

Title: TOS Protocol and Procedure: Coarse Downed Wood		Date: 02/02/2015
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TOS PROTOCOL AND PROCEDURE: COARSE DOWNED WOOD

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A_DRAFT	01/28/2015	ECO-02135	Initial draft release
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1 OVERVIEW

1.1 Background

Monitoring stocks of coarse downed wood (CDW) is important because CDW uniquely influences ecosystem function. In terms of ecosystem services, CDW provides habitat for wildlife, stabilizes soil, increases microenvironment heterogeneity, stores C and nutrients over decades, and can enhance seedling germination for trees and other plants (Harmon and Sexton 1996). Because downed coarse wood particles can persist in the environment from decades to centuries, these particles have “afterlife” effects on ecosystem function of similar magnitude to those of live trees. In addition, knowledge about the quantity and size distribution of CDW pieces at the landscape scale can be used to model the probability of fire occurrence and severity because CDW can be an important fuel source (Brown 1974, Affleck 2008).

There are two components to the sampling design that are required to accurately estimate CDW mass: volume estimation, and calculation of bulk density. There are numerous tally-based methods for estimating CDW volume that have been developed over the past 50 years. A historically common method, line intercept sampling (LIS; Warren and Olsen 1964), requires searching fixed-length transects for logs that intersect the transect. However, because the LIS method tallies CDW pieces with probability according to length, the most voluminous CDW pieces may be underrepresented, resulting in increased uncertainty in CDW volume estimates compared to frequency and length estimates (Affleck 2010). Other recently developed methods sample CDW with probability proportional to volume, and are designed specifically to estimate log volume directly from simple tallies, with reduced uncertainty compared to LIS (e.g. Affleck 2008, Gove et al. 2013). The tally-method NEON will employ, termed Line Intercept Distance Sampling (LIDS; Affleck 2008), tallies logs with probability proportional to volume and restricts the search for logs to a transect or group of radial transects at each sampling point (Affleck 2008, 2010). By using transects, detection errors in brushy or complex terrain are minimized compared to other techniques that require searching for logs over large areas (Jordan et al. 2004). Importantly, and in contrast to LIS, the length of the transect is not fixed with the LIDS method. Instead, the length of the transect increases for large-volume logs, ensuring that a representative sample of large logs is tallied across multiple field sites (Affleck 2008).

To convert estimates of CDW volume to mass and/or carbon (C) density, it is necessary to measure the bulk density of downed wood in a manner that quantitatively accounts for the proportion of the CDW particle that is void volume (i.e., internal hollows that reduce bulk density compared to a solid particle). Wood bulk density is typically measured by cutting cross-sectional disks from a statistically sufficient population of CDW particles, then determining the mass and volume of the disk samples (Harmon and Sexton 1996).

There are two additional factors that must be addressed if log volume and density estimates are to be accurately converted to CDW mass or C density per unit area at the stand scale. The first is that CDW

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density tends to change predictably as log decay progresses, and the second is that density changes with decay class are often dependent on species (Harmon and Sexton 1996). That is, different species that appear to be in the same stage of decay may have very different wood bulk density values, due to differences in the proportion of heartwood to sapwood, as well as other species-specific wood properties. In order to capture variation in density throughout the course of log decay, NEON will categorize sampled CDW particles within five standard decay classes defined by the U.S. Forest Service (Valentine et al. 2008), and all CDW particles will be identified to taxon according to a NEON-standard taxonomic identification method (for plants, this method relies heavily on the taxonomic ID system developed by the USDA; <http://plants.usda.gov>).

1.2 Scope

This document provides a change-controlled version of Observatory protocols and procedures. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.2.1 NEON Science Requirements and Data Products

This protocol fulfills Observatory science requirements that reside in NEON's Dynamic Object-Oriented Requirements System (DOORS). Copies of approved science requirements have been exported from DOORS and are available in NEON's document repository, or upon request.

Execution of this protocol procures samples and/or generates raw data satisfying NEON Observatory scientific requirements. These data and samples are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

1.3 Acknowledgments

Selection of the standard operating procedures described in this protocol was informed by Affleck (2008, 2010), Gove et al. (2013), Harmon and Sexton (1996), and Keller et al. (2004). Dr. Mark Harmon provided invaluable feedback throughout this document, but particularly for the bulk density sampling standard operating procedure.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.001155	NEON Training Plan
AD[05]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[06]	NEON.DOC.000914	NEON Science Design for Plant Biomass and Productivity
AD[07]	NEON.DOC.014051	Field Audit Plan
AD[08]	NEON.DOC.000824	Data and Data Product Quality Assurance and Control Plan

2.2 Reference Documents

Reference documents contain information that supports or complements the current document. Examples include related protocols, datasheets, or general-information references.

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
RD[04]	NEON.DOC.001271	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC.002121	Datasheets for TOS Protocol and Procedure: Coarse Downed Wood
RD[06]	NEON.DOC.001921	NEON Raw Data Ingest Workbook for TOS Coarse Downed Wood: Field Tally Data
RD[07]	NEON.DOC.001922	NEON Raw Data Ingest Workbook for TOS Coarse Downed Wood: Bulk Density Field and Lab Data
RD[08]	NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
RD[09]	NEON.DOC.001710	TOS Protocol and Procedure: Litterfall and Fine Woody Debris
RD[10]	NEON.DOC.001717	TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration

2.3 Acronyms

Acronym	Definition
C	Carbon
CDW	Coarse Downed Wood
FWD	Fine Woody Debris
LIDS	Line Intercept Distance Sampling
LIS	Line Intercept Sampling
PPE	Personal Protective Equipment

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2.4 Definitions

N/A

3 METHOD

NEON defines coarse downed wood as any fallen stem, and all of its connected branches, with diameter ≥ 2 cm at the point where the CDW particle intersects the LIDS transect. Pieces of CDW – referred to here as “logs” for convenience – that meet these criteria are divided into three different diameter classes, as defined by Keller et al. (2004): 2–5 cm, 5–10 cm, and ≥ 10 cm. Furthermore, logs ≥ 10 cm diameter must also be ≥ 1.5 m in length (Harmon and Sexton 1996). Particles of dead wood qualify as CDW if they have not yet fallen to the ground, but are suspended at an angle $> 45^\circ$ from vertical (i.e. closer to the ground than the sky)(Harmon and Sexton 1996, Affleck 2010). Dead trees (i.e. snags) that have not yet fallen to an angle $> 45^\circ$ from vertical are accounted for via the Vegetation Structure protocol (RD[08]), and logs that are suspended in the air > 2 m above the ground are ignored. Woody particles with diameter < 2 cm at the transect intersection point is considered fine woody debris and is sampled according to the Litterfall and Fine Woody Debris protocol (RD[09]).



Sites lacking dead woody particles that fit the NEON definition of coarse downed wood stated above are not sampled according to this protocol.

The Standard Operating Procedures (SOPs) presented in this protocol describe tasks that, when taken together, allow estimation of CDW volume, length, frequency, mass, and projected cover at the stand scale. Additional laboratory analyses of the wood bulk-density sub-samples allow estimation of C and nutrient density. These SOPs are:

- **SOP B: Tallying and Measuring CDW in the Field.** Includes performing CDW volume tallies in the field using the LIDS technique, measuring logs for additional variables required to convert volume tallies to length, frequency, and projected cover estimates, identifying logs to taxon, and categorizing logs into decay class.
- **SOP C: Bulk Density Sampling in the Field.** Includes field-sampling log cross-sectional disks used for bulk density estimation, and for larger logs, sub-sampling disks to generate samples for wood moisture calculations.
- **SOP D: Processing Bulk Density Samples in the Laboratory.** Steps to dry and weigh wood bulk density samples in the laboratory.

To implement SOP B, sampling locations are established at the center of each Tower plot, and also at the center of the 20 randomly selected Distributed plots that are used for co-located LAI, herbaceous clip harvest, and vegetation structure measurements. At each sampling location, three LIDS transects are established that radiate outward, with 120° separating each transect (Figure 1). The azimuthal orientation of each group of transects is chosen randomly for each of the sampling locations, in order to minimize effects of topography, directional blowdown, logging management, etc., on selection of CDW

particles across all sampling locations. The per-plot random azimuths for LIDS transects are provided by Science Operations in site-specific .csv files. Technicians search each of the 3 transects for qualifying pieces of CDW that intersect the transect, with the total transect distance searched being positively related to the cross-sectional area of the log perpendicular to the point at which it intersects the transect. In other words, the LIDS technique dictates that technicians will search for larger logs over longer transect distances in order to adequately sample relatively rare large logs that contribute disproportionately to total CDW volume. Limiting distances that correspond to various log cross-sectional areas are provided in Appendix F, and Appendix F should be used in the field as a reference to help determine whether specific logs should be included or not in a given plot's tally. Once it is determined that a log should be tallied, its cross-sectional area and length are measured, as well as the distance from the sampling location. In addition, each qualifying log is assigned to a decay class, and is identified to the finest taxonomic resolution possible (i.e., species, genus, family or "unknown hardwood" or "unknown softwood").

