TOS PROTOCOL AND PROCEDURE: COARSE DOWNED WOOD

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A_DRAFT	01/28/2015	ECO-02135	Initial draft release
B	02/02/2015	ECO-02673	Migration to new protocol template, name change
C	02/29/2016	ECO-03584	• Updated volume factor values for 5 domains (Appendix E) • Additional guidance in chainsaw and fueling safety • Updated time estimates for SOP B (Section 6.4) • Added qualifying CDW characteristics to beginning of SOP B.1 • Changed scientificName to taxonID (Table 7); updated codes for `unknown hardwood` and `unknown softwood` • Updated Branch Bark Cover percent categories and guidance for remarks(SOP B.1, Step 8) • Table 9 modified to focus less on evergreen tree characteristics; table re-structured to enable faster decayClass assessment • Added SOP B.2, devoted to tallying and measurement of forked CDW particles. • Added additional scenarios to Table 10 • Updated sampling strategy priorities for SOP C.1 and C.2 • Added special instructions for SOP E - Data Entry • Created 2-page quick reference sheet for field usage (Appendix B) • Expanded limiting distances table (Appendix F - Table 20) • Expanded minimum round diameters table (Appendix F - Table 21) • Expanded Split CDW/Round Diameter Equivalents Table (Appendix F - Table 22)
D	03/09/2017	ECO-04422	• Updated text to account for data collection using a mobile application. • SOP B: Updated field names to be consistent with DPS ingest workbook. • SOP B.1: Updated 'Unknown Hardwood' and 'Unknown Softwood' codes, and added guidance for downed logs with VegStructure tags. • SOP B.3 Troubleshooting: Added slash pile guidance • Equipment and SOP C: Replaced electronic scale with

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			tareable spring scales, based on technician feedback. • Equipment and SOP C: Added Cant Hook and Log Stand to improve safety when cutting disks. • SOP C.1: Reorganized, and added guidance for when bulk density sampling is considered complete. • SOP C.2: Changed `diskID` to an incrementing number that will enable easy per site tracking of total number of disks sampled. • SOP C.2: Diameter tape now used to record diameter of structurally sound disks with DBH ≥ 5 cm (was 10 cm). • Appendix B: Consolidated all diameter / distance tables into this appendix, eliminated old Appendix E. • Appendix D: Added transect length, F-values, for all sites to ensure repeatable, consistent tallying. • Appendix E: Newly added quarantine compliance appendix. • Appendix F: Newly added rank abundance of DSTs for targeted bulk density sampling completion.

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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 coarse downed 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 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	EHSS Policy, Program and Management Plan
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.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.000914	NEON Science Design for Plant Biomass and Productivity
AD[06]	NEON.DOC.004104	NEON Science Performance QA/QC 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
RD[11]	NEON.DOC.000913	TOS Science Design for Spatial Sampling
RD[12]	OSHDoc and Chainsaw Training	https://www.osha.gov/OshDoc/data_Hurricane_Facts/chainsaws.html), USFS S-212, and the MTDC Chain Saw and Crosscut documentation

2.3 Acronyms

Acronym	Definition
C	Carbon
CDW	Coarse Downed Wood
DST	'Decay class x sizeCategory x taxonID' combination. The number of DSTs identified at a site informs the Bulk Density sampling effort.
FWD	Fine Woody Debris
LIDS	Line Intercept Distance Sampling

Acronym	Definition
LIS	Line Intercept Sampling
PPE	Personal Protective Equipment

2.4 Definitions

Common terms used throughout this document are defined here, in alphabetical order.

Term	Definition
Coarse downed wood (CDW)	Any fallen stem, and all of its connected branches, with diameter ≥ 2 cm at the point where the CDW particle intersects the LIDS transect. Qualifying particles are referred to as 'logs' in this protocol for convenience. Qualifying logs also include standing dead that are > 45˚ off the vertical (Harmon and Sexton 1996, Affleck 2010).

3 METHOD

Qualifying particles of CDW are divided into three different diameter size categories, as defined by Keller et al. (2004): 2–5 cm, 5–10 cm, and ≥ 10 cm. Furthermore, logs of all diameter must also be ≥ 1 m in length (Harmon and Sexton 1996). Dead trees (i.e. snags) that have not yet fallen to an angle > 45˚ 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 at the transect intersection point 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 wood 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. 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.

Overview of SOP B

To implement SOP B, sampling locations are established at the center of each Tower Plot, and also at the center of 20 randomly selected Distributed Plots that are used for co-located LAI, herbaceous biomass clip harvest, and vegetation structure measurements (RD[11]). At each sampling location, three LIDS transects are established that radiate outward, with 120˚ separating each transect (**Error! Reference source not found.**). 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.

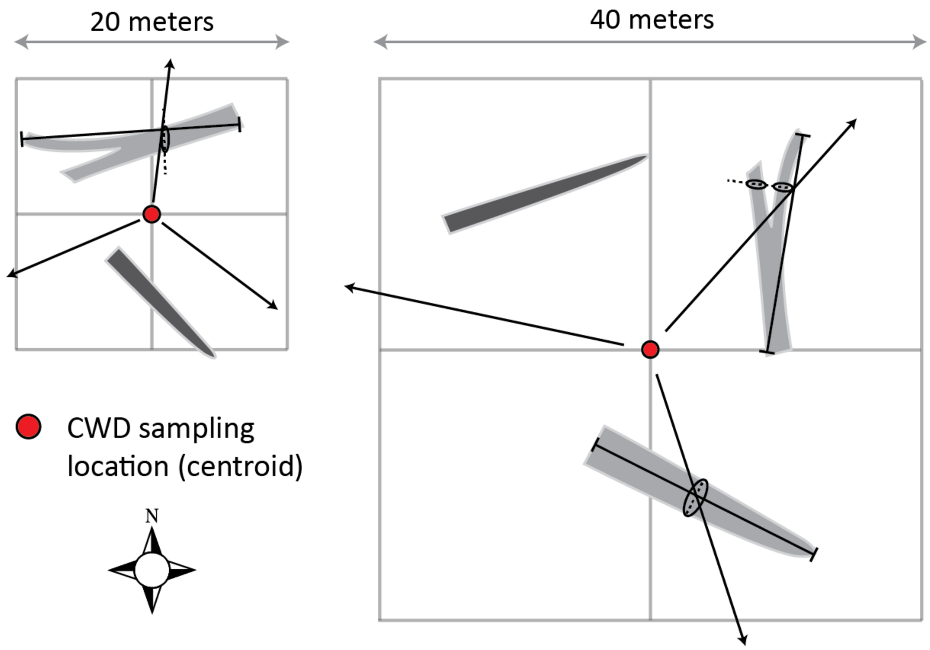

Figure 1. Illustration of three randomly oriented LIDS transects (arrow vectors) superimposed over a 20m x 20m plot (*left*), and a 40m x 40m plot (*right*). There is a 3m gap between the sampling location (i.e. the plot centroid), and the start of each transect which minimizes the chance that CDW particles 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 CDW particles selected for tally and/or bulk density sampling may lie outside of the plot boundary.

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 B, and Appendix B 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"). The latter two designations are only to be used as a last resort.

Overview of SOP C

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 5-6 years after the first implementation. Bulk density is sampled from three different diameter size categories (≥ 10 cm, 5-10 cm, and 2-5 cm), from logs that are not tallied in SOP B (**Error! Reference source not found.**). A chainsaw, or less ideally, a buck saw, is used to cut a narrow 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 mass is recorded in the field. For the two largest size categories, wedge-shaped pieces are sub-sampled from the disk, and these sub-samples are also weighed for fresh mass in the field. Subsamples are then transported back to the laboratory to calculate the disk's fresh mass : dry mass ratio. Disks sampled from the smallest size category 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.

Overview of SOP D

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 mass allows calculation of bulk density (ρ) as:

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

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

Problem Reporting and Quality Control

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.

Quality assurance will be performed on data collected via these procedures according to the NEON Science Performance QA/QC Plan (AD[06]).

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 3 y (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. SOP B should be completed prior to SOP C in order to prepare a list of taxonIDs, size classes, and decay classes from SOP B data to prioritize collection in SOP C.
	Tower	20-30†			
SOP C:Bulk	Distributed	20 max*	Once within	5-6 y	Sampling occurs twice per site. A

SOP	Plot Type	Plot Number	Sampling Events	Yearly Interval	Remarks
Density Sampling in the Field	Tower	20-30†	first 3 y of Operations; second time 5-6 y later		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.
SOP D: Processing Bulk Density Samples in the Laboratory	Distributed	20 max*	Once within first 3 y of Operations; second time 5-6 y later	5-6 y	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.

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. Refer to B.3 **Error! Reference source not found.** for sampling onset guidelines; however, provided dates are guidelines only, and it is incumbent upon Field Operations to select sampling onset dates that are appropriate for each site and consistent with the periods of storm activity described above. 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 processing (i.e., re-drying for 24 h, then weighing).

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

<table>
<tr><th>Delay/Situation</th><th>Action</th><th>Outcome for Data Products</th></tr>
<tr><td rowspan="2">Hours to days</td><td>If delay prevents completion of any of three LIDS transects originating within a given plotID, record in a field notebook:
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.</td><td>None anticipated</td></tr>
<tr><td>If delay occurs between plots, resume CDW survey at next plotID ASAP.</td><td>None anticipated</td></tr>
</table>

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

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

4.5 Criteria for Reallocation of Sampling Within a Site

Coarse Downed Wood sampling will occur on the schedule described above at up to 20 randomly selected Distributed Plots (plot selection is determined by NEON Science), and all Tower Plots per site. Ideally, sampling will occur at these sampling locations for the lifetime of the Observatory (core sites) or the duration of the site's affiliation with the NEON project (relocatable sites). However, circumstances may arise that require that sampling within a site be shifted from one particular location to another. In general, sampling is considered to be compromised when sampling at a location becomes so limited that data quality is significantly reduced. If sampling at a given plot becomes compromised, a problem ticket should be submitted by Field Operations to Science.

There are two main pathways by which sampling can be compromised. Sampling locations can become inappropriately suited to answer meaningful biological questions (e.g., a terrestrial sampling plot becomes permanently flooded). Alternatively, sampling locations may be located in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

For Coarse Downed Wood tally sampling, criteria for considering a plot compromised are the same for both Distributed and Tower Plots:

- These plots are sampled every 3 y; if sampling cannot be completed for 2 consecutive bouts then the plot should be considered compromised.
- Report compromised plots to Science, and Science will provide a randomly selected replacement plot for the current sampling bout.

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 EHSS Policy, Program and Management Plan (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.

5.1 Safety Considerations for Coarse Downed Wood Tally Procedures

5.1.1 Measuring Distances with the Laser Rangefinder

A laser rangefinder/hypsometer/compass instrument may be used to determine transect distances and measure log lengths. Safety considerations for this instrument include:

- Avoid staring directly at the laser beam for prolonged periods. The rangefinder is classified as eye-safe to Class 1 limits, which means that virtually no hazard is associated with directly viewing the laser output under normal conditions. As with any laser device, however, reasonable precautions should be taken in its operation. It is recommended that you avoid staring into the transmit aperture while firing the laser.
- Never attempt to view the sun through the scope. Looking at the sun through the scope may permanently damage the eyes.

