TOS PROTOCOL AND PROCEDURE: LTR – LITTERFALL AND FINE WOODY DEBRIS

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	09/09/2014	ECO-02136	Initial release
B	10/15/2014	ECO-02357	Migration to new protocol template
C	04/16/2015	ECO-02771	• Minor updates for clarification and to maintain consistency with other productivity protocols • Revised steps for delineating clip cells • Revised specifications for chemical analysis
D	01/02/2016	ECO-03416	• New fields added: setDate (definition changed), addDate (replaces setDate on pertrap datasheet) • Added Appendix G: clip cell coordinate maps • Added Appendix H: Safe handling of Toxicodendron • Added Appendix I: Troubleshooting • Added Appendix J: Alternative materials • Clarified relative position calculations in SOP B • Updated text in SOP G: shipping to match instructions in herbaceous clip harvest protocol. • Added dryMass QC instructions • Modified lab drying QC datasheet to accommodate multiple drying ovens • Added instruction for mass <0.01g • Added supplementalDryingTime
E	02/08/2017	ECO-04373	• Migrated to new protocol template • Clarified use cases for mixed vs. other functional groups, added mixed option for samples require >1 hour to sort • Removed supplementalDryingTime – no longer being used in litter data product • Added mixing step for creating plot level chemical analysis samples • Added mass guidelines for chemistry subsampling. • General clarification throughout
F	08/08/2018	ECO-05685	• Updated guidelines for implementing this protocol and references to new SOP • Added barcode workflow • Updated shipping instructions

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			• Clarified conditions under which 8-week sampling interval is acceptable in year-round and hybrid sampling schedules • Added table of estimated sampling time for each SOP • Added specific references to mobile application • Added guidance for invertebrate bycatch • Added ground trap sampling month to Appendix D • Excluded sampling during period of high bear activity in YELL, Appendix D • Added annual re-assessment of non-qualifying plots • Changed guidance to keep weighed material until data record is ingested, then discard
G	04/24/2019	ECO-06059	• Addressed delayed collection of ground traps, Table 3 • Added warning sticker to equipment list for use with Toxicodendron spp. • Added plot awareness to training requirements • Clarified requirement to label traps with the trapID • Added reference to use of ground cloths to catch litter throughfall • Added note about using multiple sizes of collection bags • Clarified yearBoutBegan • Added toxicodendronPossible field and workflow • Added guidance to sort plots according to Morton Order • Clarified that bags used to dry samples should be discarded • Changed sorting workflow, mix at 10%, prioritize leaves and needles • Clarified that samples must come to room temperature after removing from the drying oven before weighing • Added steps for grinding C/N samples to align with CFC protocol • Added details for collection in snow to Appendix H • Added processing guidelines for Toxicodendron to Appendix G • Added specific for trap construction at YELL to Appendix I
H	03/04/2020	ECO-06312	• Migrated to new template rev J • Added additional guidance to generate bagIDs • Added additional trap labeling guidance and figure

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			• Added collection label template to SSL, clarified that labels must be populated while in the field • Removed guidance to cool samples prior to weighing • Clarified sorting steps • Added sampleCondition field • Created new spreadsheet to track drying progress • Added bgcArchiveMass field to SOP F • Specified that cryo labels are to be used for blank tags with bgc sampleID
J	02/23/2022	ECO-06766	• Added samplingImpractical • Clarified optimization plot reductions • Added guidance for determining Fall sample timing • Replaced boutNumber with weekBoutBegan • Added inspection for non-target material to field sample collection • Require gloves for field collection and sorting of all samples in a bgc year • Require clean collection bags for bgc bouts • Added re-drying step before grinding and subsampling • Updated mass thresholds for subsamples • Eliminated grinding of needle samples to 40 mesh • Added chemistry and archive processing for functional groups other than leaves and needles, pooled by site • Outlined new bgc sample id construction for samples other than leaves and needles, pooled by site
K	02/05/2026	ECO-07178	• Migrated to protocol template rev M. • Minor text editing throughout for clarity. • Updated all plot figures with pointID labels (31, 33, 49, 51) and new subplot naming convention to aid with orientation in the plot. • Updated clip list reference throughout. • Table 1: Added footnote clarifying frond collection size requirements. • Section 3.2: Clarified bout selection for biogeochemistry sampling. • Table 2: Clarified SOP names. • Table 3: Clarified that bouts may be cancelled when sites are inaccessible. • Section 4.3: Clarified lab sorting samples away from the DSF. • Table 4: Clarified sample holding times. • Table 7: Updated to include new 'location vulnerable to planned sampling' Sampling Impractical option.

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			• SOP A.2: Updated clip list guidance to use Trap Deployment app instead of Sharepoint spreadsheets. • SOP A.3: Updated Table 9 - added trap barcode for optional use and specified that archive samples need to be in glass scintillation vials instead of plastic. • SOP B.6: Added optional barcode workflow. • SOP B.7: Added guidance for use of new clipID procedure in the Trap Deployment app. • SOP B.8: Clarified the process for annual re-survey of non-qualifying plots. • SOP C: Added guidance to use pre-existing Fulcrum Field application records pushed from previous bout. • SOP C.1: Added guidance for when to use “trap blocked” trap condition as well as how to dispose of materials blocking a trap. • SOP C.1: Added guidance for when a trap may need to be permanently relocated. • SOP C.1: Added guidance for hole repair in elevated trap mesh. • SOP C: Clarified the definition of “ISO week” when determining “yearBoutBegan”. • SOP C.2: Added guidance to sample branches still attached to downed tree boles in ground traps. • SOP D.2: Moved guidance for inspecting and laundering collection bags from SOP G. • SOP E.2: Added more guidance for handling frozen samples and added a new table outlining sample storage requirements and timelines for processing. • SOP E.2: Added guidance for storage of samples if BGC is scheduled for the site. • SOP E.2: Added more sampleCondition descriptions. • SOP E.2: Updated Table 14 to include sampleFate for a given sampleCondition. • SOP E.2: Clarified precision for recording lab masses. • SOP E.2: Clarified that trapEmpty records require a lab mass record with one zero gram 'mixed' child record. • SOP E.2: Added more descriptions regarding massSampleFates. • SOP E.2: Added Table 17 describing new samplePrepMethod field. • SOP F.1: Clarified bout selection guidance for biogeochemistry sampling and clarified that only elevated trap materials are processed for biogeochemistry.

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			• SOP F.2: Added guidance for splitting and grinding of non-needle CN samples • SOP F.2: Added more guidance for cleaning the Wiley Mill. • SOP G.3: Added guidance that unsynced tablets will cause duplicate record issues. • SOP H: Removed guidance that only needles/leaves are shipped for biogeochemistry analysis. • Table 24: Updated equipment list for length of replacement PVC elevated trap poles, added adhesive-patch for screen mesh repair, and added optional supplies needed for trap barcodes. • Appendix C: Table 18 - Updated dates based on new MODIS data as well as field science staff input regarding sampling schedule and senescence dates.

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1 OVERVIEW

1.1 Background

Quantifying production of litterfall and fine woody debris is required to estimate annual Aboveground Net Primary Productivity (ANPP) at plot, site and continental scales, and provides essential data for understanding vegetative C fluxes over time. Litterfall and fine woody debris production is estimated within Tower plots on an annual basis, based on litter accumulation in elevated and ground traps. Additionally, every 5 years the chemical composition of litterfall from elevated traps is analyzed. Carbon and nitrogen concentrations allow conversion from mass to element fluxes, while 'lignin' as quantified by the acid-detergent method gives insight into litter decomposability.

In ecosystems with continuous canopy, sampling point selection within a plot or subplot is random – that is, sampling points are selected from the same randomized list of sampling "cells" that is generated to guide herbaceous clip harvest. In ecosystems where the overstory is non-continuous (i.e., patchy), litterfall and fine woody debris sampling is targeted to litter-producing areas within the plot rather than random locations. The selected sampling strategy is used at all plots within a site. This protocol is not implemented at sites or plots with overstory vegetation < 2 meters tall.

This protocol calls for sorting fresh litter into specified functional groups prior to drying whenever possible. If it is logistically infeasible to sort fresh material before drying, litter may be sorted after drying as time allows, or be measured and reported as a mixed, unsorted, sample. However, sorting freshly collected litter is preferable as dry litter is easily fragmented and identifying small or desiccated litter fragments to functional group introduces uncertainty in sorting accuracy and makes the task more time consuming (and therefore more expensive).

Elevated litter trap dimensions are consistent with existing ForestGEO standards and traps have the same specifications (0.5 m^2 area; 70.7 cm L x 70.7 cm W x 80 cm H) as traps used by the Smithsonian Tropical Research Institute Center for Tropical Forest Studies (Muller-Landau and Wright, 2010). To minimize the number of sampling cells dedicated to fine woody debris sampling, and which then become unavailable for herbaceous biomass sampling, ground traps have the same dimensions as a single sampling cell – i.e., 3 m x 0.5 m.

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

This protocol is modeled closely after the litter monitoring protocol written by Helene C. Muller-Landau and S. Joseph Wright (2010) for the CTFS Global Forest Carbon Research Initiative.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

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

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.000724	Domain Chemical Hygiene Plan and Biosafety Manual
AD[04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[05]	NEON.DOC.004104	NEON Science Data Quality Plan
AD[06]	NEON.DOC.000914	TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index

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.002652	NEON Data Products Catalog
RD[04]	NEON.DOC.001271	AOS/TOS Protocol and Procedure: DMP – Data Management
RD[05]	NEON.DOC.002132	Datasheets for TOS Protocol and Procedure: LTR – Litterfall and Fine Woody Debris
RD[06]	NEON.DOC.003282	NEON Protocol and Procedure: SIM – Site Management and Disturbance Data Collection
RD[07]	NEON.DOC.005247	AOS/TOS Standard Operating Procedure: NEON Aquatic and Terrestrial Site Navigation
RD[08]	NEON.DOC.001025	TOS Protocol and Procedure: PLT– Plot Establishment
RD[09]	NEON.DOC.001711	TOS Protocol and Procedure: CDW – Coarse Downed Wood
RD[10]	NEON.DOC.001924	NEON Raw Data Ingest Workbook for TOS Litterfall and Fine Woody Debris
RD[11]	NEON.DOC.001813	TOS Elevated Litter Trap Assembly Instruction
RD[12]	NEON.DOC.001717	TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration
RD[13]	NEON.DOC.001716	TOS Standard Operating Procedure: Toxicodendron Biomass and Handling
RD[14]	NEON.DOC.000987	TOS Protocol and Procedure: VST – Measurement of Vegetation Structure
RD[15]	NEON.DOC.001024	TOS Protocol and Procedure: CFC – Canopy Foliage Sampling
RD[16]	NEON.DOC.014048	TOS Protocol and Procedure: SLS – Soil Biogeochemical and Microbial Sampling
RD[17]	NEON.DOC.005023	TOS Standard Operating Procedure: SVY – Survey Method for Assessing Vegetation Cover

RD[18]	NEON.DOC.014038	TOS Protocol and Procedure: BBC – Plant Belowground Biomass Sampling
RD[19]	NEON.DOC.014037	TOS Protocol and Procedure: HBP – Measurement of Herbaceous Biomass
RD[20]	NEON.DOC.005224	NEON Protocol and Procedure: SCS – Shipping Ecological Samples, Sensors, and Equipment

2.3 Acronyms

Acronym	Definition
ANPP	Aboveground Net Primary Productivity
CTFS	Center for Tropical Forest Studies
NLCD	National Land Cover Dataset
MODIS	Moderate Resolution Imaging Spectroradiometer (NASA Satellite)
SSL	Sampling Support Library
SOP	Standard Operating Procedure

2.4 Definitions

Fulcrum: Software platform used to create NEON electronic data entry applications.

Litterfall: Shed leaves and needles, reproductive parts (i.e. flowers, fruits, cones, seeds, etc.), and fine woody debris with butt-end diameter < 2 cm (modified from Clark et al. 2001, Bernier et al. 2008, **Table 1**).

- All material that falls in elevated litterfall traps is considered for collection, including material that may not have been produced in the canopy (e.g., nest material, seeds from herbaceous species, etc.).
- Material growing up through the mesh or up over the side of the trap should be clipped away and ignored.
- Woody pieces with diameter ≥ 2 cm are considered coarse downed wood and are sampled according to the NEON Field and Lab Protocol for Coarse Downed Wood (RD[09]) and are excluded from consideration in this protocol.

ServiceNow: Software tool used for problem/incident tracking and resolution.

3 METHOD

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 (ServiceNow) 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. If local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it into NEON's problem tracking system.

Quality assurance is performed on data collected via these procedures according to the NEON Science Data Quality Plan (AD[05]).

3.1 Sampling Methods

For both elevated and ground traps, only the portion of material that meets both the length and diameter criteria is sampled (Muller-Landau and Wright 2010). Litter sampled from both elevated and ground traps are sorted into functional groups following collection, using the functional groups outlined in **Table 1**.

Table 1. Functional groups with size limits collected in Elevated and Ground litter traps.

Functional Group	Elevated Traps	Ground Traps
Leaves (including fronds)*	< 50 cm length	> 50 cm length
Needles	< 50 cm length	N/A
Twigs/branches	< 2 cm diameter AND < 50 cm length	< 2 cm diameter AND > 50 cm length
Woody material (e.g. seed cones, bark, other lignified structures)	< 50 cm length	> 50 cm length
Seeds (including fruits and other attached structures**)	All	N/A
Flowers (includes pollen cones and attached structures** e.g., pedicels, peduncles…)	All	N/A
Other (lichen, mosses, frass, unidentifiable material, etc.)	All	N/A
Mixed (unsorted litter material)	< 2 cm diameter AND < 50 cm length	N/A

* Palm fronds or *perennial* tree fern fronds are collected according to the size requirements listed in Table 1. Note, that if non-woody tree fern stipes and/or palm frond components qualify for length and are > 2 cm diameter, they still should be collected.

** Sort unattached structures that may come from either flowers or seeds but cannot be confidently categorized based on time of year or maturity with the "Flowers" functional group.

To ensure the accuracy of annual litter production estimates, ground traps are cleared of all qualifying litter material following the annual sampling bout.

If site management, natural disturbance events, or regeneration/succession occur such that the cover of vegetation is significantly changed in a plot (e.g., management of woody encroachment through removal of all woody vegetation in a grassland site), submit a ServiceNow ticket to Science. Such activities will prompt a re-survey of vegetation in the plot and if total aerial cover of remaining woody vegetation > 2 m is < 10%, sampling will be discontinued at the plot.

3.2 Laboratory Processing

Following collection, litter is transported back to the laboratory, sorted to functional group, then dried at 65°C to constant mass for a minimum of 48 hrs. The woody portion of litter is cut to fit in the drying oven, then dried at 105°C to release bound water (Williamson and Wiemann 2010). Additionally, lignified structures associated with functional groups other than 'Woody material' or 'Twigs/branches' (e.g., hickory husks, walnut shells) may also require higher temperatures and extended dry times to release bound water.

Biogeochemistry sampling is scheduled to occur every five years at each terrestrial site implementing this protocol. Sampling bouts targeted for chemistry measurements and archive will be pooled at either the plot or site level (depending on functional group), the samples are ground, and then ground samples are sent to external facilities for chemical analyses of %C, %N, $\delta^{13}C$, $\delta^{15}N$, % lignin, or archive. Only materials from elevated traps are processed for biogeochemistry analysis and archive. Bouts will be considered for biogeochemistry processing if the year of the collect date (eventID) matches the year assigned for biogeochemistry sampling according to the Interannual Schedule.

3.3 Equipment

Design of PVC elevated litter traps is adopted from the CTFS design, though other materials (galvanized conduit or wood) may be substituted for PVC to accommodate site-specific conditions. Non-oxidizable rods (e.g., fiberglass, aluminum, galvanized steel, or equivalent) are used to anchor elevated litter traps in place. Where permitted by the land use agreement, the corners of ground traps are marked with non-oxidizable metal or plastic stakes to facilitate precise re-measurement of the selected sampling area.

3.4 Spatial Distribution of Sampling

NEON establishes one elevated litter trap and one paired ground trap in two randomly selected 400 m^2 subplots in 1600 m^2 Tower plots or one litter trap pair per 400 m^2 Tower plot (see RD[08] for description of different Tower plot sizes). The selected subplots are the same ones used for all other plant productivity sampling in Tower plots (RD[09], RD[18], RD[19]). This general design may be modified at sites where statistical analyses (optimization) dictate that fewer elevated traps are required to calculate productivity across Tower plots (Appendix D). At these sites, elevated traps have a paired ground trap, and a subset of plots have ground traps only.

3.5 Elevated Traps

An elevated mesh litterfall trap (0.5 m^2; 70.7 cm W x 70.7 cm L x 80 cm H) is placed at a random location within each accepted plot/subplot, with trap locations selected from randomized lists of sampling cells (see RD[19] for more information about the randomized list). Once set, traps remain in the same location within the plot for sampling in subsequent years unless traps are removed based on statistical optimization, or a selected location is no longer logistically feasible (e.g., a tree fall blocks the previously selected random sampling cell). Elevated traps reliably sample material with butt-end diameter < 2 cm *and* length < 50 cm, including shed leaves, needles, reproductive parts, and fine woody debris. Traps are sampled according to the guidelines outlined in Section 7 of this document.

Deciduous forests are sampled once in the spring, then once every two weeks during leaf senescence. Evergreen systems including coniferous, xeric, and tropical forests are sampled year-round; the ideal sampling interval is once a month, approximately every 4 weeks, but may be extended to 8 weeks if the total number of bouts is projected to exceed 12 in a sampling year, or a single bout is missed and cannot be rescheduled. Sites with both deciduous and evergreen vegetation are sampled according to a hybrid approach: monthly sampling with increased frequency during senescence.

In mixed woodland and grassland ecosystems (e.g., Domain 06 Konza Prairie Biological Station, Domain 17 San Joaquin), woody vegetation cover is frequently patchy. As such, randomly placed litter traps are unlikely to adequately capture litter dynamics from woody vegetation. In this case, NEON targets litter trap placement to randomly selected areas of the plot with woody cover. NEON data users can then scale litter production to the plot level using the plot-level percent cover of vegetation > 2 m height provided in the 'ltr_vegCover' table.