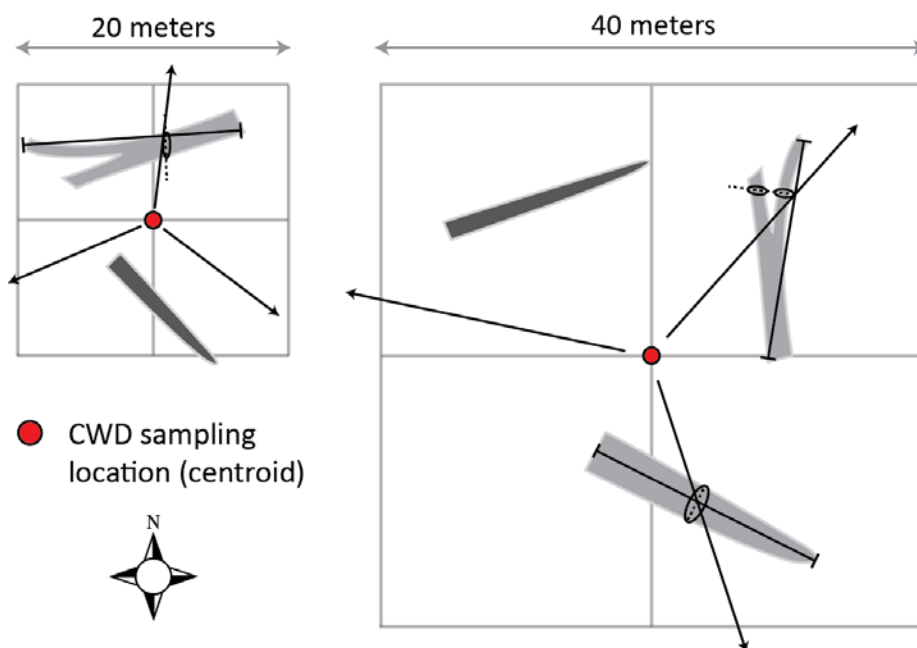


Figure 1. Illustration of three randomly oriented LIDS transects (arrow vectors) superimposed over a 20m x 20m plot (*left*), and a 40m x 40m plot (*right*). There is a 3m gap between the sampling location (i.e. the plot centroid), and the start of each transect which minimizes the chance that CDW particles close to the plot centroid get double- or triple-counted. Gray shapes represent CDW particles, dashed lines show the location and orientation of cross-sectional area measurement(s) (ovals) for those particles that intersect a LIDS transect, and capped black lines imply the particles' central axes that should be measured for length. Darker gray CDW particles do not intersect LIDS transects and are suitable for bulk-density sampling. Note that selected CDW particles may lie outside of the plot boundary.

SOP C details the field procedure for sampling of CDW for bulk density. This SOP is implemented once within the first 3 years of a site going into Operations, and once more 5 years after the first implementation. Bulk density is sampled from three different diameter size classes (≥ 10 cm, 5-10cm,

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and 2-5cm), from logs that do not intersect the LIDS transects, but that are adjacent to the transects (Figure 1). A chainsaw, or less ideally, a buck saw, is used to cut a 5-10cm height cross-sectional disk from each sampled CDW particle. The diameter and height of the disk are measured to enable calculating the volume of the disk, and the disk fresh weight is recorded in the field. For the two largest size classes, wedge-shaped pieces are sub-sampled from the disk, and these sub-samples are also weighed for fresh weight in the field. Subsamples are then transported back to the laboratory to calculate the disk's fresh weight : dry weight ratio. Disks sampled from the smallest size class are not sub-sampled, and are transported to the laboratory in their entirety.

Cross-sectional disks cannot be cut from extremely decayed logs, and instead of removing a disk, a decayed section of log is simply scooped into a plastic bag and the negative space is measured for volume with calipers. The sampled material is then transported back to the laboratory, dried, and weighed as above. Throughout the bulk density SOP, proper sample labeling and tracking of sample metadata is critical.

SOP D describes the procedure for measuring, drying, and weighing cross-sectional disks in the laboratory (or wedge-shaped subsamples generated from these disks). Knowledge of the wood sample dry weight allows calculation of bulk density (ρ) as:

$$(1) \quad \rho = \frac{\text{disk dry weight (g)}}{\text{disk volume (cm}^3\text{)}}$$

For larger disks from which wedges were generated, the fresh weight : dry weight ratio is calculated for the wedge subsample, and this ratio, along with the fresh weight of the entire disk that was measured in the field, is used to determine the dry weight of the disk. Proper sample labeling, and tracking of sample data and metadata, is extremely important to enable this calculation.

Standard Operating Procedures (SOPs), in Section 7 of this document, provide detailed step-by-step directions, contingency plans, sampling tips, and best practices for implementing this sampling procedure. To properly collect and process samples, field technicians **must** follow the protocol and associated SOPs. Use NEON's problem reporting system to resolve any field issues associated with implementing this protocol.

The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. It is therefore essential that field personnel carry out this protocol as outlined in this document. In the event that local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it in NEON's problem tracking system.

The procedures described in this protocol will be audited according to the Field Audit Plan (AD[07]). Additional quality assurance will be performed on data collected via these procedures according to the NEON Data and Data Product Quality Assurance and Control Plan (AD[08]).

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4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

The frequency and timing of CDW sampling depends on the SOP being implemented, as SOP B, “Tallying and Measuring CDW in the Field”, may be carried out independently from SOP C and SOP D. The bulk-density SOPs (SOP C and SOP D) must always be performed together, and may be carried out over more than one year in order to achieve the desired sample size (Table 11).

Sampling in Tower plots should be prioritized over sampling in Distributed plots if sufficient labor is not available to complete sampling in both Tower and Distributed/Gradient plots in a given sampling year.

Table 1. Sampling frequency, sampling effort, and timing guidelines for coarse downed wood sampling on a per-SOP basis.

SOP	Plot Type	Plot Number	Sampling Events	Yearly Interval	Remarks
SOP B: Tallying and Measuring CDW in the Field	Distributed	20 max [*]	1X per sampling year	Every 3y (one site per domain per year	Distributed and Tower plots should be sampled in the same growing season; sampling should take no longer than 3 months.
	Tower	20-30 [†]			
SOP C: Bulk Density Sampling in the Field	Distributed	20 max [*]	Once within first 3y of Operations; second time 5y later	5y	Sampling occurs twice per site. A given sampling event may occur over multiple years if target sample size cannot be achieved in one year; however, completing sampling in one season is ideal.
	Tower	20-30 [†]			
SOP D: Processing Bulk Density Samples in the Laboratory	Distributed	20 max [*]	Once within first 3y of Operations; second time 5y later	5y	Sample processing in the laboratory should occur ASAP following field work.
	Tower	20-30 [†]			

^{*} CDW sampling occurs in the same randomly selected Distributed plots that are used for other plant biomass protocols; not all Distributed plots will be sampled if CDW particles are absent from selected plots.

[†] The number of installed Tower plots vary by site; typically, forested sites that produce CDW receive twenty 40m x 40m plots; however, some sites with CDW may have thirty 20m x 20m Tower plots.

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4.2 Criteria for Determining Onset and Cessation of Sampling

Because CDW is often produced during periods of seasonal storm activity, CDW sampling should be timed to occur *after* the period of maximal expected storm activity for a given site. It is incumbent upon Field Operations to select sampling onset dates that are appropriate for each site and consistent with this guideline. For example, CDW sampling in D03 should not occur during the summer and autumn hurricane season, but may occur during winter and/or spring. However, at north-temperate sites in D16, CDW sampling should occur in summer and/or autumn, as maximum storm activity typically occurs during the winter in this domain. Regardless of sampling onset date, the temporal window in which CDW sampling in a given year must be completed is relatively long – it is only required that CDW field sampling be completed before the season of maximum storm activity resumes.

4.3 Timing for Laboratory Processing and Analysis

Because wood samples will continue to decay after collection and before drying, particularly when very moist, it is important to place wood samples into the drying oven as soon as possible following collection. Ideally, samples will be placed in the drying oven within 24 hours of collection in the field. However, if this is not logistically feasible, keep samples in muslin sample bags in a dry place, and place in the drying oven within 5 days of collection in the field. Keeping samples in a cloth bag is important (as opposed to plastic) because air-drying at room temperature can begin before the sample is placed in the drying oven.

Once wood samples are dry, they may be placed in temporary storage prior to weighing. There are no scientific limits on the time oven-dried samples may be placed in temporary storage prior to weighing and processing.

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4.4 Sampling Timing Contingencies

Table 2. Guidance indicating how to respond to unanticipated delays in field tally work (SOP B), and the consequences of potential delays

Delay/Situation	Action	Outcome for Data Products
Hours to days	If delay prevents completion of any of three LIDS transects originating within a given plotID, record in a field notebook: <ol style="list-style-type: none"> 1. Document delay for the plotID in question. 2. Note distance along transect at which delay occurred. 3. Return to transect ASAP and continue sampling at distance recorded in notebook. 	None anticipated
	If delay occurs between plots, resume CDW survey at next plotID ASAP.	None anticipated

Table 3. Guidance indicating how to respond to unanticipated delays in bulk density sample collection (SOP C), and the consequences of potential delays

Delay/Situation	Action	Outcome for Data Products
Hours to days	If delay prevents completion of bulk-density disk sampling: <ol style="list-style-type: none"> 1. Label cross-sectional disk, place any “wedges” into a labeled sample bag, and transport samples to an indoor work area. 2. Complete required disk measurements and record disk data on field datasheet. 3. Return to the field ASAP and continue sampling additional log cross-sectional disks. 	None anticipated
	If delay occurs after sampling a log is complete but before the next log is begun, resume bulk density sampling ASAP.	None anticipated

At least 10% of bulk density samples per sampling bout should be randomly selected for QA/QC for the measuring and weighing of bulk-density disks (and subsamples from disks; SOP D). Technicians re-measure, re-weigh, and record QA data in a new row on the datasheets, and mark the qaSample field appropriately. Normal data and QA data are then transcribed in the appropriate data ingest tables (RD[06], RD[07]).

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5 SAFETY

This document identifies procedure-specific safety hazards and associated safety requirements. It does not describe general safety practices or site-specific safety practices.

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

SOP C requires that technicians produce cross-sectional disks from coarse downed wood particles for generation of bulk density data. The most efficient way to generate cross-sectional disks downed logs is with a chainsaw, although a hand-powered buck saw is a less ideal option that can be employed should regulations or logistics prevent the use of a chainsaw. Should a chainsaw be chosen to complete the sampling task, there are multiple safety regulations provided by OSHA (https://www.osha.gov/OshDoc/data/Hurricane_Facts/chainsaws.html), USFS S-212, and the MTDC Chain Saw and Crosscut documentation. NEON staff should adhere to these regulations at all times in order to ensure safe operation of the chain saw.