5.1.2 Measuring Log Length

When measuring logLength, or any other log attribute, it is recommended that personnel avoid standing, climbing, or working on logs, regardless of how high off the ground the log may be. Log surfaces may be slippery, resulting in a fall hazard, or logs may roll, introducing additional crushing risks.

5.2 Safety Considerations for Coarse Downed Wood Bulk Density Procedures

5.2.1 Chainsaw Safety

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. In order to ensure safe operation of the chainsaw, NEON staff are required to complete USFS S-212 training (or equivalent) prior to operating a chainsaw.

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.

While Running the Saw

- Assure a solid, flat surface for foot placement, prior to operating the chainsaw.
- 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.
  - Safety is paramount with the saw, as is preserving chain sharpness.
  - Cut less decayed classes first, as more decayed pieces will require passing the saw into the duff / topsoil layer.
  - When cutting into the duff / topsoil layer, always use care and be ready for kickbacks.
  - If necessary and feasible, move the piece to be cut so the chain avoids contact with soil or rocks.
- 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 or above shoulder height.
- Shut off the saw or release throttle prior to retreating.
- Shut off the saw or engage the chain brake whenever the saw is carried more than 3 steps, 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

Due to EPA requirements for non-venting fuel containers/systems, all fuel containers and saws manufactured after 2010 can become pressurized during normal use, and in some cases, can create fuel 'geysers' when fuel containers are opened. Such fuel geysers have been known to catch fire, and multiple severe burn injuries have been reported when this occurs. When re-fueling the chainsaw, pay attention to the following:

- Let the saw cool before opening the fuel cap. Never add fuel to a running or hot saw.
- Cover the saw fuel cap with a rag while slowly opening the tank. This will slowly relieve any internal pressure, and prevent fine mists of any escaping fuel from finding an ignition source.
  - Similarly, cover the cap of any fuel container with a rag, and slowly open.
- 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.
  - Fueling should ideally occur on the road or nearest approach to the plots.
  - Fueling should never take place within a designated NEON plot.
  - Refuel over a tarp, so small spills can evaporate before entering soil.
- Use a funnel or flexible hose when dispensing fuel into the 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 for SOP B. Item quantities are sufficient for a team of two technicians to perform 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
	R	Field guide, regional flora reference guide and/or key	Identify downed logs to functional group (hardwood vs. softwood)	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
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 ≤ 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.

Table 5. Equipment list for SOP C. Quantities are sufficient for a team of two technicians to perform 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	Diameter tape, 64 cm*	Measure cross-sectional disk diameter	1	N
MX106349	R	Diameter 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
MX110972	R	Spring scale, 20 kg capacity, tareable	Weigh fresh mass of large cross-sectional disks	1	N
	S	Spring scale, 5 kg capacity, tareable	Weigh fresh mass of medium cross-sectional disks	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
MX100705	R	Spring scale, 1000 g capacity, tareable	Weigh fresh mass of small cross-sectional disks, and disk subsamples larger than 300 g	1	N
	R	Spring scale, 300 g capacity, tareable	Weigh fresh mass of disk subsamples	1	N
	R	Heavy duty plastic bag	Contain cross-sectional disk for weighing with spring scale	1	N
	R	Chainsaw, 18” bar minimum, tool-less chain adjustment	Collect log cross-section samples; check with local foresters to determine optimal bar length of saw	1	Y
	R	Chainsaw carrying case	Protect chainsaw during transport	1	N
MX111262	S	Cant Hook, 48” handle, LogRite brand or equivalent	Grip and maneuver CDW particles into cutting position, to enable safe cutting of bulk density disks	1	N
MX111263	S	Log Stand adapter for cant hook, LogRite brand or equivalent	Temporarily elevate CDW particle off ground to enable safe cutting of bulk density disks	1	N
	R	Uniquely marked, muslin drawstring bags, minimum 10” x 12” (size will vary depending on log size)	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, or previously sampled CDW particles	1	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	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
Consumable items					
	R	Bags, 25# kraft, 8# kraft, or plastic	Contain highly decayed cross-sectional “disks” with no internal structure	As needed	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	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

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Waterproof paper, Rite-in-the-Rain or equivalent	Material for making labels to record bulk density disk metadata in the field	10+ sheets	N
	S	CR123A	Spare battery for laser rangefinder	2	N

R/S=Required/Suggested; * Select a diameter 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.

Table 6. Equipment list for processing wood bulk-density samples in the lab (SOP D).

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 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; a metal bread pan will reduce static compared to plastic.	Varies	N

R/S=Required/Suggested

6.2 Training Requirements

All technicians must complete required safety training as defined in the Field Operations Job Instruction Training Plan (AD[04]).

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 ideally, a subset of the relatively decayed logs to either genus or family.

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. Please note that if sampling at particular locations requires significantly more time than expected, NEON Science may propose to move these sampling locations.

- **SOP B**: Tallying and Measuring CDW in the Field. Trained two-person crews will require approximately 30+ min per transect, on average, to complete LIDS tally sampling.
  - Plots with dense vegetation may take much longer to complete, with reports from 1 – 8 hours (with a mean of 2 hours).
  - Dense vegetation primarily contributes to longer sampling times by impeding accurate placement of transect tapes and/or walking a transect.
- **SOP C**: Bulk Density Sampling in the Field. Trained two person crews will require 2-16 hours per plot to complete bulk density sampling in the field, depending on CDW particle abundance.
- **SOP D**: Processing Bulk Density Samples in the Laboratory. It should require no more than 1-5 minutes to handle, dry, weigh, and record data for a given wood sample.

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. If not already known, obtain the volume factor (*F*) for CDW sampling from Science. 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 0. A single volume factor value should be used across a site, do not use multiple values. 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. Consult 0 or Science for the appropriate LIDS transect length.
   - For first-time sampling, transect lengths are informed by analysis of Vegetation Structure data.
   - Transect lengths may subsequently be revised after analysis of first-year CDW tally data.

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 (see Safety information in Section 5).
4. Cut waterproof "Rite-in-the-Rain" paper into 8 equally sized pieces per sheet for bulk density sample labels.
5. Mark unique **bagNumbers** on muslin bags with permanent ink (if no pre-marked bags exist). The same bags may be re-used for subsequent disk collections.
6. Print CDW "Field Density Datasheets" and LIDS angle list.
7. Consult Appendix F for per site ranked lists of the most abundant 'decayClass x sizeCategory x taxonID' (DST) combinations at your site (based on analysis of SOP B data). Make sure to adequately sample the most abundant DSTs.
8. Prepare drying oven
    a. Clear sufficient space for wood bulk-density samples
    b. Set temperature to 105 °C.
9. Print Drying Datasheets.

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

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

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 may also be measured in 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 plot centroid. Avoid trampling the nested subplots that flank the centroid (**Figure 1**).
   - Qualifying CDW has the following characteristics:
     - Diameter ≥ 2 cm AND length ≥ 1 m, with central axis that intersects the transect (**Figure 1**). Woody particles < 2 cm diameter are ignored for this protocol.
     - Suspended logs should *not* be tallied if:
       - The angle from the ground exceeds 45˚ *or*
       - The particle is ≥ 2 m above the ground where it intersects the transect, *or*
       - It is unsafe to measure the particle.
     - Are *not* dead stems attached to a living plant.
     - Are *not* a decumbent, but living, growth form.
   - If there is no chance you will encounter qualifying CDW along any of the three transects (e.g. the plot is grassland vegetation), go on to the next plot and record in the "Field Tally" ingest table:
     - **plotID**
     - **lidsAzimuth**
     - **targetTaxaPresent** = N; if using paper data sheets, record in the in the **taxonID** field.

     *** ***NOTE:*** Recording the absence of CDW for each **lidsAzimuth** is equally important to measuring how much CDW is present. Do NOT skip this step if CDW is absent from a plot.
   - If there is any chance you will encounter qualifying CDW along any of the three transects, continue to step (2).
2. While standing at the plot centroid, 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 in the site-specific LIDS Azimuth Lists.
3. Sight along the desired azimuth using a declination-corrected mirror-site compass or the TruPulse 360 rangefinder. 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 plot centroid toward the selected "sight guide," and anchor the end of the meter tape to the ground with a chaining pin. This point is the origin of the LIDS transect.

   This step creates a 3 meter gap between the centroid and the start of the individual transect (as in **Figure 1**), which:
   - Minimizes trampling around the centroid where diversity measurements may also occur, and
   - Reduces the chance that a piece of CDW close to the centroid will be tallied on > 1 transect.

5. Continue walking toward the "sight guide" and begin extending the meter tape to the maximum transect length (see Appendix D). Place a chaining pin or pin flag every 10 m to accurately mark the transect, and begin tallying and measuring qualifying CDW particles according to **step (6)** below.
   a. In extremely dense understory 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.
   b. If understory vegetation severely limits accurately setting up the transect tape consider the following strategies:
      i. Mark start points of transect for future reference, if allowed by site host.
         a) Mark logs or branches that indicate the beginning of the transect with marking that cannot be mistaken for CDW tags.
         b) Establish a marker at the end of the transect.
      ii. Work in shorter transect segments, rather than trying to establish the entire transect tape from beginning to end.
         a) Walk the transect tape out until you come across an obstruction.
         b) Use a highly visible marker to indicate the end of the transect segment. If allowed by the site host, these markers should be kept in place to indicate intermediate points along the transect.
      iii. Extend a transect out using a calibrated compass and/or rangefinder depending on the line of sight situation. It is critical that logDistance and azimuth are carefully and accurately tracked if a transect is paced out without the aid of a transect tape.
         a) If line of sight *can be maintained* with the beginning of the transect:
            (1) Walk the transect while maintaining the correct azimuth towards the transect end. If a qualifying particle is encountered, use the TruPulse rangefinder to determine the logDistance from the beginning of the transect, or extend the transect tape to the qualifying particle to record logDistance.

b) If line of sight ***cannot be maintained*** with the beginning of the transect:
   (1) Extend the transect tape as far as possible and survey the transect.
   (2) Upon encountering a dense, impenetrable vegetation obstacle, two technicians working together can "triangulate" around the obstacle by using the rangefinder and a compass to navigate around the obstacle and re-align with the correct transect line and bearing. Take note of the distance at which this occurred and continue pacing the transect.

6. As the transect is extended outward from the origin, 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 different size categories, and thus length measurements must be assignable to these same diameter size categories:
        - 2 cm ≤ diameter < 5 cm
        - 5 cm ≤ diameter < 10 cm
        - diameter ≥ 10 cm
      - Diameter is measured perpendicular to where the transect crosses the central axis of the particle; if the particle is bent, the measurement location will NOT be where the transect crosses the particle itself (**Figure 2**).

