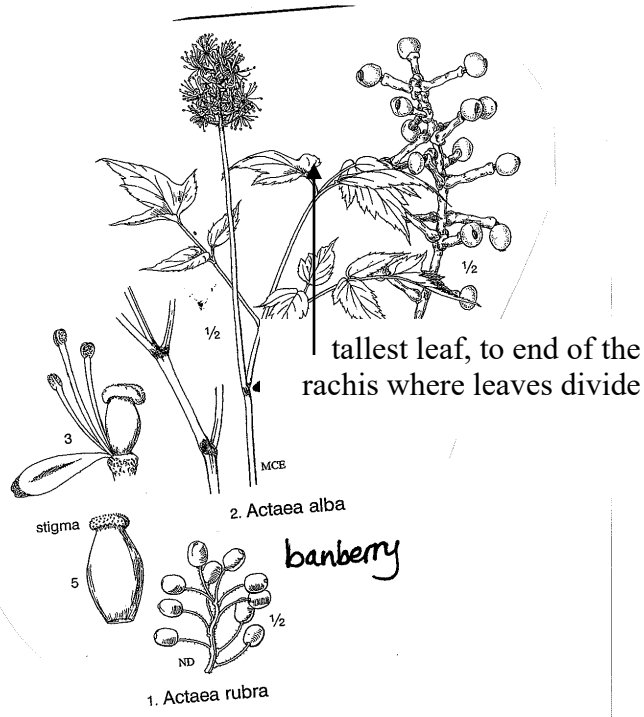
NUMBER OF NON-REPRODUCTIVE PLANTS. For each target species, tally number of non-flowering, non-fruiting plants using the dot tally system. If a plant has been browsed, but there is no evidence of reproduction, record that individual in this field.

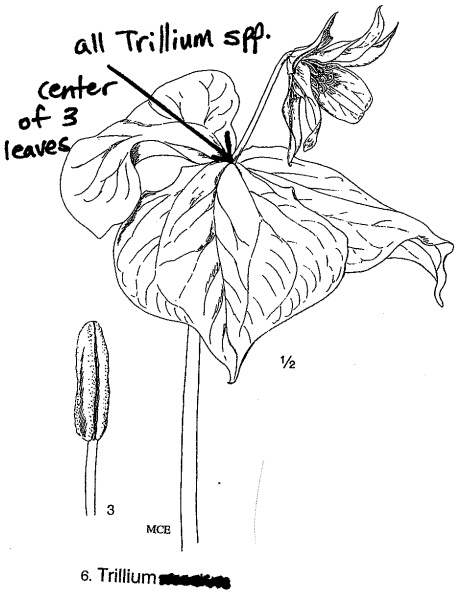
HEIGHT. For each target species, measure the height of the tallest 3 plants in each quadrat. Height is measured in centimeters, to the nearest 1 cm. Start with the plant that appears the tallest and work towards smaller plants until 3 plants have been measured (if 3 are present). To measure height, gently align the plant along a ruler. Realign the ruler along any curves present to account for additional height masked by a curved stem. See the drawings on the following pages that illustrate the point for each species at which height should be measured.

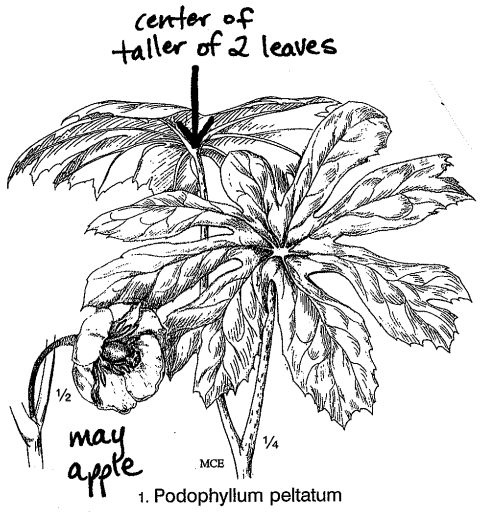
Record the height of the tallest plant under HEIGHT 1. Record the height of the second tallest plant under HEIGHT 2. Record the height of the third tallest plant under HEIGHT 3.

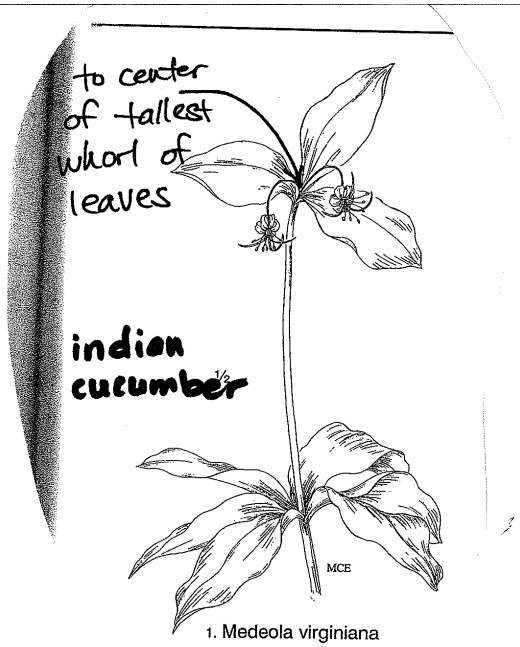

to petiole of last leaf
Solomon seal
½
WLG
2. Polygonatum biflorum and
Polygonatum pubescens
to petiole of last leaf
Prosartes
1. [redacted] maculatum
½
WLG
to petiole of last leaf
½
WLG
Prosartes
2. [redacted] lanuginosum
fairy bells
to end of last leaf
½
2
1. Maianthemum canad[redacted]
Canada mayflower
WLG
to petiole of last leaf
½
WLG
Maianthemum
2. [redacted]
starry false Solomon seal
to petiole of last leaf
3
½
Maianthemum
1. [redacted] racemosa
false Solomon seal
WLG


3. Lemna
center of
3 leaves
½
1. Arisaema triphyllum
WLG
Jack in the pulpit

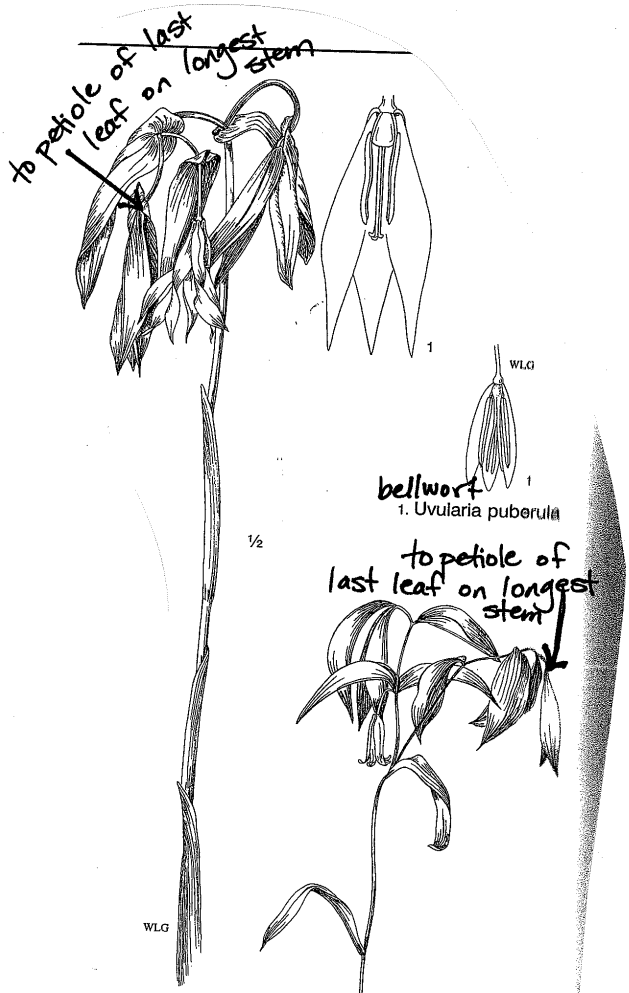

½
½
tallest leaf, to end of the
rachis where leaves divide
3
MCE
2. Actaea alba
stigma
5
banberry
½
ND
1. Actaea rubra


all Trillium spp.
center
of 3
leaves
½
3
MCE
6. Trillium [redacted]


center of
taller of 2 leaves
½
may
apple
MCE
¼
1. Podophyllum peltatum



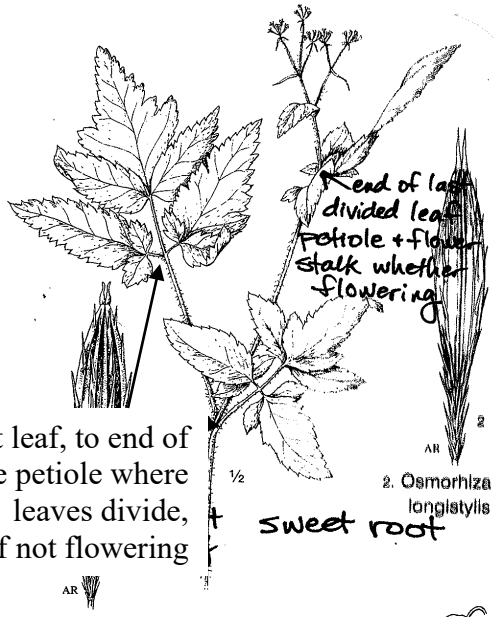

1. Medeola virginiana




1. Uvularia puberula

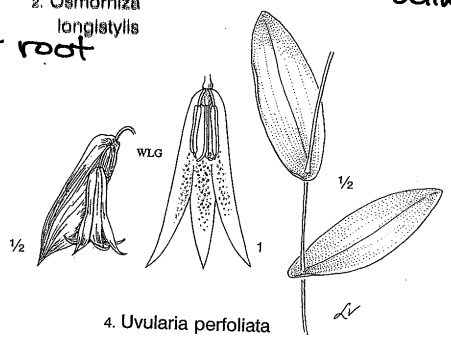
3. Uvularia grandiflora

bellwort



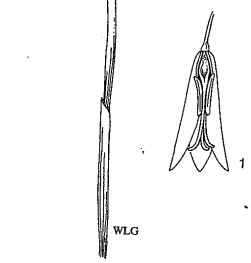

2. Osmorhiza longistylis

1. Osmorhiza claytonii




4. Uvularia perfoliata

perfoliate bellwort




2. Uvularia sessilifolia

### *Plot Species*

A time-constrained search for additional plant species is conducted on the whole 707 $m^2$ plot by an observer (vegetation crew leader or contract botanist) familiar with vegetation at the park. Record all additional vascular species with foliage that occurs within 2 meters of the ground within the plot, searching for no more than 15 minutes. If portions of the plot are wet, only emergent plants are recorded.

Record the list of additional species found in the plot on the Quadrat Species datasheet under the heading "Plot Species". Record the level of confidence in species identifications using the confidence codes listed above. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. Refer to the Master Plant List for proper nomenclature.

The objective of the time-constrained search is to capture as extensive a plant list for the plot as possible within a reasonable amount of time. These data are used in reporting presence of invasive species, in tracking biotic homogenization, and in reporting the proportion of native vs. exotic species present on the plot. The <u>number of species recorded on this list will not be monitored</u> over time. Therefore, it is acceptable for crew members to assist the botanist in compiling the species list. Botanists and crew members may note interesting species they find in the plot outside the 15-minute search and include those species in the list. Time spent keying out specimens in the field is not included in the 15-minute time limit.

## References

Braun-Blanquet, J. 1965. Plant sociology: the study of plant communities (Transl. by G.D. Fuller and H.S. Conard) Transl. of 1st edition of Pflanzensoziologie (1928). McGraw-Hill, New York and London.

Daubenmire, R. F. 1968. Plant communities: A textbook of plant synecology. Harper & Row. New York. 300p.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley &Sons. New York, NY.

Peet, R. K., Wentworth, T. R., and P. S. White. 1998. A flexible multipurpose method for recording vegetation composition and structure. Castanea 63: 262–274.

## Revision History

<u>From Version 1.0 to Version 2.0</u>

*December 2007* – Added browsed vs. unbrowsed to number of reproducing and non-reproducing deer browse indicator plants.

*February 2008* – Removed seedlings counts by species from quadrats. Seedling data will be collected in the microplots.

*April 2008* – Changed the type of species being recorded in the quadrats to all vascular plants (added woody species). Previous, only herbaceous, graminoid, fern or vine species were recorded in the quadrats and woody species were not recorded.

-- Added a time-constrained search of the plot to record species found in the plot, but not in the quadrats. This was added based on the recommendations of Johnston et al (2008) reporting the experiences of the Great Lakes Network. The Northeast Temperate Network also collects these data.

-- Added Confidence column to each quadrat and plot species record to indicate the observer's level of confidence in their identification.

<u>From Version 6.0 to Version 7.0</u>

*December 2014* – Removed browsed vs. unbrowsed from the tally of reproducing vs. non-reproducing deer browse indicator plants, based on numerous observations in the field that the remnants of browsed plants do not persist, and therefore are very difficult to accurately include in the tally of browsed plants. After comparing seven years of our data to several published studies of herbaceous plants inside and outside deer exclosures, as well as studies of censused populations of plants in which individual plants are monitored, we concluded that our data collection was NOT an accurate representation of the browse occurring in our parks, and therefore we should no longer collect those data.

<u>From Version 7.0 to Version 8.0</u>

*April 2017* – Split % Nonvascular into % Bryophyte and % Lichen, due to the difficulty of accurate detecting many forms of lichens on rocks. % Lichen will be retained for one year and to provide continuity between % Nonvascular and % Bryophyte, and then % Lichen will be dropped from the protocol.

**Tree Regeneration and Shrubs**
**Version 8.0 (April 2017)**

## Overview

This SOP quantifies live saplings, established seedlings, and shrubs by species on four 2-m radius circular microplots. Seedlings are also quantified by size class. These data yield information on advance regeneration, future cover, and the effects of deer browse.

## Definitions

Height of a seedling is the distance from the top of the soil to the top of the terminal bud. Do not include the seedling's leaves or needles in this measurement. Seedling height is determined from stems as they are naturally growing. Height is measured vertically from the top of the soil to the tip of the terminal bud, not along the axis of the stem. Stems should **not** be straightened for measurement. When measuring seedling height, begin the measurement below the leaf litter, at the point where the seedling is rooted in the soil.

Diameter-at-breast-height (DBH) is measured at 1.37 m above the ground line on the uphill side of the tree.

Horizontal distance is the level, straight line distance between two points. This contrasts with slope distance which is measured parallel to the ground surface. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

Seedlings are live juvenile trees with at least two true leaves, and that have less than 1.0 cm diameter-at-breast-height (DBH). Any juvenile tree shorter than breast height (<1.37 m tall) is a seedling. A seedling is counted only if it is rooted in the microplot. Seedlings <5 cm in height are not counted in the tally. Refer to the Master Plant List to determine which species are considered trees.