Personal Protective Equipment Requirements

- Personal Protective Equipment (PPE) for the head, ears, eyes, face, hands, and legs must be worn when operating the saw to prevent or lessen the severity of injuries to workers using chain saws.
- PPE must be inspected prior to use to ensure it is in serviceable condition.
- Do not wear loose-fitting clothing

Before Starting the Saw

- Check controls, chain tension, and all bolts and handles to ensure they are functioning properly and adjusted according to the manufacturer's instructions.
- Make sure the lubrication (bar oil) reservoir is full.
- Start the saw on the ground or on another firm support. Drop starting is never allowed.
- Start the saw at least 10 feet from the fueling area, with the chain's brake engaged.

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While Running the Saw

- Clear the area of obstacles that might interfere with cutting the log. Clear away dirt, debris, small tree limbs, and rocks from the saw's path.
- Look for nails, spikes, or other metal in the tree before cutting.
- Keep hands on the handles, and maintain secure footing while operating the chainsaw.
- Be careful that the trunk or tree limbs will not bind against the saw. Watch for branches under tension, they may move suddenly when cut.
- Do not cut directly overhead.
- Shut off or release throttle prior to retreating.
- Shut off or engage the chain brake whenever the saw is carried more than 50 ft, or across hazardous terrain.
- Be prepared for kickback; saws must be equipped with a mechanism that reduces kickback danger (chain brakes, low kickback chains, guide bars, etc.)
 - Do not saw with the tip. If equipped, keep tip guard in place.

Fueling the Saw

- Fuel the saw at least 10 feet from sources of ignition.
- Check the fuel container for the following requirements:
 - Must be metal or plastic
 - Must not exceed a 5 gallon capacity
 - Must be approved by the Underwriters Laboratory, Factory Mutual (FM), the Department of Transportation (DOT), or other Nationally Recognized Testing Laboratory
- Dispense fuel at least 10 feet from any source of ignition.
 - No smoking during fueling.
- Use a funnel or flexible hose when dispensing fuel into the saw.
- Never add fuel to a running or hot saw.

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

The following equipment is needed to implement the procedures in this document. Equipment lists are organized by task. They do not include standard field and laboratory supplies such as charging stations, first aid kits, drying ovens, ultra-low refrigerators, etc.

Table 4. Equipment list – A team of two technicians performing CDW tallying and mensuration

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
MX103218	R	Foliage filter	Allow laser rangefinder use in dense vegetation	2	N
	R	Handheld caliper, 20 cm	Measure CDW pieces up to 20cm diameter	1	N
	R	Handheld caliper, 50 cm	Measure CDW pieces up to 50cm diameter	1	N
	R	Handheld caliper, 95 cm	Measure CDW pieces up to 95 cm diameter	1	N
	R	Hammer	Drive nails	1	N
MX104369	R	Measuring tape, minimum 50 m	Delineate transect; determine whether logs central axes intersect transects		N
MX100322	R	Laser Rangefinder, ½ foot accuracy	Delineate transect; measure log distance to transect origin	1	N
MX104359	R	White reflector or reflective tape	Reflective target for laser rangefinder; aids in measuring distance to target accurately	1	N

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Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Field guide, regional flora reference guide and/or key	Identify downed logs to functional group (hardwood vs. softwood)	1	N
MX100703	S	GPS receiver, recreational accuracy	Navigate to sampling location	1	N
MX104361	S	Chaining pins or other suitable anchor	Anchor measuring tapes	1 set	N
	S	Reflector pin-pole kit	Hold reflective target	1	N
MX100320	S	Compass with mirror and declination adjustment	Delineate transect	1	N
Consumable items					
	R	Per plot LIDS angle lists	Identify randomly assigned angles for LIDS transects in each plot	Varies	N
RD[05]	R	Coarse downed wood field datasheet	Record sampling data	Varies	N
	S	CR123A battery	Spare battery for laser rangefinder	2	N
	S	AA battery	Spare battery for GPS receiver		
	R	Numbered aluminum tag, red	Tag downed logs ≥ 10 cm	As needed	N
	R	Aluminum nail	Affix tags to logs ≥ 10 cm	As needed	N

R/S=Required/Suggested

* The 20cm calipers are small, light, and suitable for measuring CDW in the 2-5cm and 5-10cm size classes, as well as larger pieces of CDW up to 20cm diameter; at sites with CDW \leq 20cm diameter, this caliper is the only caliper required. At sites with larger diameter CDW, an additional caliper is required for the larger diameter pieces.

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Table 5. Equipment list – A team of two technicians performing CDW bulk-density sampling

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
MX100322	R	Laser Rangefinder, ½ foot accuracy	Measure log distance to transect origin	1	N
MX103218	R	Foliage filter	Allow laser rangefinder use in dense vegetation	2	N
MX104359	R	White reflector or reflective tape	Reflective target for laser rangefinder; aids in measuring distance to target accurately	1	N
MX106348	R	DBH tape, 64 cm*	Measure cross-sectional disk diameter	1	N
MX106349	R	DBH tape, 200 cm*	Measure cross-sectional disk diameter	1	N
	R	Handheld caliper, 20 cm †	Measure cross-sectional disk height; measure log diameter for highly decayed CDW pieces	1	N
	R	Handheld caliper, 50 cm †	Measure cross-sectional disk height; measure log diameter for highly decayed CDW pieces	1	N
	R	Handheld caliper, 95 cm †	Measure cross-sectional disk height; measure log diameter for highly decayed CDW pieces	1	N
	R	Hatchet	Collect subsamples from cross-sectional disks	1	Y
	R	Scale, 5000 g capacity, 1g accuracy	Weigh cross-sectional disk samples for fresh weight	1	N
	R	Scale carrying case	Protect scale during transport	1	N

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Item No.	R/S	Description	Purpose	Quantity	Special Handling
MX103931	R	Plastic tray	Contain cross-sectional disk for weighing	1	N
	R	Chainsaw, 18" bar, tool-less chain adjustment	Collect log cross-section samples	1	Y
	R	Chainsaw carrying case	Protect chainsaw during transport	1	N
	R	Cloth drawstring bag	Carry cross-sectional disk samples or wedge subsamples	As needed	N
	R	Field guide, regional flora reference guide and/or key	Identify downed logs to functional group (hardwood vs. softwood)	1	N
	S	Hammer	Drive nails		
MX100703	S	GPS receiver, recreational accuracy	Navigate to plots	1	N
	S	Reflector pin-pole kit	Hold reflective target	1	N
MX104369	S	Measuring tape, minimum 50 m	Map location of sampled logs	1	N
MX100320	S	Compass with mirror and declination adjustment	Map location of sampled logs	1	N
	S	Crosscut saw	Collect log cross-section samples	1	Y
	S	Crosscut saw leather scabbard	Protect crosscut saw during transport	1	N

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Item No.	R/S	Description	Purpose	Quantity	Special Handling
Consumable items					
	R	Trash bag	Contain highly decayed cross-sectional “disks” with no internal structure	5	N
	R	Numbered, red aluminum tags	Tag downed logs ≥ 10 cm	As needed	N
	R	Aluminum nail	Affix tags to logs ≥ 10 cm	As needed	N
	R	AA battery	Spare battery for scale	3	N
	R	Chainsaw bar and chain lubricant	Lubricate chainsaw during operation	2 qts	Y
	R	Chainsaw fuel, 1 gallon container	Fuel chainsaw during operation	1	Y
	R	Permanent marker	Label sample	2	N
RD[05]	R	Coarse Downed Wood field datasheet	Record sampling data and metadata	Varies	N
	R	Per plot LIDS angle list	Ensure bulk-density sampling does not occur on LIDS transects	Varies	N
	S	CR123A	Spare battery for laser rangefinder	2	N

R/S=Required/Suggested

* Select a DBH tape size to bring to the field that will enable measuring all expected CDW sizes with one tape.

† Select the caliper size to bring to the field that will enable measuring all expected CDW sizes with one caliper.

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Table 6. Equipment list – Processing wood bulk-density samples in the lab

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable items					
MX100230	R	Drying oven	Dry samples	1-2	N
MX100265	R	Balance, 0.01 g accuracy	Weigh oven dried samples	1	N
Consumable Items					
RD[05]	R	Drying QC Datasheet	Record data	As needed	N
RD[05]	R	Lab Drymass Datasheet	Record data	As needed	N
MX100689	S	Weigh boats, large	Contain dried sample while weighing	Varies	N

R/S=Required/Suggested

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6.2 Training Requirements

All technicians must complete required safety training as defined in the NEON Training Plan (AD[04]). Additionally, technicians must complete protocol-specific training for safety and implementation of this protocol as required in Field Operations Job Instruction Training Plan (AD[05]).

As per OSHA recommendations, training requirements for chain saw use include:

- Specific work procedures, practices, and requirements of the work site, including the recognition, prevention, and control of general safety and health hazards.
- Requirements of the OSHA Logging standard, Bloodborne Pathogens standard, First Aid, and CPR training.
- How to safely perform work tasks, including the specific hazards associated with each task, and the measures and work practices which will be used to control those hazards.
- How to safely use, operate, and maintain tools which the employee will be required to utilize in completing the assigned tasks.

In addition, for both the field and laboratory work, training must emphasize the importance of consistent, detailed labeling of all samples. ***Improper or inconsistent labeling is the most common and problematic error associated with this work!***

6.3 Specialized Skills

When performing field tallies and mensuration of CDW (SOP B), and when sampling CDW for bulk density (SOP C), the lead plant technician must possess the demonstrated ability to identify most relatively undecayed logs to species based on bark and branch characteristics, and a subset of the relatively decayed logs to either genus or family.

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6.4 Estimated Time

The time required to implement a protocol will vary depending on a number of factors, such as skill level, system diversity, environmental conditions, and distance between sample plots. The timeframe provided below is an estimate based on completion of a task by a skilled two-person team (i.e., not the time it takes at the beginning of the field season). Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, a problem ticket should be submitted.