      ***** Note:** The second bullet above is the trickiest conceptual part of successfully implementing CDW measurement. Check with someone experienced with this protocol if you are unsure how to proceed.

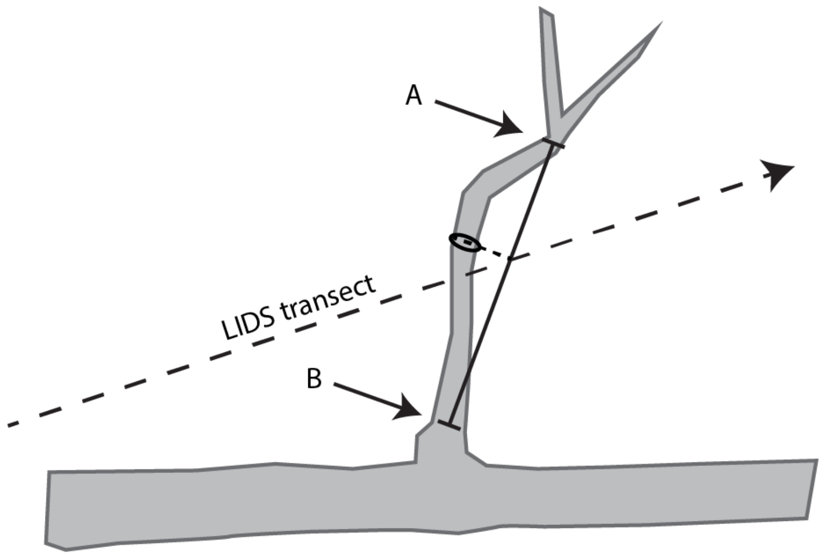

Figure 2. A LIDS transect (dashed line) intersecting a CDW particle that is tallied within the 5-10 cm diameter size class. The piece of CDW is attached to a larger piece of CDW ≥ 10 cm diameter, but is not tallied within the larger size class. Further along the branch from arrow A, the diameter is < 5 cm, and closer to the main bole from arrow B the diameter is ≥ 10 cm; the central axis (black line) is delineated along the portion of the CDW piece that is ≥ 5 cm 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 potentially qualifying piece of CDW intersects the transect:
   a. Use the mobile CDW ingest application or Appendix B to determine whether the piece of CDW should be tallied. Particles of CDW are tallied in proportion to their cross-sectional area, which is difficult to measure directly. Appendix B provides round diameter equivalents (RD_E).

      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 either **Table 14** or **Table 15** in Appendix B), measure and record the required log attributes listed in **Table 7** below in the "Field Tally" ingest table.
      - Determining whether highly decomposed logs that have begun to collapse under their own weight qualify for measurement may be tricky. This is because one must determine the round diameter circular equivalent of an ellipse.
      - To be conservative, assess the widest diameter and use to determine qualification for the tally.

c. Additional cases:
   i. Forked particles of CDW present more complex cases, and are tallied according to SOP B.2.
   ii. See SOP B.3 'Troubleshooting' for other common issues and their resolution (e.g, irregular particles, slash piles, etc.)

Table 7. Log attributes recorded during CDW LIDS tallies.

Datasheet Field	Recorded Data	Method
logDistance*	Horizontal distance from transect intersect point to transect origin; nearest 0.1 m	TruPulse 360 (**HD** mode) or transect tape
logMaxDiameter	Maximum 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. For roughly circular logs, this is the only diameter measurement required.	Calipers
logMinorDiameter	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.
forkMaxDiameter	Maximum diameter of fork at the measurement point specified by the protocol. Recorded as \`aForkMaxDiameter\`, \`bForkMaxDiameter\`, etc. to account for multiple forks.	Calipers
forkMinorDiameter	For elliptical forks, this is the minor axis of the ellipse, measured at the point specified by the protocol. Recorded as \`aForkMinorDiameter\`, \`bForkMinorDiameter\`, etc. to account for multiple forks.	Calipers, or for highly decomposed logs, push a chaining pin or the non-jaw end of the calipers into the wood until soil is reached.
logLength (see **Figure 2**)	Length of the CDW piece central axis; nearest 0.1 m.	Meter tape or TruPulse 360 (**SD** mode)
taxonID	Species, genus, family or unknown, in that order. It is preferable to assign a family and use an identification qualifier code (idQ = CF or AF) than to use the unknown codes. For true unknowns you still must choose either: • 'unknown hardwood' (code: '2Plant-H'), or • 'unknown softwood' (code: '2Plant-S') • If the log is very highly decayed, and distinguishing between hardwood and softwood is impossible, choose whichever is most likely based on the live trees in the plot,	• Visual inspection of remaining leaves, bark, surrounding live species, and other nearby downed logs; use field guide when helpful • A digital photo that can be shared with an experienced botanist may also be helpful in assigning a **taxonID**

Datasheet Field	Recorded Data	Method
	and the taxonIDs of other nearby downed logs that are less decayed.	
identification Qualifier (idQ)	See **Table 8** for idQ codes and descriptions.	Visual inspection
decayClass	Record for all qualifying logs. See **Table 9** for decayClass categories and descriptions.	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. Record the **logID**:
   a. <u>For logs ≥ 10 cm diameter:</u>
      - If not already tagged, mark with a numbered, red aluminum tag.
      - Record the tag number in the **logID** field.
      - It is helpful to place the tag in a visible location near the intersecting point. Exceptions are if the wood is highly decayed at the intersect point; in this instance, place the tag where it is likely to stay in the log.
      - For CDW particles with multiple qualifying branches, place the tag on the first branch that qualifies along the transect.
      - <u>If the log was previously tagged for VegStructure, and has now fallen:</u>
        - Add a red tag next to the existing VegStructure tag, and record this new tag number as the **logID**. Leave the VegStructure tag in place.
        - **vstTagID:** Record the VegStructure tagID number.
          - If using paper datasheets, record **vstTagID** in the **remarks** field, and transcribe into the **vstTagID** field in the electronic data ingest table.

   b. For logs < 10 cm diameter:
      - **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.

9. Assess and record the **decayClass** characteristics listed below (see additional descriptions of **decayClasses** in **Table 9**). Decay characteristics are required for logs ≥ 10 cm diameter, and may also be recorded for logs < 10 cm diameter.
    - **leavesPresent** (or needles): 'Y' or 'N'
    - **twigsPresent**: 'Y' or 'N'. Twigs are < 2 cm diameter woody structures attached to the main log to be tallied.
    - **branchesPresent**: 'Y' or 'N'. Branches are ≥ 2 cm diameter woody structures attached to the main log to be tallied.
    - **branchBarkCover**: The % cover of bark on any branches; assign from the following categories: <5%, 5-10%, 11-25%, 26-50%, 51-75%, 76-95%, >95%.
    - **logBarkCover**: The % cover of bark on the main log to be tallied. Use the same % cover categories as above.
    - **logHandBreakable**: 'Y' or 'N'. Pieces of the log (not bark) can be broken apart by hand.
    - **logHoldShape**: '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.
    - **remarks**: Since there is no remarks column, use the next available row of the datasheet.

10. Continue tallying logs that intersect the transect until the transect limit for the site is reached (Appendix D).
    - If no qualifying CDW particles are encountered on a given LIDS transect:
        - Record the **plotID** and **lidsAzimuth**
        - Record \`targetTaxaPresent = N\` in the ingest table; if using paper data sheets, record in the **taxonID** field.

11. Repeat Steps 2-10 for the second and third LIDS transects.

12. Continue sampling at the next plotID on the LIDS Angle List.

Table 8. Identification qualifer 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).

decay Class	Shape	Bark	Wood Texture	Twigs	Branches
1	Sound, freshly fallen, round.	Intact, fresh.	Intact, no rot.	Large and small diameter twigs present. Leaves/ needles may be present.	Present. Branches have most or all of their bark.
2	Sound, round.	Intact or partly missing; log has begun to lose bark.	Intact, sapwood partly soft.	Larger diameter twigs may be present.	Branches are present but have lost some bark.
3	Heartwood sound, log supports its own weight. Still round.	Trace, log has little to no bark.	Sapwood can be pulled apart by hand, or is absent.	Absent.	Branches mostly absent, those remaining are stubs with little to no bark; branch stubs are held firmly by heartwood and cannot be wiggled by hand.
4	Log does not support its own weight, but maintains shape; can be kicked apart, but breaking apart with hands is difficult	Absent.	Heartwood rotten, and may be made up of soft, small, blocky pieces; a chaining pin can be pushed easily into the log.	Absent.	Mostly stubs; intact branches absent. Branch stubs can be wiggled by hand.
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.	Absent.	Soft, powdery when dry.	Absent.	Absent.

B.2 Tallying and Measuring Forked CDW Particles

When a transect intersects a particle of CDW that is forked, there are multiple scenarios that are possible, and each requires a unique strategy to ensure that logs are tallied consistently.

SOP B.2.1 Transect intersects particle below fork, or on one fork only

1. Similar to a single bole CDW particle, the decision to tally (or not) is based on the round diameter equivalent (RD_E) at the single point at which the particle intersects the transect.
    - The RD_E is measured perpendicular to the particle's central axis at the point where the transect intersects the particle's central axis.
    - The length of the central axis is measured for the longest fork, regardless of whether the transect intersects that fork or not. That is, consider the entire particle – ***while paying attention to any diameter class breakpoints*** – when measuring log-level attributes.

2. Consult Appendix B to determine whether the log should be tallied (**Table 14** or **Table 15**).

3. Record required diameter(s) and log-level attributes on one row of the datasheet, as specified in **Table 7**.

SOP B.2.2 Transect intersects multiple forks across different diameter classes

For a simple split with only two forks, and each intersected fork is in a different diameter class:

1. Consider each fork as an independent CDW particle.

2. Measure the RD_E for each fork to determine whether the fork should be tallied.

3. Record required diameter(s) and log-level attributes on multiple rows of the data sheet as specified in **Table 7** (one row per fork).
    - Use the same **logID** for each fork.
    - Pay attention to diameter class breakpoints when determining **logLength** and the shape of the particle's central axis.

For compound splits with > 2 forks:

1. Consider groups of connected forks that are in the same diameter category separately from those forks, or groups of connected forks, that are in different diameter categories. Subsequent steps assume a CDW particle of this nature.

2. Determine whether to tally each group of connected forks within a given diameter size category one at a time. Use a single round diameter equivalent (RD_E) for each group of connected forks within the same diameter size category.

- The diameter of each group of connected forks that intersects the transect can be combined into a single RD_E using Appendix **Error! Reference source not found.** (**Error! Reference source not found.**).
- If there are > 2 forks, combine forks two at a time using the table, using intermediate RD_E values from each pair of forks until all forks have been combined into one RD_E.

3. Within a group of connected forks, for the largest fork, record required diameter(s) as well as log-level attributes as specified in **Table 7** in one row of the datasheet.
    - Record diameter data for additional forks on subsequent rows of the datasheet using the same **logID;** there is no need to repeat log-level data on these rows.
    - Pay attention to diameter class breakpoints when determining **logLength** and the shape of the particle's central axis.