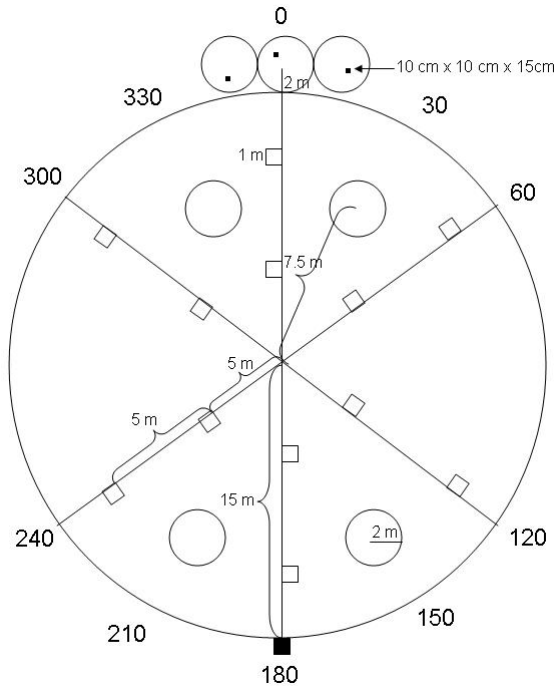
Saplings are live juvenile trees with DBH ≥1.0 cm but <10.0 cm. Saplings are alive if there are any living parts (i.e., leaves, buds, cambium) at or above DBH. Saplings that have been temporarily defoliated are considered alive. A sapling is counted only if it is rooted in the microplot. Refer to the Master Plant List to determine which species are considered trees.

Shrubs are woody species that will not reach the canopy. Refer to the Master Plant List to determine which species are considered shrubs. To be counted in this protocol, a shrub must have at least two true leaves. Shrubs are alive if there are any living parts (i.e., leaves, buds, cambium) in the above ground portion of the plant. Shrubs that have been temporarily defoliated are considered alive. Shrubs that are rooted in and/or are overhanging into the microplot are included in the percent cover measurement.

## Microplot Set Up

From plot center, measure 7.5 m slope distance in each of the following directions: 30°, 150°, 210°, and 330°, to find the center of each microplot (see figure below). Detailed directions for establishing the microplots are provided in the Site Selection and Plot Establishment SOP.

The microplot is a circular plot of 2-m radius slope distance. The boundary of the microplot is determined by using two 2-m long chains with loops at one end. To collect the microplot data, loop the end of each 2-m chain around the center spike. Stretch one chain out to the north from the center spike, marking the location of the end of the chain with the metal mallet used to set the center spike. Stretch the other chain towards 30° or 60°, creating a triangular section between the two chains. Make sure the chains are lying flat and are not caught on the vegetation.




Before the first section is searched, both crew members will scan the entire microplot and record the species codes for all observed woody species in the appropriate table (e.g., sapling, seedling, or shrub).

Then, one crew member will search the chained section for saplings, seedlings, and shrub, and will call out the species, tallies, and heights. The other crew member will record the data and assist with moving the chains. Once all data has been recorded from the first section, the chain pointing north is moved counter-clockwise to create a new section. Follow this procedure until the metal mallet marking the first chain's location is reached and the entire microplot has been searched.

## Data Collection

Microplot Characterization: Examine the vegetation <2 m in height in the microplot. Record the appropriate percent cover class for each of the vegetation category within the microplot. Imagine the percent cover of the vegetation as its shadow on the ground if the sun were directly overhead. Moss or vines growing on a vertical surface (tree trunk or rock) will have little percent cover. Use the following percent cover categories: 0=0%; 1=<1%; 2=1–2%; 3=2–5%; 4=5–10%; 5=10–25%; 6=25–50%; 7=50–75%; 8=75–95%; 9=95–100%. For reference, a 35 cm by 35 cm square is equal to 1% cover of the microplot area. The total of these four vegetation categories can be less than 100% if portions of the microplot are unvegetated or woody cover is dense. The total can exceed 100% if vegetation is dense and overlapping.

> % BRYOPHYTE. Record the cover class of all bryophytes plants, including mosses, and liverworts. Bryophyte plants on coarse woody debris that is suspended above the ground are included. Bryophyte plants on tree trunks are also included, though often have negligible cover since the trunk is vertical.
>
> % LICHEN. Record the cover class of all lichens. Lichens on coarse woody debris that is suspended above the ground are included. Lichens on tree trunks are also included, though often have negligible cover since the trunk is vertical.

% VINE. Record the percent cover class of all woody and herbaceous vine species. Refer to the Master Plant List to determine which species are vines. Vines that are >2m above the ground are not considered here.

% GRAM. Record the percent cover class for all graminoid species, including grasses, rushes, and sedges.

% FERN. Record the percent cover class for all fern species and fern allies such as *Lycopodium* spp..

% HERB. Record the total cover class for all herbaceous species (i.e., vascular plants that are not woody, graminoid, or fern). Refer to the Master Plant List to determine which species are herbaceous.

MICROPLOT SPIKE FOUND? *For plot revisits only*, record whether the spike at the center of each of the four microplots was located. (Refer to Site Selection and Plot Establishment SOP for detailed instructions.)

MICROPLOT SPIKE REPLACED? *For plot revisits only*, record whether the spike at the center of each of the four microplots was replaced, following the guidelines discussed above. (Refer to Site Selection and Plot Establishment SOP for detailed instructions.)

SAPLING SPECIES. Record the USDA PLANTS code for the genus and species of each sapling. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. If species cannot be determined in the field, collect a twig sample with foliage, buds, cones, or flowers, and/or a photograph to make a positive identification later. If possible, collect samples outside the microplot from similar specimens and make a note to correct the species code later. Plant material and photographs of plants collected for identification purposes are not retained for future reference since they were not collected in a manner to serve as herbarium voucher specimens or photovouchers. Record genus or family if it is known, and “sp01”, “sp02” etc for each unknown species. For saplings that cannot be identified to family, use “UNKCON” for Unknown Conifer and “UNKHDW” for Unknown Hardwood.

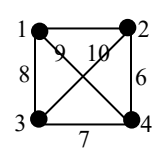
SAPLING DIAMETER. Measure the diameter at 1.37 m above the ground on the uphill side of each sapling. Use the DBH mark on the Finley pole to find the correct height (1.37 m) at which to measure the diameter. See instructions for measuring diameter in unusual situations in the Tree Measurements SOP. Use the DBH side of the logger’s tape or calipers to measure the diameter to the nearest 0.5 cm. For microplots with numerous saplings, the Finley sapling gauge may be used for saplings 1.0–8.0 cm in diameter to reduce measurement time. Juvenille trees with DBH < 1.0 cm are considered seedlings and should be tallied in that section. Remember to tally saplings that do not meet the minimum DBH requirement in the seedling section.

Do not count stump sprouts attached to a live tree as saplings. A tree is considered live if it has any living parts (i.e., leaves, buds, cambium) at or above DBH. Root suckers that are not attached to a tree bole should be measured.

Tally stump sprouts from standing dead trees, measuring each sprout as a separate sapling. A standing dead tree has no living parts (i.e., leaves, buds, cambium) at or above DBH.

For forked saplings, refer to the instructions for measuring forked trees in the Tree Measurements SOP. One additional rule applies to forked saplings with one or more main stems and one or more smaller branches with diameter >1.0 cm at DBH. In order to qualify for a separate diameter measurement, the branch in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Evaluate the angle that the pith enters the main stem, not the general form of the branch extending from the sapling. Branches that are less than 1/3 the diameter of the main stem or branch out from the main stem at an angle greater than 45 degrees should not be tallied.

SEEDLING SPECIES. Record the USDA PLANTS code for the genus and species. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. If species cannot be determined in the field, collect a twig sample with foliage, buds, cones, or flowers, and/or a photograph to make a positive identification later. Samples should not be taken if the entire plant will be killed or entirely removed from the microplot. If possible, collect samples outside the microplot from similar specimens and make a note to correct the species code later. Plant material and photographs of plants collected for identification purposes are not retained for future reference since they were not collected in a manner to serve as herbarium voucher specimens or photovouchers. Record genus or family if it is known, and "sp01", "sp02" etc for each unknown species. For seedlings that cannot be identified to family, use "UNKCON" for Unknown Conifer and "UNKHDW" for Unknown Hardwood.




SEEDLING COUNT. Within each microplot, count the number of live tree seedlings by species in the following height classes: 5–15 cm, 15.1–30 cm, 30.1–100 cm, 1.01–1.5 m, >1.5 m. Record the tally of seedlings on the datasheet using the dot tally system shown at right. Use the Steiner stick and the Finley pole to measure seedling height, following the height measuring guidelines described above. Measure the seedling height where the seedling enters at the top of the O horizon, below the leaf litter. When measuring seedling height with either the Steiner stick or Finley pole, gently push into the leaf litter until contact is made with the soil O horizon. Juvenile trees >1.5 m in height and with a DBH ≥1 cm are not included in the seedling count because they are saplings. Seedlings <5 cm in height are not counted or recorded.

Tree seedlings that originate at a common root collar (i.e., branch under the leaf litter) are independent seedlings. Tally the height of each seedling separately.

If a tree seedling forks or branches above ground, measure the height of the tallest terminal bud and count the seedling as one.

Do not count stump sprouts from a live tree as seedlings. A tree is considered live if it has any living parts (i.e., leaves, buds, cambium) at or above DBH.

Tally stump sprouts from standing dead trees, counting each sprout that forks below the leaf litter as a separate seedling. For stump sprouts forking above the leaf litter, tally the tallest sprout. A standing dead tree has no living parts (i.e., leaves, buds, cambium) at or above DBH.

BROWSED SEEDLING COUNT. The number of browsed seedlings in quarter of the microplot will be recorded. Place two poles affixed together at a 90 degree angle, with the junction on the microplot center pin, one of the poles pointing to plot center, and the other pole extending clockwise around the microplot. If a large trunk or rock occupies more than half of the area between the poles, shift the poles clockwise around the microplot to eliminate the obstruction. Record in the plot Notes how the microplot quarter location was shifted. Browse will be assessed within the microplot area bounded by the two poles.

As seedlings are tallied, record all unbrowsed seedlings in the TOTAL column by species and height class, using the dot box system. Record all browsed seedlings in the BR column by species and height class, using the dot box system. Once all seedlings have been tallied between the poles, write the number (e.g., 24, 153, etc.) of unbrowsed seedling tallied in the microplot quarter in the UN column. In the remainder of the microplot, continue tallying all seedlings in the TOTAL column, regardless of browse status.

Use the following guidelines when observing browse:

- Only browse on twigs and woody stems is considered. Browse on foliage or leaf petioles is NOT recorded as browse by this protocol.
- <u>Only browse that appears to have occurred in the previous winter or spring (during the time of active shoot expansion) will be recorded.</u> For example, a browsed branch with a green shoot with leaves on it emerging from the node just below the browsed end would count as browse. See illustrations at the end of this SOP. Do not record browse that occurred within the sampling season to avoid a sampling bias towards less browse in those plots sampled earlier in the season and more browse on late-season plots. Branch dieback is not considered browse.
- Ungulate browse is identified by looking for presence of scars (i.e., particular cut plane left by the deer teeth) on twigs. Twigs eaten by rabbits are usually cut sharply, at a 45 degree angle. Often the marks of individual teeth can be seen under magnification. Twigs eaten by deer are usually ripped off the shrub or tree, and the torn edges are rough and irregular. See illustrations at the end of this SOP.

SHRUB SPECIES. Record the USDA PLANTS code for the genus and species. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West

Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. If species cannot be determined in the field, collect a twig sample with foliage, buds, fruit, or flowers, and/or a photograph to make a positive identification later. If possible, collect samples outside the microplot and make a note to correct the species code later. Plant material and photographs of plants collected for identification purposes are not retained for future reference since they were not collected in a manner to serve as herbarium voucher specimens or photovouchers. Record genus or family if it is known, and "sp01", "sp02" etc for each unknown species. For shrubs that cannot be identified to family, use "UNK" for Unknown.

SHRUB COVER. Record the percent cover class for each shrub species using the cover classes listed below. Imagine the percent cover of each shrub as its shadow on the ground if the sun were directly overhead. Consider the entire shrub, including portions of the shrub that are >2 meters in height, in the percent cover estimate. The cover contributed by shrubs overhanging the microplot but not rooted in it are included in the total percent cover for that species. Likewise, for species which are overhanging, but do not have individuals rooted in the microplot, percent cover will be recorded for those species. Use the following percent cover categories: 0=0%; 1=<1%; 2=1–2%; 3=2–5%; 4=5–10%; 5=10–25%; 6=25–50%; 7=50–75%; 8=75–95%; 9=95–100%. Notice the exact breakpoints (e.g., 25%) are not included in any class. Classes are either above or below each breakpoint. This is not a mistake - it is to encourage the crew not to waste time trying to decide if the correct value is exactly 25%.

## Revision History

<u>From Version 1.0 to Version 2.0</u>
*December 2007* – Distance to microplot centers from plot center should be measured as slope distance instead of horizontal distance.

*February 2008* – Seedlings that are < 5 cm in height are no longer counted because: 1) seedlings <5 cm are not used in the USFS FIA Stocking Index calculations; 2) they experience high mortality; 3) between year variation will be very high depending on mast, weather, and cyclic predation; 4) this reduces the number of seedlings that the crew has to count by 30–40%, saving valuable field time.

<u>From Version 2.0 to Version 3.0</u>
*May 2009* – Clarified the measurement of shrub cover to: "Consider the entire shrub, including portions of the shrub that are >2 meters in height, in the percent cover estimate."

<u>From Version 4.0 to Version 5.0</u>
*April 2011* – Clarified rules for tallying saplings in regards to stump sprouts, root suckers, and sapling with forks or branches.

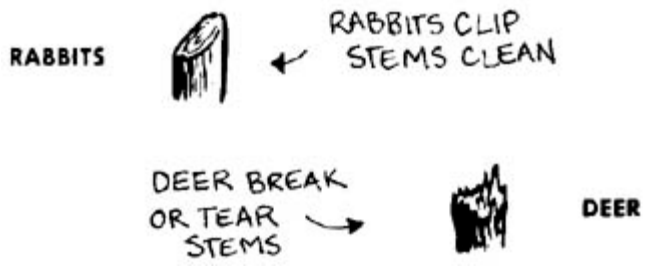
From Version 6.0 to Version 7.0

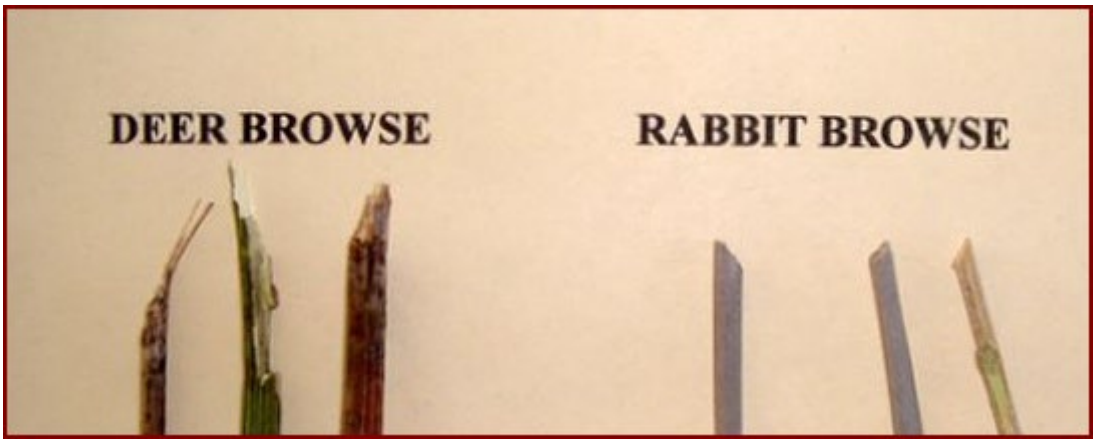
*April 2015* – Counts of shrub stems will no longer be recorded, based on analysis of ERMN observer error revisit data and the difficulties in achieving consensus among observers experienced by other I&M networks.