3.6 Ground Traps

NEON establishes ground traps that are randomly located in plots at least 2 meters from elevated traps, consistent with Muller-Landau and Wright (2010). To avoid interfering with other sampling within the plot, the basic ground trap sampling unit is one randomly selected 3 m x 0.5 m sampling cell within the same plot or subplot as the elevated trap (**Figure 11**, AD[06]). Ground traps are cleared of all litter > 50 cm in length and ≤ 2 cm diameter one year prior to the onset of sampling so that any qualifying litter within the selected area can be assumed to be the result of annual production. Ground trap sample locations do not move from year to year and are excluded from consideration as locations for any other plant productivity sampling activities that use sampling cells.

Ground traps collect material > 50 cm in length such as large leaves, palm fronds, perennial tree fern fronds, and fine woody debris with butt-end diameter < 2 cm. Only portions of large fronds or long sections of fine woody debris that lie inside the ground traps are sampled. If non-woody tree fern stipes and/or palm frond components qualify for length (> 50 cm) and are > 2 cm diameter, they still should be collected as they are exempt from the diameter requirements of woody materials.

4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

Litterfall and fine woody debris samples are collected and processed in the laboratory according to the schedule in **Table 2**. Collection frequency is dictated by trap and vegetation type.

Implementation of SOP F: Processing Litter Samples for Chemistry and Archive is on an inter-annual basis at a given site, completed as part of a suite of synchronized TOS measurements aimed at characterizing plant and soil biogeochemical dynamics. Synchronized protocols and SOPs include:

- TOS Protocol and Procedure: CFC – Canopy Foliage Sampling (RD[15])
- TOS Protocol and Procedure: SLS – Soil Biogeochemical and Microbial Sampling, including N Transformations (RD[16])
- TOS Protocol and Procedure: BBC – Plant Belowground Biomass Sampling (RD[18]).

If litterfall biogeochemistry is scheduled (i.e., it is a 'BGC year' according to the Inter-annual Schedule), samples for each functional group will be processed from their respective peak mass bout for chemistry and archive according to the criteria for bout selection outlined in SOP F.1.

Scheduling Considerations

Table 2. Sampling frequency for Litterfall and Fine Woody Debris procedures on a per SOP per plot type basis.

SOP	Plot Type	Plot Number	Bout Duration	Bouts Per Year	Bout Interval	Yearly Interval	Remarks
SOP C – Field Sampling	Tower – Elevated Trap	Up to 30*	1 wk	~12+	14 days-several months§	Every year	Refer to **Table 3** and Appendix C for additional details
	Tower – Ground Trap	All	1 wk	1	1 y	1 y	
	Distributed	NA	NA	NA	NA	NA	Distributed plots are not sampled for this protocol
SOP E – Lab Processing for Dry Mass Measurements	Tower – all trap types	All	1 wk	~12	Same as SOP C	1 y	One lab processing bout for mass per field collection bout
SOP F – Processing Litter Samples for Chemistry and Archive	Tower – Elevated Trap	All	1 wk	1x	5 y	5 y	Coordinated BGC bouts

* All Tower plots are considered for litter sampling unless a reduced plot number was implemented based on optimization analyses (**Appendix D**).

+ The target number of bouts per year is 12, but some sites may sample less given site-specific conditions and others may have 13 bouts depending on scheduling. At a minimum, 6 bouts should be targeted for completion.

§ The bout interval is dependent on the site-specific sampling strategy and varies widely across the observatory, see **Appendix C** for more details.

Table 3. Elevated trap sample timing and frequency by vegetation type.

Climate / Ecosystem	When to sample elevated traps
Temperate Deciduous	• Once in the spring, ± 2 weeks of the date listed in Appendix C. • Every two weeks during the leaf senescence period.
Coniferous / Evergreen / Tropical	• Once a month*, all year+.
Arid shrub	• Once a month*, all year.
Mixed Deciduous / Evergreen Or Deciduous - marcescent	• Once a month, during the growing season*. • Every two weeks during the leaf senescence period.

* An approximate 4-week sampling interval should be scheduled a priori to ensure data quality, but the sampling interval may be increased to once every 8 weeks if dictated by unforeseen logistical constraints.

+ It is acceptable to cancel or not schedule bouts during times of the year when the site is inaccessible (e.g., roads closed due to snow).

4.2 Criteria for Determining Onset and Cessation of Sampling

The primary objective is to generate data that enable calculation of annual or per growing season litterfall and fine woody debris production within the dominant vegetation type (i.e., within Tower plots). To that end, sampling frequency differs by vegetation type based on the seasonality of litter production. Coniferous or evergreen broadleaf forests may produce and drop needles or leaves year-round and therefore are sampled year-round but at lower frequency than deciduous forests. On the other hand, forests with a distinct dormant season target sampling activity to the growing season, and sampling is conducted with greater frequency during senescence to effectively process the greater volume of material produced. Mixed forests implement a hybrid strategy (Appendix C).

Material left uncollected in the field for longer than the specified sampling interval may be subject to granivory by small mammals, herbivory by insects, redistribution by wind, or increased decomposition resulting in loss of mass. In deciduous forests, elevated traps must be checked, at minimum, every two weeks during leaf senescence, as traps may fill in short periods. Collection of litter during leaf senescence may occur at intervals less than two weeks if litter volume is high and resources are sufficient to support additional sampling. Opportunistically increased sampling frequency is not prescribed by NEON Science.

Sampling Onset and Interval transitions – Elevated traps in sites dominated by deciduous vegetation

At sites dominated by deciduous vegetation, annual sampling typically begins with a single, early-season bout intended to capture dormant season production. Appendix C provides start dates determined by satellite-derived increasing greenness metrics. This date may be adjusted if the current season differs from the average, but the goal is to conduct the first bout of the sampling season within two weeks of the date specified in Appendix C.

Fall sampling bouts are conducted in 2-week intervals from the start of seasonal leaf drop. Appendix C provides satellite-derived estimates of the beginning of senescence for each site dominated by

deciduous vegetation. The onset of fall sampling may be adjusted based on conditions in the sampling year. The ideal trigger for determining when to initiate fall sampling varies by site but may include:

1. Deciduous tree species monitored for the Plant Phenology protocol have > 1 individual for which the 'Falling Leaves' phenophaseStatus = 'Yes'.
2. Opportunistic visit to litter traps while conducting other sampling in the Tower airshed reveals that leaves are falling, and material is collecting in traps.
3. The 'beginning of senescence' date indicated in Appendix C is met (**Table 19**).

Sampling Cessation – Elevated traps in sites dominated by deciduous vegetation

At deciduous sites, sampling of elevated traps should continue at a two-week interval until plants return to a dormant state and leaves are no longer falling. Sampling may be discontinued when:

1. Senescence is complete.
    a. Assuming senescence occurs between bouts, carry out next scheduled bout after senescence is reported, then cease sampling.
2. The stop date in Appendix C is reached.
    a. Stop dates are derived from satellite greenness data. Contact NEON Science if plants are routinely still dropping leaves at the provided date(s), and **Table 19** in Appendix C can be adjusted.

Sampling Onset and Cessation – Elevated traps in sites dominated by evergreen, mixed, arid shrub or marcescent vegetation

At sites where Tower plots are not dominated by deciduous vegetation, sampling occurs monthly and continues year-round according to site specific guidelines, with breaks for sites that are inaccessible during winter.

4.3 Timing for Laboratory Processing and Analysis

Store field collected samples in a refrigerator or cooler with ice at the end of the day, and for up to one week from the date of collection, until sorting occurs. If sorting is not possible before one week from the date of collection, move samples to the freezer (– 20°C).

If field staff remain at an "away" gradient site for an extended period of time during the collection bout, it is possible to begin conducting the lab sorting portions of this protocol (SOP E) at a location other than the DSF. However, all equipment must be available according to **Table 25**, a suitable work space must be available for sorting, and samples still must be kept in cold storage until oven drying is possible upon return to the DSF.

Table 4. Holding times for different litter sample types.

Sample type	Functional group	Activity	Holding time
Fresh field-collected sample (not frozen)	ALL	Sorting to functional group	Within 7 days of field collection[±]
Frozen field-collected sample	ALL	Sorting to functional group	Within 45 days of field collection[±]
Oven dried, sorted samples	ALL	Weigh dried samples	Within 60 days of field collection
Oven-dried chemistry and archive samples	Leaves/needles	Subsample and ship to external lab and archive facility	Preferably within 90 days of field collection but more time allowed if needed*
Oven-dried chemistry and archive samples	ALL excluding leaves/needles	Subsample and ship to external lab and archive facility	Preferably within 180 days of field collection but more time allowed if needed*

[±] See **Table 13** for more details.

* Hold times for chemistry and archive samples for leaves and needles may be longer than 90 days if material from a non-fall bout is selected, or longer than 180 days for other functional groups if material from a winter or early spring bout is selected. There is no need to reach out to NEON Science for discussion if bout selection follows the guidance in SOP F and all samples are shipped by end of January the year following the 'BGC year.'

4.4 Sampling Timing Contingencies

Table 5. Contingency decisions for Litterfall and Fine Woody Debris.

Delay/Situation	Action	Outcome for Data Products
Hours	If delay prevents completion of litter collection from a single trap, resume collection as soon as possible.	No adverse outcome
	If delay occurs between plots, resume litter trap collection as soon as possible.	
1-7 days	If delay prevents completion of litter collection from a single trap: 1. Store already collected litter in a cooler/refrigerator (acceptable), or sort and oven-dry per protocol (best), 2. Resume collection of litter traps ASAP with new labeled bags	No adverse outcome
	If delay occurs between litter traps, resume collection of remaining litter traps as soon as possible.	
8-13 days or longer*	If delay means all traps are not collected in a single bout, prioritize collection of litter from missed traps at the subsequent bout.	Some litter mass may be lost from traps or collected samples, increasing uncertainty in biomass and ANPP estimates.

Delay/Situation	Action	Outcome for Data Products
	If a delay in sorting is expected to be > 1 week, store samples in a –20°C freezer.	No adverse outcome
	If a delay in weighing occurs, dried samples may be stored for up to 30 days in ambient room conditions but must be re-dried for 24 hrs. prior to weighing.	

* If delays occur with ground trap collection, attempt to collect as soon as possible, do not delay until next bout (i.e., 1 year later). It is important that material is collected in the same year it is produced.

4.5 Missed or Incomplete Sampling

Sampling according to the schedule is not always possible, and multiple factors may impede work in the field at one or more plots or sampling locations in a given bout. For example:

- Logistics – e.g., insufficient staff or equipment
- Environment – e.g., deep snow, flooding, inclement weather, or
- Management activities – e.g., controlled burns, pesticide application

Instances such as those listed above must be documented for scheduling, tracking long-term plot suitability, and informing end users of NEON data availability. Some types of missed sampling are due to events that should be recorded in the Site Management App; refer to the Site Management and Event Reporting Protocol for more detail (RD[06]).

Missed or Incomplete Sampling Terms

Terms that inform Missed or Incomplete Sampling include:

- **Protocol Sampling Dates**: Bout-specific sampling dates (Appendix C).
- **Scheduled Sampling Dates**: Bout-specific sampling dates scheduled by Field Science and approved by Science. These dates coincide with or are a subset of the Protocol Sampling Dates.
- **Missed Sampling**: Incidence of *scheduled sampling* that did not occur. Missed Sampling is recorded at the same resolution as data that are ordinarily recorded.
- **Sampling Impractical**: The field name associated with a controlled list of values that is included in the data product to explain a Missed Sampling event – i.e., why sampling did not occur.
- **Rescheduled**: Missed Sampling is rescheduled for another time according to one of the scenarios documented in **Figure 1**, resulting in no change to the total number of sampling events per year.

The documentation that must accompany missed sampling depends on the timing, subsequent action, and the audience appropriate for numerous scenarios (**Figure 1**).

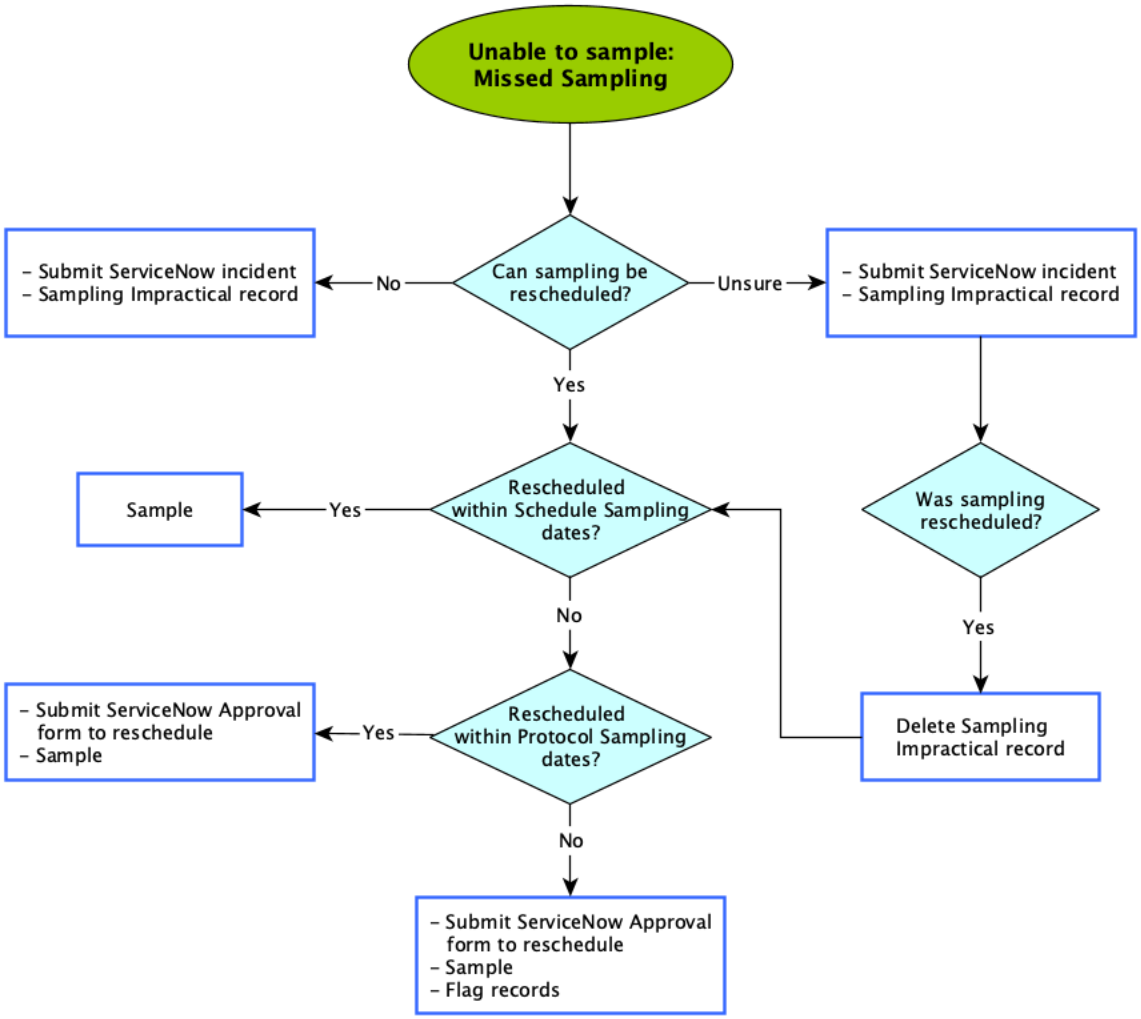

Figure 1. The documentation to account for a Missed Sampling event depends on the situation for each sampling unit not sampled per bout that is not sampled. Diamonds represent decision points and boxes describe the required action. Required actions may include: a) Submitting a ServiceNow incident, b) creating a Sampling Impractical record, c) creating a data Flag, d) creating a Site Management record, or e) some combination of (a) – (d).

To Report Missed or Incomplete Sampling:

1. Missed or Incomplete sampling that cannot be rescheduled within the Schedule sampling dates must be communicated to Science by a ServiceNow Incident.
    a. For Missed Sampling that is Rescheduled, there are some cases that require approval by Science and Operations (**Figure 1**).
    b. Consult **Table 6** below to determine required actions if scheduled activities are delayed or canceled. This protocol is the ultimate source of information should any discrepancy exist

between this document and other summary materials – e.g., the 'Scheduled Field Activities – Delays and Cancellations' spreadsheet linked via the SSL.

2. Create a Sampling Impractical record in Fulcrum for each trap in the field that was not sampled and cannot be rescheduled.

    a. Litter records are reported at the resolution of the trapID, each trap not sampled in a given eventID will have a sampling impractical record created.

    b. Missing data in downstream applications (e.g., Lab apps) are not recorded. For example, if samples are normally weighed, but weren't collected at all, no entries are made in the lab mass app.

NOTE: All Sampling Impractical values other than 'OK' should have no associated lab mass data.

3. For each Missed Sampling record, the **Sampling Impractical** field must be populated in the mobile collection device (**Table 7**) using the Field Sampling application only.

NOTE: If Sampling Impractical = "Location vulnerable to planned sampling" is selected, a ServiceNow incident must be created to notify Science staff and to determine the best course of action moving forward.

4. For Rescheduled sampling events that occur outside of the defined Protocol Sampling Dates, a protocol-specific Flag must also be recorded (**Figure 1**).

Table 6. Guidance for responding to delays and cancellations encountered during implementation of the Litterfall and Fine Woody Debris protocol.

Activity Name	Days Delayed from Schedule	Delay Action	Cancellation Action
TOS Litterfall Collection	> 14 days	IS/OS Schedule Change Request	Create Sampling Impractical record for each trapID. Submit Incident ticket.

Table 7. Protocol-specific Sampling Impractical reasons entered in the Fulcrum application. In the event that more than one is applicable, choose the dominant reason sampling was missed.

Sampling Impractical reason	Description
Extreme weather	Events that compromise safety and access (e.g., thunderstorms, hurricanes).
Location flooded	Standing or flowing water too deep to complete sampling.
Location snow covered	Snow too deep to complete sampling at selected trap.
Location vulnerable to planned sampling	Indicates when scheduled sampling would result in excessive plot-specific damage.
Logistical	Site or plot access compromised, staffing issues, errors (e.g., equipment not available).
Management	Management activities such as controlled burn, pesticide applications, etc.
Other	Sampling location inaccessible due to other ecological reason described in the remarks.

Sampling Impractical reason	Description
Wildfire	Sampling location inaccessible due to active wildfire or post fire safety hazards.
Wildlife hazard	Wildlife hazard, specific hazard described in remarks.

4.6 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 (**Table 8**) 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, Science may propose to move these sampling locations.

Field collection time is expected to only take a couple of minutes for each trap. Most time in the field is spent travelling between plots; travel time varies by site.