Example:
The transect crosses the main bole of a downed tree (main bole diameter = 25 cm @ intersect point), then crosses two forks of a connected branch (8 cm diameter and 5.5 cm diameter @ intersect points). The connected branch is 9.5 cm diameter where it emerges from the main bole.

Here, the main bole that is intersected is considered independently from the forked branch because it is in a different diameter class; the RD_E = 25 is used with **Table 14** *or* **Table 15** *to determine whether to tally and further measure the main bole.*

For the two forks of the connected branch that also intersect the transect, given the input intersect diameters above, the RD_E = 10 cm (from ***Error! Reference source not found.****). The RD_E = 10 value is used with* **Table 14** *or* **Table 15** *to determine whether to tally and further measure the forked branch. If the branch is tallied, the* ***logLength*** *is measured from the origin of the branch (where it is 9.5 cm diameter) to either the branch tip, or the point at which diameter is < 5 cm, whichever comes first. Be mindful that* ***decayClass*** *may be more advanced for the forked branch than for the main bole, due to its smaller diameter.*

SOP B.2.3 Transect intersects multiple forks within the same diameter class

1. Consider connected forks originating from a common central axis AND that are in the same diameter class together as one CDW particle.
2. Determine whether to tally forked CDW particles based on a single round diameter equivalent (RD_E).
    - The diameter of each fork that intersects the transect can be combined into a single RD_E using Appendix **Error! Reference source not found.** (**Error! Reference source not found.**).

3. If the CDW particle qualifies based on the combined RD_E, record required diameter(s) for the largest fork, as well as log-level attributes as specified in **Table 7**, in one row of the datasheet.
   - Pay attention to diameter class breakpoints when determining **logLength** and the shape of the particle's central axis.
   - Record diameter data for additional forks on subsequent rows of the datasheet using the same **logID**.

B.3 Troubleshooting

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

Issue	Description	Action
Too few CDW particles	< 5 pieces of CDW were tallied at > 20% of the sampled plotIDs	• Issue a problem ticket to procure a different volume factor (*F*) and transect length for sampling CDW at the site. • Record the new F value at the top of each new datasheet.
Zero CDW particles	Zero pieces of CDW were tallied at > 1 of the sampled plotIDs	
Too many CDW particles	> 20 pieces of CDW were tallied at > 20% of the sampled plotIDs	
Transect intersects boundary	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.). *Note*: transitions between habitat/land cover (e.g. from forest to agricultural field) along a transect do not meet the definition of a physical barrier.	At the boundary, turn 180˚, reflect the transect back onto itself, and continue walking back toward the transect origin, tallying until the *total distance traveled* equals the distance originally desired for the transect (Gregoire and Monkevich 1994).
Uncertainty in **taxonID**	Cannot identify log to species, genus, or family rank.	• Determine whether log is "softwood spp." or "hardwood spp." • In the taxonID field on the datasheet, record either '2plant-S' (unknown softwood) or '2plant-H' (unknown hardwood). Use nearby logs/trees to inform decision of Hardwood vs. Softwood. • If possible, take a photo to enable an experienced botanist to help determine the **taxonID**.

Issue	Description	Action
Particle irregularity	Particle has an irregular base – e.g. a stem base that is wider than the rest of the trunk	• Move diameter measurement point to the nearest "regular" point on the log i.e. the first point at which the diameter stops changing
CDW intersects > 1 transect	Particle is tallied on more than one transect; that is, when plots are relatively dense, a particle intersects two transects that originate from different plots.	• Only one tag is required • Tally the log on each transect it intersects; that is, the log will generate two data records. • In **remarks** fields for each record of the log, note: 'also tallied in [plotID]'
Slash piles	The transect intersects a particle that is part of a 'slash pile.' Slash piles are heaped collections of waste CDW particles, created mechanically after logging or other clearing activities.	• The LIDS tally method cannot estimate the volume of slash piles: Do not tally or measure particles that are part of these piles. • For each slash pile encountered, note in the **remarks**: "Slash pile @ X meters", and also record in the **remarks** the approximate diameter and height (in meters). • Continue the transect straight through the slash pile; do NOT adjust transect length to accommodate interruption by a slash pile.

SOP C Bulk Density Sampling in the Field

C.1 Sampling strategy overview

Bulk density will be sampled twice at each site, and the second sampling will be 5-6 y after the first sampling event.

Sampling cross-sectional disks from downed logs

For logs ≥ 10 cm diameter, it is ideal to:

- Cut cross-sectional disk samples with a chainsaw; however, if there are restrictions on chainsaw use, a buck or cross-cut type saw is an alternative.
- Cut cross-sectional disk samples at least 1 m in from the end of the log; and
- 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 5-6 y interval while still cutting each disk at least 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 per bout: At each of the two sampling bouts, disks are cut at least 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.

Where to sample

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 tagged in SOP B that intersect LIDS transects 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

- Avoid sampling logs < 10 cm diameter within approximately 10 m of the plot centroid, as these logs are frequently tallied via SOP B.
- When sampling within Distributed plots, do not cut CDW particles where doing so would cause a change in plant diversity data collection from 1 m^2 nested subplots (e.g. a change in the percent abiotic cover).
- Be cognizant of trampling effects, and do not select logs for cross-sectional disk sampling that will require working within 10 m^2 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 50 m 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.***

Prioritizing sampling effort

For estimation of bulk-density, the goal is to sample logs for the most abundant DSTs, as identified by Science. Target sample sizes for different DSTs are listed in **Table 11**). When performing bulk density sampling:

- Target the most common CDW 'decayClass x sizeCategory x taxonID' combinations (DSTs) at a given site (see Appendix F for per site ranked lists of DSTs).
- Search all plots designated for CDW sampling, and opportunistically sample while traveling between plots (if allowed).
- Preferentially sample the largest diameter logs, as these logs are typically rarer, and also comprise the majority of CDW mass in an ecosystem (Keller et al. 2004) (**Table 11**).
- To enable repeat bulk density sampling of the same logs over the two bulk density sampling bouts, first try to find logs ≥ 3 m length for sampling. Search across all plots for logs meeting this criteria before sampling smaller length logs in any given plot.

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.

taxonID	decayClass	sizeCategory	sampleSize
Acer rubrum	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…

Guidelines and caveats for conducting bulk density sampling:

- Once the desired sample size is achieved for a given DST, stop searching for that combination in other plots.
- For widespread taxa that occur throughout the site, generate samples from as many pots as is feasible. For uncommon DSTs, it is acceptable to meet the desired sample size in only one plot.
- It may be difficult to achieve the desired sample size for DSTs associated with "unknown hardwood" and "unknown softwood" taxonIDs if most logs are identifiable to higher taxonomic resolution. Do your best given site conditions and the prescribed search area around the plot centroids.
- Sample sizes listed in **Table 11** may be achieved over <u>up to two field seasons</u>; however, completing sampling in one field season is preferred.

Determining when sampling is complete

The bulk density sampling effort is inherently variable from site to site, as it is driven by the number of DSTs, which is strongly dependent on site-level tree diversity. For each site, Science uses CDW tally data to create a list of DSTs ranked by tally abundance.

- Consider sampling complete once all rank-ordered DSTs that cumulatively make up 80% of the total tallies have been sampled (see Appendix F for per site lists of ranked DSTs).
- Desired sample sizes may not be achievable for all DSTs. Sampling can be considered complete for a given DST if all plots with applicableModule = 'cdw' have been searched within an approximately 50 m radius of the centroid, and the desired sample size has not been met.

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 required to determine CDW bulk density. To quantify uncertainty in bulk density measurements, QA must also be performed on these field measurements. Field QA consists of selecting 5% of sampled disks for re-measurement by the technician who did not perform the original measurements. To record QA data:

- Record **qaSample** = 'Y' for the next line or record of the Field Bulk Density ingest table (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.
- Ascertain whether any wood quarantines affect your site (Appendix E). For example, sampling at Emerald Ash Borer (EAB) affected sites must occur during the non-flight season for EAB, and all samples must be double-bagged for transport back to the Domain Lab. See Appendix E for additional instructions.

To Generate Bulk Density Samples:

1. To help target the bulk density sampling effort, use the ranked list of DSTs in Appendix F. Tally each sampled log in the table to track sampling progress across DSTs.
2. Navigate to a desired plot that is suitable for CDW bulk-density sampling.
   - ***With site host permission***, logs may be selected up to approx. 50 m from the plot centroid.
3. Search for pieces of CDW that qualify for bulk density sampling. The most common CDW taxa for a site should be targeted first:

- For CDW < 10 cm diameter: Pieces must be ≥ 1 m length, and only one bulk density sample per particle is allowed.
- 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 tagged CDW pieces for bulk-density sampling that were tallied on a LIDS transect. If you are unsure, be conservative and do NOT sample the piece in question.

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 to the middle of the log, 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.
      - If the log was previously tagged for VegStructure, and has now fallen:
        - Add a red tag next to the existing VegStructure tag, and record this new tag number as the **logID**. Leave the VegStructure tag in place.
        - **vstTagID:** Record the VegStructure tagID number.
          - If using paper datasheets, record **vstTagID** in the **remarks** field, and transcribe into the **vstTagID** field in the electronic data ingest table.

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**: Assign as described in SOP B.1. Determine the finest resolution taxonID to which the log can be assigned (*Genus species → Genus → Family → "unknown hardwood"/ "unknown softwood")*.
     - *Genus-species* or *Genus rank identifications* should be possible for logs in decayClass 1-3; lower resolution taxonIDs are more likely for decayClasses 4 and 5.
     - See **Table 7** for additional guidelines.
   - **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,** record **decayClass** characteristics (see **Table 9** for more details)**:**
   - **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: <5%, 5-10%, 11-25%, 26-50%, 51-75%, 76-95%, >95%.
   - **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, record:
   - **pointID**: The ID of the plot marker that is closest to the sampled log.
   - **logDistance**: The distance to the nearest plot marker, nearest 0.1 m
   - **logAzimuth**: The azimuth relative to True North, measured from the log facing toward the nearest plot centroid.

     Note:
     - If the nearest plot marker is not visible from the log, GPS coordinates may be recorded to enable re-finding the log (UTM format with easting / northing is easiest to use in the field).

- Record coordinates into the **remarks** field during data entry. If using paper data sheets, use the next blank row of the datasheet to record **remarks**.

5. Prepare a label and a muslin bag 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 permanent marker.
   - **For logs ≥ 5 m in length**, two disks will be cut, one from either end of the log, and two labels are therefore required.
   - **For all logs**, record on the label:
     - **collectDate**: The date the bulk density sample is collected in the field, *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, incrementing numeric identifier for the disk. In addition to linking dry mass data to disk data, the diskID may be used by technicians to track the total number of disks sampled.