From Version 7.0 to Version 8.0

*April 2017* – Split % Nonvascular into % Bryophyte and % Lichen, due to the difficulty of accurate detecting many forms of lichens on rocks. % Lichen will be retained for one year andto provide continuity between % Nonvascular and % Bryophyte, and then % Lichen will be dropped from the protocol.

– Pilot tested recording browse by seedling species and height class in ¼ of each microplot area.


RABBITS
RABBITS CLIP STEMS CLEAN
DEER BREAK OR TEAR STEMS
DEER


DEER BROWSE
RABBIT BROWSE

Rabbit Browse

Deer
Browse

These browsed seedlings would NOT count as browsed since the browse is older than the previous winter or spring.

These browsed plants WOULD count as browsed since the browse is occurred during the previous winter or spring.

**Tree Measurements**
**Version 8.0 (April 2017)**

## Overview

This SOP records species, diameter, and condition of all live and standing dead trees ≥10 cm diameter-at-breast-height on 15-m radius plots. These data provide information on tree growth, mortality, condition, and stand structure and composition.

## Caution

Dead trees can be a safety hazard. Crews must exercise caution. Trees deemed unsafe to measure should be estimated but not touched.

## Definitions

Diameter-at-breast-height (DBH) is measured at 1.37 m above the ground line on the uphill side of the tree.

Horizontal distance is the level, straight line distance between two points. This contrasts with slope distance which is measured parallel to the ground surface. Slope distance and horizontal distance are equivalent on flat land. On sloped land, the horizontal distance between two objects is less than the slope distance.

Dead standing trees lack any living parts (i.e., leaves, buds, cambium) at or above DBH, and lean <45 degrees from vertical, as measured along the bole. They need not be self-supported. Once included, standing dead trees are tracked until they no longer qualify as standing dead. Dead trees leaning >45 degrees from vertical are considered coarse woody debris and are measured according to the Coarse Woody Debris SOP.

Live trees have living parts (i.e., leaves, buds, cambium) at or above DBH. Live trees that have been temporarily defoliated or are leaning or fallen are considered live trees. Live trees do not have to be self-supported. They may be supported by other trees, branches, or their crown.

Trees are woody species (live or dead) with a diameter greater than or equal to 10 cm at DBH and capable of attaining heights >7 m. Refer to the Master Plant List to determine which species are considered trees.

## Procedure for New Plots

According to the Site Selection and Plot Establishment SOP, six transects are established within the plot. Begin tallying trees from the 0 degree (north) transect and continue clockwise around the plot.

A tree on the plot boundary will be included only if the center of the stump lies directly on or within the plot boundary. To determine if the center of the stump falls in the plot, measure the horizontal distance from plot center to the front of a crew member standing adjacent to the stump's center. If this distance is greater than 15 m, then the tree falls outside the plot and is not tallied. The lean of the tree bole into or out of the plot does not affect whether the tree is tallied.

For each tree, measure and record the horizontal distance to the front edge of the trunk from plot center using the laser. The front end of the laser (not your eye) should be over plot center while

taking the distance measurement. Make sure that "HD" is visible in the laser viewfinder while all distance measurements are taken. If a tree bole is leaning significantly into or out of the plot, do not shoot the tree bole with the laser unless you can see the base of the tree in the viewfinder. Instead, have a crew member stand adjacent to and level with the front of the tree base. Measure the distance to the front of the crew member with the laser.

In plots with tall dense shrubs or saplings, the laser may not work. In these circumstances, the Sonin distance measure can be used. However, the Sonin device measures slope distance, not horizontal distance. Therefore, the two parts of the Sonin device must be held at the same horizontal level when measuring distance. When this is not possible, the distance measurement must be converted from slope distance to horizontal distance using the slope conversions table provided on the end of this SOP.

Measure and record tree azimuth from plot center using a compass. If a tree leans significantly to the right or the left, measure the azimuth from plot center to the center of the stump, not the bole.

Measure the diameter at breast height, using the white DBH mark on the Finley pole to identify the correct DBH height. Unusual DBH situations are discussed below. Use the blue mark on the Finley pole to identify the location of the scribe mark (5 cm below DBH), and create a horizontal mark on the bark of the tree, using the tree scribe or tree paint. When using tree paint, mark the scribe location with a paint marker, measure the DBH, then paint the tree using tree paint. This will ensure that the tree is measured and scribed accurately and that paint does not obscure the numbers on the DBH tape. Scribes cut through the corky layer of bark to enter the phloem, but do not reach the cambium. Thus, a scribe permanently marks the tree bole without wounding the tree. Scribes are 5–7 cm in length and are perpendicular to the tree axis. The scribe mark should always be located 5 cm below where the diameter was measured. If the diameter was measured in an unusual place, the scribe mark must be placed 5 cm below the location of the diameter measurement. This will allow accurate remeasurement of DBH during return visits. The scribe mark should face plot center. At FONE, FRHI, ALPO, and JOFL, if there is a trail close to the plot, scribe marks should be placed on the far side of the tree, away from the trail, so that the marks are not seen from the trail. If the scribe mark is not facing plot center, or is unusual in any way, write a description of the irregularity in the Tree Notes section.

Scribe snags unless they are unstable or in an advanced stage of decay. <u>Do not scribe snags that sway when touched or are unstable</u> to ensure that no snags are knocked down. If a sang is knocked down during sampling, measure it and record the data as if it were standing, but also record in the Notes that it was knocked down. If the wood of the snag is decayed around DBH such that scribing the snag would remove wood near the area of DBH measurement, <u>do not scribe the snag</u>. Note in Tree Notes that snag was not scribed, and proceed to record data as usual.

Use a DBH tape or logger's tape to measure DBH, checking to make sure that the tape is perpendicular to the tree bole and not sagging on the far side of the tree. **<u>Do not use calipers</u>** to measure tree DBH unless it is physically impossible to use a tape.

## Procedure for Plot Revisits

Unique Tree Sheets are created for each plot at the beginning of the season based on tree data from the previous sampling visit. Tree Sheets provide the tree numbers, species, distance, azimuth, and previous status for each tree. Most plots have one to three pages of Tree Sheets, depending on the number of trees in the plot at the last visit. Use the information on the Tree Sheet to locate each tree in the plot. Begin tallying trees from Tree #1, typically the first tree clockwise from the 0 degree (north) transect.

If tree species identification differs from that shown on the Tree Sheet, the crew leader and one or more crew members with strong tree identification skills should discuss the identity of the tree and decide collectively that the species should be changed before alterations are made to the data sheet. Check the Tree Notes on the Tree Sheet to see if the species identification has been changed before. If uncertainty exists, err on the side of *not* changing the species.

If you find significant errors in distance or azimuth measures, correct them on the datasheet. Clearly mark a line through the old value and clearly write the new value next to it.

It is ***imperative*** that ***DBH be measured 5 cm above the scribe mark***, no matter where the scribe is on the tree. Even if you feel that the scribe mark was incorrectly placed during the previous visit, measure DBH 5 cm above that mark. Do not make a new scribe mark to try to "correct" DBH or measure diameter in a new location where you think DBH should be. Moving DBH from its previously measured location will cause serious misrepresentation of tree growth (or shrinking trees!). Use the blue mark on the Finley pole to identify the location of the scribe mark (5 cm below DBH), mark the scribe location with a paint marker, measure the DBH, then paint the tree using tree paint. This will ensure that the tree is measured and scribed accurately and that paint does not obscure the numbers on the DBH tape.

If calipers were used to measure DBH during the last visit due to large vines, use calipers to remeasure DBH. A check mark to the left of the tree number on the Tree Sheet indicates that calipers were used during the last visit. If calipers are used during the current visit for certain trees, check the "Calipers Used?" box on the right side of the Tree Sheet for those trees.

Pay attention to all trees in the plot to make sure that no trees were missed during previous visits. Check small trees with diameter close to 10 cm to determine if they have "grown in" to the sample by attaining at least 10 cm diameter since last visit. Check trees on the plot boundary to determine if they were properly included or excluded. If uncertainty exists, err on the side of *not* changing the previous tally. Trees cannot grow into the plot from across the plot boundary because the distance measurement is taken to the center of the tree stump, which does not change as the tree grows. Use the procedures outlined above in "Procedure for New Plots" and below in "Data Collection" to scribe and record data on new trees.

For clumped trees, make sure the correct measurements are recorded for the correct tree. Check the Tree Notes on the Tree Sheet for guidance on the arrangement of the trees in the clump.

## Data Collection

TREE NUMBER. Assign each live or dead tree >10 cm DBH a sequential number, starting with 1, 2, 3, etc, on the 15-m radius plot. The tree closest to the 0 degree transect is labeled 1 and tree

numbers are assigned proceeding clockwise around the plot. During revisits, new trees added to the sample should be assigned the next available sequential number at the bottom of the list of trees.

SPECIES. Record the USDA PLANTS code for the genus and species of each tree. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary. If species cannot be determined in the field, collect a twig sample with foliage, buds, cones, or flowers, and/or a photograph to make a positive identification later. Record genus or family if known, and "sp01", "sp02", etc for each unknown species. For standing dead trees that cannot be identified to family, use "UNKCON" for Unknown Conifer and "UNKHDW" for Unknown Hardwood.

DISTANCE. Measure the <u>horizontal distance</u> to the front edge of the trunk from the plot center using the laser. Record the distance to the nearest 0.1 meter. When measuring distance with the laser, the front edge of the laser should be directly over plot center, not your eye. The laser measures distance from the front edge of the instrument, not the eye piece. Remember that horizontal distance is the distance that determines if a tree is in the plot, not slope distance.

AZIMUTH. Measure the azimuth from the plot center to each tree, sighting the center of the base of each tree with a compass. Record the true north azimuth to the nearest degree (see Site Selection and Plot Establishment SOP for compass declination instructions).

*Note concerning clumped trees*: If the same distance and azimuth are recorded for two or more adjacent trees (the trees are clumped), record some identifying feature of each tree in the Notes section. For example, "left", "middle", and "right" in the Notes section for three adjacent trees would signify that from plot center, the trees were measured from left to right. In general, all clumped trees should be measured clockwise, from left to right. Recording some manner of identifying individual trees within a clump is important so that the remeasurement of DBH is recorded with the correct tree during the next sampling visit. For clumped trees that are not near the plot boundary, the distance and azimuth for each tree can be measured at the point on the tree at which DBH was measured, instead of at the center of the trunk base. This will provide distinctive distance and azimuth readings for each tree in the clump. Do not use this method near the plot boundary where distance is used to determine if trees are in or out of the plot.

DBH. Measure tree diameter at breast height (1.37 m) above the ground on uphill side of tree (see figures below). Round diameter measurement to the nearest 0.1 cm. Use the blue DBH mark on the Finley pole to consistently find breast height. Use the blue mark on the Finley pole to identify the location of the scribe mark (5 cm below DBH), mark the scribe location with a paint marker, measure the DBH, then paint the tree using tree paint. This will ensure that the tree is measured and scribed accurately and that paint does not obscure the numbers on the DBH tape.

Use a DBH tape or logger's tape to measure DBH. Press the hook at the end of the tape into the bark and then run the tape around the trunk, ensuring that the tape is straight and pulled

perpendicular to the axis of the trunk (see figures below). Tapes that are not run straight will overestimate the trunk diameter. Wrap the tape tightly around the tree and read the number where the tape crosses the zero mark at the hook end of the tape. Make certain that you are reading the correct side of the DBH tape; often one side has standard centimeters and the other side has units calibrated to give the diameter in centimeters when wrapped around the circumference of the tree. **Do not use calipers** to measure tree DBH unless it is physically impossible to use a tape.

For unusual situations, determine where DBH should be located on the tree using the guidelines below (also see illustrations below). Always scribe the tree 5 cm below where DBH is taken, even if DBH is taken in an unconventional place on the trunk. Note the location of the DBH measurement in Tree Notes, using distances and unique tree characteristics.

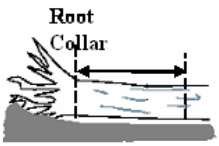
When **re-measuring the diameter of a tree tallied in a previous survey, always take the measurement 5 cm above the scribe mark** unless it is physically impossible (e.g., tree buried by mudslide, scribe cannot be found) or there is a new abnormality at the previous diameter measurement point. The data recorder will have the tree DBHs from the previous visit, however, the recorder may not share the previous DBH measurements with the crew member measuring the trees in order to avoid biasing the current measurements. The recorder should make sure that the current tree DBH is greater than or equal to the previous visit's DBH and that the tree has not grown more than 3 cm or shrunk more than 0.3 cm since the previous visit. If the DBH falls within those parameters, the DBH is recorded for the tree. If a live tree has grown more than 3 cm or shrunk more than 0.3 cm, remeasure DBH to determine that there was no error in the current measurement. If the second measurement does not change, record it as the DBH and write in the Notes section that the DBH was double checked. If it is clear that the previous visit's DBH was not measured exactly 5 cm above the scribe mark (due to a swelling, branch, or abnormality), measure above and below the abnormality and select the location that was most likely measured during the previous visit. Write detailed notes in the Note section describing where DBH was taken. Always complete the Diameter Check field and note deviations from previous measurements in the Tree Notes section.

Irregularities at DBH: If there is an abnormality (e.g., swelling, bump, depression, or branch) at DBH, take the measurement just below the abnormality if possible. If the abnormality extends far below DBH, then take the measurement just above DBH. Describe the location of the measurement in Tree Notes.

Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark. Record diameter of the wood and bark as the tree is, and note that wood or bark was missing in Tree Notes.

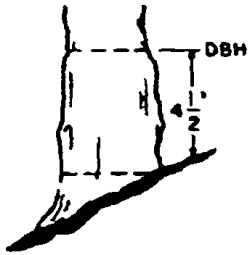
Leaning tree: Diameter is always measured perpendicular to the bole axis. Find the point equivalent to breast height (1.37 m) by measuring along the uphill side of the tree. Measure diameter perpendicular to the bole as shown in Picture 3–Leaning Tree below.

Curved bole: Treat a curved bole as if it were a leaning tree. Measure a straight line from the uphill side of the tree base to 1.37 m. Do not measure along the curve of the bole.

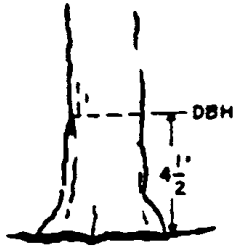


Live windthrown tree: Find the point equivalent to breast-height (1.37 m) by measuring from the top of the root collar along the bole, as shown in picture at right.