Lab processing time depends heavily on the volume of material collected and number of functional groups present in a given collection. Sorting material prior to drying typically takes less than an hour per trap. Weighing dry material is also dependent on the sample volume but should not take more than a couple of minutes per functional group per trap. Grinding, subsampling, filling and labeling vials may take 10-15 minutes per functional group per trap.

Table 8. Estimated staff and labor hours required for implementation of the Litterfall and Fine Woody Debris protocol.

SOP	Estimated time	Suggested staff	Total person hours
SOP A: Preparing for sampling	1 hr.	2	2 hrs.
SOP B: Initial Deployment of traps	1-2 hrs./plot	2	2-4 hrs./plot
SOP C: Field Sampling	0.25 hrs./plot	2	0.5 hrs./plot
SOP E: Laboratory Processing for Dry Mass Measurement	2 hrs./plot (2 traps per plot)	1	2 hrs./plot (2 traps per plot)
SOP F: Processing Litter Samples for Chemistry and Archive	0.5 hrs./plot	1	0.5 hrs./plot
SOP G: Data Entry and Verification	TBD per bout	2	TBD per bout
SOP H: Sample shipment	1-2 hrs. per bout	1	1-2 hrs. per 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 EHS Safety Policy and Program Manual (AD[01]) and Operations Field Safety and Security Plan (AD[02]). Additional safety issues associated with this field procedure are outlined below. If an employee witnesses any unsafe conditions or uncontrolled hazards that present an imminent danger, they should immediately take action to stop work and report such conditions to their manager. Employees must also report all workplace injuries, illnesses, incidents, or releases to the environment as soon as possible, regardless of the severity.

A laser rangefinder/hypsometer/compass instrument is used to locate randomly assigned trap locations. 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.

Pipe glue used to attach PVC legs to the elevated trap is highly flammable and may cause skin and eye irritation. Vapors are also potentially dangerous if inhaled. Employees using glue should familiarize themselves with the hazards associated with this product (refer to the SDS), and with proper handling techniques.

Personnel assigned the task of constructing elevated traps shall complete Hand and Power Tool Safety Training and Machine Shop Safety (available on the Safety page of the NEON intranet) if cutting of PVC for construction is necessary, or if wood traps are used instead of PVC. Personnel shall be trained in the safe use, maintenance and cleaning of the Wiley® Mill or equivalent. *Toxicodendron* spp. (i.e., poison ivy, poison oak and poison sumac) are common and may cause skin rashes on susceptible individuals. The best defense is the use of clothing that covers the body with long pants and long-sleeved shirts and application of over-the-counter products for exposure to urushiol oils. Refer to NEON Operations Field Safety and Security Manual (AD[02] Section 7.1) and to Appendix G of this document and TOS Standard Operating Procedure: Toxicodendron Biomass and Handling (RD[13]) for safe handling instructions.

Heavy work gloves are recommended when collecting litter from ground traps or any time when sorting through litter where unseen hazards (e.g. spines, *Toxicodendron*, snakes, spiders) may be present.

When using the Wiley Mill to grind samples for biogeochemistry analyses and archive, wear a dust mask if not grinding plant material in the hood.

6 PERSONNEL

6.1 Training Requirements

All technicians must complete protocol-specific training as required in the Field Operations Job Instruction Training Plan (AD[04]). Additional protocol-specific required skills and safety training are described here.

6.2 Specialized Skills

The lead Field Ecologist responsible for this protocol must possess the demonstrated ability to identify collected plant structures to functional group via visual inspection. Preferably, the field ecologists sorting litter are the same staff who harvested the litter in the field.

7 STANDARD OPERATING PROCEDURES

SOP Overview

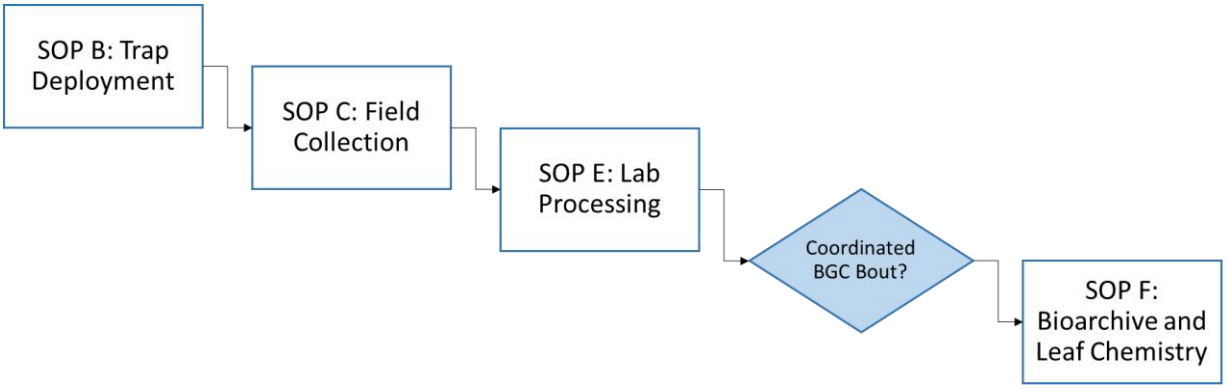

Figure 2. A high level workflow diagram that visually shows how the separate SOPs are sequentially connected.

This protocol is divided into eight Standard Operating Procedures (SOPs). Each SOP addresses one discrete task and may be utilized as a standalone document as needed for specific field or lab tasks.

- **SOP A Preparing for Sampling**: Describes how to prepare for data collection, including: gathering equipment, preloading the GPS with the necessary waypoints, and label and barcode preparation for samples collected.
- **SOP B Initial Deployment of Traps**: Describes how to deploy traps, including: how to locate sampling points, how to deploy trap pairs at the plot, how to construct traps, and how to survey for qualification for sampling.
- **SOP C Field Sampling**: Describes how to collect samples from both elevated and ground traps in the field.
- **SOP D Post-Field Sampling Tasks**: Describes how to document incomplete sampling at the site level and next steps.
- **SOP E Laboratory Processing for Dry Mass Measurement:** Describes how to process samples in the laboratory including sorting, drying and weighing.
- **SOP F Processing Litter Samples for Chemistry and Archive:** Describes the steps for sub-sampling and grinding dried samples for biogeochemistry analysis and archive storage.
- **SOP G Data Entry and Verification**: Describes data entry procedures, including: mobile applications and paper datasheets, label and barcode use, data entry and upload, and quality assurance of data.
- **SOP H Sample Shipment**: Briefly describes shipping procedures of applicable samples with directive to reference the shipping protocol RD[20].

SOP A Preparing for Sampling

A.1 Preparing for Data Capture

Mobile applications are the preferred mechanism for data entry. Mobile devices should be fully charged at the beginning of each field day, whenever possible.

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.

A.2 Preparing for Field Sampling

1. Plan and save sampling routes for field teams using standard site navigation procedures (RD[07]). Route planning enhances sampling efficiency and helps avoid accidental foot traffic within NEON plots.
2. Generate randomized number lists for sites with targeted selection to aid in determining how to select a patch when more than one qualifies. A coin could also be used to randomly select a patch.
3. The clip list is maintained in the Fulcrum application TOS: Clip List, which can be viewed independently or accessed within the LTR: Trap Deployment application.
    - Litterfall sampling locations are selected from the plot-specific randomized lists created for herbaceous clip harvest locations (RD[19]). These lists are therefore essential for the completion of the trap deployment procedure and must be updated to reflect the fact that two of the clipID locations are occupied by litter traps (elevated and ground).
        - For the purpose of this protocol, trap location and clipID are used interchangeably.
    - The Fulcrum Clip List application maintains status updates for clipIDs (i.e., not yet evaluated, accepted, rejected) once a given clipID is used/attempted to be used in the field. ClipIDs that are accepted or rejected are sent back to the Clip List database and removed from Fulcrum, while new ClipIDs are pulled from the database and uploaded to Fulcrum in their place.
    - These lists are utilized in the field regardless of selected trap placement strategy (i.e., random vs. targeted).
    - For **Random trap placement:** clipIDs available for use are automatically displayed in the app.
    - For **Targeted trap placement:** the list of possible clipIDs for use will need to be loaded into the application for a given site by the app developer. The list will be made available temporarily upon request by Field Science.
        - Submit a ServiceNow ticket to request the app developer load clipIDs for targeted trap placement into the Fulcrum application, this is especially important for ground trap bouts in case a trap needs to be located.

4. Gather all field equipment.
    - If *Toxicodendron* is likely to be encountered, include cotton gloves and pre-weighed paper bags.
    - Include replacement mesh, PVC pipe, zip ties, and other construction materials to repair broken traps as needed.
    - Bring barcodes and pigtail stakes/adhesive (if used) for replacement traps (if applicable to domain workflow)
    - Preparing field barcodes in the lab ahead of time will save time in the field. **Figure 3** depicts a fire-resistant field trap barcode stamped with a hole and attached to a pigtail stake, which will go into the ground at the trap leg upon deployment.

Figure 3. Example field barcode attached to pigtail stake.

    - To minimize the risk of cross-contamination, verify that all collection bags are clean and free of litter material from the previous bout (see SOP D.2 for cleaning procedures).
    - If collection bout may be processed for chemistry and archive (elevated traps only), include nitrile gloves for sample collection.
5. Download the 'LTR collection label template' from the SSL. Print on rite-in-the-rain paper. Cut for use during field collection.

    TIP: Permanent, laminated collection labels that may be re-used from bout-to-bout can be made with only the **trapID** and **trapType** filled in (see **Figure 4** below).

Figure 4. Example of laminated, re-usable collection labels.

6. Use a permanent marker to label cloth collection bags with a character string of any length, so each bag may be uniquely identified. This is the **bagID**. This string may contain numbers, letters, symbols but be aware that longer, more complicated strings may slow down data entry while in the field.
7. Prepare navigation device:
    - Charge batteries.
    - Load plot locations.
    - Defining a route to each plot prior to going to the field will enable completion of the field collection bout in the least amount of time.
        - *Field tip:* Draw the selected route on a paper map then laminate for ease of navigation if not following a route via GPS.
8. Prepare laser rangefinder (typically used for locating sampling cells during trap installation), see RD[12] for details.
    - Check battery and charge.
    - Clean lenses with lens cloth or lens tissue (if necessary).
    - Check/set correct declination.
    - Calibrate tilt sensor.
    - Calibrate internal compass.
9. Prepare compass (if using).
    - Check/set correct declination. Note that declination changes with time and should be looked up annually per site: http://www.ngdc.noaa.gov/geomag-web/
10. Print backup datasheets (RD[05]) on all-weather paper.

A.3 Labels and Identifiers

Barcodes are required for all samples processed for chemistry analysis and archive. Barcodes are strongly recommended for field-collected samples. Optional barcodes include trap barcodes, and lab mass samples (not sent for external analysis or archive). All barcodes need to be applied to dry containers 30 mins before use. Type I (prefix A, plus 11 numbers) are used for all field samples and any non-cryo applications; they have a tolerance from 4°C to 105°C and still scan.

Preparing labels for lab chemistry samples

1. Prepare final sample containers by affixing one Type I adhesive barcode label to each vial used to contain each sample. Use **plastic** scintillation vials for chemistry samples and **glass** scintillation vials for archive samples.
    a. Adhesive barcode labels should be applied to dry, room temperature containers in advance of their use in the field (at least 30 minutes prior but may be applied at the start of the season).
    b. Barcode labels should be oriented such that it is possible to scan them (**Figure 6**); the scanner will not work on a curved surface. This means aligning the barcode lengthwise along a vial, *not* horizontally wrapping around a vial.
    c. Barcode labels must be associated with a unique sample, and each barcode must be mapped to one sample in the database. Barcodes are unique, but are not initially associated with a particular sample, so you are encouraged to adhere barcode labels to needed containers in advance.
    d. Pre-label scintillation vials with barcode labels and blank or pre-formatted cryo-labels for the bgc sampleID.
        i. Affix the barcode to each vial to be filled with a unique sample.
        ii. Affix the blank cryo-label such that it does not interfere with the barcode label.

Figure 5. An example of a Type I barcode. These large-size, field-tolerant barcodes have a prefix of 'A' followed by 11 numbers.

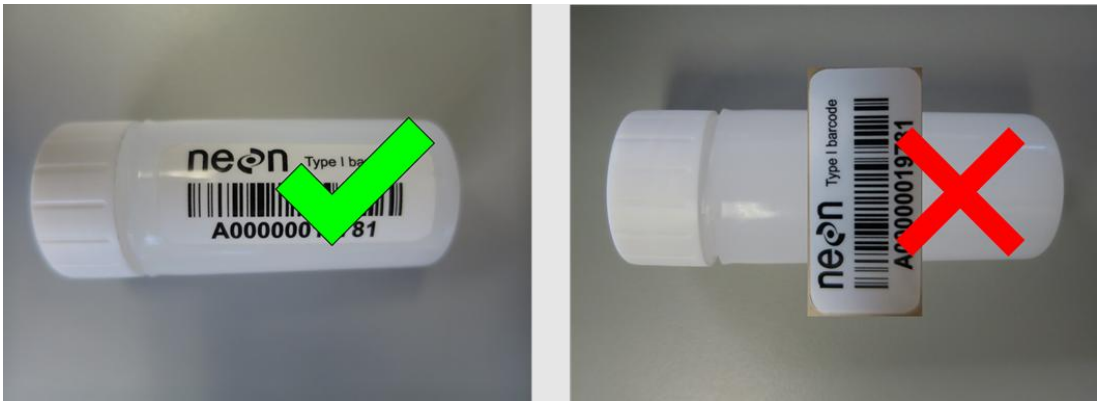

Figure 6. An example of a Type I barcode properly affixed lengthwise on a vial (green check mark) versus an improper orientation (red x).

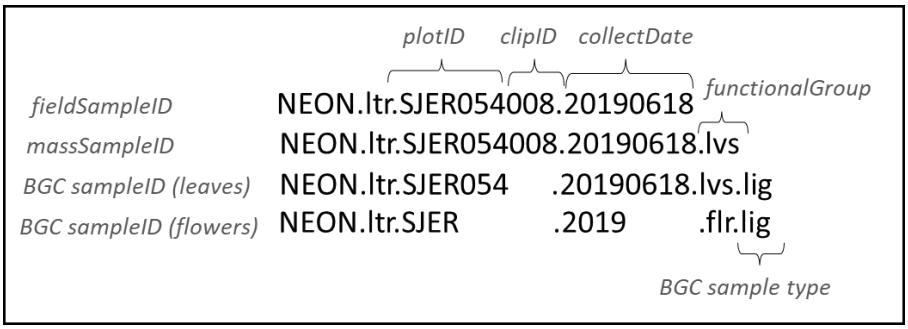

Figure 7. Annotated sampleID example. All sampleIDs are auto-generated in the Fulcrum mobile application based on user inputs to metadata fields. BGC sampleIDs vary in format depending on the functional group.

About Barcode Uses and Placement

This protocol generates mixed samples from the field, sorts those samples into functional groups for dry mass measurements, then pools samples within functional groups at the plot scale for grinding and chemical analyses.

Although it is always acceptable to use barcodes, in some cases barcodes are absolutely required. Barcodes help avoid transcription errors that may occur on handwritten labels. Likewise, the final disposition of all vialed samples must have a barcode affixed to assist in the shipping and receipt of samples destined for the Biorepository or an external laboratory. **Table 9** provides a quick reference to the types of samples this protocol generates that require barcodes.

Table 9. Barcode requirements for sample types generated by the Litterfall and Fine Woody Debris protocol. BGC sampleIDs vary in format depending on the functional group.

Sample Type	Description	Example Identifier	Fulcrum App	Container Type	Barcode Used	Barcode Required?	Barcode Qty
Trap barcode (field only)	Barcode attached to trap or on pigtail stake in ground next to trap leg, supplemental to human readable trapID	E RMNP_047_275	LTR: Trap Deployment	Trap	Aluminum	Optional	1 per trap
Field samples	Unsorted samples from elevated or ground traps	NEON.ltr.SJER045008.20190618 *(NEON.ltr.plotID.trapID. collectDate)*	LTR: Field Sampling	Cloth bag	Type I	Recommended, affix to paper tag inside bag	1 per trap per bout
Mass samples	Litter field samples sorted to functional group	NEON.ltr.SJER045008.20190618.lvs *(NEON.ltr.plotID.trapID. collectDate.functionalGroup)*	LTR: Lab Mass Data	Paper bag	Type I	Optional	1 per sub sample
Chemistry Samples	Functional group specific samples pooled by either plot or site	NEON.ltr.SJER045.20190618.lvs.lig *(NEON.ltr.plotID.collectDate.functionalGroup.bgcSampleType)* NEON.ltr.SJER.2019.flr.lig *(NEON.ltr.siteID.yearBoutBegan.functionalGroup. bgcSampleType)*	LTR: BGC Sub-sampling	20 mL plastic scintillation vials	Type I	Required	1 per sample
Archive Samples	Functional group specific samples pooled by either plot or site	NEON.ltr.SJER045.20190618.lvs.ar *(NEON.ltr.plotID.collectDate.functionalGroup.bgcSampleType)* NEON.ltr.SJER.2019.flr.ar *(NEON.ltr.siteID.yearBoutBegan.functionalGroup. bgcSampleType)*	LTR: BGC Sub-sampling	20 mL glass scintillation vials	Type I	Required	1 per sample

SOP B Initial Deployment of Traps

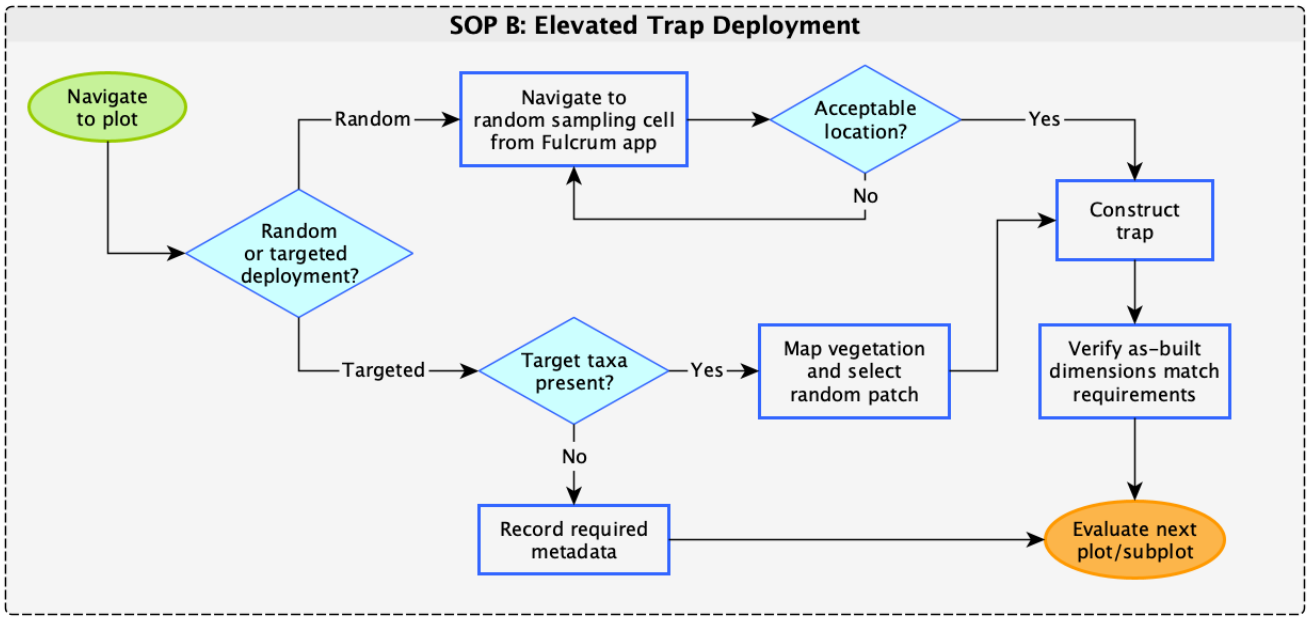

Figure 8. Workflow diagram for litterfall trap deployment.