6. Cut a cross-sectional disk (or disks) from the log using a method approved by the site host (if approved, chainsaws are always preferable). If only sampling from one end of the log – e.g., the log is < 5 m length – randomly choose an end to sample. Use the guidelines in

7. **Table 12** below, and see **Figure 3** below for example information.
   - When feasible, use the Cant Hook and attached log stand to maneuver the CDW particle into safe cutting position, elevated off the ground with the log stand.
   - **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 approximately 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 in the Field Bulk Density ingest table the same data on the label from 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	• 5+ cm width disk • ≥ 1 m buffer from log end	• 10 cm width disk • ≥ 50 cm buffer from log end
decayClasses 4-5	• 10 cm width disk • ≥ 1 m buffer from log end • Chain at highest speed before initiating cuts	• 10 cm width disk • ≥ 50 cm buffer from log end • Chain at highest speed before initiating cuts

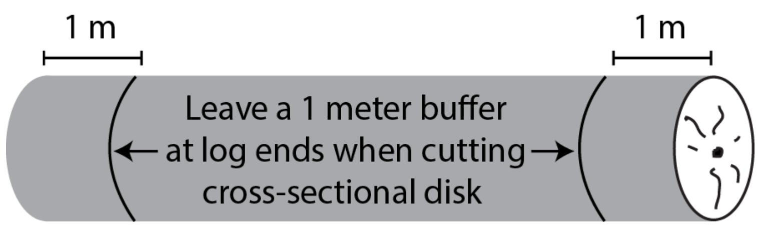

Figure 3. A minimum 1 m buffer should be left on either end of a ≥ 10 cm diameter CDW piece when cutting a cross-sectional disk for bulk-density sampling. The log depicted is > 5m length and is sampled from both ends at each of the two sampling timepoints. Qualifying logs < 5m length are only sampled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

8. Measure the required dimensions of the cross-sectional disk, and record in the Field Bulk Density ingest table.
   a. **For disks with structural integrity that hold their shape:**
      i. *For disks ≥ 5 cm diameter:*
         - Measure diameter with a diameter tape. Record to the nearest 0.1 cm:
           - **diameter**: The diameter of the cross-sectional disk
           - **ninetyDiameter**: Leave blank
         - Measure disk heights with calipers. Record to the nearest 0.1 cm:
           - **maxDiskHeight**: The maximum disk height
           - **minDiskHeight**: The minimum disk height
           - **aDiskHeight**: Technician selected representative intermediate disk height
           - **bDiskHeight**: Technician selected representative intermediate disk height

      ii. *For disks < 5 cm diameter:*
         - Measure diameter with calipers. Record to the nearest 0.1 cm:
           - **diameter**: The maximum disk diameter; i.e., the major ellipse axis
           - **ninetyDiameter**: The minimum disk diameter; i.e., the minor ellipse axis
         - Measure disk heights with calipers. Record to the nearest 0.1 cm:
           - **maxDiskHeight**: The maximum disk height
           - **minDiskHeight**: The minimum disk height
           - **aDiskHeight**: Leave blank

- **bDiskHeight**: Leave blank

b. **For "disks" lacking structural integrity that do NOT hold their shape,** and have already been manually scooped into a plastic bag:

i. *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:
  - **diameter**: The maximum disk diameter; i.e., the major ellipse axis
  - **90diameter**: 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:
  - **maxDiskHeight**: The maximum disk height
  - **minDiskHeight**: The minimum disk height
  - **aDiskHeight**: Technician selected representative intermediate disk height
  - **bDiskHeight**: Technician selected representative intermediate disk height

ii. *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:
  - **maxDiskHeight**: The maximum disk height
  - **minDiskHeight**: The minimum disk height
  - **aDiskHeight**: Leave blank
  - **bDiskHeight**: Leave blank

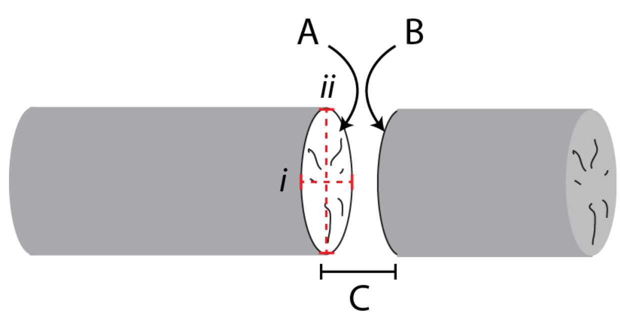

Figure 4. Measurements required for the space from which a crumbly "disk" was extracted by hand from a highly decayed log. Freshly cut surfaces are indicated by A and B, and C shows the height of the "disk." Highly decayed logs are often collapsed under their own weight, and show elliptical cross-sections (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, **diameter** is typically the average of A.*i* and B.*i* ; **90diameter** is typically the average of A.*ii* and B.*ii*

9. Measure the fresh mass of the entire cross-sectional disk sample using a spring scale.
   - Choose an appropriately sized spring scale for the disk sample.
   - Break up unwieldy pieces that do NOT exceed the spring scale limit with a hatchet, and weigh together, if feasible.
   - Break up large pieces that exceed 20 kg with a hatchet, and weigh pieces one at a time.
     - Generate as few pieces as possible to prevent compounding mass measurement error.
     - Do NOT use a chainsaw for breaking the disk, as the saw will remove wood mass.
   - Be sure to check the tare before each weighing.
   - Record in the Field Bulk Density ingest table:
     - **diskFreshMass**; precision is determined by the spring scale that was used (not all scales are listed below).
       - 20 kg scale: Estimate to the nearest 100 g
       - 1000 g scale: Estimate to the nearest 5 g
       - 300 g scale: Estimate to the nearest 1 g

10. Cut an approximate 100 – 400 g subsample from the disk to take back to the laboratory and determine the fresh:dry mass ratio (see **Figure 5** below for subsampling guidelines).
    - Skip this step if the entire disk has a fresh mass < 400 grams.
    - When subsampling disks:
      - Larger masses, closer to 400 g, will be needed to generate a representative, wedge-shaped subsample from large-diameter disks (**Figure 5**A).
      - Smaller masses, closer to 100 g, will be sufficient for smaller-diameter disks (**Figure 5**B).
    - If decay throughout the disk appears non-uniform, i.e. a portion of the disk is more decayed than the rest:
      - Generate two subsamples that weigh approximately 100 – 400 g total, with volume of the two subsamples roughly proportional to the affected areas of the disk.
      - Both subsamples can be placed into the same, numbered muslin bag.
    - **For "disks" lacking structural integrity that do NOT hold their shape**:
      - Subsample approx. 100-200 g of well mixed sample by hand from the plastic bag.

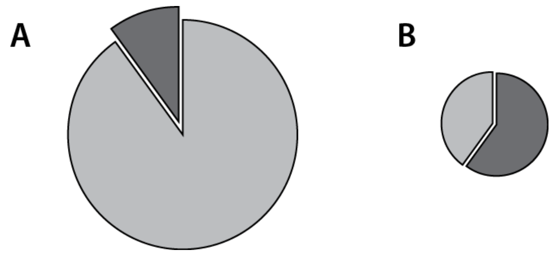

Figure 5. Creating wedge-shaped subsamples from cross-sectional disks from relatively large disks (A), and relatively small disks (B). In both A and B, the dark grey area is approx. 100 g, and the light grey is discarded.

11. Weigh the subsample created in step 10, and determine the fresh mass with an appropriate spring scale. Always tare the scale first. Record in the Field Bulk Density Disk ingest table:
    - **sampleFreshMass**: Fresh mass of the disk subsample; nearest 1 g
    - **sampleFreshMass =** ***NA*** if the disk did not require subsampling in step (10).
12. Place the subsample into a numbered muslin bag, along with its associated label, and tie the bag.
    - Record the **bagNumber** in the Disk and Disk Subsample ingest table. The bagNumber will be used to track the sample through drying and weighing.
13. Return to step (3), above, and continue cutting bulk density disks.

C.3 Post-field sampling tasks

1. Place numbered muslin bags containing cross-sectional disks, or subsamples of disks, into the 105 ˚C drying oven(s).
   - Track drying progress with the Lab Bulk Density Drying Datasheet (see SOP D.1 for details).
   - Bulk density samples can air-dry for up to 5 days before going into the oven if oven-space is not immediately available.
2. Perform routine chainsaw maintenance:
   - Sharpen chain if necessary. Keep in mind that during sampling of downed logs, the chain may come into frequent contact with the ground, and could dull 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. ALWAYS fill the bar oil reservoir when re-fueling to ensure it does not run dry.

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 6**A):
  - 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 6**B):
  - 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.

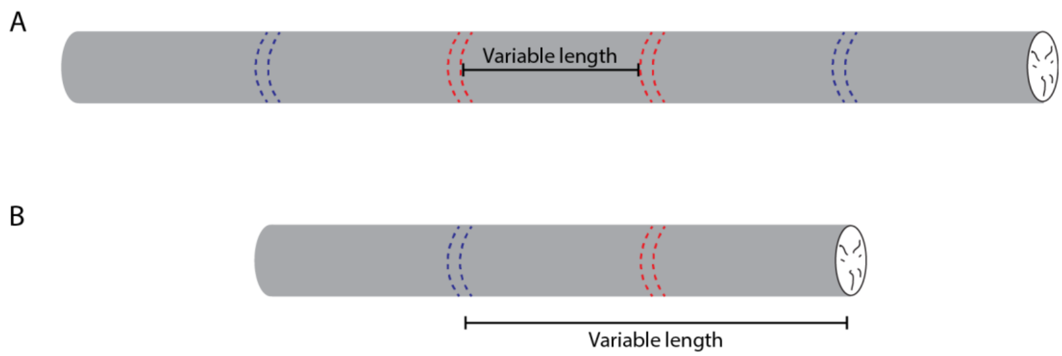

Figure 6. Strategy for generating cross-sectional disks from logs re-sampled for bulk density in Bout 2. (A) Logs ≥ 5 m length in Bout 1 and ≥ 3 m length in Bout 2; (B) Logs < 5 m length in Bout 1 and < 3 m length in Bout 2. Pairs of blue dashed lines represent Bout 1 disks, and pairs of red dashed lines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

SOP D Processing Bulk Density Samples in the Laboratory

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

D.1 Drying and weighing samples

1. Record on the Drying Datasheet:
   - **bagNumber**
   - The **ovenStartDate** and **time** the samples are placed in the drying oven.

Critical step: Recording the 'bagNumber' allows for easy tracking of drying progress for individual bags without having to open bags to see the label, and enables assessment of how long different batches of wood samples have been in the oven. Trackable, numbered bags are especially useful when samples from different days are in the same oven. The same bags may be re-used for subsequent disk collections.