- **SOP B:** Tallying and Measuring CDW in the Field. Trained two-person crews will require approximately 35 min per plot, on average, to complete LIDS tally sampling (range = 21-45 minutes/plot, depending on CDW particle abundance) (Affleck 2010).
- **SOP C:** Bulk Density Sampling in the Field. Trained two person crews will require 1-4+ hours per plot to complete bulk density sampling in the field, depending on CDW particle abundance. More accurate time ranges will be provided once NEON has implemented this protocol.
- **SOP D:** Processing Bulk Density Samples in the Laboratory. It should require no more than 1-3 minutes to handle, dry, weigh, and record data for a given wood sample.

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7 STANDARD OPERATING PROCEDURES

SOP A Preparing for Sampling

A.1 Preparing for Tallying and Measuring CDW in the Field (SOP B)

1. Charge GPS and load target plot locations.
2. Check/set correct compass declination. Note that declination changes with time and should be looked up annually per site: <http://www.ngdc.noaa.gov/geomag-web/>
3. Prepare laser rangefinder according to guidelines in RD[10].
4. Print (on all-weather paper) CDW “Field Tally Datasheets” and site-specific LIDS angle list.
5. Determine the volume factor (F) for CDW sampling. The volume factor (F) is analogous to plot size, and along with the diameter of CDW present at a site, determines the sampling effort required at a given site. Site-specific volume factors (F) are provided in Appendix E. The per site determination of F is in accordance with these general guidelines:
 - Large F when CDW is plentiful and of relatively large diameter.
 - Small F when CDW is sparse and of relatively small diameter
6. Determine the appropriate LIDS transect length.
 - a. Using your knowledge of the site, estimate the largest diameter CDW that will commonly be encountered across ALL of the plots intended for sampling. Vegetation Structure data previously collected from living trees are an excellent source of information.
 - b. Given the estimated maximum CDW diameter and the provided volume factor, consult Appendix F to determine the length of the LIDS transect that should be used at the site.

Example: Looking up the Volume Factor and Determining the LIDS Transect Length at OSBS

- The volume factor F shown for OSBS in Appendix E is 10
- Previously collected vegetation structure data from OSBS indicate that maximum CDW particle diameter is approximately 55 cm (example diameter only, not based on real data).
- Looking at the left-most column of Table 17 in Appendix F, the 55 cm maximum log diameter falls between values of 50 and 60 for RD_{min} . Round up and choose $RD_{min} = 60$.
- Looking at the column associated with $F = 10$ in the left half of Table 17, the LIDS transect length should be 150 meters (rounding up, not down, to the nearest 10 meters).

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A.2 Preparing for Bulk-Density Sampling in the Field (SOP C)

1. Charge GPS and load target plot locations.
2. Check/set correct compass declination. Note that declination changes with time and should be looked up annually per site: <http://www.ngdc.noaa.gov/geomag-web/>
3. Prepare chainsaw, when chainsaw use is permitted.
 - a. Inspect chain and sharpen if necessary
 - b. Inspect chain tension and adjust if necessary
 - c. Prepare 2-cycle fuel in gallon fuel container
 - d. Fill fuel and bar oil reservoirs
4. Prepare battery-powered field scale
 - a. Check batteries
 - b. Check accuracy with 100g standard weight
5. Cut waterproof "Rite-in-the-Rain" paper into 8 equally sized pieces for bulk density sample labels
6. Print CDW "Field Density Datasheets" and LIDS angle list
7. Prepare drying oven
 - a. Clear sufficient space for wood bulk-density samples
 - b. Set temperature to 105°
8. Print drying QC datasheets

A.3 Preparing for Laboratory Processing of Bulk Density Samples (SOP D)

1. Print lab weighing datasheets
2. Check lab scale accuracy with 100g standard weight

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SOP B Tallying and Measuring CDW in the Field

B.1 Procedure

At sites where CDW is present, it is tallied and measured in all Tower plots, a subset of Distributed plots (20 randomly selected plots), and Gradient plots (if this plot type exists at a given site).

1. Navigate to the plot to be sampled (using the GPS if necessary), and locate the point at the center of the plot (Figure 1). This center point is defined as the CDW sampling location, “S”.
 - If there is no qualifying CDW in the plot (e.g. the plot is grassland vegetation), go on to the next plot and record in the “Field Tally Datasheet”:
 - **plotID**
 - “targetTaxaPresent = N”; because there is no **remarks** field on the datasheet, write anywhere in the appropriate table row.
2. While standing at S, use the “LIDS Angle List” to determine the azimuth relative to true north for the first LIDS transect. Azimuths for 3 LIDS transects per plot are provided by Science Operations in the site-specific LIDS Azimuth List file named “[siteID]_lidsList.csv”
3. Site along the desired azimuth using a declination-corrected mirror-site compass or the TruPulse 360. Select an object in the middle distance (e.g. unique looking tree, rock, or other feature), and use this object as a “sight guide” for transect establishment along the desired azimuth.
4. Use the meter tape to measure exactly 3 meters from S toward the selected “sight guide,” and anchor the end of the meter tape to the ground with a chaining pin.

This step creates a 3 meter gap between S and the start of the individual transect (as in Figure 1), which:



- minimizes trampling near the centroid where diversity measurements may also take place; and
 - reduces the chance that a piece of CDW close to S will be tallied on more than one transect.
5. Continue walking toward the “sight guide” and extend the meter tape to the distance determined in SOP A.1. Place a chaining pin every 10 m to accurately mark the transect.
 - a. In extremely brushy conditions, in which line of sight is obscured beyond more than several meters, it will be very difficult to keep the tape straight. Do your best in these conditions, but do not spend too much time if it appears that minor deviations from a relatively straight line cannot be removed.

6. Return to the end of the transect closest to S, and begin surveying the transect for qualifying pieces of CDW ≥ 2 cm diameter AND ≥ 1 m length with central axes that intersect the transect (see examples in Figure 1).
 - a. Assess qualifying diameter and length with respect to the point at which the central axis of the piece of CDW intersects the transect (Figure 2). In Figure 2, the length of the central axis is measured from diameter “breakpoints” because bulk density is calculated separately for 2-5 cm, 5-10 cm, and > 10 cm diameter pieces, and thus length measurements must be assignable to these same diameter categories.

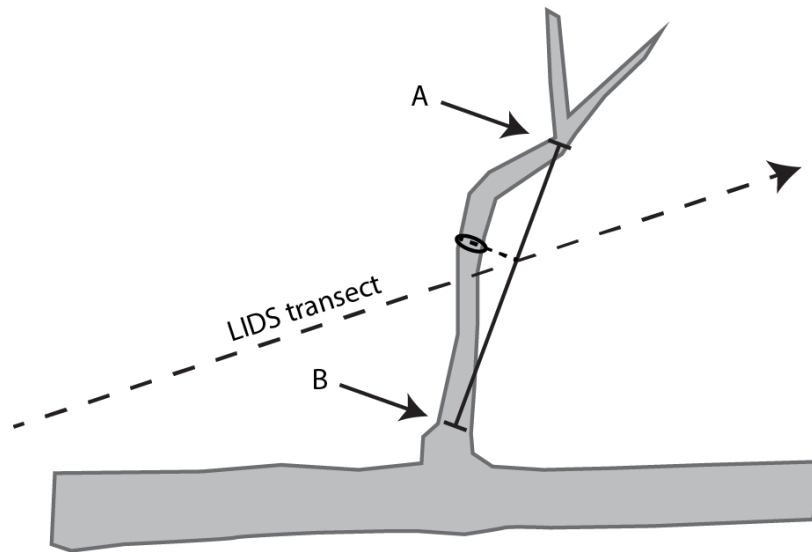


Figure 2. A LIDS transect (dashed line) intersecting a CDW particle that is tallied within the 5-10 cm diameter size class. The piece of CDW is attached to a larger piece of CDW ≥ 10 cm diameter, but is not tallied within the larger size class. Above arrow A the diameter is < 5 cm, and below arrow B the diameter is > 10 cm; the central axis (black line) is delineated along the portion of the CDW piece that is > 5 diameter and < 10 cm diameter. Diameter is measured perpendicular to the central axis as shown by the oval in the figure. Diameter is not measured perpendicular to where the log intersects the transect, and diameter is not measured parallel with the transect where it intersects the log.

7. When a qualifying piece of CDW intersects the transect:
 - a. Use Appendix F as a guide to determine whether the piece of CDW should be tallied.

Example 1: Assuming a volume factor of $F=8$, pieces of CDW with $D < 13.9$ cm are NOT tallied if you have already walked 10 m along the transect.

Example 2: Assuming a volume factor of $F=8$, do NOT tally pieces of CDW with $D < 10$ cm if you have already walked 5.14 m along the transect.

- b. If the log should be tallied, or it is unclear whether the log should be tallied (e.g. the diameter of a log falls between two rows of Appendix F), measure and record the required log attributes listed Table 7 below on the “Field Tally Datasheet”:

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Table 7. Log attributes

Datasheet Field	Recorded Data	Method
logDistance*	Horizontal distance from transect intersect point to transect origin; nearest 0.1 m	TruPulse 360 (HD mode)
logDiameter	Diameter of the CDW piece perpendicular to the log central axis at the point where the transect intersects the central axis (Figure 2); nearest 0.5 cm	Calipers
minorLogDiameter	For elliptical logs (often highly decomposed), this is the minor axis of the ellipse; nearest 0.5 cm	For highly decomposed logs, push a chaining pin or the non-jaw end of the calipers into the wood until soil is reached. Measure and record this depth.
logLength (see Figure 2)	Length of the CDW piece central axis; nearest 0.1 m	Meter tape or TruPulse 360 (SD mode)
scientificName	Species, genus, family or ‘unknown hardwood’/‘unknown softwood’ – in that order of preference	Visual inspection of remaining leaves, bark, and surrounding live species; use field guide when helpful
identification Qualifier (idQ)	See Table 8 for idQ codes and descriptions	Visual inspection
decayClass	See Table 9 for decayClass categories	Visual inspection

* In extremely brushy conditions in which line of sight is obscured beyond a few meters, use the TruPulse with the brush filter in “FLt” mode, and establish waypoints along the transect at known distances from the transect origin. Measure distances from waypoints as needed.