Data entry guidelines and instructions for using the 'LTR: Trap Deployment [PROD]' Fulcrum application are found in the Fulcrum manual for this protocol, available on the SSL.

B.1 Selecting Litter Trap Location Strategy

To enable scaling of litter production across the site, the strategy for trap placement (i.e., Targeted or Random) is consistently applied across *all plots at a site* rather than based on plot-specific conditions.

- **Targeted selection** is utilized for patchy vegetation, where overstory species ≥ 2 m height constitute < 50% canopy cover averaged across all Tower plots.
- **Random selection** is employed in forested sites with ≥ 50% canopy coverage of individuals ≥ 2 m in height.

Refer to Appendix C for the recommended strategy by site; these recommendations are based on a combination of NLCD vegetation classification, satellite imagery, and site characterization data. If the selected trap placement strategy appears inappropriate given current site conditions (based on the criteria above), create a ServiceNow ticket to iterate with Science about the trap placement strategy.

Litter traps are typically deployed in pairs, with one elevated trap and one ground trap deployed in each of two randomly selected 400 m^2 subplots within a 1600 m^2 Tower plot. In smaller, 400 m^2 Tower plots, only one litter trap pair is deployed. Trap placement utilizes the same sampling cells developed for the herbaceous clip harvest protocol (RD[19]), and the random subplot selection list provided by NEON Science. Review and print Elevated Trap Assembly Instructions (RD[11]) for use in the field.

targetTaxaPresent = No

Any site dominated by herbaceous species, where woody vegetation is infrequent and too short to be reliably sampled by elevated litter traps (i.e., < 2 m), is excluded from consideration for implementation of this protocol. At sites where litterfall sampling does occur, all Tower plots must be considered for deployment of litter traps.

Plots and sites with targetTaxaPresent = No will be re-surveyed every 5 years to determine whether qualifying vegetation is present and the litterfall protocol should be implemented.

- If a random sampling strategy is employed and a given plot does not contain any vegetation > 2 m height
    - Record **targetTaxaPresent** = No
    - If **targetTaxaPresent** = Yes for a 40m x 40m plot, but no qualifying vegetation is present in a given 20m x 20m subplot, traps must still be deployed and sampled; **targetTaxaPresent** is a plot-level assessment.
- If a targeted sampling strategy is employed, a subplot or plot may be rejected if there is not sufficient woody vegetation > 2 m tall to allow for placement of both elevated and ground traps OR if all sampling locations beneath qualifying patches are within excluded sampling areas (i.e., the 1 m buffer around the plot edge, and 1 m^2 and 10 m^2 diversity sampling areas).
    - Excluded clipCells are NOT available on the provided clipLists.
    - Record **targetTaxaPresent** = No on datasheet or mobile app and continue to the next plot/subplot.
- Plots where **targetTaxaPresent** = 'No' will be re-visited annually to assess if woody vegetation has graduated to qualifying size.

B.2 Litter Trap Coordinates

Appendix G provides x, y-coordinates specific to litter trap placement, but note that the clipIDs maintained in the TOS: Clip List Fulcrum application include coordinates for the SW corner of ***clip strips*** used to sample herbaceous biomass/productivity (RD[19]). Therefore, Appendix G is necessary, along with the plot specific clip list to determine trap locations. **Figure 9** provides an overview of the relationship between clip list coordinates and litter trap locations.

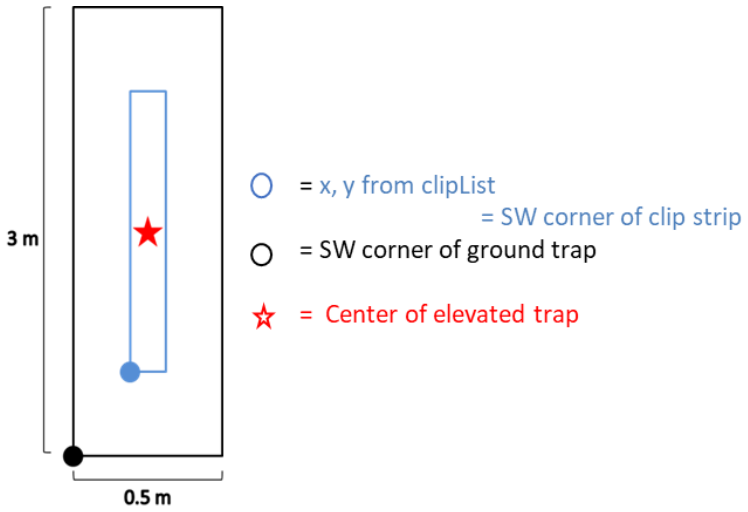

Figure 9. x, y-coordinates for litter trap placement (red star, black circle, see Appendix G). These coordinates differ from those provided in the clipLists for use with the herbaceous clip protocol (blue circle) RD[19].

B.3 Targeted Sampling: Litter Trap Placement

Sites with patchy vegetation, where overstory species ≥ 2 m height constitute < 50% canopy cover of the Tower airshed sampling area, implement targeted trap placement in all Tower plots (see Appendix C).

1. Navigate to the desired plot and, if sampling in a 40 m x 40 m plot, the randomly selected subplot.
2. Assess the location of patches of qualifying vegetation (≥ 2 m tall, outside of 1 m^2 and 10 m^2 diversity plots) within the plot or subplot (depending on plot size). Number each patch with an incrementing integer (i.e., “1”, “2”, “3”, etc.). Assign values sequentially, left to right, bottom to top, beginning in the SW corner (**Figure 10**).

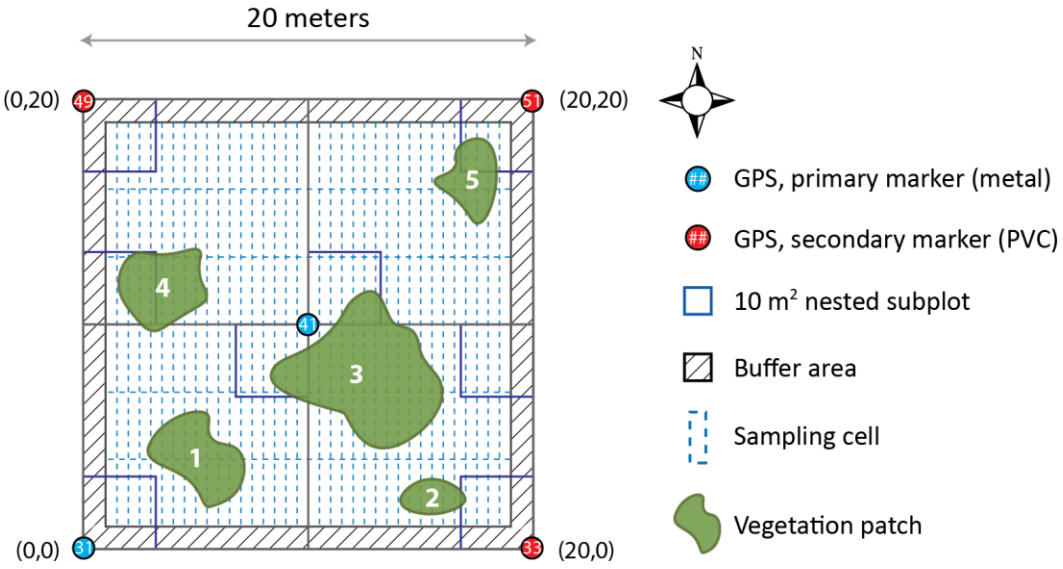

Figure 10. Example of numbering system for qualifying patches of vegetation within a plot.

a. If no qualifying patches are present, record **targetTaxaPresent** = "No" for the plot or subplot.

b. If only a single qualifying patch is available, elevated and ground traps may be placed on opposite sides of the patch (even if < 2 m apart), provided the elevated trap is not situated such that it could potentially affect large particle distribution in the ground trap.

3. Use either a random number list, a series of coin flips, or other unbiased method of selection to select a patch to target for litterfall and fine woody debris sampling.

4. Once a patch is selected, select a location under the canopy, central to the patch to place an elevated litter trap.

a. Avoid the 1-meter buffer around the plot edge, and the 1 m^2 and 10 m^2 nested subplots used for diversity sampling. Clip cell coordinates are not generated for those locations.

b. If excluding 1 m^2 and 10 m^2 nested subplots removes all qualifying patches of vegetation from consideration, record **targetTaxaPresent** = "No" and move to the next plot/subplot.

c. If the selected patch is composed of dense, impenetrable vegetation such that traps cannot be placed centrally within the patch, traps may be placed along the patch edge according to one of the following strategies, listed in order of priority:

i. Place trap along the patch edge where there is overhanging vegetation.

ii. If there is a dominant wind direction, place trap along the leeward side of the patch so that the wind will carry litter from the vegetation toward the trap.

iii. Use a random selection routine to select a cardinal direction.

5. Place the elevated trap over the centroid of the sampling cell that is nearest to the center of the target patch.

a. Use the range finder to measure the distance to plot/subplot edges.

i. From the selected location, measure the distance due east or west to the nearest N-S plot boundary, this determines the x-coordinate of this point.

ii. Then measure the distance due north or south to the nearest E-W plot boundary, this determines the y-coordinate of this point.

iii. Use the sampling cell map to identify the cell located closest to the selected point.

b. Navigate to the centroid of that cell (Appendix G).

6. If practical, center trap over the cell centroid point; this minimizes the number of sampling cells that are removed from consideration for herbaceous clip harvest.

a. For example, the coordinates associated with the nearest sampling cell centroid from the center of patch 4 are: x = 3.7, y = 11.5 (**Figure 10**).

b. Not centering the trap over a cell centroid is acceptable but not ideal, as adjacent cells will also be excluded from consideration for herbaceous clip harvest.

7. Place a pin flag at the selected trap location.

B.4 Random Sampling: Litter Trap Placement

Sites where overstory species ≥ 2 m height constitute ≥ 50% canopy cover of the Tower airshed, sampling area will implement random trap placement in all Tower plots (**Table 19**).

Use the LTR: Trap Deployment Fulcrum application or the TOS: Clip List Fulcrum application to identify the first potential clip-strip location by selecting Clip List-Random Sampling – which will display a list of 10 possible clipIDs.

NOTE: ClipIDs can also be viewed in the independent TOS: Clip List App.

1. Navigate to the SW corner of the clip strip of the first available clipID on the randomized list:

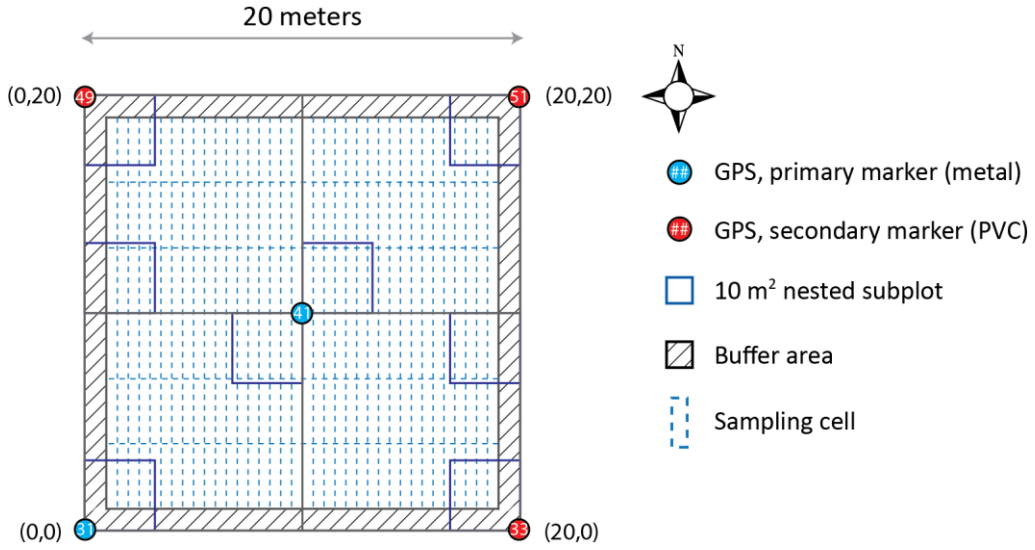

Figure 11. A 20 m x 20 m NEON plot showing the locations of 0.5m x 3m sampling "cells" (dashed blue lines). Larger plots have different nested subplots, but the coordinate numbering system for the 20 m subplot within these plots follows the same conventions as shown above.

If the Y-coordinate is < 10:

a. Run a tape East/West along the south edge of the plot or subplot between the (0,0) → (20,0) plot markers (**Figure 11**) and stretch the tape taut.

b. Place a pin flag at the desired relative X-coordinate.

c. Standing directly over the pin flag that was just placed at the X-coordinate, use the laser rangefinder in **HD** mode with a reflective surface to locate the Y-coordinate.

- Make sure the azimuth is 0˚ (True North) when shooting the laser rangefinder to find the Y-coordinate (see RD[12]).

d. Place a pin flag at the clip-strip (X, Y) location.

If the Y-coordinate is > 10:

a. Run a tape East/West from the plot/subplot centroid (10,10) to either the (0,10) position or the (20,10) position (**Figure 11**). *Note: in 40 m x 40 m plots, subplot centroids may not permanently marked*.

Table 10. X-coordinates relative to tape layout directives.

X-Coordinate	Tape Layout[1]
1 < X < 10	From (10,10) to (0,10)[1]
10 < X < 20	From (10,10) to (20,10)[1]

[1] Use the laser rangefinder in **AZ** mode to guide the tape along the correct azimuth.

b. Place a pin flag at the desired relative X-coordinate.

c. Standing directly over the pin flag that was just placed at the X-coordinate, use the laser rangefinder in HD mode with a reflective surface to locate the Y-coordinate.

d. Make sure the azimuth is 0˚ (True North) when shooting the laser rangefinder to find the Y-coordinate (see RD[12]).

e. Place a pin flag at the clip-strip (X, Y) location.

Note: If laser rangefinder is not available, the same routine described here may be completed using a handheld compass to verify azimuth and a tape measure for distance.

BEST PRACTICES

- If the plot slope is > 20% or there is significant brush present in the plot, measuring by tape and compass *will not work*. Use the laser rangefinder in **HD** mode to place flags.
- Plot slope can be quickly estimated using the inclinometer in the laser rangefinder (**INC** mode) or the inclinometer on the handheld compass.

2. Assess the suitability of the sampling cell for an elevated litter trap:

- Accept the cell if no obstacles are present that prevent trap placement and anchoring – e.g., large shallow rock covering a majority of the cell, large boulders, impermeable vegetation, or low-lying fallen trees that divert litter away from the trap location.
- Reject the cell if the selected cell is within 2 meters of: an LAI sampling point, a ground trap, or other sampling equipment located within the plot (e.g., grazing exclosure).

- If the sampling cell is not acceptable for placement of an elevated litter trap, move to the next one on the list but do NOT record the cell status as 'rejected' for herbaceous biomass sampling.

3. Navigate to the center of the cell and place a pin flag (**Figure 9**). Elevated traps are centered over this point.
    - If the trap cannot be anchored over the center of the cell, the trap may be shifted up to 1 meter North or South.
4. Follow **SOP B.7** to record trap deployment information in the LTR: Trap Deployment application.

B.5 Ground Trap Placement

Ground traps are established to occupy one entire sampling cell and may not be placed such that more than one cell per 400 m^2 is occupied by a ground trap.

- **Targeted selection** – repeat the process described in B.4 for randomly selecting a patch in which to locate the ground trap.
    - Do not exclude the patch selected for the elevated trap from consideration.
    - If the same patch selected for elevated trap placement is randomly selected, place the ground trap on the opposite side of the selected patch or > 2 meters from the elevated trap such that the elevated trap cannot re-direct litter particles toward or away from the ground trap.
- **Random selection** – continue using the randomized sampling cell locations in sequential order as described in B.4
    - Assess the suitability of the next potential sampling cell that has not previously been sampled or rejected.
    - Reject the trap location if the selected cell is < 2 meters from the elevated trap or if conditions prevent placement of stakes in all four corners of the selected cell.

1. Navigate to the SW corner of the selected cell and place a pin flag (**Figure 9**).
2. Delineate the 3 m x 0.5 m sampling cell that will be used for the ground trap using meter tape and compass or laser rangefinder to ensure that the trap is oriented to the cardinal directions.
3. Hammer in brightly colored or aluminum stakes in each of the four corners leaving ~20cm visible above ground.
    a. At sites/plots with shallow soil or abundant rocks that preclude placement of stakes, mark the sampling cell with an alternative appropriate method that is acceptable to the site host. Plots cannot be rejected from ground trap placement due to the presence of rocks.
4. Remove all large leaves, large palm fronds, perennial tree fern fronds, and all fine woody debris > 50 cm length and < 2 cm diameter from within the ground trap area.

a. It is not necessary to remove small leaves, fronds, etc. that are normally sampled with the elevated litter traps.