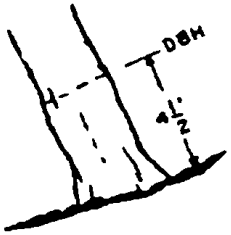
# DIAMETER BREAST HIGH MEASUREMENT IN A VARIETY OF SITUATIONS



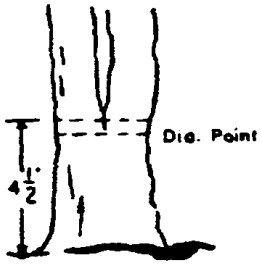

1. Tree on slope



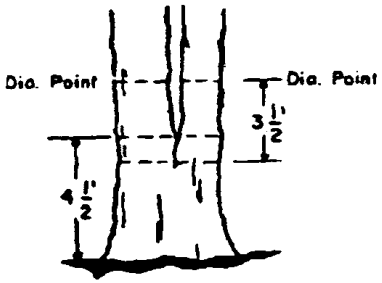

2. Tree on level ground



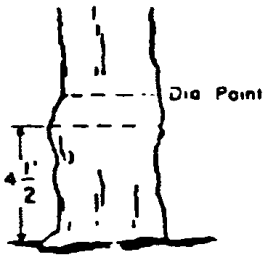

3. Leaning tree



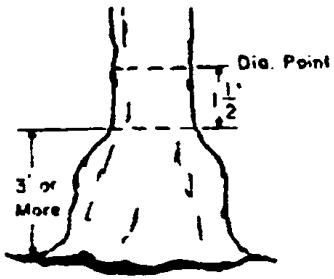

4. Tree forking at or above 4 1/2 feet



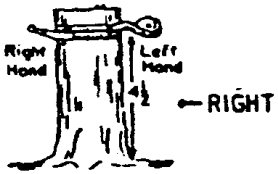

5. Tree forking below 4 1/2 feet



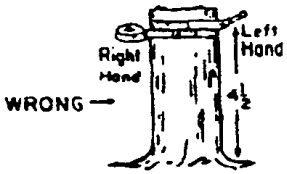

6. Tree deformed at 4 1/2



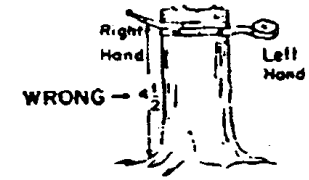

7. Bottleneck tree



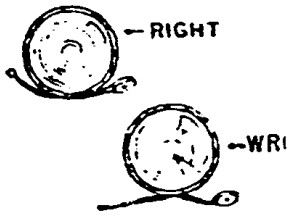

LEFT HANDED- Right hand crossed under.

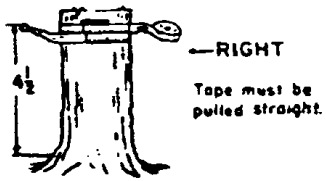



RIGHT HANDED- Left hand crossed over.



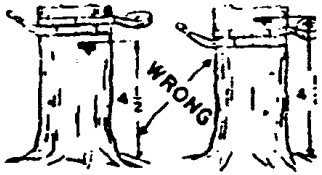

LEFT HANDED- Right hand cross



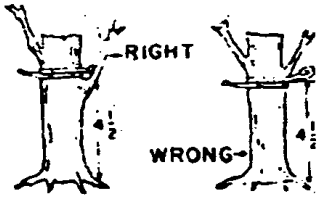

Tape must be pulled straight.

The tape must be at right angles to the lean of the tree.



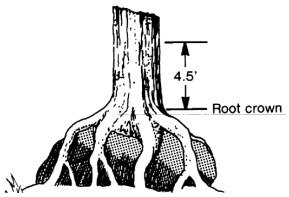

Always assume that the 4 1/2 ft D.B.H. point is at the top of lower tape at this point

Don't place tape at abnormal place on the bole



Swollen bases: Trees with swollen bases rising higher than 1.0 m are measured 0.5 m above the top of the swelling. Trees with swelling below 1 m are measured at standard DBH.

Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, and explain the situation in Tree Notes.



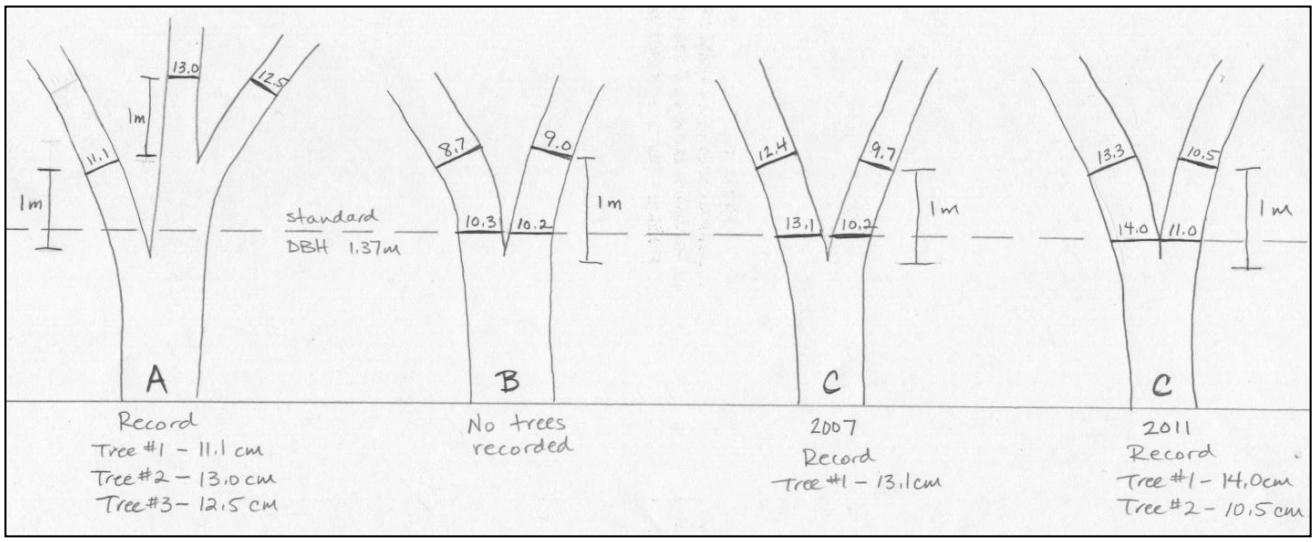

Trees growing on objects: When trees are growing on objects, such as rocks or logs, measure diameter at 1.37 m above the root crown rather than above the forest floor.

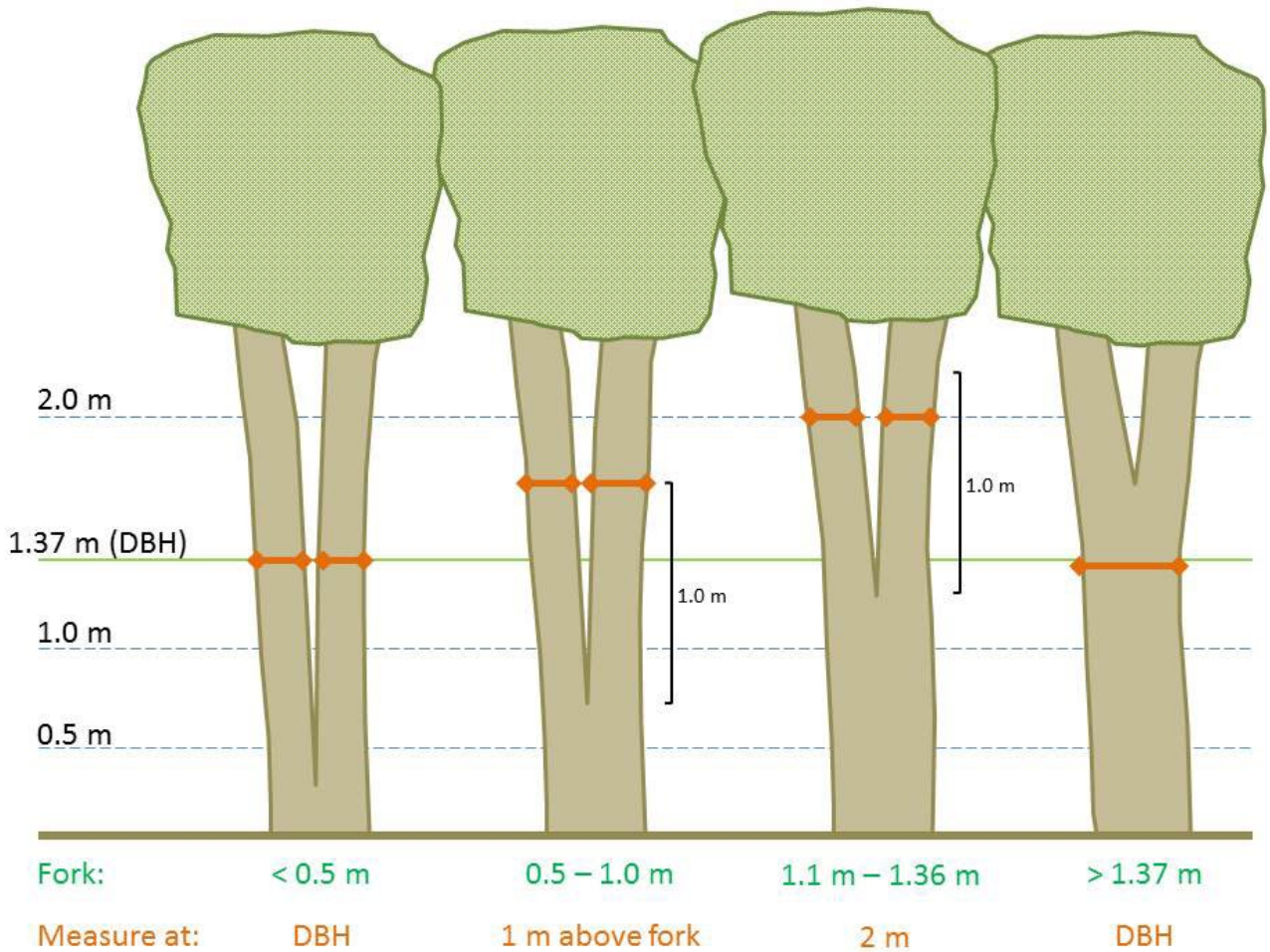
Large Vines on Tree Boles: For trees with many (>4) large vines (poison ivy or otherwise) on the trunk, measure the diameter of the trunk with the calipers at standard DBH height. If the trunk is not circular, measure the diameter with the calipers from two perpendicular directions and record the average of the measurements. Record in the Tree Notes section that calipers were used.

Forked tree: Trees which fork at or above breast height (1.37 m) are tallied and measured as one tree. Diameter should be measured below the point at which forking affects DBH (see Picture 4 above). Scribe the trunk with a horizontal mark 5 cm below where DBH was measured. This point should be recorded in Tree Notes.

For trees that fork below breast height (1.37 m), each trunk ≥10 cm is tallied as a separate tree. Use the following rules to measure the DBH of forked trees:

- If the fork is less than 0.5 m above the ground, measure DBH of each trunk at standard breast height (1.37 m).
- If the fork is greater than 0.5 m above the ground, measure the diameter of each trunk at 1 m above the fork, up to a maximum height of 2 meters. Do not measure DBH above 2 meters from the ground to ensure that all future crew members will be able to reach the measurement point.
- If the diameter measurement is < 10 cm for each stem at 1 m above the fork, then the tree is not tallied, even if the diameter measurement at standard DBH height is >10 cm (see Tree B below).
- For trees with multiple forked stems, measure diameter at 1 m above the highest reachable fork to which that stem is connected, as long as stems are >10 cm in diameter (see Tree A below).
- See Tree C below. In 2007, only one stem with diameter of 13.1 is recorded because the smaller stem is <10 cm in diameter at 1 m above the fork. However, in 2011, the smaller stem has grown to >10 cm in diameter at 1 m above the fork. Therefore, the smaller stem is measured at 1 m above the fork, however, the larger stem is still measured at standard DBH where it was originally measured in 2007.
- For clumped or forked trees, stems should be recorded from left to right when facing the trees from plot center. Note the spatial relationship of forked trees to each other in Tree Notes.
- Scribe each trunk with a horizontal mark 5 cm below where DBH was measured.


13.0
12.5
1m
11.1
1m
standard
DBH 1.37m
8.7
9.0
10.3
10.2
1m
12.4
9.7
13.1
10.2
1m
13.3
10.5
14.0
11.0
1m
A
B
C
C
Record
Tree #1 – 11.1 cm
Tree #2 – 13.0 cm
Tree #3 – 12.5 cm
No trees
recorded
2007
Record
Tree #1 – 13.1 cm
2011
Record
Tree #1 – 14.0 cm
Tree #2 – 10.5 cm


2.0 m
1.37 m (DBH)
1.0 m
0.5 m
1.0 m
1.0 m
Fork:
< 0.5 m
0.5 – 1.0 m
1.1 m – 1.36 m
> 1.37 m
Measure at:
DBH
1 m above fork
2 m
DBH

During plot revisits, it is ***imperative*** that ***DBH be measured 5 cm above the scribe mark***, no matter where the scribe is on the tree. Even if you feel that the scribe mark was incorrectly placed during the previous visit, measure DBH 5 cm above that mark. Do not make a new scribe mark to try to "correct" DBH or measure diameter in a new location. If there is a check mark to the left of the Tree Number on the Tree Sheet or the Tree Notes indicate that calipers were used for previous diameter measurement, use BOTH tape AND calipers to measure the current diameter. Record both values on the datasheet, clearly indicating which diameter corresponds with which instrument.

CALIPERS USED? Check the box if calipers were used during the current visit to measure DBH for that tree.

DIAMETER CHECK. Record a code for each tree to identify any irregularities in diameter measurement that may affect use of the tree in growth/change analyses. If both codes 1 and 2 apply, use code 2. If code 4 and codes 1 or 2 apply, use code 4. Record in the Tree Notes the words for the second applicable code and why the irregularity occurred (e.g. scribe could not be found, large poison ivy vines, etc.).

0 Diameter measured accurately.
1 Diameter estimated.
2 Diameter measured at a different location than previous measurement.
3 Code no longer used as of 2014
4 Diameter measured at previous location, but the DBH has changed significantly.

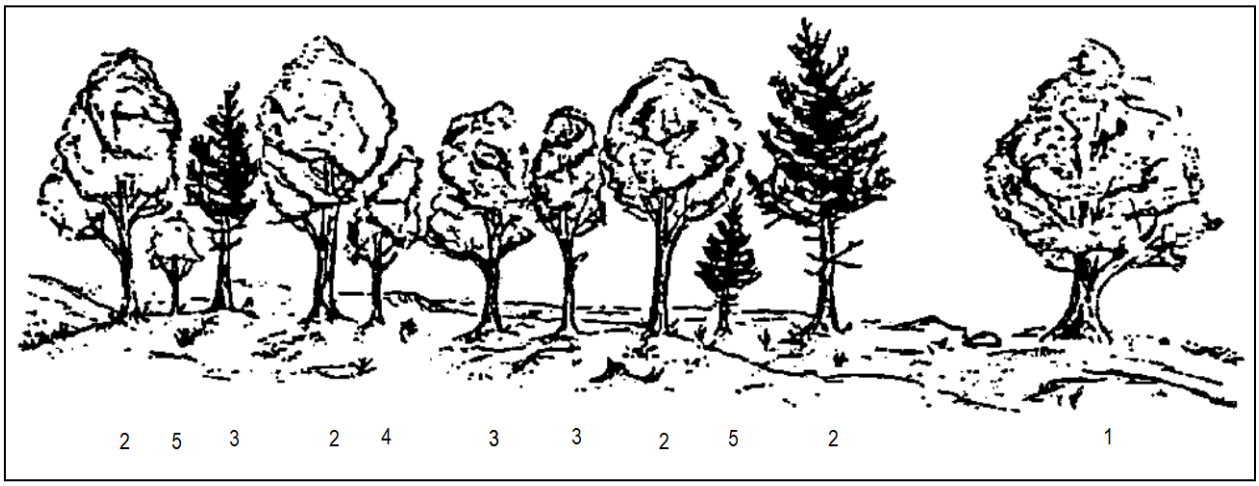
TREE STATUS. Record a status code for each tree reflecting its current status.