8. For logs ≥ 10 cm diameter:
 - a. Mark with a numbered, red aluminum tag, and record the tag number in the **logID** field.
 - b. Assess and record the following **decayClass** characteristics:
 - **presenceLeaves** (or needles): ‘Y’ or ‘N’
 - **presenceTwigs**: ‘Y’ or ‘N’. Twigs are < 2 cm diameter woody structures attached to the main log to be tallied.
 - **presenceBranches**: ‘Y’ or ‘N’. Branches are ≥ 2 cm diameter woody structures attached to the main log to be tallied.
 - **coverBarkBranches**: The % cover of bark on any branches; assign from the following categories: 0-10%, 10-20%, 20-50%, 50-80%, 80-90%, 90-100%
 - **coverBarkLog**: The % cover of bark on the main log to be tallied. Use the same % cover categories as above.
 - **handBreakableLog**: ‘Y’ or ‘N’. Pieces of the log (not bark) can be broken apart by hand.
 - **holdsShapeLog**: ‘Y’ or ‘N’. The log holds its original shape, and does not slump or conform to the shape of the substrate upon which it lies. Breaks or indentations due to the impact of falling do not count.

9. Continue tallying logs that intersect the transect until the limiting distance associated with the largest diameter logs present at the site is reached (Appendix F).
10. Repeat Steps 2-9 for the second and third LIDS transects.
11. Continue sampling at the next plotID on the LIDS Angle List.

Table 8. Identification qualifier codes (idQ) to designate unknown species, or those species with uncertain identification in the field

idQ Code	identificationQualifier	Description
CS	cf. species	Roughly equals but “not sure” about the species
AS	aff. species	“Similar to, but is not” the species
CG	cf. genus	Roughly equals but “not sure” about the genus
AG	aff. genus	“Similar to, but is not” the genus
CF	cf. family	Roughly equals but “not sure” about the family
AF	aff. family	“Similar to, but is not” the family

Table 9. Decay classes for CDW pieces (modified from classes defined by the U.S. Forest Service).

decayClass	Characteristics	Texture
1	Sound, freshly fallen. Leaves/needles may be present, and twigs and branches are present. Branches have most or all of their bark.	Intact, no rot
2	Sound. Larger diameter twigs may be present; branches are present but have begun to lose bark. Log has begun to lose bark.	Intact, sapwood partly soft
3	Heartwood sound, log supports its own weight. Branches mostly absent, those remaining are stubs and have little to no bark; branch stubs are held firmly by heartwood and cannot be wiggled by hand. Log has little to no bark.	Sapwood can be pulled apart by hand, or is absent
4	Heartwood rotten, branch stubs can be wiggled by hand. Log does not support its own weight, but maintains shape; can be kicked apart, but breaking apart with hands is difficult	Soft, small, blocky pieces; a chaining pin can be pushed easily into the log
5	No structural integrity remains; log does not retain shape and can be broken apart with hands; majority of log not incorporated into litter layer of soil	Soft, powdery when dry

B.2 Troubleshooting

Table 10. Troubleshooting common issues encountered when tallying and measuring CDW in the field.

Issue description	Action
< 5 pieces of CDW were tallied at > 20% of the sampled plotIDs	Issue a problem ticket to procure a different volume factor (<i>F</i>) for sampling CDW at the site.
Zero pieces of CDW were tallied at > 1 of the sampled plotIDs	
> 20 pieces of CDW were tallied at > 20% of the sampled plotIDs	
A LIDS transect encounters a boundary before the limiting distance is reached, and the boundary prevents further sampling (e.g. fence, poison oak thicket, impenetrably dense vegetation, property boundary, etc.)	<ul style="list-style-type: none"> • At the boundary, turn 180°, reflect the transect back onto itself, and continue walking back toward the transect origin, tallying until the <i>total distance traveled</i> equals the distance originally desired for the transect (Gregoire and Monkevich 1994). • Record “reflection at X meters” in your field notebook.

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SOP C Bulk Density Sampling in the Field

C.1 General sampling strategy

Bulk density will be sampled twice at each site, and the second sampling will be 5 y after the first sampling event. For logs ≥ 10 cm diameter, it is ideal to:

- Cut cross-sectional disk samples at least 1 m in from the end of the log; and
- To repeat sample the same logs across both sampling bouts.
- Preferentially sample logs > 3 m length, due to the fact that two disks can be cut from the same log at a 5 y interval while still cutting each disk 1 m in from the end of the log at each sampling event.
- For logs ≥ 10 cm diameter and > 5 m length, cut two disks per log: At each of the two sampling bouts, disks are cut 1 m in from either end of the log.

Logs with diameter < 10 cm are not repeat sampled, and disks may be cut 50 cm from the end of the particle.

Cutting cross-sectional disk samples from CDW pieces for bulk-density estimation is carried out in and around Tower plots and Distributed plots, although logs that intersect LIDS transects within a given plot should not be sampled (Figure 1). Because sampling involves cutting and removing a small section of downed log, individual site hosts may impose additional restrictions on where within a site it is allowed to perform the sampling. Be sure to check with the Field Operations Manager regarding potential sampling restrictions. Additional restrictions for bulk-density sampling include:

- When sampling within Distributed plots, do not cut CDW particles where doing so would cause a change in plant diversity data collection from 1 m² nested subplots (e.g. a change in the % abiotic cover).
- Be cognizant of trampling effects, and do not select logs for cross-sectional disk sampling that will require working within 10 m² nested subplots.
- To facilitate re-sampling logs during the second of the two prescribed bulk density sampling bouts, logs may be selected up to approximately 50m from the plot centroid. Logs > 50 m from the centroid may be difficult to re-locate, and should be avoided. Be sure the site host has granted permission for sampling logs outside plot boundaries.

For estimation of bulk-density, the goal is to sample logs for each unique combination of diameter class (2-5 cm, 5-10 cm, and > 10 cm), decay class (listed in Table 9), and taxonID (for highly decayed logs, the taxonID resolution may be at the family level or “unknown hardwood” / “unknown softwood” for some sites). Because larger diameter logs are typically more rare, and also contribute the majority of the CDW biomass, the largest diameter logs are preferentially selected for bulk-density sampling (Keller et al. 2004) (Table 11). Sample sizes listed in Table 11 may be achieved over up to two field seasons; however, completing sampling in one field season is ideal.

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Table 11. Example of desired CDW bulk-density sample size across multiple decay and diameter classes for an abundant species. Below, only the first two decayClasses for one taxon are shown for the sake of brevity, but all taxon x decayClass combinations present should be sampled.

taxonID*	decayClass [†]	diameterClass [‡]	sampleSize
<i>Acer rubrum</i>	1	2-5 cm	5
		5-10 cm	5
		≥ 10 cm	10
	2	2-5 cm	5
		5-10 cm	5
		≥ 10 cm	10
	etc...	etc...	etc...

* It may not be possible to achieve the desired sample size for rare taxa; moreover, it may be difficult to achieve the desired sample size for the “unknown hardwood” and “unknown softwood” taxonIDs if most logs are identifiable to higher taxonomic resolution.

† Achieving the desired sample size for all decayClasses may not be possible if particles in some decayClasses are rare – i.e., the distribution of CDW particles is not uniform across decayClasses. For example, a recently logged site will not have highly decayed CDW. Do your best given site conditions and the prescribed search area around the plot centroids.

‡ Within the ≥ 10 cm diameter size class, seek out and sample the largest diameter CDW pieces (e.g. diameter ≥ 30 cm), and then populate the rest of the desired sample with randomly selected CDW pieces.

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C.2 Initial bulk-density sampling in the field (Bout 1)

The field procedure described below enables calculation of both the volume and fresh mass of cross-sectional disks cut from pieces of CDW, both of which are critical components to determining CDW bulk density. To quantify uncertainty in bulk density measurements, QA must also be performed on these field measurements. Field QA consists of selecting 10% of sampled disks for re-measurement by the technician who did not perform the original measurements. To record QA data:

- Record **qaSample** = 'Y' on the Field Bulk Density Disk and Disk Subsample Datasheet (RD[05])
- When not recording QA data, record **qaSample** = 'N'.



Before performing any of the steps below, be sure you are permitted to obtain CDW bulk-density samples from the intended sampling area, and determine whether chainsaw sampling is a permitted activity.

- Make a table in your field notebook similar to Table 11 to help target the sampling effort for CDW bulk density sampling. Tally each sampled log in the table to track sampling progress across taxa and decayClasses.
 - To avoid over-representing any particular micro-climate within a plot in the sample pool, try to distribute CDW bulk density sampling as evenly as possible across all the plots that contain qualifying CDW pieces.
- Navigate to a desired plot that is suitable for CDW bulk-density sampling.
 - Logs may be selected up to approx. 50 m from the plot centroid with site host permission.
- Search for pieces of CDW that qualify for bulk density sampling:
 - For CDW < 10 cm diameter: Pieces must be ≥ 1 m length
 - For CDW ≥ 10 cm diameter: Pieces must be ≥ 2 m length, but ideally ≥ 3 m (to enable tagging and repeat sampling at two timepoints).
 - Sample as many logs as you can that are ≥ 3 m length during Bout 1.** Repeat sampling of the same logs in Bout 2 will be a major contribution to this field of ecology.
 - If you are sampling within an established NEON plot, use the LIDS Angle List to ensure that you do NOT select CDW pieces for bulk-density sampling that intersect the LIDS transects. If you are unsure, be conservative and do NOT sample the piece in question.