2. Place marked muslin bags, with sample labels inside, into a 105 ˚C drying oven until samples are dried to a constant mass. Drying may take up to 5 days (120 h) or longer.
3. Check the drying progress using the Drying Datasheet.
   a. Choose 5 numbered muslin bags per **ovenStartDate** to monitor for drying time. If there are different size categories of sample (e.g. wedges from larger logs vs. cylinders of various sizes from smaller logs), choose 5 samples per size category and perform the steps below separately for each size category.
   b. Record the mass of the sample in these 5 bags through time to track drying progress. There is no need to remove samples from the bags: Simply record the mass of the bag + the sample inside.
   c. Each time drying progress is checked, calculate the difference in mass between the last two timepoints for each bag + sample(s).
   d. Samples are dry when the average difference between the last two timepoints equals zero (i.e., the change in mass averaged across all 5 bags = 0, to within ± 0.5 g or ± 0.5% of the previous timepoint mass, whichever is larger).
      - The time difference between weight checks may need to be longer than 24 h, depending on wood water content and sample size.
4. Remove dried bulk-density samples from the drying ovens, let cool until safe to touch, and weigh as soon as possible.
   - Oven-dried wood will readily absorb water from the air, particularly in humid environments. Weigh samples one or two at a time 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.

5. Remove dried wood from the muslin bag, and weigh each individual disk sample or 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 in the Lab Bulk Density ingest table:
      - **plotID**: The unique identifier for the plot (or closest plot)
      - **collectDate**: 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'
      - **ovenStartDate / Time**: The date and time the sample was placed in the oven; *YYYY-MM-DD* and *HH:mm* 24-h format
      - **ovenEndDate / Time**: The date and time the sample was removed from the oven
      - **dryMass**: The oven dry mass, without the muslin bag, of the sample; nearest 0.01 g

6. Return dried wood samples to temporary storage in marked muslin bags once all data have been recorded.
   - Samples may be discarded after all data have been recorded, successfully ingested into the Lab Bulk Density ingest table, and QC checked.
   - Numbered muslin bags may be re-used for subsequent sampling events.

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 5% 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 within a few hours of the initial weighing, return samples targeted for QA to a 105 ˚C drying oven for 24 h prior to re-weighing.
2. For all QA records, find the existing sample record on the Lab Drymass Datasheet and record:
   - **qaDryMass**, nearest 0.01 g
3. Return wood samples to temporary storage until all data have been successfully entered into the Lab Bulk Density ingest table. Samples may be discarded once data have been successfully entered and QC checked.

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.

SOP E Data Entry and Verification

Mobile applications are the preferred mechanism for data entry. Data should be entered into the protocol-specific application as they are being collected, whenever possible, to minimize data transcription and improve data quality. Mobile devices should be synced at the end of each day, where possible; alternatively, devices should be synced immediately upon return to the Domain Support Facility.

However, given the potential for mobile devices to fail under field conditions, it is imperative that paper datasheets are always available to record data. Paper datasheets should be carried along with the mobile devices to sampling locations at all times. 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.

E.1 Field Data Sheets

- Paper Field Data sheets for tally and bulk density sampling may be used if the mobile application ingest platform is unavailable or compromised.

E.2 Lab Data Sheets

- Lab Drying QC data are not transcribed for ingest into the NEON database.

SOP F Sample Shipment

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

8 REFERENCES

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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.

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APPENDIX A DATASHEETS

The following datasheets and ingest documents 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.

APPENDIX B QUICK REFERENCES

B.1 Minimum Round Diameters and Limiting Distance Tables

If it is unclear whether a log should be measured, err on the side of caution and measure it – i.e., RD rounds UP, D_{lim} rounds DOWN.

Table 14. Limiting distances (D_{lim}) for round diameters (RD) across various LIDS volume factors (*F*). Double-lines indicate breaks between diameter sizeCategories.

	D_{lim} (m)				
RD (cm)	**F=5**	**F=8**	**F=10**	**F=15**	**F=20**
2	0.3	0.21	0.16	0.11	0.08
3	0.7	0.46	0.37	0.25	0.19
4	1.3	0.8	0.7	0.4	0.3
5	2.1	1.3	1.0	0.7	0.5
6	3.0	1.9	1.5	1.0	0.7
7	4.0	2.5	2.0	1.3	1.0
8	5.3	3.3	2.6	1.8	1.3
10	8.2	5.1	4.1	2.7	2.1
12	11.8	7.4	5.9	4.0	3.0
14	16.1	10	8.1	5.4	4.0
16	21.1	13	11	7.0	5.3
20	32.9	21	16	11	8.2
25	51.4	32	26	17	13
30	74	46	37	25	19
35	100	63	50	34	25
40	131	82	66	44	33
50	205	129	103	69	51
60	296	185	148	99	74
70		252	202	134	101
80		329	263	175	132
90			333	222	167
100				274	206
110				332	249
120					296

Table 15. Minimum round diameters (RD_{min}) for fixed distances (*D*) for various LIDS volume factors (*F*). Log diameters larger than those listed are tallied at any distance.

	RD_{min} (cm)				
D (m)	**F=5**	**F=8**	**F=10**	**F=15**	**F=20**
0.5	2.5	3.1	3.5	4.3	4.9
1	3.5	4.4	4.9	6.0	7.0
2	4.9	6.2	7.0	8.5	9.9
4	7	8.8	9.9	12.1	13.9
6	8.5	10.8	12.1	14.8	17.1
8	9.9	12.5	13.9	17.1	19.7
10	11	13.9	15.6	19.1	22.1
15	13.5	17.1	19.1	23.4	27.0
20	15.6	19.7	22.1	27.0	31.2
25	17.4	22.1	24.7	30.2	34.9
30	19.1	24.2	27.0	33.1	38.2
35	20.6	26.1	29.2	35.7	41.3
40	22.1	27.9	31.2	38.2	44.1
45	23.4	29.6	33.1	40.5	46.8
50	24.7	31.2	34.9	42.7	49.3
60	27	34.2	38.2	46.8	54.0
70	29.2	36.9	41.3	50.5	58.3
80	31.2	39.4	44.1	54.0	62.4
90	33.1	41.8	46.8	57.3	66.2
100	34.9	44.1	49.3	60.4	69.7
120	38.2	48.3	54.0	66.2	76.4
140	41.3	52.2	58.3	71.5	82.5
160	44.1	55.8	62.4	76.4	88.2
180	46.8	59.2	66.2	81.0	93.6
200	49.3	62.4	69.7	85.4	98.6
220	51.7	65.4	73.1	89.6	103.4
240	54.0	68.3	76.4	93.6	108.0
260	56.2	71.1	79.5	97.4	112.4
280	58.3	73.8	82.5	101.1	116.7

B.2 Forked CDW and Single Round Diameter Equivalents

A CDW particle may be forked where it intersects the LIDS transect. Because tallying depends on total cross-sectional area for the piece, for forked pieces it is necessary to calculate the equivalent RD at the point of LIDS intersection as a function of the total cross-sectional area that is made up of each fork. Equivalent RD_E values for CDW split into two forks are provided in (**Error! Reference source not found.**); for > 2 input forks, work in groups of two and calculate intermediate RDs until one equivalent RD is computed.

Table 16. The round diameters of split CDW pieces (RD_{INPUTS}), and corresponding calculated equivalent round diameters (RD_E).

RD_{INPUTS}	RD_E	RD_{INPUTS}	RD_E	RD_{INPUTS}	RD_E	RD_{INPUTS}	RD_E
1, 2	2.2	3, 14	14.3	7, 9	11.4	18, 22	28.4
1, 3	3.2	3, 16	16.3	7, 10	12.2	18, 24	30
1, 4	4.1	3, 18	18.2	7, 12	13.9	18, 26	31.6
1, 5	5.1	3, 20	20.2	7, 14	15.7	18, 28	33.3
1, 6	6.1	4, 5	6.4	7, 16	17.5	18, 30	35
1, 7	7.1	4, 6	7.2	7, 18	19.3	20, 22	29.7
1, 8	8.1	4, 7	8.1	7, 20	21.2	20, 24	31.2
1, 9	9.1	4, 8	8.9	8, 9	12.0	20, 26	32.8
1, 10	10.0	4, 9	9.8	8, 10	12.8	20, 28	34.4
1, 12	12.0	4, 10	10.8	8, 12	14.4	20, 30	36.1
1, 14	14.0	4, 12	12.6	8, 14	16.1	22, 24	32.6
1, 16	16.0	4, 14	14.6	8, 16	17.9	22, 26	34.1
1, 18	18.0	4, 16	16.5	8, 18	19.7	22, 28	35.6
1, 20	20.0	4, 18	18.4	8, 20	21.5	22, 30	37.2
2, 3	3.6	4, 20	20.4	9, 10	13.5	24, 26	35.4
2, 4	4.5	5, 6	7.8	9, 12	15.0	24, 28	36.9
2, 5	5.4	5, 7	8.6	9, 14	16.6	24, 30	38.4
2, 6	6.3	5, 8	9.4	9, 16	18.4	26, 28	38.2
2, 7	7.3	5, 9	10.3	9, 18	20.1	26, 30	39.7
2, 8	8.2	5, 10	11.2	9, 20	21.9	28, 30	41
2, 9	9.2	5, 12	13.0	10, 12	15.6	28, 32	42.5
2, 10	10.2	5, 14	14.9	10, 14	17.2	28, 34	44
2, 12	12.2	5, 16	16.8	10, 16	18.9	28, 36	45.6
2, 14	14.1	5, 18	18.7	10, 18	20.6	28, 38	47.2
2, 16	16.1	5, 20	20.6	10, 20	22.4	28, 40	48.8
2, 18	18.1	6, 7	9.2	12, 14	18.4	28, 42	50.5
2, 20	20.1	6, 8	10.0	12, 16	20.0	28, 44	52.2
3, 4	5.0	6, 9	10.8	12, 18	21.6	30, 32	43.9
3, 5	5.8	6, 10	11.7	12, 20	23.3	30, 34	45.3
3, 6	6.7	6, 12	13.4	14, 16	21.3	30, 36	46.9
3, 7	7.6	6, 14	15.2	14, 18	22.8	30, 38	48.4
3, 8	8.5	6, 16	17.1	14, 20	24.4	30, 40	50
3, 9	9.5	6, 18	19.0	16, 18	24.1	30, 42	51.6
3, 10	10.4	6, 20	20.9	16, 20	25.6	30, 44	53.3
3, 12	12.4	7, 8	10.6	18, 20	26.9	32, 34	46.7

B.3 Limiting Distance and Log Diameter Examples

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.

APPENDIX C 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 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.

The dates below 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 17. Satellite-derived average dates of green-up and senescence that bound the CDW sampling window.