5. Follow **SOP B.7** to record trap deployment information in the LTR: Trap Deployment application.

B.6 Elevated Trap Construction and Installation

1. Center the square trap frame over the pin flag placed in the center of the selected sampling cell.
2. Mark trap corners with pin flags.
   a. The trap frame is 70.7 cm wide, as measured from the outside edges of the PVC. Since a sampling cell is 50 cm wide, trap legs will be anchored 10 cm into the adjacent cells on either side of the selected cell.
3. Hammer non-oxidizable metal stakes into the ground at the pin flag locations to anchor trap legs, leaving 50 cm above ground.
4. Attach trap legs to the square frame. Legs may optionally be glued in place.
5. Cut the trap legs so that, once installed, the square frame is level (use bubble level to check), and approximately 0.8 m above the ground.
   a. Do not reject a potential trap location if woody vegetation is located beneath the trap, provided that the vegetation does not affect the shape/sag of the litter trap mesh.
   b. If possible, do not manipulate existing vegetation, though some clipping of branches up to a height of 2 m from the ground is allowed at sites with continuous mid-level vegetation where a suitable location would otherwise not be available, and existing vegetation prohibits access to the deployed litter trap.
6. Slide trap legs over stakes.
7. Use a permanent marker and a meter stick to draw a 50 cm line along one side of the trap frame. This will be used during collection bouts to assess the length of qualifying material.
8. Attach screen mesh to the square frame with the provided zip ties.
   a. The pre-cut screen is larger than the trap area and should not be taut across the trap, a minimum of 20 cm difference between the plane of the trap frame to the lowest point in the mesh is ideal to prevent litterfall from blowing away. A >20 cm sag may be employed as necessary to accommodate high litter production sites (e.g., deciduous forest). (**Figure 12**)
   b. (Optional) Add snap clamps to trap edges to hold the screen in place. Snap clamps are useful for sites where heavy snow loads routinely rip screens only attached with zip ties (**Figure 13**).

Figure 12. Fully constructed elevated litter trap.

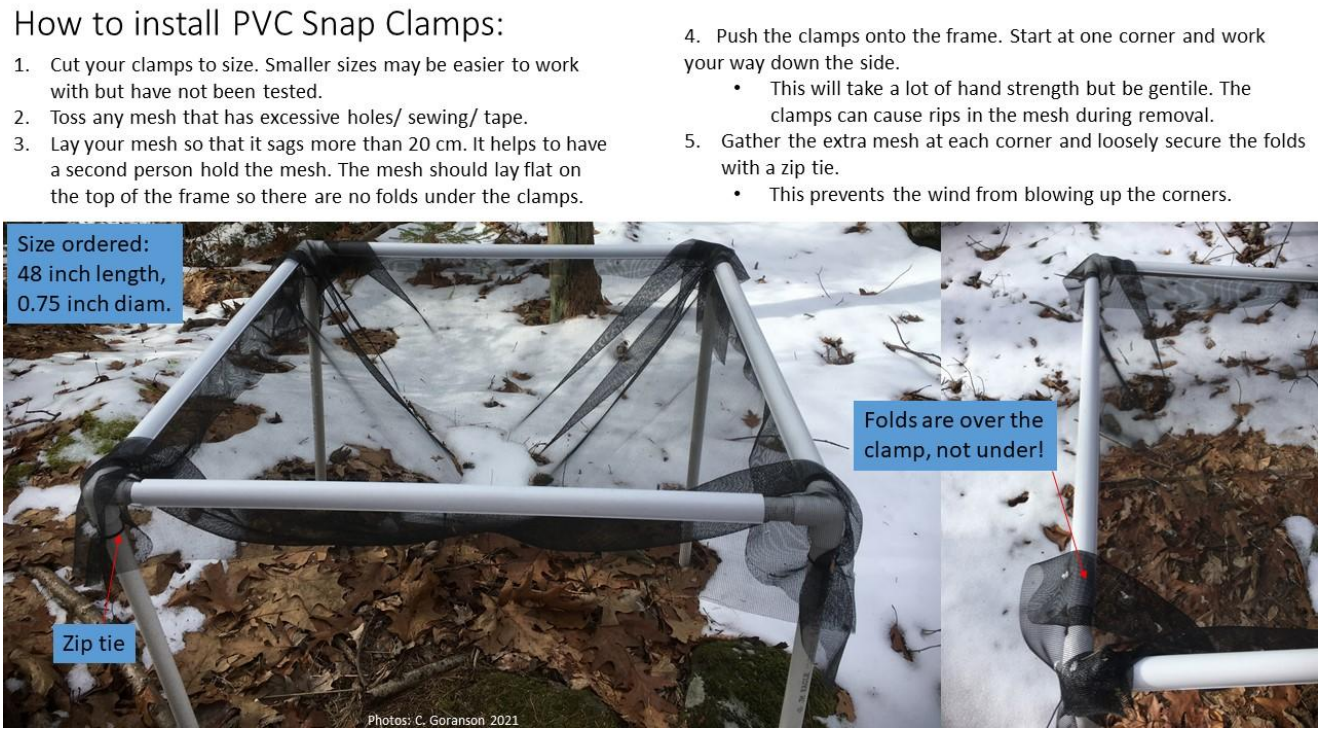

Figure 13. How to install PVC Snap Clamps.

9. Physically label the trap with trapID and subplotID by writing the information on one leg of elevated trap with a permanent marker or by affixing a metal tag with the trap information engraved on it, to the trap frame or a pigtail stake on the ground (**Figure 14**).

    a. (Optional): If field barcodes are used, either affix the barcode to the trap frame or put the pigtail stake with barcode attached into the ground near the trap leg and scan it using the mobile collection device (**Figure 15**).

Figure 14. Label elevated traps with the trapID either written on a leg with permanent marker (right) or stamped into a metal tree tag (left).

Figure 15. Example of barcode deployed in the field using a pigtail stake.

9. If the trap is ready to begin collecting litter material, record **addDate** as the **setDate** for the first collection bout.

B.7 Record Trap Deployment Data

When this protocol is implemented at a site, EVERY Tower Plot must be assessed for presence of qualifying vegetation.

1. For each plot, record:
    - **measuredBy/recordedBy**
    - **setDate:** date of initial deployment
    - **samplingProtocolVersion**
    - **siteID, plotID**, **subplotID**
    - **trapPlacement:** 'random' or 'targeted'; this must be the same for *all Tower Plots* at a site and is pre-populated in the mobile app.
    - **trapType:** 'elevated' or 'ground'
    - **trapSize (auto-fills):** 0.5 if trapType = elevated; 1.5 if trapType = ground

- **targetTaxaPresent: Yes/No.** Does the plot contain vegetation that qualifies for inclusion in litter sampling?
- **Clip List:**
  - **Targeted Sampling** – select the applicable clipID for where the trap was placed.

    NOTE: For targeted sampling, all possible clipIDs need to be pre-loaded into the Fulcrum Trap Deployment application by the app developer so the complete list is available to choose from. See SOP A.2.
  - **Random Sampling** – select the first record from the list of available clip IDs.
    - **clipidStatus** will default to 'Not Yet Evaluated' – once accepted or rejected you will need to click on the field again **Clip List – Random Sampling** and update the **samplingStatus** field.
      - If 'Rejected' then fill in the date and add a required remark for why it was rejected
      - If 'Accepted' then select the LTR option in the **protocolSampled** field and add the date.
- **Trap Barcode:** Scan the barcode on the trap if applicable, barcodes are optional.
- **Remarks:** Free text entry about trap deployment
- **Does trap need a drop date?**: This field is only used when a trap is dropped permanently from sampling.

B.8 Annual Re-survey of Non-qualifying Plots

At sites that qualify for litter sampling but do not have litter traps deployed in all Tower plots/subplots, non-qualifying plots/subplots (i.e., those plots assessed as **targetTaxaPresent** = "No" the year before) must be reassessed annually and new traps set if the plot/subplot now contains:

- Overstory vegetation ≥ 2 m in height AND
- 1 or more individuals with stem diameter (DBH) ≥ 10 cm OR
- 10 or more individuals with stem diameter (DBH) ≥ 5 cm

If vegetation structure sampling was completed in a non-qualifying plot the previous year, re-assessment may be completed from the DSF.

1. Download records from 'VST: Apparent Individuals [PROD]' Fulcrum application for non-qualifying plots.
2. If the criteria above are not met, create new 'LTR: Trap Deployment [PROD]' record for the plot with current date as **setDate** and **targetTaxaPresent** = "No".

3. If the criteria above are met, flag this plot for new trap deployment and follow guidelines in the preceding sections of this SOP.

If vegetation structure sampling was *not* completed in the non-qualifying plot the previous year a field visit is required to assess the plot.

1. Include a visit to non-qualifying plots in the spring data collection bout at sites with seasonal sampling strategy or in the first bout of the calendar year at sites with hybrid or year-round sampling strategy.
2. Survey the plot for qualifying vegetation (RD[17]).
3. If the plot now qualifies, record **targetTaxaPresent** = “Yes” and deploy traps. If the plot still does not contain qualifying vegetation, create a new Deployment record for each previously assessed plot with **targetTaxaPresent** = “No” as in past sampling years.

SOP C Field Sampling

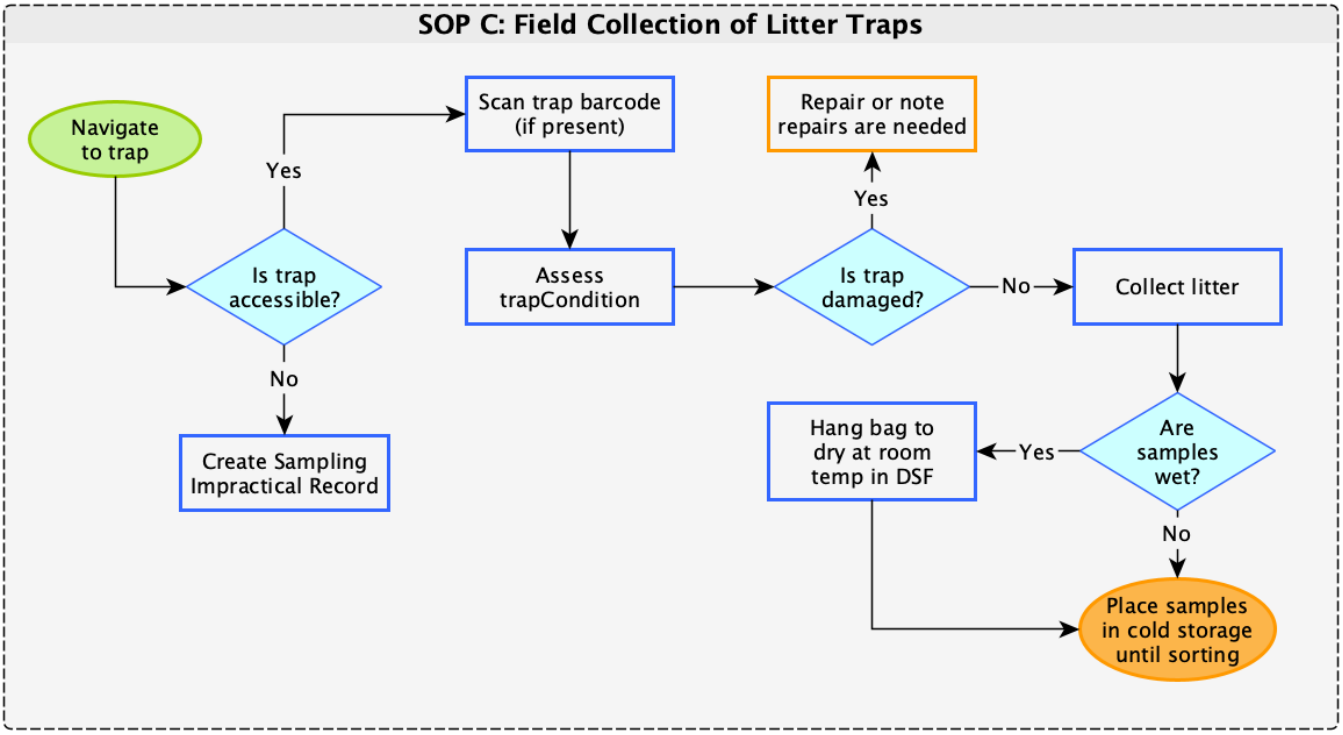

Figure 16. Workflow diagram for field collection of litter traps.

Data entry guidelines and instructions for using the 'LTR: Field Sampling [PROD]' Fulcrum application are available in the Fulcrum Manual for this protocol, available on the SSL.

If the field collection bout is cancelled or a particular plot or set of plots are inaccessible, create a record for each trap that would have been visited with a **samplingImpractical** value describing why sampling did not occur (**Table 7**).

C.1 Litter Collection – Elevated Traps

1. Navigate to the plot.
2. Locate a trap and confirm that the trapID on the trap label matches what is expected (or confirm by scanning the barcode if applicable).
3. Find the pre-existing Fulcrum Field Sampling record from the prior bout for the trapID.
    a. This record has a pre-populated **setDate** from the prior bout and is ready to begin data entry for the current bout. This workflow reduces **setDate** errors between bouts.
    b. If there is not a pre-existing Fulcrum record from the prior bout, then create one and be sure to confirm the correct **setDate** from the prior bout.
4. Assess feasibility of sample collection.

a. If the trap is undamaged and a sample can be collected, record **samplingImpractical** = 'OK' (defaulted on mobile application).

b. If the trap is undamaged but cannot be sampled for any reason, create a **samplingImpractical** record indicating no sample was collected (**Table 7**). The trap will be sampled in the next scheduled field collection bout.

5. Assess and record the **trapCondition** (**Table 11**).

Table 11. Litter **trapCondition** codes.

Code	Description
OK	Litter collected - Trap in good shape, no issues
TE	Litter not collected – Trap empty
HO	Litter not collected - Holes large enough for leaves to pass through. Holes near the base of the screen (the lowest hanging point) are of greater concern than holes on the side of the screen.
TB*	Litter not collected – trap blocked. Large branches or leaves (especially palm fronds) present in or above the trap, which may have prevented the trap from collecting litter, or may have diverted falling litter away from the trap.
TT	Litter not collected – trap tilted ≥ 10° (use clinometer on compass to measure)
RE	Litter not collected – trap broken
PF	Litter collected – Trap previously flooded

* Do not use TB – trap blocked for traps with too much snow mounded to confidently collect all material, instead create a samplingImpractical record for the trap (**Table 7**).

a. If the trap is not in good condition, discard the litter haphazardly around the trap, then make necessary repairs. Broken traps should be replaced immediately if possible.

   i. A damaged trap must be replaced or repaired within one week if repair/replacement is not possible at the time of collection. Note the date on which trap was repaired/replaced and reset; this will be the **setDate** for the next collection bout.

b. There is no defined threshold for when litter should be discarded from traps with holes (HO). Because the size and location of holes in the mesh that may allow material to be lost varies based on the dominant vegetation at a site, it is at the discretion of the technician collecting litter to determine if the sample should be discarded due to the presence of holes. If it is likely that < 5% of mass has been lost through the holes, material may still be collected with a **trapCondition** code = 'OK'. Holes should still be repaired.

   i. Recommendations for repairing screen mesh holes include:

      1) For holes up to ~ 3 cm: sew a screen mesh patch over the hole.

      2) For small holes, 0.5 – 1 cm: use a screen repair adhesive-patch over the top of the hole. Because patches are sticky, apply face-down and size just big enough to cover the hole.

3) For holes too large to repair: replace entire mesh.

4) For mesh that has several holes and/or has previously been repaired: replace entire mesh.

5) For mesh that is fragile/weathered from sun/rain: replace entire mesh.

c. If a trap was blocked and litter was not collected, then you may clear it for the next collection by haphazardly discarding the material blocking the trap around the vicinity.

NOTE: If there is permanent impediment from sampling a trap at its current location, for example, an entire tree fell on top of it and it can no longer be assessed and is blocked indefinitely, then the trap should be dropped and moved to a new location (follow steps in SOP B). If in doubt, submit a ServiceNow incident for discussion with Science staff to determine best course of action.

d. Record common causes for damaged traps in the **remarks** field using the provided dropdown options.

e. If the trap is in good condition (OK) or previously flooded (PF): continue with collection.

6. If the plot contains needle bearing species and needles may be small enough to pass through the mesh, spread a cloth below the trap to catch any material that falls through during collection to save as part of the sample (**Figure 17**).

Figure 17. Use of ground cloth to catch trap throughfall.

7. Discard litter > 50 cm in length, this material is not reliably collected in elevated traps and is sampled in ground traps.
    - All woody material > 2 cm diameter is quantified according to the Coarse Downed Wood (CDW) protocol (RD[09]). Use calipers to measure the diameter of woody branches and:
        - Discard branches > 2 cm at the narrowest point.
        - For branches that taper to ≤ 2 cm, cut off and discard the portion > 2 cm diameter; drop the discarded portion of branches haphazardly around the elevated litter trap (i.e., do not group or stack discarded material).
8. Briefly inspect remaining material for vertebrates and other non-target organisms or material caught in the trap. Release non-target organisms locally and dispose of other material as appropriate.
9. Transfer all other material, including parts hanging out of the trap, into the cloth bag designated for elevated trap litter.
    a. A plastic scoop or laminated card may be useful for collecting fine or difficult to grab material from an elevated litter trap and to minimize handling of material.
    b. Wear clean gloves while collecting elevated trap samples during a 'BGC' year. Nitrile gloves are best, but clean work gloves are also acceptable if dictated by weather or to protect hands against sharp material in traps.

Note: Cotton bags of varied sizes may be utilized throughout the year to accommodate variable volumes of material in traps (e.g., larger bags during senescence or if snow is present in traps; smaller bags during periods of low production).

10. Using a pre-printed label template (available on the Sampling Support Library), write the clipID, date, trap type, and technician name (**Figure 18**), and place inside the bag prior to collecting material.
    a. If material from a single trap does not fit in a single cloth collection bag, create a duplicate tag for the second bag and add "1 of 2", "2 of 2" to each tag. Record the additional **bagID** in the **remarks** field of the mobile app and pool contents of each bag for sorting, drying and weighing.

Field tip: Attach bags from the same trap to each other so they can easily be combined for sorting and weighing.