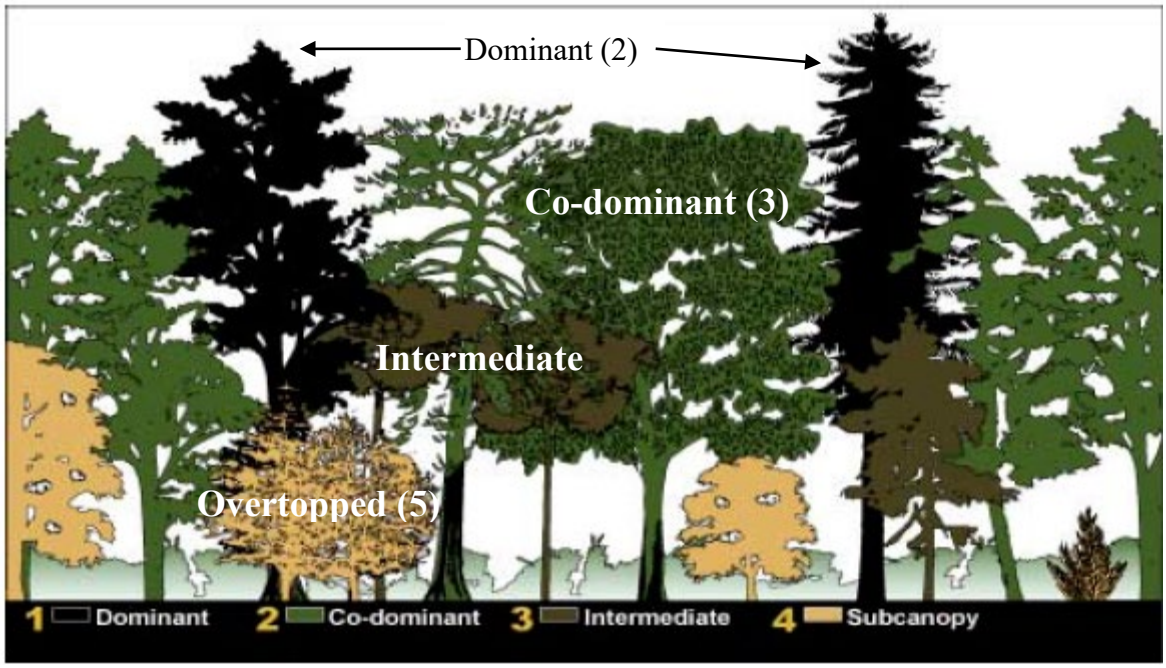
0 No status. Previously tallied tree is no longer in sample because the tree: a) shrunk below 10.0 cm DBH, b) moved outside the plot boundaries, c) was incorrectly tallied last time, or d) a change in procedure now excludes this tree. Record reason in Tree Notes.
1 Live tree. New live trees in remeasured plots are assumed to be in-growth. If a tallied new tree was obviously missed during a previous inventory, note this in Tree Notes.
2 Standing dead tree.
3 Removed. Previously tallied tree has been cut and removed by humans during harvest, silviculture treatment, or land clearing.
4 Fallen dead tree. Previously tallied tree has fallen and will no longer be tracked as a live tree.

CROWN CLASS. Assign crown class code describing tree crown position in canopy and amount of sunlight received (see illustrations below).

1 Open-grown – crown has received full sunlight from above and all sides through much of its life, particularly during early development, as seen by well-developed lower branches.
2 Dominant – crown extends above canopy, receiving full light from above and some light from sides. Taller than the average tree in stand and has well-developed crown.

3 Co-dominant – crown at the general level of the canopy, receiving full light from above but little direct light from sides. Typically, co-dominant trees have medium-sized crowns and are crowded on the sides; in dense stands, co-dominant trees have small crowns.
4 Intermediate – tree is shorter than co-dominant trees but with a crown that extends into the general canopy. Tree has small crown and is very crowded from the sides.
5 Overtopped – crown is entirely below the general level of the canopy.



TREE VIGOR. Vigor is a measure of overall tree health and vitality. This measure compares the subject tree to a "healthy" specimen of that species growing in similar stand conditions. Several factors should be considered when assessing vigor:

- How much of the crown is missing or damaged from recent or long past disturbances? Old injuries should be considered in the vigor assessment until the tree builds a new crown that makes the old injury largely invisible.
- How much of the crown is composed of dead snag branches? Snag branches are large branches without small twigs <2.5 cm in diameter, usually with the bark absent or with dead bark peeling away.
- How much of the crown contains foliar discoloration or dwarfed or misshapen leaves?
- How much of the crown is overtopped and covered by vine foliage? Is the growth and structure of the tree being affected by vines?
- What would a "reasonably normal" crown look like for this species in this stand situation?

Current defoliation should NOT be considered in the vigor assessment. A defoliated tree does not necessarily have low vigor. Vigor is difficult to assess for trees that are currently undergoing partial or severe defoliation. For those trees, make the best assessment possible by considering crown structure, snag branches, and any intact foliage that may remain.

Vigor should be assessed using species-specific concepts for "healthy tree specimens". For example, a healthy Virginia pine (*Pinus virginiana*) has a very different growth form than a healthy eastern hemlock (*Tsuga canadensis*) or a healthy eastern white pine (*Pinus strobus*). The same is true for deciduous trees; the growth forms are very different among river birch (*Betula nigra*), sourwood (*Oxydendrum arboreum*), and scarlet oak (*Quercus coccinea*), for example. Crew members must be familiar with "healthy" specimens of the tree species found in ERMN parks and must use these concepts as reference points when assessing vigor.

Record the general overall health of the tree using the codes below. Estimate vigor before estimating dieback or recording tree or foliage conditions.

1 <u>Healthy</u>. Tree appears to be in reasonably good health, with no major branch mortality. The crown is reasonably normal within the stand situation, and has <10% missing/damaged crown, branch or twig mortality, discoloration, or dwarfed leaves present.

2 <u>Light Decline</u>. Less than 25% of the crown is missing or damaged. Branch mortality, twig dieback, foliage discoloration, or dwarfed leaves are present on 10 – 25% of the crown.

3 <u>Moderate Decline</u>. Branch mortality, twig dieback, foliage discoloration or dwarfed leaves on 26 – 50% of the crown. Between 26 and 50% of the crown is missing or damaged.

4 <u>Severe Decline</u>. More than half of the crown is missing, damaged, or contains branch mortality, dieback, discoloration or leaf dwarfing, but foliage still present to indicate that the tree is alive.

5 <u>Functionally Dead</u>. There may be a few epicormic shoots on the bole, but the vast majority of the crown branches are missing or dead and leaf-less. Phloem under bark has brown streaks.

DIEBACK. Twig dieback is defined as branch mortality that begins at the terminal portion of a limb and progresses downward. Dieback is assumed to be the result of stress on the tree. Short-term stresses such as excessive seed production, weather extremes, or insect defoliation may cause temporary dieback, but when the stress is removed the trees may recover. Prolonged stresses may, however, result in an increase in dieback, and eventual decline and death of the tree.

Dieback is assessed only on twigs that are 2.5 cm in diameter or smaller at the point of attachment. Twigs with prematurely dead terminals are considered to have dieback down to the next lower fork of equal sized branch.

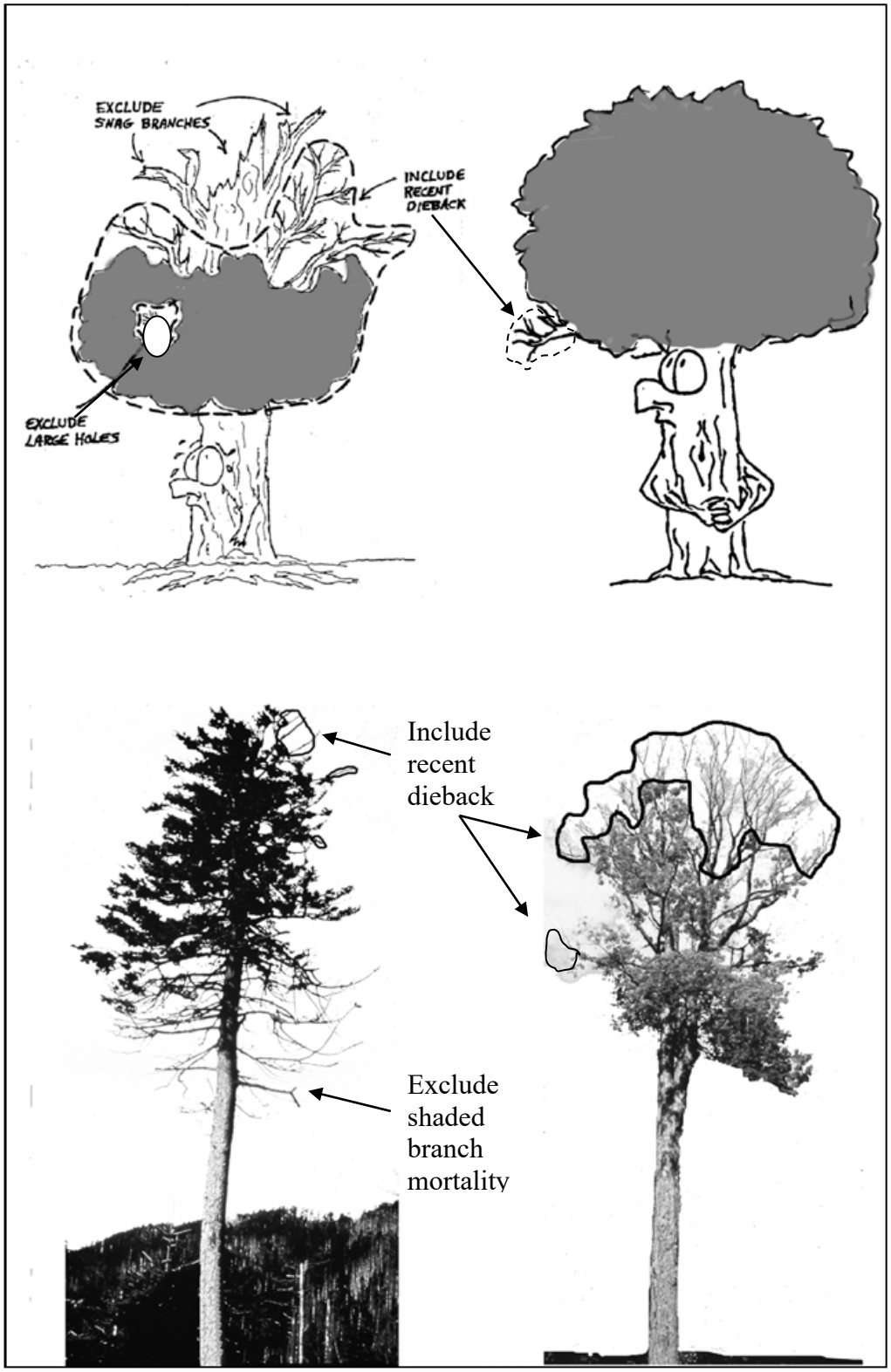
This measurement is an estimate of the proportion of the crown silhouette involved in dieback. Assume the perimeter of the crown is a two-dimensional outline from branch-tip to branch-tip. Then examine all twigs 2.5 cm in diameter or smaller in the crown, including twigs on dead branches. Look for twigs with dieback. Estimate the amount of the outline that includes dieback. The following should be **excluded** from the dieback percentage:

- Snag branches are large dead branches, usually with the bark absent or peeling away. Snag branches are assumed to have died much earlier and should not be included in the dieback percentage.
- Twigs or branches that are larger than 2.5 cm in diameter at the point of attachment.
- Large holes or gaps in the crown where branches never developed.
- Branch mortality at the base of the crown, assumed to be the result of shading. Some evergreen tree species, as well as scarlet oak (*Quercus coccinea*), tend to retain dead branches at the base of the crown. These should not be included in dieback assessment.

Estimate the proportion of the crown with twig dieback using the following categories:

| Dieback class code | Dieback class range (percent of twigs with dieback) |
|---|---|
| 0 | 0 % |
| 5 | 1–5 % |
| 10 | 6–15 % |
| 20 | 16–25 % |
| 30 | 26–35 % |
| 40 | 36–45 % |
| 50 | 46–55 % |
| 60 | 56–65 % |
| 70 | 66–75 % |
| 80 | 76–85 % |
| 90 | 86–95 % |
| 99 | 96–100 % |

Dieback should be estimated when leaves are mature, but before the appearance of fall color. Two crew members are required to make the estimate of dieback from two different sides of each tree, standing at a minimum of a 90° angle apart around the tree. When the two estimates disagree, the percentage class nearest the average of the two is recorded. The diagrams on the following page illustrate what to include and exclude when assessing dieback.




(adapted from USFS 2005a)

TREE CONDITIONS. Record the presence of any of the following pests, pathogens, or damages. If none of these conditions exist, record a horizontal line in the Tree Condition box.

Pests and Pathogens

- ALB - Asian Longhorned Beetle
- BBD - Beech Bark Disease
- BTC - Butternut Canker
- DWA - Dogwood Anthracnose
- EAB - Emerald Ash Borer
- EHS - Elongate Hemlock Scale
- ETC - Eastern Tent Caterpillar
- FTC - Forest Tent Caterpillar
- GPM - Gypsy Moth
- HWA - Hemlock Wooly Adelgid
- SOD - Sudden Oak Death

FOLIAGE CONDITIONS. Visually assess canopy foliage and record up to three (3) problems as chlorosis (C), necrosis (N), holes (H), small leaves (S), wilting (W), leaf loss (L), or other (O – describe in Tree Notes). Only record L for needle loss if fine twigs in the canopy are affected – disregard lower branches and large dead branches. If none of these conditions exist, record a horizontal line in the Foliage Condition box.

Current defoliation should be recorded here. If the defoliating pest is known and recorded under Tree Conditions, record O (other) for Foliage Conditions. If the defoliating pest is unknown or not listed under Tree Conditions, record L (leaf loss). Record the amount of defoliation in Foliage Percentage below.

FOLIAGE PERCENTAGE. Estimate amount of crown affected for each foliage condition using the following classes: 1–10, 10–25, 25–50, 50–75, 75–100%.