Domain	Site	Approx. Start Date	Approx. End Date
01	BART	04/30	10/27
	HARV	04/20	10/27
02	BLAN	03/16	11/06
	SCBI	03/26	11/16
	SERC	03/21	11/21
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
05	STEI	04/30	09/07
	TREE	04/30	09/07
	UNDE	05/05	10/12
06	KONA	03/31	10/27
	KONZ	03/31	10/27
	UKFS	03/16	11/26
07	GRSM	03/31	11/06
	MLBS	04/20	11/06
	ORNL	03/31	11/11
08	DELA	03/01	11/26
	LENO	03/11	12/01
	TALL	03/16	11/26

Domain	Site	Approx. Start Date	Approx. End Date
09	DCFS	04/30	10/17
	NOGP	04/25	10/17
	WOOD	04/30	10/17
10	CPER	03/31	12/16
	RMNP	04/30	10/12
	STER	03/31	09/27
11	CLBJ	03/01	11/21
	OAES	03/16	11/06
12	YELL	04/30	10/07
13	MOAB	03/26	10/27
	NIWO	05/20	09/27
14	JORN	03/21	11/16
	SRER	05/31	11/26
15	ONAQ	03/16	10/07
16	ABBY	04/20	10/27
	WREF	04/25	10/17
17	SJER	09/27	06/04 (next calendar year)
	SOAP	03/31	10/17
	TEAK	04/30	10/27
18	BARR	06/24	08/08
	TOOL	06/09	08/28
19	BONA	05/15	09/07
	DEJU	05/10	09/07
	HEAL	05/15	09/01
20	PUUM	TBD	TBD

APPENDIX D SITE-SPECIFIC VOLUME FACTORS (F) AND TRANSECT LENGTHS FOR LIDS SAMPLING

Initial F-values and transect lengths come from analysis of Vegetation Characterization data collected from Tower Plots, and may be modified in subsequent years following analysis of site-specific tally data by Science.

- See SOP B.3 'Troubleshooting' if you believe there is a problem with the F-value and transect length for your site.

Table 18. Site-specific volume factors and transect lenghts for coarse downed wood tally sampling with the LIDS method.

Domain Number	siteID	Sampling by plotType	F-value	Transect Length (m)	Additional Information
01	BART	Dist: Yes Tower: Yes	5	190	
	HARV	Dist: Yes Tower: Yes	5	170	
02	BLAN	Dist: Yes Tower: Yes	5	290	Many Distributed and Tower Plots will have no CDW due to pasture, crop cover.
	SCBI	Dist: Yes Tower: Yes	8	240	Some Distributed Plots may have no CDW due to pasture cover.
	SERC	Dist: Yes Tower: Yes	5	300	Some Distributed Plots may have no CDW due to crop cover.
03	DSNY	Dist: Yes Tower: No	5		Some Distributed Plots may have no CDW due to pasture cover.
	JERC	Dist: Yes Tower: Yes	5	260	Some Distributed Plots may have no CDW due to crop cover.
	OSBS	Dist: Yes Tower: Yes	5	130	Some Distributed Plots may have no CDW due to wetland cover.
04	GUAN	Dist: Yes Tower: Yes	5	90	
	LAJA	Dist: Yes Tower: No	*TBD*	*TBD*	Most Distributed Plots will have no CDW due to pasture, crop cover.
05	STEI	Dist: Yes Tower: Yes	5	110	
	TREE	Dist: Yes Tower: Yes	5	140	
	UNDE	Dist: Yes Tower: Yes	5	120	
06	KONA	Dist: No Tower: No	*NA*	*NA*	Ag site, no qualifying CDW expected.
	KONZ	Dist: Yes Tower: No	*TBD*	*TBD*	Most Distributed Plots may have no CDW due to grassland cover.
	UKFS	Dist: Yes	5	140	Some Distributed Plots may have no

Domain Number	siteID	Sampling by plotType	F-value	Transect Length (m)	Additional Information
		Tower: Yes			CDW due to grassland cover.
07	GRSM	Dist: Yes Tower: Yes	8	180	
	MLBS	Dist: Yes Tower: Yes	*TBD*	*TBD*	
	ORNL	Dist: Yes Tower: Yes	5	270	Some Distributed Plots may have no CDW due to pasture cover.
08	DELA	Dist: Yes Tower: Yes	5	240	
	LENO	Dist: Yes Tower: Yes	8	180	
	TALL	Dist: Yes Tower: Yes	5	190	
09	DCFS	Dist: No Tower: No	*NA*	*NA*	Grassland site, no CDW anticipated.
	NOGP	Dist: No Tower: No	*NA*	*NA*	Grassland site, no CDW anticipated.
	WOOD	Dist: No Tower: No	*NA*	*NA*	Grassland site, no CDW anticipated.
10	CPER	Dist: No Tower: No	*NA*	*NA*	Grassland site, no CDW anticipated.
	RMNP	Dist: Yes Tower: Yes	*TBD*	*TBD*	
	STER	Dist: No Tower: No	*NA*	*NA*	Agricultural site, no CDW anticipated.
11	CLBJ	Dist: Yes Tower: Yes	5	160	Many Distributed Plots may have no CDW due to grassland cover.
	OAES	Dist: No Tower: No	*NA*	*NA*	Grassland and shrub/scrub site, no CDW anticipated.
12	YELL	Dist: Yes Tower: Yes	*TBD*	*TBD*	
13	MOAB	Dist: Yes Tower: No	*TBD*	*TBD*	Most Distributed Plots may have no CDW due to shrub/scrub cover.
	NIWO	Dist: Yes Tower: No	5	110	Some Distributed Plots may have no CDW due to tundra cover.
14	JORN	Dist: No Tower: No	*NA*	*NA*	2015 sampling → no CDW tallied.
	SRER	Dist: No Tower: No	*NA*	*NA*	Shrub/scrub desert site, no CDW expected.
15	ONAQ	Dist: Yes Tower: No	5	*TBD*	Most Distributed Plots may have no CDW due to shrub/scrub cover.

Domain Number	siteID	Sampling by plotType	F-value	Transect Length (m)	Additional Information
16	ABBY	Dist: Yes Tower: Yes	15	180	
	WREF	Dist: Yes Tower: Yes	*TBD*	*TBD*	
17	SJER	Dist: Yes Tower: Yes	5	280	Most Distributed Plots may have no CDW due to grassland cover.
	SOAP	Dist: Yes Tower: Yes	8	170	
	TEAK	Dist: Yes Tower: Yes	10	230	
18	BARR	Dist: No Tower: No	*NA*	*NA*	Tundra site, no CDW expected.
	TOOL	Dist: No Tower: No	*NA*	*NA*	Tundra site, no CDW expected.
19	BONA	Dist: Yes Tower: Yes	5	50	Some Distributed and Tower Plots may have no CDW due to shrub/scrub cover.
	DEJU	Dist: Yes Tower: Yes	5	30	Some Distributed and Tower Plots may have no CDW due to shrub/scrub cover.
	HEAL	Dist: No Tower: Yes	5	20	2016 sampling: No CDW tallied in Dist Plots.
20	PUUM	Dist: Yes Tower: Yes	*TBD*	*TBD*	

APPENDIX E QUARANTINE COMPLIANCE

E.1 Summary of Quarantines by Site Affecting CDW Sampling

A summary of quarantines that affect CDW sampling is provided on a per site basis in this subsection. Additional sub-sections below describe how each quarantine affects CDW sampling, and steps that must be taken to ensure that NEON complies with quarantine regulations. Quarantine status for a given site may change mid-season, and it is therefore imperative to monitor NEON's problem tracking system for mid-season updates.

Table 19. Summary of quarantines by site that affect Coarse Downed Wood sampling.

Domain	Site	Quarantine List	Requirements
D06	UKFS	Emerald Ash Borer (EAB)	• Compliance Agreement from Kansas PPQ prior to sampling. Check with Domain Manager to ensure necessary paperwork is complete prior to scheduling sampling. • Schedule sampling during EAB non-flight period (1st Nov to 1st March). • Follow all guidance in Appendix E.2

E.2 Emerald Ash Borer Quarantine (EAB)

The EAB quarantine applies to all NEON Coarse Downed Wood samples collected in a quarantined county that are then transported to a non-quarantined county, or that pass through non-quarantined counties, when samples are brought back to the Domain Lab.

Required Steps to Comply with EAB Quarantine:

1. Schedule sampling during the EAB non-flight season only (see **Table 19**).
2. Upon returning to the field vehicle after sampling, all muslin-bagged CDW bulk density samples must be double-bagged in large plastic trash bags.
    - Knot each trash bag independently.
3. Upon arriving at the Domain Lab, once the trash bags are opened, all muslin bagged samples must be placed directly into a 105 ˚C drying oven.
    - Once trash bags are opened, no temporary storage of the muslin bagged samples is allowed.
    - Unopened trash bags may be stored in the Domain Lab for up to 5 days.
4. Kill any beetles found inside the trash bags. Contact USDA if any dead specimens are thought to be EAB.

APPENDIX F BULK DENSITY SAMPLING TARGETS PER SITE

Bulk Density sampling is considered complete when the specified number of disks have been sampled from each of the 'decayClass x sizeCategory x taxonID' (DST) combinations that cumulatively comprise 80% of the total number of logs counted during tally sampling. Per site rank abundance lists of DSTs are provided in each sub-section below.

F.1 D01: Bartlett Experimental Forest (BART)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
BART	FAGR	3	>=10cm	10.08	10.08	10	10
BART	ACRU	3	>=10cm	6.45	16.53	10	20
BART	FAGR	2	>=10cm	6.25	22.78	10	30
BART	FAGR	4	>=10cm	6.25	29.03	10	40
BART	BEPAP	3	>=10cm	5.65	34.68	10	50
BART	ACRU	2	>=10cm	5.24	39.92	10	60
BART	BEPAP	2	>=10cm	4.84	44.76	10	70
BART	PIRU	2	>=10cm	4.03	48.79	10	80
BART	TSCA	2	>=10cm	3.43	52.22	10	90
BART	2PLANT-H	3	>=10cm	3.02	55.24	10	100
BART	TSCA	3	>=10cm	3.02	58.26	10	110
BART	2PLANT-H	4	>=10cm	3.02	61.28	10	120
BART	FAGR		5-10cm	3.02	64.3	5	125
BART	BEAL2	3	>=10cm	2.62	66.92	10	135
BART	PIRU	3	>=10cm	2.62	69.54	10	145
BART	ACRU	4	>=10cm	2.22	71.76	10	155
BART	FAGR		2-5cm	2.02	73.78	5	160
BART	2PLANT-S	4	>=10cm	1.61	75.39	10	170
BART	2PLANT-H	5	>=10cm	1.41	76.8	10	180
BART	2PLANT-H		5-10cm	1.41	78.21	5	185
BART	TSCA		5-10cm	1.41	79.62	5	190
BART	2PLANT-H	2	>=10cm	1.21	80.83	10	200