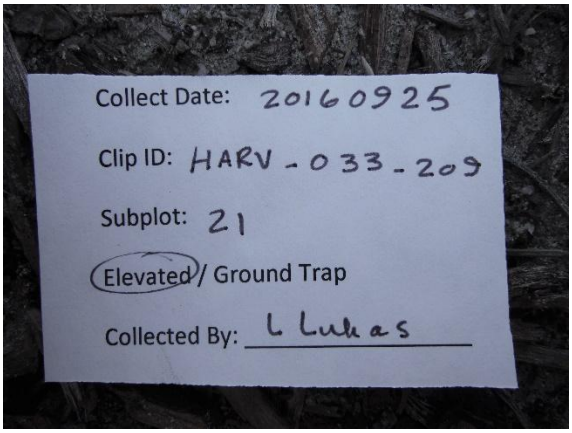

Figure 18. Example field collection label.

11. Knot or tie off the cloth bag to prevent material from falling out while in transport.
12. The mobile application for field sampling is a 'flat app', there are no parent/child relationships within records. Each trap visited will have its own Fulcrum record with **plotID, subplotID, trapType** prepopulated from the Deployment application based on the selected **trapID**.

    Reminder: Use the pre-populated records that should exist from the bout prior, these will have the previous **setDate** auto-populated and will have a load_status of SKIP until they are opened and edited.
13. Record the following using the "LTR: Field Sampling [PROD]" mobile application:
    - **samplingImpractical**: Samples and/or measurements were not collected due to the indicated circumstance; defaults to 'OK'.
    - **collectedBy/recordedBy**
    - **samplingProtocolVersion:** defaults to most recently released version.
    - **trapTypeFilter:** Elevated.
    - **trapID:** Unique identifier for trap location within the plot, designated by the clipID.
    - **yearBoutBegan:** The calendar year the collection bout began (i.e., the year associated with the **collectDate** for the first trap collected in a given bout) – typically the current year except when a collection bout begins late December and does not conclude until early January.

      NOTE: NEON uses the International Organization for Standardization (ISO) standard for week numbering. ISO weeks begin on Mondays but are numbered based on the day of year falling on the Thursday of that week. For example, January 1, 2025 was a Wednesday, this means December 30 and 31 2024 were in ISO week 01 of 2025.

- **setDate:** The date the trap was set/reset, if previous bout trapCondition = OK then setDate=previous collectDate, else, date that damaged trap was replaced /repaired and reset.
- **collectDate**: Use *YYYYMMDD* format.
- **trapCondition:** Condition of litter trap and indication of whether litter was collected (**Table 11**).
- **bagID:** Transcribe from cloth bag, this is a unique string, written on the individual bag. If a collection label is lost, metadata can be recovered by linking the bagID to the fulcrum record for the collection event so this is important to record accurately.
- **Reset Trap:** Yes – creates a placeholder record for the next bout.

- **Toxicodendron Possible:** 'Yes', 'No'. Report 'Yes' if any *Toxicodendron sp.* is present anywhere in the plot, even if not present in the trap. There is no need to conduct a full survey of the plot, report Toxicodendron Possible = 'Yes' if a *Toxicodendron sp.* is visible in any direction from the trap.

14. If *Toxicodendron spp*. are present and *Toxicodendron* tissue may be present in the trap:
    a. Follow the guidelines established in TOS Standard Operating Procedure: Toxicodendron Biomass and Handling (RD[13]) and Appendix H to minimize exposure to toxic oils and for guidance on how to clean equipment.
    b. Collect the litter sample in a pre-weighed paper bag rather than the cloth bag.
    c. Label sample bags that may contain Toxicodendron with a sample warning label so samples will be handled with appropriate caution during downstream processing.
13. Record **remarks** if necessary.
14. Conduct necessary trap maintenance before navigating to the next trap.
    a. Repair damage to traps (i.e., screen holes, broken supports). If repairs cannot be completed that day, set status on Fulcrum record to "Trap Needs Repair", and return to repair as soon as logistically feasible.
    b. Trim vegetation under and around the trap that impacts trap function. New saplings that are pushing the screen up may be clipped if the trap is not located within a nested subplot utilized for vegetation structure. In forests with continuous vertical canopy, small low branches (< 2 m from forest floor) that have grown over the trap such that they interfere with trap sampling may be trimmed to the finest degree possible to enable access to the trap.

C.2 Litter Collection – Ground Traps

1. Locate the stakes marking the ground trap location.
2. Verify the trapID from the trap label and select the corresponding trapID record from the Fulcrum drop drown.
3. Assess and record **trapCondition** (**Table 12**).

Table 12. Modified **trapCondition** codes for ground traps.

Code	Description
OK	Litter collected - Trap in good shape, no issues
TE	Litter not collected – Trap empty
TB*	Litter not collected – trap blocked. Large branches or tree > 10 cm diameter have fallen over trap which may have diverted falling litter away from the trap.
PF	Litter collected – Trap previously flooded

* Do not use TB – trap blocked for traps with too much snow mounded to confidently collect all material, instead create a samplingImpractical record for the trap (**Table 7**).

   a. If **trapCondition** is blocked (code = TB), do not collect. If the obstruction cannot be cleared, move the ground trap to a new location using the list of sampling cells and either the random or targeted approach described in **SOP B.5**.

      i. Record the new **clipID** in the LTR: Trap Deployment app.

      ii. Clear all qualifying litter from the new sampling cell.

      iii. Do not collect. The trap must accumulate qualifying litter for a year prior to collection.

4. Wrap nylon cord around the four staked corners of the ground trap, delineating the trap edges.
5. Identify qualifying litter, including all litter particles (e.g., leaves, fronds, twigs/branches) which are:

   a. > 50 cm length, and

   b. < 2 cm diameter (averaged between major and minor axes if elliptical), and

   c. < 2 m from the soil surface (suspended litter, caught in overhanging vegetation, if within the 0.5 m x 3 m sampling cell, qualifies).

   Note: If non-woody tree fern stipes and/or palm frond components qualify for length and are > 2cm diameter, they still should be collected.

6. Material found in ground traps clearly originating from herbaceous plants present in the ground traps, and that would otherwise qualify for collection in the herbaceous clip harvest protocol (RD[19]), may be excluded from ground trap collections.

7. Cut off and discard portions of qualifying litter which extend beyond trap edges, retaining only the portion which lies within the trap perimeter, even if the retained portion is < 50 cm in length (**Figure 19**).

    a. This includes downed branches still attached to the tree bole (that is located outside the trap and not blocking it), cut as necessary according to size requirements.

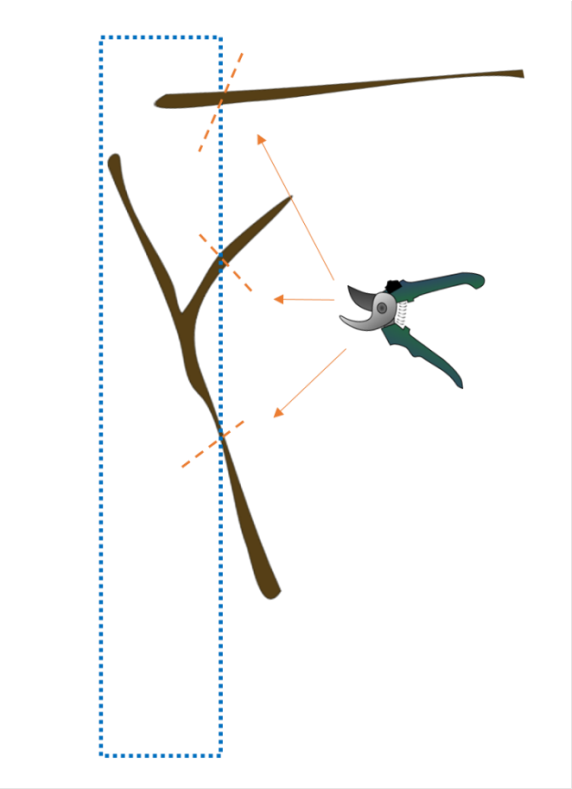

Figure 19. All particles >50 cm length qualify for collection (both particles here are > 50 cm), but only the portions located within ground trap boundaries (blue dotted line) are collected.

8. Cut off and discard portions of woody branches > 2 cm diameter (**Figure 20**).

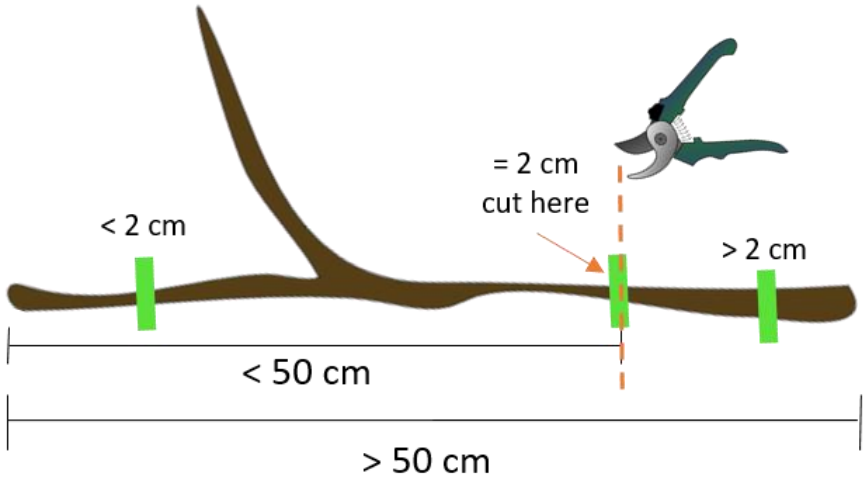

Figure 20. Discard portions of a qualifying particle that are > 2 cm diameter even if the resulting particle is < 50 cm in length.

9. Collect all remaining qualifying litter from within the ground trap and transfer material to a uniquely numbered cloth bag.
    a. Pieces may be cut into smaller lengths if they are too long to fit in the cloth collection bags.
10. Move remaining litter that is too large to qualify for collection outside of the ground trap boundaries to avoid re-assessing in future collection bouts.
11. Create a label with clipID, collectDate, trapType, and technician name (**Figure 18**), and attach to the bag.
12. Knot the cloth bag to prevent material from falling out while in transport, do not use draw strings if present on bags.
13. The mobile application for field sampling is a 'flat app' – i.e., there is no parent/child relationship between records. Each trap visited will have its own Fulcrum record with **plotID, subplotID,** and **trapType** pre-populated from the Deployment application based on the selected **trapID**. Record the following using the "LTR: Field Sampling [PROD]" mobile application:
    - **samplingImpractical:** Samples and/or measurements were not collected due to the indicated circumstance; defaults to 'OK'.
    - **collectedBy/recordedBy**
    - **weekBoutBegan:** Use XX format, where XX is the ISO week the bout began.
    - **yearBoutBegan:** The calendar year the collection bout began (i.e., the year associated with the **collectDate** for the first trap collected in a given bout) – typically the current year except

in rare cases where a collection bout begins late December and does not conclude until early January.

- **setDate:** The date the trap was set/reset; if the previous bout trapCondition = "OK" then setDate = the previous collectDate – i.e., the year prior for ground traps.
- **collectDate:** Use *YYYYMMDD* format
- **plotID:** SITE_###: Assigned by NEON Science.
- **subplotID:** See Appendix F for a plot map.
- **trapID:** Unique identifier for the trap location within the plot, designated by the clipID.
- **trapType:** Ground.
- **trapCondition:** Condition of litter trap and indication of whether litter was collected (**Table 12**).
- **bagID:** Transcribe from the cloth bag. This is a unique string, written on the individual bag. If a collection label is lost, metadata can be recovered by linking the bagID to the Fulcrum record for the collection event so this information is important to record accurately.
- **trapReset**: Yes, No
- **toxicodendronPossible:** 'Yes', 'No'. Report 'Yes' if *Toxicodendron sp.* is present anywhere in the plot, even if not present in the trap. There is no need to conduct a full survey of the plot, report Toxicodendron Possible = 'Yes' if *Toxicodendron sp.* is visible in any direction from the trap.

14. If a *Toxicodendron spp* is present and *Toxicodendron tissues may* be sampled:
    a. Follow the guidelines established in TOS Standard Operating Procedure: *Toxicodendron* Biomass and Handling (RD[13]) and Appendix H to minimize exposure to toxic oils and for guidance on how to clean equipment.
    b. Collect the sample in a pre-weighed paper bag rather than the cloth bag.
    c. Label sample bags that may contain *Toxicodendron* with a sample warning label so samples will be handled with appropriate caution during downstream processing.
15. Record **remarks** if necessary.

SOP D Post-Field Sampling Tasks

D.1 Document Incomplete Sampling Within a Site

Litterfall and Fine Woody Debris sampling is scheduled to occur at all prescribed sampling locations according to the frequency and timing described in Section 4 and Appendix C. 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 (gradient sites). However, sampling may be shifted from one location to another when sampling is compromised. In general, a sampling location is compromised when sampling becomes so limited that data quality is significantly reduced.

There are two main pathways by which sampling can be compromised. First, sampling locations can become inappropriately suited to answer meaningful biological questions – e.g., a terrestrial sampling plot is compromised after road-building activities, or a stream moves after a flood, and the location is no longer within the stream channel). Second, sampling locations may be in areas that are logistically impossible to sample on a schedule that that is biologically meaningful.

A given plot must be sampled at least 50% of the bouts expected over a two-year period (i.e., a minimum of 6 bouts per year, covering multiple seasons). Plots that cannot be sampled on this schedule should be considered compromised.

After a field sampling bout is complete, review all records created during that bout to verify a record exists for *every trap at the site*. The **trapCondition** field indicates whether or not a plot was successfully sampled; for this reason, there is no need to create a problem ticket for every time a plot/trap cannot be sampled. Staff Scientists will periodically review field data to determine if a plot has become compromised. Field Science may request a review of whether a plot is compromised by submitting a problem ticket.

If site management, natural disturbance events, or regeneration/succession occur such that the cover of vegetation is significantly changed (e.g., management of woody encroachment through removal of all woody vegetation in a grassland site), submit a problem ticket to Science HQ. Such activities will prompt a re-survey of vegetation in Tower plots and if total aerial cover of remaining woody vegetation > 2 m is < 10%, sampling will be discontinued at the site.

If sampling at a given plot is not possible during a given bout, a problem ticket should be submitted by Field Science staff.

To document locations not sampled during the current bout:

1. Review the completed sampling effort and create **Sampling Impractical** records as described in Section 4.5 for plots at which sampling was scheduled but was not completed.
2. To document whether a location is compromised according to the criteria above:

a. Review **Sampling Impractical** records from the *LTR: Field Sampling [PROD]* application and Portal data to identify locations where sampling was scheduled but was not completed due to environmental or site management factors.

3. Create an incident with the following naming convention to document the missed sampling and compromised location: 'TOS Sampling Incomplete: LTR– [Root Cause Description]'

   a. Example: 'TOS Sampling Location Compromised: LTR – Could not access plot for 2 consecutive bouts due to persistent flooding'

   a. **Reminder**: If Sampling Impractical = 'Location vulnerable to planned sampling' is used, a ServiceNow incident must be created to notify Science staff and to determine the best course of action moving forward.

Staff scientists review incident tickets periodically to determine whether a sampling location is compromised.

D.2 Equipment Maintenance, Cleaning, and Storage

1. Charge/replace laser rangefinder batteries, if necessary.
2. Charge GPS unit.
3. Visually inspect field collection bags for cleanliness and wear and tear:

   a. Rinse field collection bags as needed. Do not use soap, water only.

   b. Hang to air dry or tumble dry on low.

   NOTE: If field collection bags have hit their acceptable use lifespan – i.e., dirty beyond cleaning, torn, etc. – discard and purchase new ones.

4. Clean grinding mill and splitters.

SOP E Laboratory Processing for Dry Mass Measurement

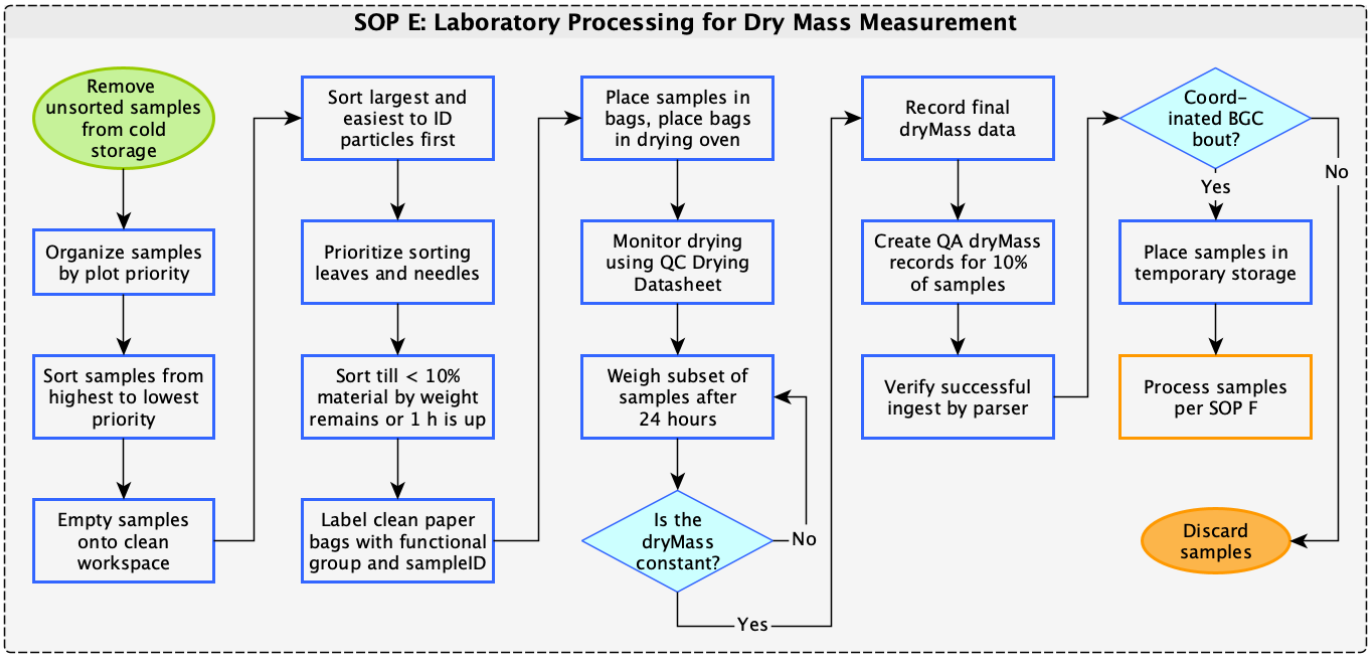

Figure 21. Workflow diagram of laboratory processing of litter trap samples. *Note, samples are discarded only after successful ingest by the parser and loading to the NEON database (PDR)*.