TREE NOTES: Record any unusual tree features or notes required above, including location of diameter measurement if not measured at breast-height or the relative position of clumped trees that have the same distance and azimuth. Record the species of vine present.

| Damage Code | Description of Damage |
|---|---|
| **ABGR** | Abnormal growth pattern for the species of concern. This category would include a range of physical deformities not included in the remainder of the damage codes. |
| **BIRD** | Bird damage such as woodpecker or sapsucker holes. |
| **BLIG** | Blight is generally defined as any plant disease or injury that results in general withering and death of the plant without rotting. Blight can result from a wide variety of needle, cone, and stem rusts, as well as canker diseases, and is often species- or genus-specific. |
| **BROK** | Broken top of the tree. |
| **BROM** | Witches' broom diseases are characterized by an abnormal cluster of small branches or twigs on a tree as a result of attack by fungi, viruses, or insects. |
| **BURL** | A hard, woody, often rounded outgrowth on a tree. This occurs naturally in some tree and shrub species, and is a sign of an infection or disease in other species. |
| **CONK** | The knobby fruiting body of a tree fungal infection visible on a tree bole, such as a shelf fungus. |
| **CROK** | Crooked or twisted bole for species in which this is uncharacteristic. |
| **DECY** | Advanced decay of bole and limbs. |
| **DTOP** | Dead top. |
| **EPIC** | Epicormic sprouting, adventitious shoots arising from suppressed buds on the stem; often found on trees following thinning or partial girdling. |
| **FIRE** | Fire scar or cambial damage due to fire. |
| **FORK** | Use for trees that are forked above DBH. For trees that are forked below DBH, do not record this forked code, however, note that tree#X and tree#Y are forked with each other in the Tree Notes. |
| **FRST** | Frost crack or other frost damage. |
| **GALL** | Galls found on stems, leaves or roots. Galls are formed by infection of the plant by bacteria or fungi, or by an attack by certain mites, nematodes, or insects, most notably wasps. |
| **HOLW** | Hollowed-out trees. Repeated hot fires can burn through the bark and the tree's core may then rot out, especially in trees with tough bark, but soft heartwood. These hollowed-out trees are sometimes called "goose pens" because early settlers kept poultry in them. |
| **INSE** | Visible insects in the tree bole or the canopy, or their sign, such as frass, pitch tubes or bark beetle galleries. |
| **LEAN** | Tree is leaning significantly. If on a slope, tree deviates considerably from plumb. |
| **LIGT** | Lightning scar or other damage to the tree caused by lightning. |
| **MAMM** | Damage caused by mammals, such as bear claw marks, porcupine or beaver chewings, and deer or elk rubbings. |
| **OZON** | Ozone damage. Ozone injury is often seen in the form of stippling or speckling on the leaves or needles of trees. This discoloration varies among species and ranges in color from red or purple to yellow or brown. Susceptible species often drop their leaves prematurely. |
| **ROOT** | Large exposed roots. |
| **ROTT** | A rot of fungus other than a conk, often associated with a wound or crack in a tree. |
| **SPAR** | Unusually sparse foliage for that species and size of tree. |
| **SPRT** | Basal sprouting; new shoots arising from the root collar or burl. |
| **UMAN** | Human-caused damage such as axe marks, embedded nails or fence wire, or vandalism. |
| **VINE** | Vines present in canopy or climbing bole of tree. Vines on the trunk below DBH are not considered here. List vine species or genus in the Notes section of the paper data sheet or the Vine Species section of the database. |
| **WOND** | A wound to a tree that cannot be identified by one of the other damage codes, including wounds or cracks of unknown cause. |

SNAG DECAY CLASS. For each standing dead tree, record code indicating the tree's stage of decay.

| Class | Bark | Log shape and integrity | Color of exposed wood | Texture of rotten portions | Primary surface substrate | Branches and twigs |
|---|---|---|---|---|---|---|
| **1** | Firmly attached | Round and solid. Freshly fallen, intact logs | Fresh color, not stained by weathering | Intact, no rot or conks. Stem decay absent. | Sound, tight bark | Branches retain many small twigs |
| **2** | If present, decayed, faded and not firmly attached | Round and solid | May be bleached and relatively smooth (like driftwood) | Mostly intact, sapwood partly soft and starting to decay, but can't be pulled apart by hand | Decayed bark and hard wood - impenetrable with fingernail or pen point, may be case hardened with power wood beneath | Branches retain some small twigs, often with peeling bark |
| **3** | Generally absent, except in Betula and Prunus | Round and firm, piece supports its own weight | Reddish-brown, or original color | Hard, large pieces of sapwood can be pulled apart by hand. | Soft wood - will spring back if compressed, easily penetrated with fingernail or pen point | No small twigs, but branch stubs will not pull out |
| **4** | Absent | Oval or flattened, no longer a solid piece, though some hard chunks remain. Piece does not support its own weight, but maintains its shape | Reddish or light brown | Soft, small blocky pieces, a metal pin can be pushed into heartwood | Very spongy wood - responds to finger pressure and may exude moisture. Powder wood flows through fingers like coarse sawdust | No small twigs, branch stubs pull out |
| **5** | Absent | Quite flat or flat with some rounding. Piece longer maintains its shape, but spreads out on the ground | Red-brown to dark brown | Soft, powdery when dry | Loosely aggregated powder wood | No small twigs. Branch stubs and pitch pockets have usually rotted down |

(adapted from Pyle and Brown 1998 and USFS 2005b)



17

## References

Miller, I., D. Lachance, W. G. Burkman, and D. C. Allen. 1991. North American Sugar Maple Decline Project: organization and field methods. General Technical Report NE-154. Radnor, PA: US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Pyle, C., and M. M. Brown. 1998. A rapid system of decay classification for hardwood logs of the eastern deciduous forest floor. Journal of the Torrey Botanical Society 125: 237–245.

United States Forest Service. 2005a. Forest Inventory and Analysis National Core Field Guide Phase 3 – Crowns: Measurements and Sampling. Version 3.0. United States Forest Service.

United States Forest Service. 2005b. Forest Inventory and Analysis National Core Field Guide Phase 3 – Downed Woody Materials. Version 3.0. United States Forest Service.

## Revision History

<u>From Version 1.0 to Version 2.0</u>
*December 2007* – Added notes about identifying clumped trees with same distance and azimuth.

*February 2008* – Clarified distance and azimuth measures for leaning trees. Add notes on the importance of proper scribe location.

<u>From Version 2.0 to Version 3.0</u>
*February 2009* – Added assessment of tree vigor, using 5 classes ranging from healthy to functionally dead, as defined by NAMP (Miller et al 1991). This was recommended by Long during protocol review and hopefully will add useful information on forest health (% healthy trees, % severe decline, etc).

-- Added assessment of dieback, using percentage class categories recommended by Long that are consistent with our existing foliage conditions percentage class. Definitions and field methods for dieback adapted from NAMP (Miller et al 1991) and USFS FIA (USFS 2005).

<u>From Version 4.0 to Version 5.0</u>
*April 2011* – Added instructions for tallying trees during plot revisits.
*September 2011* – Added Diameter Check field to identify irregularities in the measurement of diameter.

– Clarified rules for measuring DBH of forked trees.

<u>From Version 5.0 to Version 6.0</u>
*September 2013* – Added rules for referencing tree DBHs from previous visits.

Slope Conversion Table

| Slope | | HORIZONTAL DISTANCE = SLOPE DISTANCE * X | SLOPE DISTANCE = HORIZONTAL DISTANCE * X |
|---|---|---|---|
| **Degrees** | **Percent** | **Multiplier X** | **Multiplier X** |
| 0 | 0 | 1.0000 | 1.0000 |
| 1 | 2 | 0.9998 | 1.0002 |
| 2 | 3 | 0.9994 | 1.0006 |
| 3 | 5 | 0.9986 | 1.0014 |
| 4 | 7 | 0.9976 | 1.0024 |
| 5 | 9 | 0.9962 | 1.0038 |
| 6 | 11 | 0.9945 | 1.0055 |
| 7 | 12 | 0.9925 | 1.0075 |
| 8 | 14 | 0.9903 | 1.0098 |
| 9 | 16 | 0.9877 | 1.0125 |
| 10 | 18 | 0.9848 | 1.0154 |
| 11 | 19 | 0.9816 | 1.0187 |
| 12 | 21 | 0.9781 | 1.0223 |
| 13 | 23 | 0.9744 | 1.0263 |
| 14 | 25 | 0.9703 | 1.0306 |
| 15 | 27 | 0.9659 | 1.0353 |
| 16 | 29 | 0.9613 | 1.0403 |
| 17 | 31 | 0.9563 | 1.0457 |
| 18 | 32 | 0.9511 | 1.0515 |
| 19 | 34 | 0.9455 | 1.0576 |
| 20 | 36 | 0.9397 | 1.0642 |
| 21 | 38 | 0.9336 | 1.0711 |
| 22 | 40 | 0.9272 | 1.0785 |
| 23 | 42 | 0.9205 | 1.0864 |
| 24 | 45 | 0.9135 | 1.0946 |
| 25 | 47 | 0.9063 | 1.1034 |
| 26 | 49 | 0.8988 | 1.1126 |
| 27 | 51 | 0.8910 | 1.1223 |
| 28 | 53 | 0.8829 | 1.1326 |
| 29 | 55 | 0.8746 | 1.1434 |
| 30 | 58 | 0.8660 | 1.1547 |

**ERMN Vegetation Vital Sign Protocol**
**Collecting and Aging Tree Cores**
**Version 8.0 (April 2017)**

## Overview

This SOP details the process of collecting and reading tree core samples. Many of the methods are adapted without citation from Maeglin (1979), which is a U.S. Forest Service technical report that details methods for collecting and processing tree cores.

## Definitions

Increment borer is used to core trees, and consists of a handle, auger, and extractor (Figure 1).
Pith is the central core of the tree.

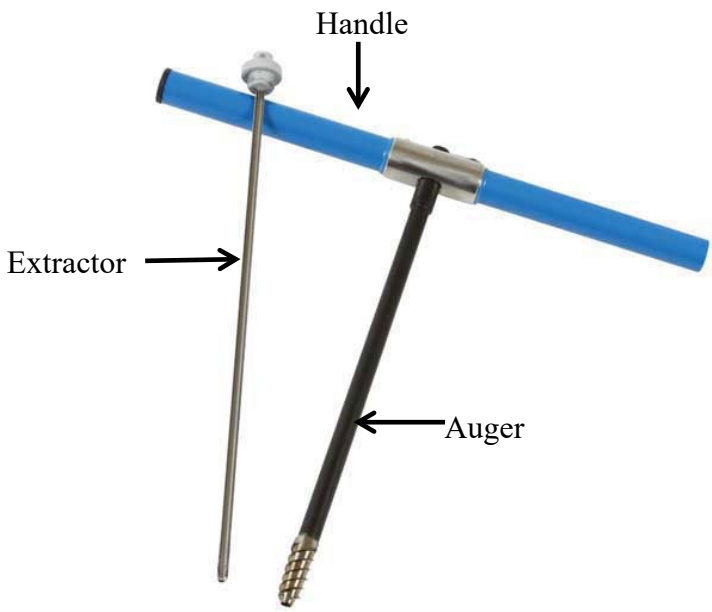



**Figure 1.** Parts of the increment borer.

## Procedure

### *Coring the Trees*

At each plot, select two living co-dominant trees outside the plot and within 10 m of the plot boundary. The two trees selected are identified as "Tree A" and "Tree B".

Selected trees must be representative of co-dominant trees in the plot, however, trees should be selected based on the species selection guidance provided in Table 1. For plots that do not have either of the preferred species (Table 1), select trees that are as representative of the trees in the plot as possible. If preferred species are present outside the plot but are NOT representative of the plot (e.g. preferred species do not occur in plot, or obviously originated from a different cohort), select trees that are representative of the plot even though they are not preferred species. If no suitable trees can be found within 10 m of the plot boundary, choose the nearest trees that

are representative of the plot. If the plot falls near an ecotone such that the vegetation community or stand structure changes outside the plot, choose trees that are representative of the dominant forest conditions in the plot, avoiding the area containing differing vegetation.

Select trees that have a straight, normal growth pattern, free of wounds, rot, and decay. In particular, cores should not be taken from:

1. Forked trees, that are crowded on one side, and add more wood to the opposite side. This causes the pith to be shifted toward the fork.
2. Leaning trees, that form "reaction wood" which is difficult to interpret and not representative of the true age. If a leaning tree must be cored, take the core along the contour of the slope (i.e. neither on the upslope nor downslope side of the tree).
3. Trees with significant cover of vines in the canopy, unless this is typical for the plot. Abundant vines in the canopy can suppress tree growth .

**Table 1.** Tree species selection for coring with regard to park and site condition.

| Park | Vegetation Domain | Primary Preferred Species | Secondary Preferred Species |
|---|---|---|---|
| ALPO | All Plots | *Acer rubrum* | *Prunus serotina* |
| BLUE | Xeric | *Quercus alba* | *Quercus velutina* |
| | Mesic | *Liriodendron tulipifera* | *Quercus rubra* |
| DEWA | Xeric | *Quercus prinus* | *Quercus rubra* |
| | Mesic | *Acer rubrum* | *Pinus strobus* |
| FONE | All Plots | *Liriodendron tulipifera* | *Acer rubrum* |
| FRHI | All Plots | *Liriodendron tulipifera* | *Acer rubrum* |
| GARI | Xeric | *Quercus alba* | *Liriodendron tulipifera* |
| | Mesic | *Liriodendron tulipifera* | *Acer rubrum* |
| JOFL | All Plots | *Prunus serotina* | *Acer rubrum* |
| NERI | Xeric | *Quercus prinus* | *Acer rubrum* |
| | Mesic | *Liriodendron tulipifera* | *Tilia americana* |

Note that hickories (*Carya* spp.) are particularly difficult to core.

Select an area on the bole is free of wounds, branch stubs, unusual swellings, etc. The core should be taken at DBH (diameter at breast height, standardized at 1.37 meters from the ground), or within 30 cm of DBH where it is comfortable for the person coring the tree to have maximum leverage. If possible, collect the core along the longest bole radius to the pith, as this will minimize anomalies such as missed rings (Figure 2).

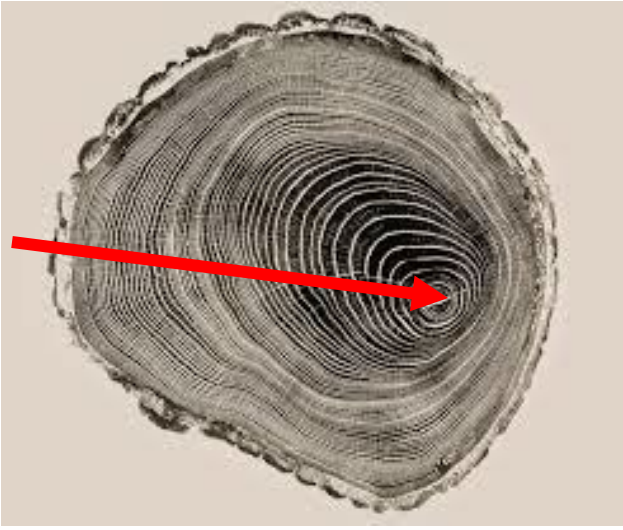


**Figure 2.** Cross section of tree bole to show arrangement of borer along the longest axis (red line).

Align the borer as straight as possible, and make every effort to hold the borer auger steady. Allowing the borer auger to wobble upon penetration will cause the tip of the core sample to break into many pieces.

1. Use the smallest borer that will reach the pith as possible, and check that the borer you are using will reach the pith by lining up the extractor. A smaller borer will allow for better leverage and easier penetration into the tree.
2. Borer starters may also be used in order to steady the borer shaft. Starters consist of a plate that is pressed against one's chest, which allows for both hands to rotate the borer and stabilizes the pivot points of the barrel.
3. If a borer starter is not used, begin coring by steadying the threaded tip end with one hand and rotating the borer clockwise with the other hand. Once the threaded bit has fully penetrated the wood, use both hands to rotate the borer.

Pay special attention to the alignment of the borer to ensure it is heading into the pith of the tree, otherwise multiple annual rings may be missed. Although the pith is not always located directly in the geometric center of the tree, this is generally the best location to aim. Branch stubs point towards the pith of the tree, and can also be helpful for aligning the borer. To estimate if the center of the tree has been reached, hold the core extractor next to the borer. The borer and extractor are similar lengths, and thus the end of the extractor provides a good estimate of where the end of the borer is in the stem.