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4. Record required log-level data in the Field Bulk Density Log Datasheet (RD[05]):
 - a. Record the **logID**. This is an identifier used to link log-level data with field and lab data associated with cross-sectional disks sampled from the log.
 - For logs ≥ 10 cm diameter AND ≥ 3 m length that will be repeat sampled:
 - Affix a red, numbered tag and record the number in the **logID** field.
 - For logs not meeting these criteria:
 - **logID** = 'LXX', where 'XX' are sequential numbers assigned in the field that start over at '01' at each new plot. Always use the 'L' prefix for these logs to enable separation from tagged logs in the NEON database.
 - b. Record the following for all logs:
 - **plotID**: The plotID in which the cross-sectional disk is sampled. If the log does not lie within a plot, record the nearest plotID.
 - **taxonID**: The finest resolution taxonID to which the log can be assigned (*Genus species* → *Genus* → *Family* → "unknown hardwood"/ "unknown softwood"). *Genus species* or *Genus* should be possible for logs in decayClass 1-3, higher levels for decayClasses 4 and 5.
 - **idQ**: Any relevant identificationQualifiers (see Table 8 in SOP B)
 - **decayClass**: Categories 1-5 (see Table 9 in SOP B)
 - c. **For logs ≥ 10 cm diameter:**
 - **presenceLeaves** (or needles): 'Y' or 'N'
 - **presenceTwigs**: 'Y' or 'N'. Twigs are defined as < 2 cm diameter woody structures attached to the main log or portion of log from which a disk will be cut.
 - **presenceBranches**: 'Y' or 'N'. Branches are defined as ≥ 2 cm diameter woody structures attached to the main log or portion of log from which a disk will be cut.
 - **coverBarkBranches**: The % cover of bark on any branches; assign from the following categories: 0-10%, 10-20%, 20-50%, 50-80%, 80-90%, 90-100%
 - **coverBarkLog**: The % cover of bark on the main log or portion of log from which a disk will be cut. Use the same % cover categories as above.
 - **handBreakableLog**: 'Y' or 'N'. Pieces of the log can be broken apart by hand (bark does not count).
 - **holdsShapeLog**: 'Y' or 'N'. The log holds its original shape, and does not slump or conform to the shape of the substrate upon which it lies. Breaks or indentations due to the impact of falling do not count.
 - d. **For logs ≥ 10 cm diameter AND ≥ 3 m length** that will be re-located for repeat sampling:
 - **logDistance**: The distance to the nearest plot centroid, nearest 0.1 m
 - **logAzimuth**: The azimuth relative to True North, measured from the log facing toward the nearest plot centroid.

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5. Prepare a label for the disk (or disks) that will be cut from the selected log. Use a pre-cut piece of 'Rite-in-the-Rain' type paper, and write with a sharpie.
 - **For logs ≥ 5 m in length**, two disks will be cut, one from either end of the log, and two labels are therefore required.
 - Record on the label:
 - **bdSampleDate**: The date the bulk density sampling is performed, *YYYYMMDD* format.
 - **plotID**: The unique identifier for the plot (or closest plot).
 - **logID**: The logID previously recorded in step 4.a above
 - **diskID**: A technician assigned numeric identifier for the disk – either '1' or '2'
6. Cut a cross-sectional disk (or disks) from the log using a chainsaw. If only sampling from one end of the log (i.e., the log is < 5 m length), randomly choose an end to sample. Use the guidelines in Table 12 below, and see Figure 3 for example information.
 - **For highly decayed logs that do not hold their shape**: It will be impossible to remove and measure a cross-sectional disk without it crumbling in the process. To deal with this situation, two cuts are made approx. 10 cm apart in the rotten log.
 - Keep the chain at the highest speed when cutting to make a clean cut and prevent rotten material from being thrown by the saw.
 - When both cuts are complete, simply scoop out the "disk" between the cuts by hand into a plastic garbage bag.
 - Thoroughly mix the sample by hand.
 - Record on the Field Bulk Density Disk and Disk Subsample Datasheet the same data recorded on the label in step (5):
 - **plotID**
 - **logID**
 - **diskID**

Table 12. Guidelines for cutting cross-sectional disks from CDW with different diameter and decayClass combinations

	≥ 10 cm diameter log	< 10 cm diameter log
decayClasses 1-3	<ul style="list-style-type: none"> • 5+ cm width disk • 1 m buffer from log end 	<ul style="list-style-type: none"> • 10 cm width disk • 50 cm buffer from log end
decayClasses 4-5	<ul style="list-style-type: none"> • 10 cm width disk • 1 m buffer from log end • Chain at highest speed before initiating cuts 	<ul style="list-style-type: none"> • 10 cm width disk • 50 cm buffer from log end • Chain at highest speed before initiating cuts

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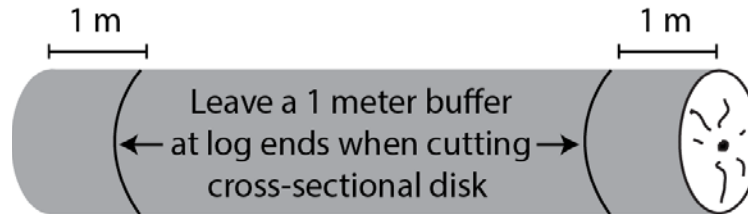


Figure 3. A 1 m buffer should be left on either end of a ≥ 10 cm diameter CDW piece when cutting a cross-sectional disk for bulk-density sampling. The log depicted is > 5 m length and is sampled from both ends at each of the two sampling timepoints. Qualifying logs < 5 m length are only sampled at one end.

7. Measure the required dimensions of the cross-sectional disk, and record on the Field Bulk Density Disk and Disk Subsample Datasheet (RD[05]).
 - a. **For disks with structural integrity that hold their shape:**
 - 1) For disks ≥ 10 cm diameter:
 - Measure diameter with a Lufkin DBH tape. Record to the nearest 0.5 cm:
 - **diskDiameter:** The diameter of the cross-sectional disk
 - **minorDiskDiameter:** Leave blank
 - Measure disk heights with calipers. Record to the nearest 0.1 cm:
 - **diskHeight1:** The maximum disk height
 - **diskHeight2:** The minimum disk height
 - **diskHeight3:** Technician selected representative intermediate disk height
 - **diskHeight4:** Technician selected representative intermediate disk height
 - 2) For disks < 10 cm diameter:
 - Measure diameter with calipers. Record to the nearest 0.1 cm:
 - **diskDiameter:** The maximum disk diameter; i.e., the major ellipse axis
 - **minorDiskDiameter:** The minimum disk diameter; i.e., the minor ellipse axis
 - Measure disk heights with calipers. Record to the nearest 0.1 cm:
 - **diskHeight1:** The maximum disk height
 - **diskHeight2:** The minimum disk height
 - **diskHeight3:** Leave blank
 - **diskHeight4:** Leave blank

b. For “disks” lacking structural integrity that do NOT hold their shape (and have already been manually scooped into a plastic bag):

1) For “disks” ≥ 10 cm diameter:

- Measure diameters on both faces of the remaining cut log using calipers (Figure 4). For each field below, record the average of both cut faces, to the nearest 0.1 cm:
 - **diskDiameter**: The maximum disk diameter; i.e., the major ellipse axis
 - **minorDiskDiameter**: The minimum disk diameter; i.e., the minor ellipse axis
- Measure disk height with calipers (i.e., the width of the scooped out log area; “C” in Figure 4). Be sure to subtract 2X the width of the saw kerf from the measured height (i.e., 2X the width of the saw blade). Record to the nearest 0.1 cm:
 - **diskHeight1**: The maximum disk height
 - **diskHeight2**: The minimum disk height
 - **diskHeight3**: Technician selected representative intermediate disk height
 - **diskHeight4**: Technician selected representative intermediate disk height

2) For “disks” < 10 cm diameter:

- Measure diameters on both faces of the remaining cut log using calipers as above for ≥ 10 cm logs. Record to the nearest 0.1 cm.
- Measure disk height with calipers as above for ≥ 10 cm logs. Record to the nearest 0.1 cm:
 - **diskHeight1**: The maximum disk height
 - **diskHeight2**: The minimum disk height
 - **diskHeight3**: Leave blank
 - **diskHeight4**: Leave blank

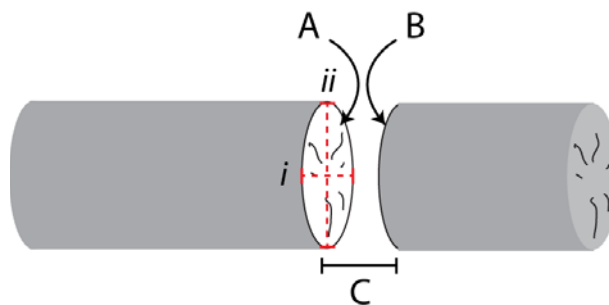


Figure 4. Illustration of measurements required for the space from which a crumbly “disk” was extracted by hand from a highly decayed log. Freshly cut surfaces are indicated by A and B, and C shows the height of the “disk.” Highly decayed logs are often collapsed under their own weight, and show elliptical cross-sections (i.e., the red dashed lines *i* and *ii* where $i > ii$, which represent the major and minor ellipse axes, respectively). In the steps above, **diskDiameter** is typically the average of A.*i* and B.*i*; **minorDiskDiameter** is typically the average of A.*ii* and B.*ii*

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8. Measure the fresh mass of the entire cross-sectional disk sample using a portable electronic scale.

- Break up large pieces that exceed the scale limits, or that are unwieldy, with a hatchet and weigh one at a time.
- Use an upside-down plastic frisbee as a weigh boat, and tare before each weighing.
- Record to the nearest 1 g on the Field Bulk Density Disk and Disk Subsample Datasheet (RD[05]):

- **diskFreshMass**

9. Cut an approx. 100 g subsample from the disk to take back to the laboratory and determine the fresh:dry mass ratio (see Figure 5 for subsampling guidelines). Use either the hatchet or the chainsaw. Skip this step if the entire disk has a fresh mass < 100 grams.

- If decay throughout the disk appears non-uniform, i.e. a portion of the disk is more decayed than the rest, generate up to two subsamples with mass of the two subsamples proportional to the affected areas of the disk.
 - Create a second label for the second subsample, with sample information as in step 5.
 - Add **numericID** to each label. This is either '1' or '2'.
- **For “disks” lacking structural integrity that do NOT hold their shape:**
 - Subsample approx. 100 g of well mixed sample by hand from the plastic bag into the frisbee (which should be tared and sitting on the scale).