F.2 D01: Harvard Forest (HARV)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
HARV	Acer rubrum	3	>=10cm	8.26	8.26	10	10
HARV	Pinus strobus	NA	5-10cm	7.44	15.7	5	15
HARV	Acer rubrum	2	>=10cm	4.96	20.66	10	25
HARV	Pinus resinosa	2	>=10cm	4.96	25.62	10	35
HARV	Picea rubens	3	>=10cm	4.96	30.58	10	45
HARV	Acer rubrum	4	>=10cm	4.96	35.54	10	55
HARV	Pinus resinosa	3	>=10cm	4.13	39.67	10	65
HARV	Tsuga canadensis	2	>=10cm	3.31	42.98	10	75
HARV	Betula papyrifera	3	>=10cm	3.31	46.29	10	85
HARV	Tsuga canadensis	4	>=10cm	3.31	49.6	10	95
HARV	Picea rubens	2	>=10cm	2.48	52.08	10	105
HARV	Acer rubrum	5	>=10cm	2.48	54.56	10	115
HARV	2Plant-S	5	>=10cm	2.48	57.04	10	125
HARV	Quercus rubra	2	>=10cm	1.65	58.69	10	135
HARV	Fraxinus americana	3	>=10cm	1.65	60.34	10	145
HARV	2Plant-H	3	>=10cm	1.65	61.99	10	155
HARV	Pinus strobus	3	>=10cm	1.65	63.64	10	165
HARV	Tsuga canadensis	3	>=10cm	1.65	65.29	10	175
HARV	Betula alleghaniensis	4	>=10cm	1.65	66.94	10	185
HARV	Pinus strobus	4	>=10cm	1.65	68.59	10	195
HARV	Acer rubrum	3	2-5cm	1.65	70.24	5	200
HARV	Quercus rubra		2-5cm	1.65	71.89	5	205
HARV	Tsuga canadensis	3	5-10cm	1.65	73.54	5	210
HARV	Betula papyrifera	2	>=10cm	0.83	74.37	10	220
HARV	Fagus grandifolia	2	>=10cm	0.83	75.2	10	230
HARV	Fraxinus americana	2	>=10cm	0.83	76.03	10	240
HARV	Pinus strobus	2	>=10cm	0.83	76.86	10	250
HARV	2Plant-S	2	>=10cm	0.83	77.69	10	260
HARV	Betula alleghaniensis	3	>=10cm	0.83	78.52	10	270
HARV	Quercus rubra	3	>=10cm	0.83	79.35	10	280
HARV	Betula lenta	4	>=10cm	0.83	80.18	10	290

F.3 D03: Ordway-Swisher (OSBS)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
OSBS	PIPA2	3	>=10cm	9.23	9.23	10	10
OSBS	PINUS	3	>=10cm	6.15	15.38	10	20
OSBS	QULA2	3	>=10cm	6.15	21.53	10	30
OSBS	PIEL	2	>=10cm	4.62	26.15	10	40
OSBS	PIPA2	2	>=10cm	4.62	30.77	10	50
OSBS	QULA2	2	>=10cm	4.62	35.39	10	60
OSBS	PIPA2	5	>=10cm	4.62	40.01	10	70
OSBS	2PLANT-H	2	>=10cm	3.08	43.09	10	80
OSBS	PITA	2	>=10cm	3.08	46.17	10	90
OSBS	2PLANT-H	3	>=10cm	3.08	49.25	10	100
OSBS	2PLANT-H	5	>=10cm	3.08	52.33	10	110
OSBS	QUERC	5	>=10cm	3.08	55.41	10	120
OSBS	QULA2	5	>=10cm	3.08	58.49	10	130
OSBS	QUVI	5	>=10cm	3.08	61.57	10	140
OSBS	QUHE2		2-5cm	3.08	64.65	5	145
OSBS	PIPA2		5-10cm	3.08	67.73	5	150
OSBS	QUHE2		5-10cm	3.08	70.81	5	155
OSBS	QULA2		5-10cm	3.08	73.89	5	160
OSBS	PIPA2	1	>=10cm	1.54	75.43	10	170
OSBS	NYSSA	2	>=10cm	1.54	76.97	10	180
OSBS	QUHE2	2	>=10cm	1.54	78.51	10	190
OSBS	QUNI	2	>=10cm	1.54	80.05	10	200

F.4 D05: Steigerwaldt (STEI)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
STEI	2PLANT-H		5-10cm	10.27	10.27	5	5
STEI	2PLANT-S		5-10cm	9.19	19.46	5	10
STEI	2PLANT-H		2-5cm	6.49	25.95	5	15
STEI	2PLANT-H	3	>=10cm	5.95	31.9	10	25
STEI	THOC2	3	>=10cm	4.86	36.76	10	35
STEI	ACRU		5-10cm	4.86	41.62	5	40
STEI	2PLANT-S	4	>=10cm	4.32	45.94	10	50
STEI	ACRU	2	>=10cm	3.78	49.72	10	60
STEI	2PLANT-H	4	>=10cm	3.78	53.5	10	70
STEI	2PLANT-H	2	>=10cm	2.7	56.2	10	80
STEI	2PLANT-H	5	>=10cm	2.7	58.9	10	90
STEI	THOC2	4	>=10cm	2.16	61.06	10	100
STEI	2PLANT-S	5	>=10cm	2.16	63.22	10	110
STEI	2PLANT-S	3	>=10cm	1.62	64.84	10	120
STEI	ACRU	3	>=10cm	1.62	66.46	10	130
STEI	POTR5	4	>=10cm	1.62	68.08	10	140
STEI	ACRU		2-5cm	1.62	69.7	5	145
STEI	2PLANT-S	2	>=10cm	1.08	70.78	10	155
STEI	ACER	2	>=10cm	1.08	71.86	10	165
STEI	ACSA3	2	>=10cm	1.08	72.94	10	175
STEI	ACSA3	3	>=10cm	1.08	74.02	10	185
STEI	ABBA	4	>=10cm	1.08	75.1	10	195
STEI	ACSA3	5	>=10cm	1.08	76.18	10	205
STEI	ABBA		2-5cm	1.08	77.26	5	210
STEI	ACSA3		2-5cm	1.08	78.34	5	215
STEI	2PLANT		5-10cm	1.08	79.42	5	220
STEI	ABBA		5-10cm	1.08	80.5	5	225

F.5 D07: Great Smoky Mountain National Park (GRSM)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
GRSM	PINUS	4	>=10cm	7.73	7.73	10	10
GRSM	TSCA	3	>=10cm	5.15	12.88	10	20
GRSM	2PLANT-H	4	>=10cm	4.64	17.52	10	30
GRSM	2PLANT-H	5	>=10cm	4.64	22.16	10	40
GRSM	PIRU	3	>=10cm	4.12	26.28	10	50
GRSM	TSCA	4	>=10cm	4.12	30.4	10	60
GRSM	TSCA	2	>=10cm	3.87	34.27	10	70
GRSM	PINUS	5	>=10cm	3.61	37.88	10	80
GRSM	TSCA	5	>=10cm	3.61	41.49	10	90
GRSM	LITU	3	>=10cm	3.09	44.58	10	100
GRSM	2PLANT-H	3	>=10cm	2.84	47.42	10	110
GRSM	LITU	4	>=10cm	2.84	50.26	10	120
GRSM	LITU	2	>=10cm	2.58	52.84	10	130
GRSM	PINUS	3	>=10cm	2.32	55.16	10	140
GRSM	ACRUR	3	>=10cm	2.06	57.22	10	150
GRSM	ACRUR	4	>=10cm	2.06	59.28	10	160
GRSM	2PLANT-H		5-10cm	2.06	61.34	5	165
GRSM	ACRUR	2	>=10cm	1.55	62.89	10	175
GRSM	PIRU	4	>=10cm	1.55	64.44	10	185
GRSM	PIPU5	4	>=10cm	1.29	65.73	10	195
GRSM	QUERC	4	>=10cm	1.29	67.02	10	205
GRSM	PIRU	5	>=10cm	1.29	68.31	10	215
GRSM	QUCO2		5-10cm	1.29	69.6	5	220
GRSM	QUMO4	2	>=10cm	1.03	70.63	10	230
GRSM	QUERC	3	>=10cm	1.03	71.66	10	240
GRSM	ABFR	4	>=10cm	1.03	72.69	10	250
GRSM	2PLANT-H	2	>=10cm	0.77	73.46	10	260
GRSM	PINUS	2	>=10cm	0.77	74.23	10	270
GRSM	PIRI	2	>=10cm	0.77	75	10	280
GRSM	PIVI2	2	>=10cm	0.77	75.77	10	290
GRSM	ROPS	2	>=10cm	0.77	76.54	10	300
GRSM	PIVI2	3	>=10cm	0.77	77.31	10	310
GRSM	QURU	3	>=10cm	0.77	78.08	10	320
GRSM	QUMO4	4	>=10cm	0.77	78.85	10	330
GRSM	2PLANT-S	5	>=10cm	0.77	79.62	10	340
GRSM	ACRUR	5	>=10cm	0.77	80.39	10	350

F.6 D08: Dead Lake (DELA)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
DELA	2PLANT-H	4	>=10cm	30.7	30.7	10	10
DELA	2PLANT-H	3	>=10cm	28.51	59.21	10	20
DELA	2PLANT-H	2	>=10cm	5.7	64.91	10	30
DELA	2PLANT-H	5	>=10cm	4.39	69.3	10	40
DELA	QUERC	3	>=10cm	3.07	72.37	10	50
DELA	2PLANT-H		5-10cm	3.07	75.44	5	55
DELA	QUERC	2	>=10cm	2.19	77.63	10	65
DELA	CELA	1	>=10cm	1.32	78.95	10	75
DELA	QUERC	1	>=10cm	1.32	80.27	10	85

F.7 D11: Caddo / LBJ National Grassland (CLBJ)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
CLBJ	QUERC	3	>=10cm	25	25	10	10
CLBJ	QUST	3	>=10cm	17.31	42.31	10	20
CLBJ	QUST	2	>=10cm	13.46	55.77	10	30
CLBJ	ULMUS	3	>=10cm	7.69	63.46	10	40
CLBJ	2PLANT-H	3	>=10cm	5.77	69.23	10	50
CLBJ	QUMA3	3	>=10cm	5.77	75	10	60
CLBJ	QUERC	4	>=10cm	3.85	78.85	10	70
CLBJ	QUERC	5	>=10cm	3.85	82.7	10	80

F.8 D13: Niwot Ridge (NIWO)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
NIWO	2PLANT-S	5	>=10cm	20.53	20.53	10	10
NIWO	2PLANT-S	4	>=10cm	17.88	38.41	10	20
NIWO	2PLANT-S	3	>=10cm	8.28	46.69	10	30
NIWO	PIEN	3	>=10cm	6.95	53.64	10	40
NIWO	ABLAL	4	>=10cm	5.96	59.6	10	50
NIWO	ABLAL	3	>=10cm	5.3	64.9	10	60
NIWO	PIEN	2	>=10cm	4.97	69.87	10	70
NIWO	ABLAL		5-10cm	4.64	74.51	5	75
NIWO	PIEN	4	>=10cm	4.3	78.81	10	85
NIWO	ABLAL	2	>=10cm	3.64	82.45	10	95

F.9 D16: Abby Road (ABBY)

siteID	taxonID	decay Class	size Category	relative Abundance	cumulative Abundance	sampled DiskNum	cumulative DiskNum
ABBY	PSMEM	4	>=10cm	36.62	36.62	10	10
ABBY	PSMEM	3	>=10cm	20	56.62	10	20
ABBY	2PLANT-S	5	>=10cm	7.04	63.66	10	30
ABBY	PSMEM	5	>=10cm	6.48	70.14	10	40
ABBY	2PLANT-S	4	>=10cm	5.63	75.77	10	50
ABBY	PSMEM	2	>=10cm	5.07	80.84	10	60