If the increment borer becomes suddenly and significantly easier to turn while boring, immediately begin removing the borer by turning it counter-clockwise and assisting the threads by pulling back on the borer simultaneously. Advanced techniques can be employed to remove a borer if it is stuck in the tree. The most commonly used technique involves creating a make-shift "come along" that will pull on the increment borer while the person removing the borer simply turns the handles. Use a clove hitch to fasten together a heavy-duty cord that is looped around the shaft of the borer and a tree. Have one person hold a stick in the loop and begin to turn the borer counter-clockwise. The tension from the rope will assist pulling the borer out. When the borer is nearly out of the tree, remove the stick to release the tension and back the borer out the

rest of the way. For further detail see: Yamaguchi, D. K. Mechanical devices for extracting stuck increment borers. *Canadian Journal of Forest Research* 21: 712-714

When the pith is reached, gently insert the core extractor inside the borer. Rotate the borer two full turns in a counter-clockwise direction and remove the extractor and the core. Be particularly careful removing the extractor so the core is not dropped. Discard cores that are rotten or broken in such a way as they cannot be accurately measured, and select another tree to core. Repeat this process until you have two good cores each from two co-dominant trees. Do not core more than 8 trees total for a plot.

For each core removed, record on the data sheet the tree letter (A or B), species, distance from plot center, azimuth from plot center, the DBH of the tree (diameter at 1.37 m), core number, and any notes. See Data Collection section below for specific details.

Store the core sample in a plastic or paper straw that is sealed with masking tape at both ends. If the core is too long to fit in one straw, multiple straws may taped together to create a longer storage tube. Label each core by recording the park, plot number, tree letter, core number, and date on a piece of masking tape and attaching that masking tape to the straw containing the core. If using plastic straws, cut slits in the straws after the cores are collected in order to allow the cores to dry. Place straws in the PVC core-carrying tube to safely transport them back to the field house.

Immediately after the core is completed, remove the borer from the tree by turning it in a counter-clockwise direction. Compressed wood surrounding the auger will rebound and cause the borer to become stuck if left in the tree for long. Once the borer is removed, check that the tip is clear; often a small piece of core will remain jammed in the tip of the borer. To dislodge this piece, use a small hardwood peg or dowel (bamboo skewers work well). Center the peg on the jammed wood, and gently tap it out with a rubber mallet. Avoid hammering the core out with a metal tool, as this will inevitably chip the cutting edge of the borer. Do not plug the hole in the tree left by the core.

## Data Collection

TREE IDENTIFIER. Choose “A” for one tree and “B” for the other.

SPECIES. Record the USDA PLANTS code for the genus and species of each tree. Plant taxa identified as part of the Eastern Rivers and Mountains Network Vegetation Monitoring Program follow the Flora of the Southern and Mid-Atlantic States (Weakley 2015) for the three West Virginia national parks and the Plants of Pennsylvania (Rhoads and Block 2000) for national parks in Pennsylvania. The Master Plant List (tlu_Plants) in the Vegetation Monitoring Database is based on the USDA PLANTS Database (USDA, NRCS 2007) with taxonomy updated to match Weakley (2015) and Rhoades and Block (2000) as necessary.

DISTANCE. Measure the horizontal distance to the front edge of the trunk from the plot center using the laser. Record the distance to the nearest 0.1 meter.

AZIMUTH. Measure the azimuth from the plot center to each tree, sighting the center of the base of each tree with a compass. Record the true north azimuth to the nearest degree (see Site Selection and Plot Establishment SOP for compass declination instructions).

DBH. Measure tree diameter at breast height (1.37 m) above the ground on uphill side of tree. Refer to the Tree SOP for detailed instructions on measuring DBH.

CORE INDENTIFIER. Choose "#1" for one core and "#2" for the other core, for each tree.

NOTES. Record any unusual tree features or notes about the core or coring process.

## Increment Borer Maintenance

Common issues such as broken, ragged, and stained cores can be easily minimized by following basic maintenance procedures to keep the increment borer in good condition.

### *Cleaning the Borer*

Wrap a piece of tissue paper or cloth patch around the extractor tip, and spray with WD-40. Rub the paper along the inside of the borer. Spray WD-40 directly onto the borer barrel and extractor and wipe clean. Alternatively, a .22 caliber gun cleaning kit also works well. Clean the borer daily when it is being used.

### *Sharpening the Borer*

Sharpening the borer will require a flat sharpening stone, a round sharpening stone, and cleaning oil. Begin by adding a few drops of oil to the flat stone and place the tip of the cutting edge on the stone at a 45° angle. Move the cutting edge up and down along the stone, while rotating the tip continuously clockwise and counter-clockwise between your fingers. Continue until the cutting edge appears sharp. Next, add a drop of oil to the rounded stone, and insert about three-fourths of the way into the cutting edge hole. Align the stone until it is in contact with the inside wall of the hole. Rotate the borer shaft a few times until sharp.

In general, a borer that is cleaned more often will require sharpening less often, because keeping the cutting edge clean will reduce rust and corrosion. Avoid metal-to-metal contact with the tip of the borer. Such preventative care will keep the borer in better condition for a longer period.

## Analyzing Tree Cores

### *Core Preparation*

Allow cores to air dry inside of the straws by cutting slits in the straws once they have been brought back from the field. Mount the cores on wooden core mounts by gluing the cores and taping them with masking tape to hold them in place while the glue dries. If possible, orient the cores so the xylem vessels are facing vertically when placing them on the core mounts. The xylem vessels are small vertical tubes in the wood that are important for water transport along the stem, and appear as small oval to circular-shaped holes in the core. Sand the core by hand using progressively finer grits, finishing with at least a 320 grit. Dampen a paper cloth with water and rub along the length of the core in order to remove the sawdust clogging the vesicles. As an alternative, buffing the core with a lamb's wool pad may achieve the same result.

Distinguishing rings can be particularly difficult for diffuse-porous hardwoods (especially aspens). Several staining methods are available, though they vary in effectiveness and some involve using hazardous chemicals. Fehling's Solution, which is a solution of copper sulfate, potassium sodium tartrate, and sodium hydroxide, is a common staining option for distinguishing between heartwood and sapwood, but may not help distinguish early and late wood within rings (Asherin and Mata 2001). Fluorescent markers may help distinguish early and late wood, especially if a black light is available. Phloroglucinol may be most effective but is also most hazardous, as the process involves soaking the core in 50% HCl solution (Maeglin 1979).

### *Reading the Cores*

Rings can be counted using a 10x dissecting microscope. The use of a dissecting needle is beneficial for keeping track of counted rings.

Because specific annual rings are not being assigned specific years, and because only living trees are being cored, the process of cross dating is not necessary for the purpose of this SOP. Simple ring counting will generally provide a reasonably accurate stand age. QA/QC procedures should be implemented in order to assess the reliability of ring counts, such that a random sample of 10% of the cores should be counted by a second person. QA/QC counts that are within 5% of the original count are considered acceptable.

In some situations, the core may not include the pith of the tree, either because the core was too short, or because it was taken at an improper angle. If a core was taken at an improper angle, and the arcs of the inner rings are visible, it may be possible to estimate the distance to the missing pith and estimate the number of missing rings. There are numerous geometric and graphical methods for achieving this estimation. A pith locator designed by Applequist (1958) is a commonly used method, particularly for research designed to simply determine general stand age. At the risk of being slightly less precise than other methods, a pith locator is far more time efficient while still giving a good estimate of the missing number of rings.

The pith locator is designed as a series of concentric half-circles of various widths that are printed on transparent film (Figure 3). For example, circles can be arranged every 1mm, 2mm, 3mm, etc. To use, match one of the half-circles with the ring width of the inner arc of the core. Superimpose the locator over a similar ring on the core, so that multiple rings match. When an adequate match is found, the location of the pith is indicated, and the number of missing rings can be easily counted. This method assumes a constant growth rate between the rings near the center of the pith and the missing rings at the pith. If the 10 innermost rings near the center of the pith are not roughly equal in thickness, then this method will be less accurate.

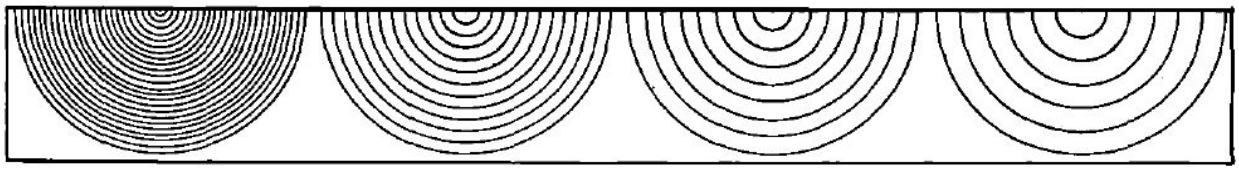


**Figure 3.** Example of a pith locator from Applequist 1958.

## References

Applequist, M. B. "A simple pith locator for use with off-center increment cores." Journal of Forestry 56.2 (1958): 141.

Asherin, Lance A., and Stephen A. Mata. "Basic tree-ring sample preparation techniques for aging aspen." Sustaining Aspen in Western Landscapes, Proceedings RMRS-P-18. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO (2001): 347-351.

Maeglin, R.R. 1979. Increment Cores: How to collect, handle and use them. U.S. Department of Agriculture Forest Service General Technical Report FPL-25. http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr25.pdf

## Revision History

Implementation of this SOP began in Version 6.0

*April 2014* – Tree cores were first collected in the summer of 2014 and will continue through the summer of 2017.

From Version 7.0 to Version 8.0

*April 2017* – Increased buffer around plot from 10 m to 15 m, in which cored trees can be located. It was frequently difficult to find representative trees suitable for coring within 10 m of the plot boundary.

**Data Quality Assurance**
**Version 8.0 (April 2017)**

## Overview

Careful, accurate data collection and stewardship are critical to the success of the vegetation monitoring program. A Quality Assurance Plan (QAP, Perles et al. *in preparation*) for the ERMN Vegetation Monitoring Protocol documents the standards, policies, and procedures used by the ERMN for activities related to the collection, processing, storage, analysis, and publication of monitoring data. This SOP highlights the data quality assurance (QA) procedures performed by the field crew, and is a subset of the QAP.

## Field Crew Responsibilities

The crew leader is responsible to ensure that all crew members:

1) can correctly identify plant species,
2) understand all field protocols,
3) understand data fields and values on paper field forms and in the database.

Crew members are responsible for learning species identification, field protocols, and all data fields and values on paper field forms and in the database. In addition, each crew member is responsible to do the following whenever they are unsure or unclear about the protocol:

1) Do not guess or decide for yourself.
2) **Read the relevant standard operating procedures** in the binder.
3) Ask the crew leader or other crew members.
4) Call the supervisor.
5) Take copious and clear notes about the uncertainty.
6) Follow through to securing guidance and correcting the uncertainty.
7) Err on the side of collecting too much data.

## Data Collection

Field data are collected in two ways. First, field crews may enter data directly into a field copy of the Vegetation Monitoring Database on the tablet computer. Alternatively, field crews may record data on paper field forms and later enter the data into the project database.

Regardless of the data collection method, all data values shall be called out and repeated when one crew member is measuring and one crew member is recording. The measurer shall clearly call out the value record. The recorder shall clearly repeat the value aloud as it is recorded, to ensure that the value was heard and recorded accurately. If the measurer does not hear a response from the recorder, the measurer shall repeat calling out the measurement until a response is obtained.

### *Field computer*

When weather and technology permit, the field crew will record data directly into the ERMN Vegetation Monitoring Database on the tablet computer. This eliminates potential errors in transferring data from paper field forms to the database. The database incorporates many functions and utilities to help reduce data entry errors such as look-up fields and appropriate upper and lower bounds for fields.

At the end of every plot, before the crew leaves the site, a crew member must click the "Check / Refresh" button on the "Check Tab" and then review all sections of the Check Tab for potential errors. Any errors must be rectified before leaving the plot.

The computer database is backed up daily, using an external hard disk and/or Google Drive depending on internet access availability. The field computer and the hard disk shall be stored separately. For example, when the computer is in the field, the hard disk shall be stored in another location (i.e., a hotel room, or in a vehicle). Furthermore, the database should be uploaded to another ERMN computer at least monthly during the field season as directed by the Netowrk Data Manager.

Do not use the field computer in rain more than a light sprinkle. In case of steady rain the computer should be packed away and Rite-in-Rain datasheets used as directed below.

### *Datasheets*

The crew must always bring paper datasheets on plain and Rite-in-Rain paper as a backup for data collection in case of rain or computer malfunction. Carry datasheets within an enclosed clipboard. **Print legibly** all information on datasheets using pencil.

At the end of every plot, before the crew leaves the site, crew members must review all sections of the paper data sheets to ensure all fields are complete and no obvious errors exist. Each data sheet must be reviewed by someone other than the person who originally recorded the data on that sheet. Once it has been determined that the data sheet is complete, a crew member will sign his or her initials in the "DATA QA" box in the upper right hand corner of the page. The most common data omissions are:

- Subcanopy and Canopy Heights in the Stand section
- Decay Class for standing snags on the Tree sheet
- Vine species for Trees that received a VINE code
- Any data associated with the last few trees in the plot
- Coarse woody debris data for the 300 Transect
- Microplot Vegetation Characterizations (% cover of nonvascular, vine, graminoid, etc)
- Whether plot and transect slopes were remeasured
- Whether transect and microplot spikes were found and/or replaced

Scan the original paper data sheets to electronic .pdf files within one week of data collection, and check to ensure all original data is present and legible. Deliver the electronic files to the Network Data Manager to store them in a building separate from the original data sheets.

## Data Entry

If paper data sheets are used, data must be entered into the Vegetation Monitoring Database. The database incorporates many functions and utilities to help reduce data entry errors such as look-up fields and appropriate upper and lower bounds for fields.

After each section of data is entered, the person entering the data must sign their initials and write the date in the margins of the data sheet using a red pen. If there are any uncertainties about an entry (e.g., data is illegible or is inconsistent with the database), **do not guess**. Instead, mark the data sheet with a Post-it Note. Describe the illegible or inconsistent entry on the Post-it Note

with an arrow pointing to the questionable item. The crew leader or a supervisor will review and reconcile these Post-it Note questions before data verification.

## Data Verification

Following data entry, the crew leader or a supervisor shall review all entered data to ensure values present on paper field forms are accurately and completely entered into the database. This process is time consuming, but is critical to ensuring data quality. After each section of data is verified, the person doing the verification will initial the form and write the date in the data sheet margins using a blue pen.

## Revision History

From Version 2.0 to Version 3.0

*January 2009* – Added DATA QC box to the upper right hand corner of each data sheet. New for the 2009 field season: Before the crew leaves each plot, a crew member other than the person who recorded on that data sheet must review that the data has been completely and correctly entered, and then sign their initials in the DATA QC box.

**ERMN Vital Sign Protocol**
**Soil Measurements and Sampling**
**Version 8.0 (April 2017)**

## Overview

This SOP serves to characterize forest soil chemistry and provide information on the effects of atmospheric deposition upon the ability of soils to support forested ecosystems. Soil samples are shipped to designated facilities for soil chemistry analysis. This SOP includes a rapid assessment of earthworm presence, to characterize their spatial extent across the network.

Three soil samples approximately 10×10×10 cm in size are collected. One sample is collected from each of three 2-m radius circles along the northern edge of the 15-m plot. Soil 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. 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.

## Definitions

Earthworm burrows are temporary or permanent soil channels made by earthworms. Burrows appear as circular openings on the soil surface. Sometimes burrows are covered by, or surrounded by, casts, litter or organic matter.