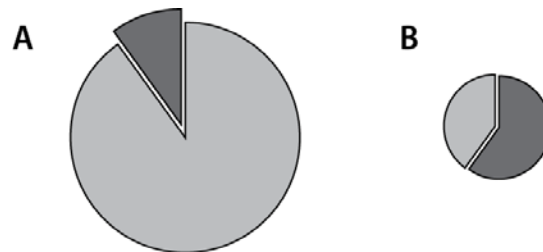


Figure 5. Creating wedge-shaped subsamples from cross-sectional disks from relatively large disks (A), and relatively small disks (B). In both A and B, the dark grey area is approx. 100 g, and the light grey is discarded.

10. Weigh the subsample created in step 9, and determine the fresh mass to the nearest 1 gram. Always tare the scale first if using the frisbee as a weigh boat. Record on the Field Bulk Density Disk and Disk Subsample Datasheet (RD[05]):

- **numericID:** A numeric identifier for the wedge-shaped subsample; either '1' or '2'.
- **sampleFreshMass:** Fresh mass of the disk subsample

11. Place the subsample into a muslin bag with its associated label, and tie the bag.

12. Return to step 3.

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C.3 Post-field sampling tasks

1. Place cross-sectional disks, or subsamples of disks, into the 105 °C drying oven(s).
 - Track drying progress with the Lab Bulk Density Drying QC Datasheet.
2. Perform chainsaw maintenance:
 - Sharpen chain if necessary. Keep in mind that during sampling of downed logs, the chain makes frequent contact with the ground and dulls quickly. That said, the chain does not have to be particularly sharp to cut decayed logs, so only sharpen if you find you are having difficulty making straight(ish) cuts.
 - Check controls, chain tension, and all bolts and handles to ensure they are functioning properly and adjusted according to the manufacturer's instructions.
 - Make sure the lubrication (bar oil) reservoir is full.

C.4 Repeat bulk-density sampling in the field (Bout 2)

The process of cutting, measuring, weighing, and subsampling cross-sectional disks from selected logs is identical to that described in SOP C.1 for Bout 1 sampling. However, the process of selecting logs for sampling is different: Only those logs ≥ 10 cm that were tagged with a red, aluminum tag in Bout 1 are re-sampled in Bout 2. For these logs that are re-sampled, cut cross-sectional disks per log according to the following strategy (see Figure 6):

- **For all logs:**
 - Use the disk sampling guidelines in Table 12.
- **For logs ≥ 3 m length** (that were ≥ 5 m length in Bout 1)(Figure 6A):
 - Cut two cross-sectional disk samples, 1 meter in from each end of the log.
- **For < 3 m length** (that were < 5 m length in Bout 1)(Figure 6B):
 - Cut one cross-sectional disk sample, 1 meter in from either end of the log.
 - For logs exactly 2 m long, cut the disk from the center of the log.

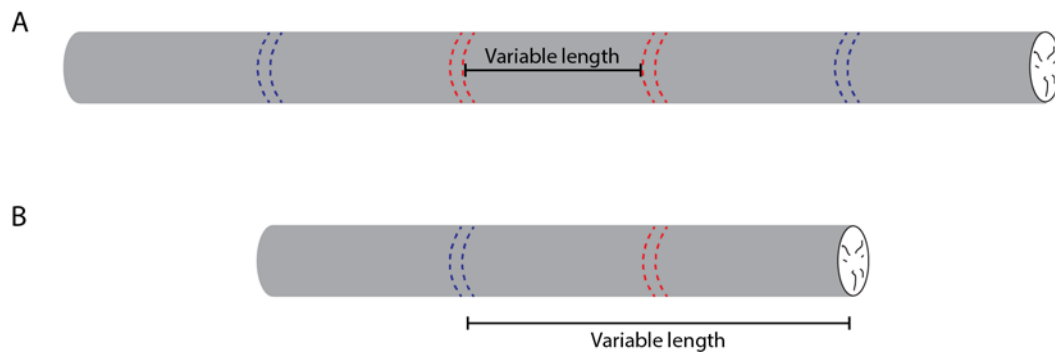


Figure 6. Strategy for generating cross-sectional disks from logs re-sampled for bulk density in Bout 2. (A) Logs ≥ 5 m length in Bout 1 and ≥ 3 m length in Bout 2; (B) Logs < 5 m length in Bout 1 and < 3 m length in Bout 2. Pairs of blue dashed lines represent Bout 1 disks, and pairs of red dashed lines indicate Bout 2 disks.

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SOP D Processing Bulk Density Samples in the Laboratory

Bulk-density samples from SOP C are dried to constant weight in the laboratory, and the weight of the dried wood samples is recorded so that bulk-density can be calculated for each diameter class (2-5 cm, 5-10 cm, > 10 cm) by decay class (Table 9) by taxon combination within each site.

D.1 Weighing and recording sample dry mass

1. Label muslin bags containing bulk density samples with the **ovenInDate** and time the samples are placed in the drying oven.



Critical step: Labeling envelopes allows assessment of how long different batches of wood samples have been in the oven, especially when samples generated from multiple days occupy the same oven. To create a label, wrap a piece of lab tape around the drawstrings, and write with a sharpie.

2. Place labeled muslin bags into a 105 °C drying oven until samples are dried to a constant weight. Drying may take up to 5 days (120 h) or longer.
3. Check the drying progress using the “Drying QC” datasheet.
 - a. Choose 5 muslin bags per sampling date to monitor for drying time. If there are different size classes of sample (e.g. wedges from larger logs vs. cylinders of various sizes from smaller logs), choose 5 samples per size class and perform the steps below separately for each size class.
 - b. Record the weight of the sample in these 5 envelopes through time to track drying progress. There is no need to remove samples from the bags: Simply record the weight of the bag + the sample inside.
 - c. At each timepoint that drying is checked, calculate the difference in weight between the last two timepoints for each envelope + sample(s).
 - d. Samples are dry when the average weight difference between the last two timepoints equals zero (averaged across all 5 bags, to within ± 0.5 g).
4. Remove dried bulk-density samples from the drying ovens, let cool, and weigh as soon as possible.
 - Oven-dried wood will readily absorb water from the air, particularly in humid environments. Weigh samples in small batches soon after removal from the oven to prevent this problem.
 - **If not weighing samples the same day they are removed from the oven**, record **ovenOutDate** and time on the tape label, and place in temporary storage. Samples not weighed on the same day they are removed from the oven must be returned to a 105 °C drying-oven for 24 h prior to weighing.

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5. Weigh biomass from each individual disk sample or wedge-shaped subsample using a mass balance (0.01 g accuracy) and a large weigh boat if necessary.
 - a. Tare the balance + weigh boat prior to weighing each sample.
 - b. Record mass data, metadata written on the 'Rite-in-the-Rain' sample label, and drying metadata on the Lab Bulk Density Drymass Datasheet (RD[05]):
 - **plotID**: The unique identifier for the plot (or closest plot)
 - **bdSampleDate**: The date the wood was sampled in the field; YYYY-MM-DD format
 - **logID**: Either the number from the red, aluminum tag, or 'LXX' format, where 'XX' are sequential numbers assigned in the field that start over at '01' at each new plot.
 - **diskID**: A technician assigned numeric identifier for the disk – either '1' or '2'
 - **numericID**: A numeric identifier for the wedge-shaped subsample; either '1' or '2'
 - **ovenInDate**: The date and time the sample was placed in the oven; YYYY-MM-DD and HH:mm 24-h format
 - **ovenOutDate**: The date and time the sample was removed from the oven
 - **qaDryMass**: A 'Y' or 'N' indicator of whether the **dryMass** value is of standard type (qaDryMass = 'N') or QA type (qaDryMass = 'Y')
 - **dryMass**: The oven dry mass, without the bag, of the sample; nearest 0.01 g
6. Return dried wood samples to temporary storage once all data have been recorded.
 - Samples may be discarded after all data and QA data have been recorded and transcribed, successfully ingested into the NEON Cyberinfrastructure, and the data have passed through initial QA/QC algorithms.

D.2 Data Verification and QA

To quantify uncertainty associated with weighing dried wood samples, a portion of dried samples are re-weighed by a different technician than the person who originally weighed the biomass.

1. Select 10% of dried, previously weighed samples for re-weighing by a different technician than he/she who performed the initial weighing.
 - If QA weighing does not take place on the same day as the initial weighing, return samples targeted for QA to a 105 °C drying oven for 24 h prior to re-weighing.
2. Record **qaDryMass** = 'Y' on the Lab Drymass Datasheet for these records.

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D.3 Equipment Maintenance

- Check balances before each use with a standard weight.
- Balances should be calibrated with a standard calibration weight set
 - After initial installation
 - Any time the balance is moved
 - Every 6 months, or
 - If the check above indicates the balance is reporting masses outside the manufacturer's specified tolerances.

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SOP E Data Entry and Verification

As a best practice, field data collected on paper datasheets should be digitally transcribed within 7 days of collection or the end of a sampling bout (where applicable). However, given logistical constraints, the maximum timeline for entering data is within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

Currently, there is a change-controlled spreadsheet version of the ingest document, as well as a working database version of the document. The data entry tables are the same in both the spreadsheet and database versions, but the change-controlled spreadsheet version contains summary information about each table, as well as summary information about each field, data type, example entries, etc.

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SOP F Sample Shipment

This protocol does not generate any samples that require shipment to external facilities for analysis or archive.