E.1 Preparing for Data Capture

Mobile applications are the preferred mechanism for data entry.

Data on dry mass values from litter samples are entered in the 'LTR: Lab Mass Data [PROD]' Fulcrum application. Data entry guidelines and instructions for using this app are available in the Fulcrum Manual or this protocol, available on the SSL.

Verify that the Field Sampling application has been synched, as the Lab Mass Data entry application references that application and provides a constrained list of field samples based on data uploaded from the Field Sampling effort.

E.2 Sorting, Drying and Weighing Litter Samples

- If litter and bags are very wet (i.e., dripping) or filled with snow, hang bags to melt and air dry for up to 24 hours before further processing.
- If transfer of arthropods or gastropods between sites is a concern, freeze collection bags for a minimum of 24 hours prior to sorting.
- Details regarding sample storage and sorting requirements are outlined below in **Table 13** in addition to the following reminders:

- If sorting immediately following collection is not possible, store samples in the refrigerator for up to a week from the date of collection to slow decomposition.
- If there is a delay transferring sorted samples to the drying oven, sorted samples may be stored in ambient conditions to begin air drying if space allows, for up to 7 days. Samples must be in breathable bags (i.e., muslin or paper) – no plastic!
- If sorting will not occur within 7 days or drying will not start within 7 days after sorting and ambient storage, move samples to the -20°C freezer (assuming samples were not previously frozen).
- Samples should not be moved back and forth between cold storage and ambient conditions – i.e., do not unfreeze, sort, and re-freeze a sample, follow direction instead in **Table 13**.

- If this is a BGC year according to the Inter-annual Schedule, samples for each functional group will be processed from the peak mass bout for chemistry and archive according to the criteria for bout selection outlined in SOP F. **Dried samples must be saved from each bout until the BGC bout is determined.**

Table 13. Sample storage and sorting requirements and timelines for processing in the laboratory.

Sample location in lab	Storage timeline	Requirements for sorting	Requirements for sorted sample
Fresh (ambient) sample	24 hours. Refrigerate if sorting cannot occur in that timeframe.	Sort within 24 hours.	Put in drying oven the same day sample is sorted.
Refrigerated sample	Can be stored in refrigerator for up to one week from day of collection.	Sort within one week of collection.	Put in drying oven the same day sample is sorted OR temporarily store at ambient conditions (ambient storage not to exceed 7 days)*
Frozen sample (delay in sorting by >1 week)	Can be stored in the freezer for up to 45 days from day of collection.	Sort after removal from freezer. Samples must be sufficiently thawed prior to sorting to avoid brittleness.	Put in drying oven the same day sample was sorted OR temporarily store at ambient conditions (ambient storage not to exceed 7 days)±

* This may be the preferred workflow if keeping all samples from a bout together and oven drying at the same time is a priority for lab logistics.

± This may be the preferred workflow if there is not enough staff to sort an entire bout in one day; in addition to other lab logistics described above.

Sorting, drying, and weighing steps

1. Order samples according to the Plot Prioritization list to ensure that the highest priority plots are always sorted even if sorting of all samples is not completed.
    a. Plot priority lists area available on Sharepoint in the TOS Support Library.
2. Assess the **sampleCondition** (**Table 14**). The **sampleCondition** field reports the status of a field collected sample when processed in the lab. For most records, **sampleCondition** = 'OK'; this is the default value for this field in the mobile application. However, if storage requirements are not met or a field collected sample is compromised or lost after collection such that it cannot be processed for dry mass, create records for each **fieldSampleID** for which no mass samples will be generated.
    a. If **sampleCondition** is 'Compromised' or 'Lost', create a record in the mobile application to document.
        i. If 'Compromised' is selected there will be a required 'Remarks' field to write a description of what happened to the sample(s).
    b. If the **sampleCondition** = 'Cold chain broken', create a parent record for the **fieldSampleID** to document the **sampleCondition,** then continue with sorting.
    c. If **sampleCondition** = 'OK', no action is required; this is the default value in the mobile application. Parent and child records may be created when samples are placed in the drying oven or when they are weighed.

Table 14. Litterfall sampleCondition values.

SampleCondition Code	Description	Sample handling	Field sample fate*	Mass sample fate*
OK	Sample(s) are okay, no issues	No changes	Processed	Discarded
OK - no mass for functional group**	Functional group is not present	Not an actual sample	Processed	Null
Cold chain broken±	Holding times in Table 13 were not met, and samples were not stored at required temperatures.	Add remark describing storage condition issues	Processed	Discarded
Compromised	Sample integrity compromised during collection, drying, or weighing	Discard	Rejected	Rejected
Lost	Sample lost after collection and before measurement of dryMass	None, sample lost	Lost	Lost
Gloves not worn for field collection (bgc bouts only)	Gloves were forgotten in the field	No changes	Processed	Active
Gloves not worn during lab sorting (bgc bouts only)	Gloves were forgotten in the lab	No changes	Processed	Active
Gloves not worn for field collection or lab sorting (bgc bouts only)	Gloves were forgotten in the field and the lab	No changes	Processed	Active
Other (specified in remarks)	Use if other values do not describe an anomalous condition of the sample	Remarks are required to describe sample condition	Processed	Discarded

* Field and mass sample fates are hidden fields in the LTR: Lab Mass application, this table includes what sampleCondition code triggers what fate for FS knowledge.

** This sampleCondition code is only applicable at the child level of the LTR: Lab Mass application and will be the default value where dryMass=0 grams.

± Use cold chain broken if fridge or freezers break during cold storage of samples.

3. Sort litter from each trap to litter functional group.

    a. If it is a 'BGC' year for the site, wear nitrile or latex-free gloves while sorting **all bouts** from elevated traps since it is not known ahead of time which bouts will be analyzed for a given functional group, thus all bouts should be sorted wearing gloves. Gloves will prevent contamination of litter from sweat and oils. Gloves may be re-used between samples.

    b. Clear adequate bench space in the laboratory.

c. Empty the cloth bag filled with litter onto the bench or sorting tray (material is easier to see against a light-colored surface). Turn collection bag inside out to verify all material is accounted for in the sorted samples.

d. Remove invertebrate bycatch. Place living individuals in the freezer to euthanize. Do not release invertebrates locally. Euthanized invertebrates may be disposed of with laboratory waste.

e. Sort litter to the functional groups defined in **Table 15** (Elevated trap collection bags) or **Table 16** (Ground trap collection bags).

   i. Limit sorting time to 1 hour. Any unsorted material after 1 hour may be grouped into the 'mixed' functional group.

   ii. Sorting may stop after less than 1 hour if < 10% of the initial mass remains.

Note: It may be useful to create a domain specific litter sorting guide to help streamline identification of litter material and overall sorting time.

f. Clean off any dirt attached to litter.

g. Cut or break any large seeds into smaller sections (i.e., dime size or greater). The primary goal is to break the seed coat to allow water to escape in the drying process; if seeds cannot be cut all the way through, partial cuts are acceptable for this purpose.

Table 15. Elevated trap litter functional group codes and descriptions (code is for use on paper data sheets, data entry application has the full functional group name).

Code	functionalGroup – Description
ELVS*	Leaves (including petioles, rachis, palm fronds or perennial tree fern fronds < 50 cm length, non-woody tendrils, and herbaceous stems).
ENDL	Needles/scales/awls from coniferous species.
ETWI	Twigs/branches < 2 cm diameter *and* < 50 cm length.
EWDY	Woody material (e.g., bark, woody seed cones, etc.).
ESDS	Seeds (including fleshy seed cones, fleshy or dry fruit, and associated structures).
EFLR	Flowers (including associated pedicels and pollen cones).
EOTR[±]	Other (cactus spines, bud scales, lichen, mosses, frass, mistletoe, unidentifiable material, etc.).
EMXT[±]	Mixed, unsorted, all litter functional groups included.

*Note, that if non-woody tree fern stipes and/or palm frond components qualify for length and are > 2cm diameter, they still should be collected.

[±] Only use EOTR for material that cannot be identified or does not qualify for another category; remarks indicating details of materials sorted with 'other' are optional. EMXT should be used for unsorted material in which individual particles may be identifiable, but sorting did not occur; use only if 1 hour sorting limit is reached, if only tiny fragments left to sort and material < 10% of total mass, or if directed by Science.

Table 16. Ground trap litter functional group codes and descriptions (code is for use on paper data sheets, data entry application has the full functional group name).

Code	functionalGroup – Description
GLVS*	Leaves and needles > 50 cm length (including petioles, rachis, palm fronds or perennial tree fern fronds > 50 cm length and non-woody tendrils).
GWDY	Woody material (e.g., bark, seed cones, etc.) > 50 cm length.
GTWI	Twigs/branches < 2 cm diameter *and* > 50 cm length (including non-qualifying material still attached to qualifying particle – i.e., moss/lichen/needles).
GOTR	Other (non-qualifying material previously attached to qualifying particle).
GMXT±	Mixed, unsorted, all litter functional groups included.

*Note, that if non-woody tree fern stipes and/or palm frond components qualify for length and are > 2cm diameter, they still should be collected.

± Use GMXT only if 1 hour sorting limit is reached, or if directed by Science. For woody particles from ground traps, still attached leaves, needles and lichen do not require special sorting or detaching. Likewise, if only one functional group was collected, particles that detach in transit may be sorted into 'other' functional group or sorted with original source functional group.

TIPS FOR EFFICIENT SORTING:

i. Quickly remove large or woody particles that are easy to ID and fast to sort (~3 mins).

ii. Weigh remaining material.

iii. Begin sorting, prioritizing leaves and needles, then sort remainder beginning with largest particles and working down in size.

iv. Periodically re-weigh.

v. When the weight of unsorted material is < 10% of initial weight (total collection, minus large and woody particles), stop sorting. Categorize remaining material as Mixed, unsorted.

vi. Continue to next sample even if 1-hour maximum sorting time has not been reached.

h. Label clean, unused, paper bags or coin envelopes to hold sorted litter functional groups from each trap.

- If it is a BGC year, only new bags or envelopes should be used to eliminate the risk of isotope cross-contamination.
- If it is not a BGC year, clean, undamaged bags or coin envelopes may be reused.

i. Include sampling information from the tag on the cloth bag, as well as the appropriate **litterCode** (**Table 15**, **Table 16**).

ii. Choose either 8# or 25# kraft bags, or smaller, or manila coin envelope depending on the quantity of litter.

iii. Pre-formatted stamps (**Figure 22**) with blank fields for all required information are optional and may facilitate consistent labeling of bags and organization of samples in drying ovens.

Figure 22. Pre-formatted stamp used in herbaceous clip harvest sorting and drying.

3. On the paper bag, write the **ovenStartTime** (24 hr. time, e.g. 1645 for 4:45 pm) and **ovenStartDate** (YYYYMMDD) that bags are placed in the drying oven.
    a. Place all bags from a given **clipID** or **collectDate** in the drying oven at the same time.
    b. ***Critical step***: Labeling bags allows assessment of how long different batches of bags have been in the oven, especially when litter collections from multiple days occupy the same oven. Additionally, organizing the oven by grouping samples from a given day in the same area will streamline the re-measurement process; samples may be located and removed for weighing without requiring a complete unloading of the contents of the oven.
4. Record the number of bags and the specific **litterCodes** present for each clipID on the "Sorting QC Datasheet".
5. Place bags of sorted litter in the drying oven/s until constant mass is attained.
    a. Non-woody functional groups (leaves, needles, seeds, flowers, other) must be dried for a minimum of 48 hrs. (2d) at 65°C.
        i. The "mixed" functional group (no lignified tissues present in the sample) should be dried the same as non-woody functional groups.
    b. Functional groups with lignified tissues (twigs/branches, woody, some seeds) must be dried for a minimum of 48 hrs. (2d) at 105°C.
        i. Mixed functional group (with lignified tissues present in the sample) should be dried the same as woody functional groups.
    c. If multiple drying ovens are available, (a) and (b) may occur simultaneously; otherwise, complete drying of litter material at 65°C before increasing the temperature to 105°C to dry lignified tissue. ***Woody material requires higher drying temperatures to release wood-bound water.***

6. Check the drying progress of litter bags using the generalized "Multi-Protocol Drying Datasheet" available on the SSL.
    a. Check the weight of the same subset of n=10 bags per **collectDate** after day 1, 2, 3, etc.
    b. Calculate the difference in weight between the latest two time points for each bag.
    c. Samples are dry when the average weight difference between the latest two timepoints = 0 (Mean delta between t1 and t2 across all n=10 bags = 0 ± 0.05 g or 0 ±1% of the t1 mass, whichever is greater).
7. Once constant mass is achieved, remove samples from the oven, one at a time, for final weighing.
    a. Record **ovenOutDate** and **ovenOutTime.**
    b. Material will be weighed from each functional group (i.e**., litterCode**) with a mass balance (0.01 g minimum measurement precision).
        i. Prolonged exposure to ambient humidity prior to weighing may affect the measurement. If material cannot be weighed immediately, store sorted material in labeled paper bags (8# or 25# kraft bags, or similar), inside a larger, sealed, plastic container (e.g., a black plastic garbage bag, plastic tub with lid, or equivalent).
        ii. If necessary, dried samples may also be stored for up to 30 days in ambient room conditions prior to weighing.
        iii. Samples stored after drying and not weighed within 1 h of being removed from the drying oven must be returned to the drying oven for 24 hrs. prior to weighing.
    c. Only trap + date combinations from which samples were collected will be available for **dryMass** data entry (i.e., **trapCondition** = OK or PF), except for trap empty (TE) records that WILL have a dryMass record.
    d. Verify that **dryMass =** '0' for all functional groups not present in the sample (except Mixed). The mixed functional group only requires a value if this category was used.
        - If the field sample was discarded or the trap skipped, no entry should occur for **dryMass** for any **functionalGroup**. ***Do not enter '0' for traps for which samples were not collected.***
        - ***HOWEVER, for traps that were empty one lab mass child record will be automatically created in the lab mass app upon finalizing the field app record. It will be a 'mixed' functional group with a dryMass of 0 grams that needs to be opened and saved to ingest the database, this is important data for the end user. Do not forget this step!***
    e. Record the **dryMass** to the nearest 0.01 g.

i. If material weighs >0.01 g, only record to the nearest 0.01g precision – i.e., finer precision is not required.

ii. If material weighs <0.01 g, record the actual value from the balance. For example, if a very small sample registers as 0.008 g, record **dryMass** = 0.008 (finer precision is not required, to the nearest thousandth is sufficient).

iii. If a sample exists but the balance does not register material, record value as 0.005 g.

f. For large volumes of biomass that do not readily fit into a large weigh boat, use any of the following strategies:

- Crush or chop the biomass to reduce volume so it will fit into a weigh boat.
- Use an HDPE tray, 'larval tray' plastic box lid (or equivalent) instead of a weigh boat.
- Avoid splitting biomass into subgroups for weighing as this will increase the total amount of error introduced by the weighing process.

g. Return litter samples to temporary storage until all data have been successfully ingested into the NEON database or processed for chemistry and archive.

h. During 'BGC' years, determine whether the bout will or may be used for chemical analyses and archive before discarding material; see SOP F for more details.

Note: Paper bags or a large piece of cardboard may absorb atmospheric moisture resulting in skewed mass measurements. If using a paper or cardboard container as a weigh boat, the balance must be zeroed out immediately prior to adding litter mass for each measured sample, or such containers should be avoided in humid environments.

8. Re-weigh a subset of mass samples to assess uncertainty associated with the measurement process.

a. QA measurements must be completed by a different technician than the person who originally weighed the sample.

b. For each **eventID**, select a random subset of 10% of dried, previously weighed samples for re-weighing.

i. The method for selecting samples for QA is at the discretion of the staff completing biomass measurements but the goal is to select an unbiased subset (i.e., not just the largest samples, or the first or last 10% of ordered samples; rather, choose the 10% QA subset from throughout the collection of dried samples).

ii. If QA weighing does not occur coincident with initial measurement, dried samples may be stored as described above then returned to the drying oven for 24 hrs. prior to QA weighing.

c. Create a new child record for the sample being re-weighed.

i. This will result in 2 child records, with differing **qaDryMass** values, for each **massSampleID** selected for QA.

d. Record the **weighDate.**

e. Record QA **dryMass** to the nearest 0.01 gram.

f. Record **qaDryMass** = 'Yes'

g. Return litter samples to temporary storage until all data have been successfully ingested into the NEON database or processed for chemistry and archive.

9. If it is a BGC year for the site:

a. Record **biogeoSample** = 'Yes' if the samples will be processed for chemistry and archive.

b. Record **biogeoSample** = 'Maybe' if the bout is under consideration for BGC processing.

c. Return biomass samples to paper bags and store them together in a large plastic bag or clean rigid tote (e.g., Action Packer), seal, and place in temporary storage.

i. Label the container with the litter functional group and date.

d. Samples in temporary storage can then be prepared as time permits for leaf chemical analyses and archive (SOP F) according to the holding times specified in **Table 4**.

i. Target time for processing leaf and needle samples = within 90 days of collection, though more time may be needed if material from a non-fall bout is selected.

ii. Other functional groups may be processed within 180 days, or have longer storage times until the peak mass bout for the entire year has been identified.

e. All other material may be discarded in a manner approved by the site host or domain office.

10. If the collection event has not been selected for chemistry analyses and archive, discard all litter material and paper bags used for drying after data have been successfully ingested to the NEON database. Reuse of clean, undamaged coin envelopes is acceptable, but do not reuse paper bags for subsequent bouts.

11. Record the appropriate samplePrepMethod (**Table 17**) to document any frozen storage prior to drying.

a. The default value will be 'Stored ambient or refrigerated' in the Fulcrum application.

Table 17. **samplePrepMethod** values for indicating storage conditions.

SamplePrepMethod	Description
Stored ambient or refrigerated	Sample not stored in freezer at any point
Stored frozen	Sample stored in freezer at any point

SOP F Processing Litter Samples for Chemistry and Archive

Dried litter samples collected from elevated traps are ground and submitted for chemistry analyses and archive at each site, every five years. Criteria for which bout is selected is by functional group – i.e., an early-season bout may be selected for chemical analysis and archive of woody material, and a later-season bout may be selected for leaves and needles. The leaf and needle samples are pooled at the plot level for chemistry and archive processing, while all other functional groups are pooled at the site level.