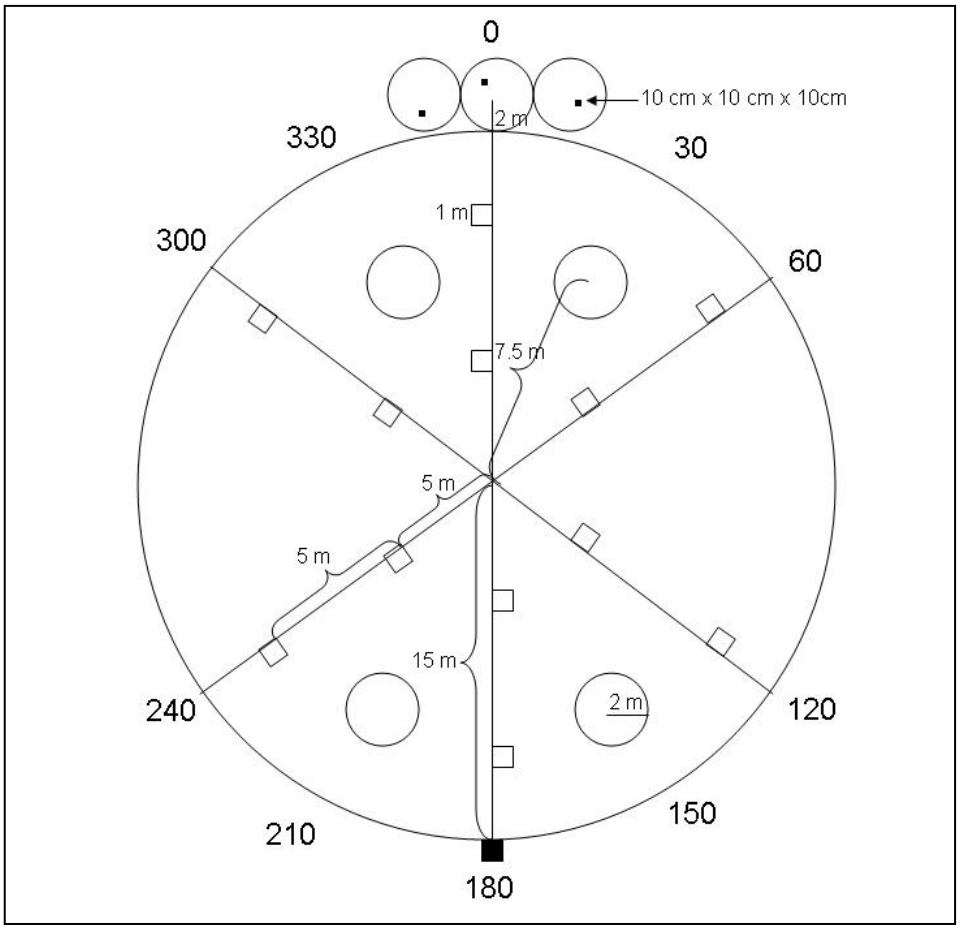
Earthworm casts are earthworm excrement comprised of soil mixed with digested plant residues. Casts appear as distinctive, moist aggregates of rich soil. In areas with established earthworm populations, casts may be visible throughout the summer. Cast production is highest during moist spring and fall seasons.

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.

O horizon is defined, for this protocol, as the consolidated organic material in between the unconsolidated litter and the top of the mineral soil. The O horizon in this protocol includes the Oa and Oi horizons, but not the Oe horizon. In other nomenclature, the O horizon in this protocol includes the F and H horizons, but not the L horizon.



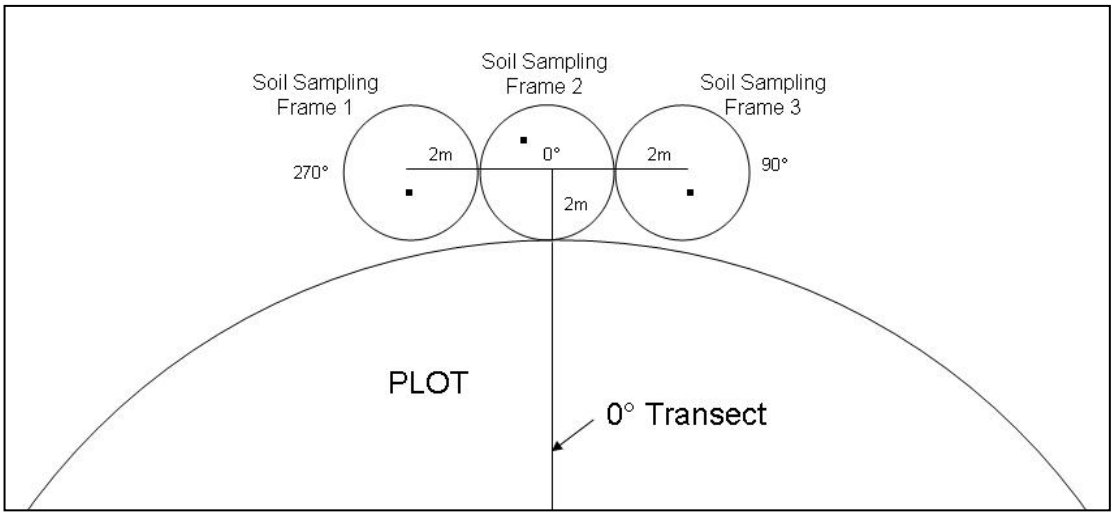

## Sampling Location

Locate the soil sampling frames along the plot's northern edge (see figure above). To locate the middle soil sampling frame, measure 2 m slope distance along the 0° azimuth from metal spike that marks the end of that transect. This point is also 17 m slope distance from the plot center along the 0° azimuth. Place a chaining pin at this point. This is the center of Soil Sampling Frame 2 (see figure below).

From the first chaining pin, measure 4 m slope distance along the 270° azimuth. Place a chaining pin at this point. This is the center of Soil Sampling Frame 1 (see figure below).

From the chaining pin in the center of Soil Sampling Frame 1, measure 8 m slope distance along the 90° azimuth. Place a chaining pin at this point. This is the center of Soil Sampling Frame 3 (see figure below). 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, fire rings, etc., unless these features are widespread throughout the plot and generally representative of the site conditions. If soil cannot be sampled at the end of the 0° transect due to obstructions or site



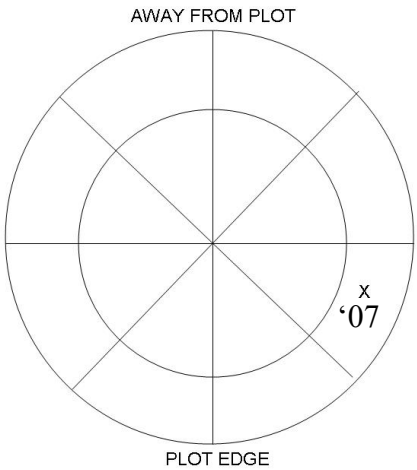

anomalies, establish the sampling frames on the end of the 60° transect. If soil cannot be sampled there, move clockwise around the plot to subsequent transects, until a suitable location is found. In these cases, note the location of the sampling frames in Frame Location field on the datasheet.

## Soil Sampling Procedure

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

For each vegetation monitoring plot, take one soil sample in each soil sampling frame (i.e., in each 2-m radius circle).

First, select a 10×10 cm 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. The selection of a sample location should be biased towards collecting litter and soil samples, however, the sample location should be representative of the sampling frame in general (i.e. don't intentionally select the location with the deepest leaf litter, but if most of the frame contains leaf litter, select a location with a representative amount of leaf litter). Avoid placing the quadrat on top of very decayed logs, animal burrows, trash, charcoal, or other anomalies that would influence the soil sample. 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 and in the adjacent figure. Determine which sector of the sampling frame contains the selected quadrat sampling area. Use the 2 m 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. "'07") 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.

In the selected area, place the 10 x 10 cm 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 cm.

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 (MM/DD/YY), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Litter, as shown in the following example: NERI.052, Frame 1, Litter, 06/02/08. Do not remove consolidated litter which has begun to compress and decompose. Do not include any animal scat in the litter sample. Deer pellets 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, and enter a brief note explaining why in Soil Notes.

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 (MM/DD/YY), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (O), as shown in the following example: NERI.052, Frame 1, O Horizon, 06/02/08. Discard all recognizable woody debris and rocks greater than 2 mm 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 mm 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 cm 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 similar to 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 (MM/DD/YY), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (A), as shown in the following example: NERI.052, Frame 1, A Horizon, 06/02/08. 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 dark brown A horizon and the lighter brown or pale B horizon underneath.

<u>If the lower boundary of the A horizon is distinct and apparent</u>, 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").

<u>If the lower boundary of the A horizon is not observed,</u> do not collect more than 15 cm in depth of A horizon soil. Measure the depth of the exposed A horizon to the nearest 0.5 cm 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 cm. Record the color of the A horizon (e.g. "light brown", "dark gray"). Circle "N" next to "Observed Bottom of A Horizon".

<u>If the A horizon is <5cm in depth</u>, carefully measure and record the depth of the A horizon to the nearest 0.5 cm. 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 (MM/DD/YY), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (B), as shown in the following example: NERI.052, Frame 1, B Horizon, 06/02/08. Continue carefully removing soil until a maximum depth of 15 cm 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 cm. Circle "Y" next to "Collected B Horizon". Wipe the trowel clean on a rag or leaves before collecting the next sample.

<u>An E horizon</u>, if present, will be a band of markedly lighter colored soil between the overlying A and underlying B horizons. If the E horizon is present, follow the same procedures described above for A and B horizons. Label the soil bag with Collection Date (MM/DD/YY), Park (Four letters), Vegetation Monitoring Plot Number, Soil Sampling Frame Number (1, 2, or 3), and Horizon (E), as shown in the following example: NERI.052, Frame 1, E Horizon, 06/02/08. Clearly mark on the datasheet that the soil collected was an E horizon.

Next, repeat this entire procedure in the remaining two soil sample plots.

## Soil Sampling Procedure on Remeasurement Plots

On subsequent remeasurements, use the same soil sampling frames. Read the Frame Location notes from the previous visit's datasheet. Reestablish the center points of the three sampling frames at the end of the transect specified in Frame Location.

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. "'07") 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.

## Data Collection

FRAME LOCATION. Record the location (distance and azimuth) of the center point of soil sampling Frame 2 in relation to the end of a transect. (e.g. "2 meters north of the end of the 0° transect").

SAMPLE LOCATION. Place an X in the appropriate sector to show the soil sample location in the sampling frame. Write the last two digits of the current year (e.g. "'07") 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.

LITTER THICKNESS UP-SLOPE and DOWN-SLOPE SIDES. At the approximate midpoints of the up-slope and down-slope edges of the soil quadrat, measure the depth of the litter to the nearest 0.5 cm as described above. If the ground is level, select two opposite sides of the quadrat on which to measure litter depth.

LITTER SAMPLE COLLECTED. Circle Y if a litter sample was collected. Circle N if a litter sample was not collected. If a sample was not collected, record the reason in the Soil Notes field.

EARTHWORMS. Record the presence (1) or absence (0) of earthworm casts and burrows at the soil sampling location for the current year. If examination is inconclusive, record 9, and record a brief note explaining why in Soil Notes.

O HORIZON THICKNESS. After excavating the O horizon, record the thickness of the O horizon as the distance from the top of the consolidated litter to the top of the mineral soil. Measure the thickness to the nearest 0.5 cm.

O HORIZON COLOR. Record the color of the O horizon, such as "dark brown", "grayish brown".

O HORIZON COLLECTED. Circle Y if any O horizon soil was collected. Circle N if O horizon soil was not collected. If a sample was not collected, record the reason in the Soil Notes field.

A HORIZON THICKNESS. Measure and record to the nearest 0.5 cm the thickness of the A horizon as observed in the soil profile. If the lower boundary of the A horizon is not observed, 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 cm and the lower boundary of the A horizon was not observed.

A HORIZON COLOR. Record the color of the A horizon, such as “medium brown”, “grayish brown”.

A HORIZON COLLECTED. Circle Y if any A horizon soil was collected. Circle N if A horizon soil was not collected. If a sample was not collected, record the reason in the Soil Notes field.

OBSERVED THE BOTTOM OF A HORIZON. Circle Y if the lower boundary of the A Horizon was observed. Circle N if the lower boundary of the A Horizon was not observed.

B HORIZON THICKNESS. Measure and record to the nearest 0.5 cm the exposed depth of B horizon as observed in the soil profile. In most cases, the lower boundary of the B horizon will not be observed. If these cases, write a “>” symbol before the observed thickness. For example, record “>5.0 cm” if the observed depth of exposed B horizon soil was 5.0 cm and the lower boundary of the B horizon was not observed.

B HORIZON COLOR. Record the color of the B horizon, such as “light brown”.

COLLECTED B HORIZON. Circle Y if any B horizon soil was collected. Circle N if B horizon soil was not collected.

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 features.

### 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. 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 labeled newspaper or metal pans to dry completely before being returned to plastic bags.

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 ERMN, and include a copy with the samples when shipped or delivered to the testing lab.

## Sample Analysis

Send dried samples to the designated soil chemistry lab experienced in analyzing forest soils. Several soil laboratories have sufficient capabilities, including the Analytical Lab at the University of Maine (http://anlab.umesci.maine.edu, contact Sue Ehrich erich@maine.edu).

The lab should prepare samples by passing each through a 2 mm sieve to remove larger particles. Analysis must include:

- 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 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.

## Revision History

From Version 1.0 to Version 2.0

*February 2008* – Added the collection of leaf litter samples in order to weigh them, since litter weight may be a more consistent variable for long-term monitoring than litter depth.

**Limiting Exotic Species Transport (LEST)**
**Version 8.0 (April 2017)**

## Overview

This SOP provides instructions for cleaning clothing and field equipment in order to limit the spread of exotic species by monitoring crew members. The introduction and spread of exotic insects, diseases, and plants is a serious threat to the parks' vegetation and other natural resources. Therefore, crew members shall be responsible for taking reasonable actions to limit the spread of exotic species between plots and especially between parks.

## When to Implement LEST

The crew is always encouraged to limit species transport in the parks, but certain situations will require following the procedures in this SOP. These situations include:

- Any time an early detection species is encountered that is setting seed or has probably set seed in previous years.
- After leaving a site with any abundant invasive species that is currently dispersing seed.
- Before leaving a park, boots and equipment must be cleaned and clothing must be washed before starting work at a new park.
- Before the start of the work week, for crew members who have been hiking in other places over the weekend.

## Materials Needed

- 5 gallon bucket
- Wire brushes
- Coarse fibered brushes

These materials will be stored in the field vehicle for use after visiting a site where exotic species or their propagules were present.

## Removing Exotic Species

Before leaving a site that requires following these procedures, the crew shall visually inspect gear, clothing and boot treads and remove any obvious attached seeds, plant fragments, or excess soil. When the crew returns to the vehicle, they should remove the 5 gallon bucket and do a more thorough investigation for exotic species. Use the coarse fibered brush to brush any seeds off of pants and boots and into the bucket. Remove any material that is stuck in treads of boots with the wire brushes and drop it into the bucket. It may be necessary to unlace and clean out seeds that are trapped under boot laces.

Field equipment that is contaminated should also be cleaned into the bucket using the brushes. Equipment that needs to be cleaned includes, but is not limited to: packs, soil trowel, Findley pole, and any other potentially contaminated equipment.

The contents of the bucket should be placed into a plastic bag and thrown into the trash. If large quantities of material are being collected in the bucket, the crew should investigate safe manners in which to burn the material once it is dried.

If there is a possibility that a forest pest or pathogen that is not already widespread within the park has been in contact with your clothing, your clothes must be washed at the end of the day.

## Revision History

From Version 3.0 to Version 4.0

*April 2010* – Added LEST procedures to the monitoring program.