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8 REFERENCES

- Affleck, D. L. R. 2008. A line intersect distance sampling strategy for downed wood inventory. *Canadian Journal of Forest Research* **38**:2262-2273.
- Affleck, D. L. R. 2010. On the efficiency of line intersect distance sampling. *Canadian Journal of Forest Research* **40**:1086-1094.
- Brown, J. K. 1974. Handbook for inventorying downed woody material. USDA Forest Service **General Technical Report INT-16**:1-32.
- Gove, J. H., M. J. Ducey, H. T. Valentine, and M. S. Williams. 2013. A comprehensive comparison of perpendicular distance sampling methods for sampling downed coarse woody debris. *Forestry* **86**:129-143.
- Gregoire, T. G., and N. S. Monkevich. 1994. The reflection method of line intercept sampling to eliminate boundary bias. *Environmental and Ecological Statistics* **1**:219-226.
- Harmon, M. E., and J. Sexton. 1996. Guidelines for measurements of woody detritus in forest ecosystems. Publication No. 20 **Long-term Ecological Research Network Office, University of Washington**:1-42.
- Jordan, G. J., M. J. Ducey, and J. H. Gove. 2004. Comparing line-intersect, fixed-area, and point relascope sampling for dead and downed coarse woody material in a managed northern hardwood forest. *Canadian Journal of Forest Research* **34**:1766-1775.
- Keller, M., M. Palace, G. P. Asner, R. Pereira, and J. N. M. Silva. 2004. Coarse woody debris in undisturbed and logged forests in the eastern Brazilian Amazon. *Global Change Biology* **10**:784-795.
- Valentine, H. T., J. H. Gove, M. J. Ducey, T. G. Gregoire, and M. S. Williams. 2008. Estimating the carbon in coarse woody debris with perpendicular distance sampling. Pages 73-87 *in* C. M. Hoover, editor. *Field Measurements for Forest Carbon Monitoring*. Springer Science, New York.
- Warren, W. G., and P. F. Olsen. 1964. A line intersect technique for assessing logging waste. *Forest Science* **10**:267-276.

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APPENDIX A DATASHEETS

The following datasheets are associated with this protocol:

Table 13. Datasheets associated with this protocol

NEON Doc. #	Title
NEON.DOC.002121	Datasheets for TOS Protocol and Procedure: Coarse Downed Wood
NEON.DOC.001921	NEON Raw Data Ingest Workbook for TOS Coarse Downed Wood: Field Tally Data
NEON.DOC.001922	NEON Raw Data Ingest Workbook for TOS Coarse Downed Wood: Bulk Density Field and Lab Data

These datasheets can be found in Agile or the NEON Document Warehouse.

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APPENDIX B QUICK REFERENCES

N/A

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APPENDIX C REMINDERS

N/A

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APPENDIX D ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

In general, the temporal strategy for sampling is outlined in Section 4, and the primary goal is to avoid sampling during periods of maximal seasonal storm activity that potentially create large fluxes of CDW. For most north-temperate sites, maximal seasonal storm activity occurs in the winter, and as such, CDW sampling should not occur in this time period. The dates in Table 14 below put coarse bounds on the northern hemisphere winter season, and are derived from MODIS-EVI phenology data, averaged from 2001-2009. The 'Approximate Start Date' field corresponds to the average date of greenup, and thus presumably, the end of winter and associated storm activity. The 'Approximate End Date' field corresponds to the average date by which greenness has returned to baseline 'winter' levels, and by which winter storms have presumably begun. Dates are provided in 'Day-of-Year' format; Table 15 provides conversion to 'MM-DD' format.

The dates in Table 14 provide a coarse window only, and it is essential that domain staff monitor real-time conditions to determine when to start (and stop) sampling, as described in Section 4 of this protocol. For example, the hurricane season in the Southeastern U.S. and Puerto Rico is not meaningfully captured by this 'winter' window, and is therefore noted specially. Moreover, not all sites for which dates are listed below produce CDW; be sure to follow provided guidelines to determine whether the protocol should be implemented..

Table 14. Estimated dates of green-up and senescence that bound the CDW sampling window

Domain	Site	Approx. Start Date	Approx. End Date
01	BART	120	300
	BURL	TBD	TBD
	HARV	110	300
02	BLAN	75	310
	SCBI	85	320
	SERC	80	325
03	DSNY	Hurricane season ends	Hurricane season begins
	JERC	Hurricane season ends	Hurricane season begins
	OSBS	Hurricane season ends	Hurricane season begins
04	GUAN	Hurricane season ends	Hurricane season begins
	LAJA	Hurricane season ends	Hurricane season begins
	MAME	Hurricane season ends	Hurricane season begins
05	STEI	120	250
	TREE	120	250
	UNDE	125	285
06	KONA	90	300
	KONZ	90	300
	KUFS	75	330
07	GRSM	90	310
	MLBS	110	310
	ORNL	90	315

Domain	Site	Approx. Start Date	Approx. End Date
08	CHOC	70	335
	DELA	60	330
	TALL	75	330
09	DCFS	120	290
	NOGP	115	290
	WOOD	120	290
10	CPER	90	350
	RMNP	120	285
	STER	90	270
11	CLBJ	60	325
	KLEM	75	310
	TBD	TBD	TBD
12	BOZE	105	285
	PARA	105	285
	YELL	120	280
13	MOAB	85	300
	NIWO	140	270
	TBD	TBD	TBD
14	JORN	80	320
	SRER	150	330
	TBD	TBD	TBD
15	ONAQ	75	280
	RBUT	105	310
	TBD	TBD	TBD
16	ABBY	110	300
	THAY	110	300
	WREF	115	290
17	SJER	270	155 (next calendar year)
	SOAP	90	290
	TEAK	120	300
18	BARO	175	220
	TOOL	160	240
	TBD	TBD	TBD
19	DEJU	130	250
	HEAL	135	245
	POKE	135	250
20	OLAA	TBD	TBD
	PUFO	TBD	TBD
	PUGR	TBD	TBD

Table 15. Day-of-year calendar for non-leap years

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029		088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

APPENDIX E SITE-SPECIFIC VOLUME FACTORS (F) FOR LIDS SAMPLING INFORMATION

Table 16. Site-specific volume factors for coarse downed wood tally sampling with the LIDS method

Domain Number	siteID	CDW Sampling	F	Additional information
01	BART	Yes	10	
	BURL			
	HARV	Yes	10	
02	BLAN			
	SCBI	Yes	8	
	SERC			
03	DSNY	Yes	15	No CDW sampling in Tower plots
	JERC	Yes	10	
	OSBS	Yes	10	Some Distributed plots may have no qualifying CDW
04	GUAN			
	LAJA			
	MAME			
05	STEI			
	TREE			
	UNDE	Yes	10	
06	KONA			
	KONZ			
	KUFS			
07	GRSM			
	MLBS			
	ORNL	Yes	10	
08	CHOC			
	DELA			
	TALL		8	
09	DCFS			
	NOGP			
	WOOD	No	NA	Grassland site, no qualifying CDW anticipated
10	CPER	No	NA	Grassland site, no qualifying CDW anticipated
	RMNP			
	STER	No	NA	Agricultural site, no qualifying CDW anticipated
11	CLBJ			
	KLEM			
	TBD			
12	BOZE			
	PARA			
	YELL			
13	MOAB			
	NIWO			

Domain Number	siteID	CDW Sampling	F	Additional information
	<i>TBD</i>			
14	JORN			
	SRER			
	<i>TBD</i>			
15	ONAQ	Yes	15	Likely no qualifying CDW in Tower plots
	RBUT			
	<i>TBD</i>			
16	ABBY			
	THAY			
	WREF			
17	SJER			
	SOAP			
	TEAK			
18	BARO			
	TOOL			
	<i>TBD</i>			
19	DEJU			
	HEAL			
	POKE			
20	OLAA			
	PUFO			
	PUGR			

APPENDIX F LIMITING DISTANCE BY LOG DIAMETER GUIDELINES FOR LIDS SAMPLING

Use the table below to determine the limiting distance from the transect origin for CDW particles of a given diameter (*left side*), or to determine the minimum diameter required to tally a CDW particle at a given distance from the transect origin (*right side*).

Table 17. Limiting distances (D_{lim}) for fixed round diameters (RD), and minimum round diameters (RD_{min}) for fixed distances (D), across various LIDS volume factors (F , $m^3 ha^{-1}$) for a three-segment transect.

RD (cm)	D_{lim} (m)			D (m)	RD_{min} (cm)		
	F=8	F=10	F=15		F=8	F=10	F=15
1	0.05	0.04	0.03	1	4.4	4.9	6.0
2	0.2	0.2	0.1	2	6.2	7.0	8.5
3	0.5	0.4	0.3	3	7.6	8.5	10.5
4	0.8	0.7	0.4	4	8.8	9.9	12.1
5	1.3	1.0	0.7	5	9.9	11.0	13.5
6	1.9	1.5	1.0	6	10.8	12.1	14.8
7	2.5	2.0	1.3	7	11.7	13.0	16.0
8	3.3	2.6	1.8	8	12.5	13.9	17.1
10	5.1	4.1	2.7	10	13.9	15.6	19.1
12	7.4	5.9	4.0	12	15.3	17.1	20.9
14	10.1	8.1	5.4	14	16.5	18.5	22.6
16	13.2	10.5	7.0	16	17.6	19.7	24.2
20	20.6	16.5	11.0	20	19.7	22.1	27.0
25	32.1	25.7	17.1	25	22.1	24.7	30.2
30	46.3	37.0	24.7	30	24.2	27.0	33.1
35	63.0	50.4	33.6	35	26.1	29.2	35.7
40	82.3	65.8	43.9	40	27.9	31.2	38.2
50	128.5	102.8	68.5	50	31.2	34.9	42.7
60	185.1	148.0	98.7	60	34.2	38.2	46.8

Example 1:

Walking down the first LIDS transect with a volume factor $F=8$, you encounter a CDW particle 32 cm in diameter, and you are 56 m from the transect origin: should the CDW particle be tallied? Looking at the left side of the table, 32 cm falls between 30 cm and 35 cm, so round up and use $RD = 35$ cm. For $RD = 35$ and $F=8$, the corresponding value of $D_{lim} = 63.0$ meters. Because the distance along the transect of 56 meters is $< D_{lim}$, the CDW particle should be tallied.

Example 2:

You have walked 11 m from the origin of a LIDS transect with a volume factor $F=15$. Is it necessary to keep looking for and tallying CDW particles with diameter ≤ 20 cm? Looking at the right side of the table, a distance of 11 m falls between 10 m and 12 m, so round down to 10 m to be conservative. For $D_{lim} = 10$ and $F=15$, the minimum diameter is 19.1 cm, meaning any CDW particles < 19.1 cm diameter can be ignored. However, logs ≥ 19.1 cm diameter should still be tallied.