Verify with the Domain Manager and cross-check the TOS Inter-annual Schedule to ensure that the current year is scheduled for litter chemistry and archive before processing and eventually shipping samples.

Data entry guidelines and instructions for using the 'Litter: BGC Sub-Sampling [PROD]' Fulcrum application are provided in the Fulcrum Manual for this protocol, available on the SSL.

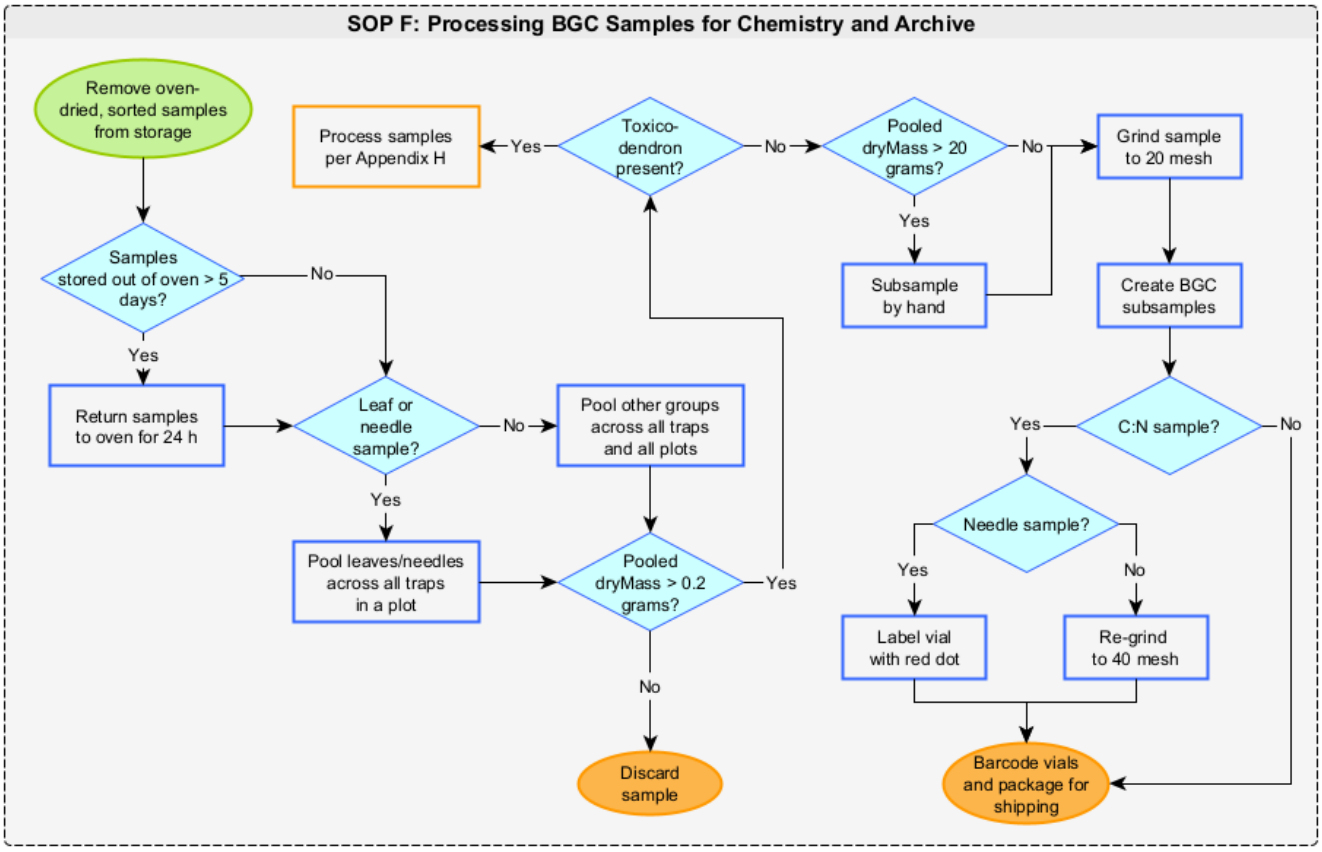

Figure 23. Workflow diagram for Biogeochemistry (BGC) subsampling.

F.1 Bout Selection

For chemistry and archive processing, use the following guidance to select bouts depending on functional group:

- **Leaves**: Select the bout with the greatest leaf mass from the period of peak senescence. If there is no peak, select the highest mass bout where the trapping duration does not exceed 1.5 months.
- **Needles**: Select a collection bout that maximizes the ability to generate different chemistry subsamples (i.e., C:N, lignin) while also representing the most plots. In other words, select a bout that maximizes BOTH the needle mass AND the number of traps from which needles were collected. Exclude bouts where trapping duration exceeds 1.5 months. See Box 1 below for scenarios.
- **Other** functional groups: Select the highest mass collection bout from the entire year for that functional group type, regardless of trapping duration.

Identify these bouts using the following procedure:

1. After collecting dry mass measurements, save dried samples.
    a. For all functional groups except leaves and needles, pool samples into a single paper bag (or more as needed to contain the entire mass). Label the bag with the **eventID** and **functionalGroup**.
    b. For leaf and needle samples, maintain bags or envelopes at the trap level.
2. Note the summed mass for each functional group for the bout (and per plot for needles), calculated from mass data records, or retrieve these values from the Litter QC Shiny application.
3. Place dried samples for any bouts that may be candidates for BGC processing in temporary storage. Material from non-candidate bouts does not need to be saved.
4. At the end of the season, process the highest-mass bout per functional group for chemistry and archive, considering the criteria outlined above and in Box 1 below.
5. If there are questions about which bout should be selected, reach out to Science to discuss.

Box 1. Scenarios and decision making for selecting needle bouts for chemical analysis and archive.

Note: These scenarios are most likely to occur at sites where needle production is low relative to other functional groups, or where needle-bearing trees are heterogeneously distributed across plots.

Scenario 1: The litter collection bout with the highest total needle mass contains samples from four plots, yet all masses are too small to support lignin or archive subsampling. The next highest mass bout contains samples from three plots, but in at least one of those there is enough mass to support lignin subsample creation.

Solution: Select the second highest mass bout to prioritize getting more kinds of chemistry subsamples.

Scenario 2: The litter collection bout with the highest total needle mass only contains material from two plots, yet all three subsample types can be created in each. The next highest mass bout contains material from seven plots, in five of these both CN and lignin samples can be created and in two of those an archive sample can also be created.

Solution: Select the second highest mass bout to get a better spatial distribution of samples without sacrificing subsample types.

Scenario 3: The litter collection bout with the highest total needle mass had a trapping duration of 72 days. Regardless of the spatial coverage or number of subsamples, this bout cannot be considered for chemistry subsampling since the trapping duration is >1.5 months (i.e., 45 days).

Solution: Select the next highest mass bout that yields the best balance of plot coverage and subsample types as discussed above.

F.2 Pooling, Grinding, and Subsample Creation

For leaf and needle samples, domains generate a maximum of one leaf sample and one needle sample per subsample type (C:N, lignin, archive) per plot (**Figure 24**). All other functional groups are pooled at the site level, resulting in one sample per subsample type (C:N, lignin, archive) per site (**Figure 25**).

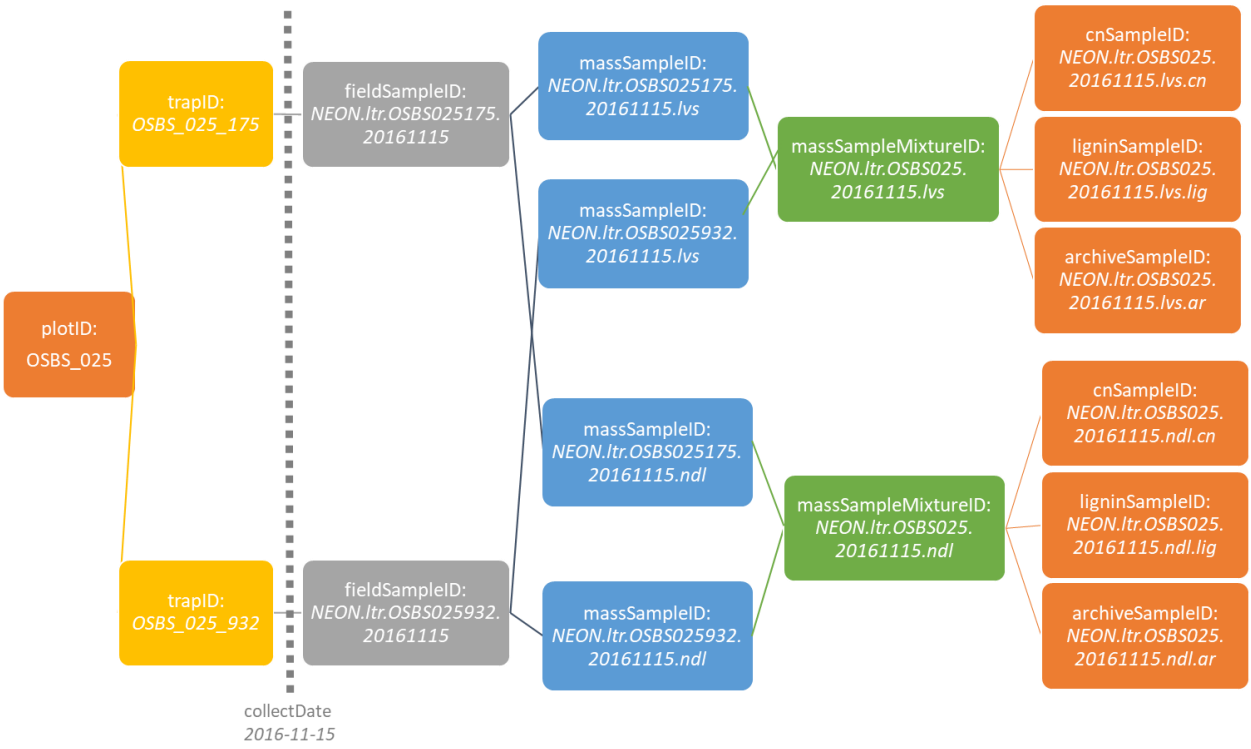

Figure 24. Anatomy of a **sampleID** for leaf and needle samples, pooled at the plot level. Note, if samples from only one trap are created, a **massSampleMixtureID** must still be created. Data generated maintain traceability to original trap locations.

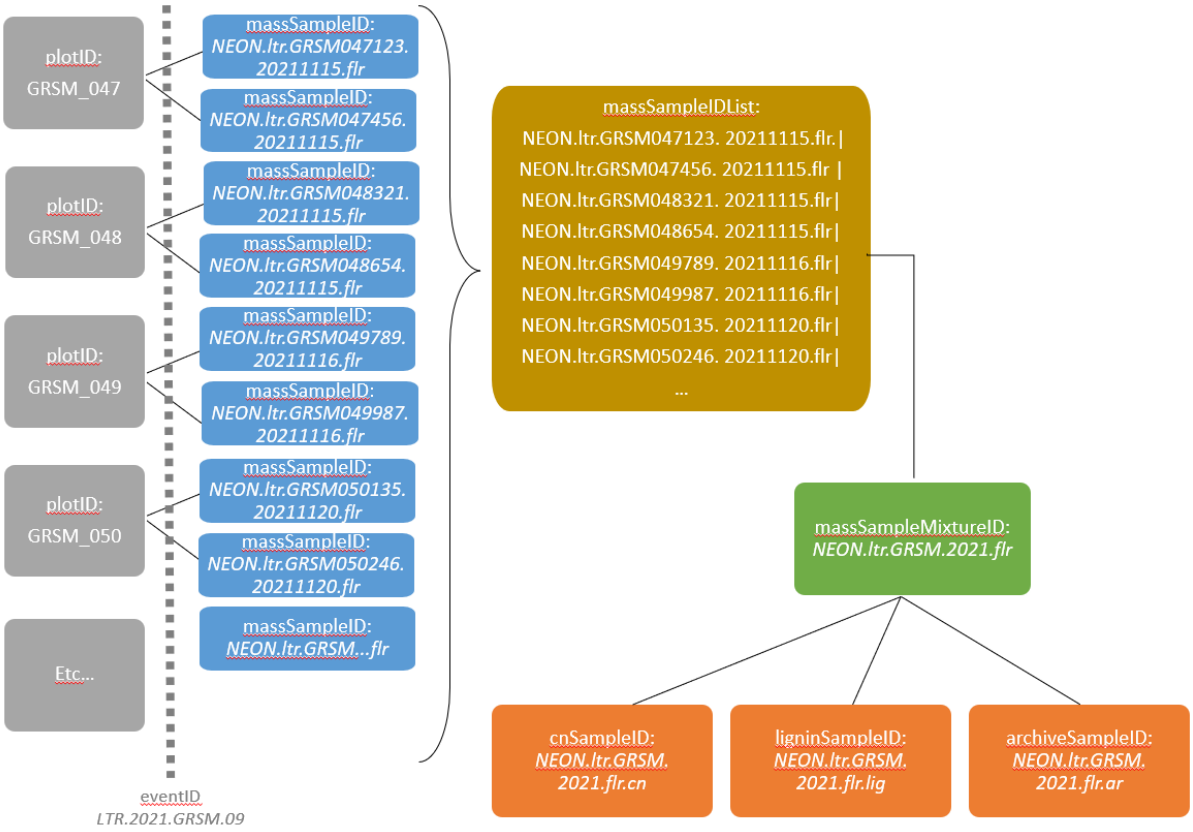

Figure 25. Anatomy of a **sampleID** for twig, woody, seed, flower, mixed, and other samples, pooled at the site level. Note, a **massSampleMixtureID** must still be created regardless of the number of samples that contribute to the pooled sample. Data generated maintain traceability to the site and year of sampling.

Oven-dried samples that have been stored out of the oven for > 5 days prior to processing for chemistry and archive must be re-dried at 65°C for a minimum of 24 hours before grinding and subsampling. This will ensure consistent sample condition for long term archive and prevent any continued decomposition or microbial activity.

1. Wear a pair of Nitrile (Latex-free) gloves when handling and subsampling foliage and while handling equipment used to process material intended for chemical analyses. Gloves may be used for >1 sample but should be changed if they become visibly dirty or coated in sap or residue. Rinse with ethanol between samples.
2. Review **toxicodendronPossible** data recorded during the field sampling event and pool samples with the appropriate safeguards as needed.
    a. If **toxicodendronPossible** = 'No' for all samples:
        i. Pool dried material: each pooled sample will contain only one functional group.

1) Leaf and needle samples: In a clean container, combine material from all (one or two) elevated traps in a given plot to generate a mixture for each functional group for each plot for the selected bout (**Figure 24**).

2) Twig, woody, seed, flower, mixed, and other samples: In a clean container, combine material for all elevated traps to generate a single mixture for each functional group for the site for the selected bout (**Figure 25**).

ii. Place litter material in totes if the pooled sample is large (e.g., 5-Gallon bucket, Action Packer, etc.), or in paper bags if small. Small bins can be used to organize bags by functional group prior to pooling.

iii. If pooling occurs in a large container, either use a plastic bag liner that can be changed between pooled samples, or clean between uses with laboratory soap (Contrex, Alconex, or similar), rinse several times with tap water, and perform a final rinse with house DI. Wait for the container to dry before re-using.

b. If **toxicodendronPossible** = 'Yes' for ≤ 5 samples:

i. Exclude the samples where **toxicodendronPossible** = 'Yes' (individual samples should have a warning sticker affixed to the dried sample bag.

ii. Discard in a manner approved by the site host or domain office.

iii. Pool samples with **toxicodendronPossible** = 'No' by functional group (either plot or site scale as described above).

1) If pooling occurs in a large container, either use a plastic bag liner that can be changed between pooled samples, or clean between uses with laboratory soap (Contrex, Alconex, or similar), rinse several times with tap water, then perform a final rinse with house DI. Wait for the container to dry before re-using.

c. If **toxicodendronPossible** = 'Yes' for > 5 samples:

i. Pool samples by functional group (either plot or site scale as described above), place litter material in a tote lined with a plastic bag (large sample) or pool samples in a paper bag stored in the tote (small sample).

ii. Process according to Toxicodendron-specific instructions (**Appendix H**).

iii. Thoroughly clean and decontaminate totes that have contacted Toxicodendron with Tecnu once the sample has been processed, as outlined in RD[06].

3. Weigh the pooled mixture. Do not save and process for chemical analysis if dry mass is < 0.2 grams.

a. If the pooled mass is > 20 g, subsample material by hand before further processing:

i. With a nitrile gloved hand, coarsely crush material into a clean container (e.g., bucket for substantial amounts of material, bowl for less).

ii. Break large, bulky particles into smaller pieces to create an even blend.

1) Pinecones or large woody pieces may be placed in a cotton bag and smashed with a rubber mallet.

2) Twigs and small diameter pieces may be broken by hand or cut with a pruner to create particles roughly 5 cm in length.

3) Large leaves may be lightly crushed by hand.

4) Other methods that do not result in loss of material and do not contaminate samples are acceptable.

iii. Mix thoroughly and haphazardly select one or several handfuls of material, ~20 g to grind and process for chemical analysis.

Note: Use a balance to achieve the target mass for the first couple of samples but after this initial 'calibration,' it is okay to estimate sample quantity by eye.

4. Clean the Wiley Mill and all its metallic accessories (splitter, mesh, etc.) before grinding, to remove any debris adhered to the equipment and prevent cross contamination. Use canned air or a vacuum, plus ethanol if there is evidence of resin. Also clean the other equipment used in the grinding process (funnel, collection cup), including use of canned air or a vacuum to remove coarse debris, plus an ethanol + lab wipes treatment to remove fine sample residues.

5. Based on the starting mass of the sample prior to grinding and splitting, note which samples will be created based on the mass thresholds noted below and in **Table 18**.

6. If the combined dry mass from the selected trap(s) for a given functional group is < 2 grams but > 0.2 g, there is no grinding and all of the sample goes for carbon-nitrogen analyses (**Table 18**).

7. If the combined dry mass from the selected trap(s) for a given functional group is > 2 grams, coarsely grind material with a Wiley Mill (0.85 mm, 20 mesh size).

a. Steadily pour the sample into the mill and push/crush it into the funnel using the wooden dowel, do not feed material piece by piece.

b. Continue grinding until no more material is observed exiting the grinding compartment. Depending on the species, a significant amount of material may remain stuck in the mill.

Table 18. Sub-sampling guidelines for C:N, Lignin and Archive subsamples.

Initial Dry Mass Before Grinding	Samples to Create			Processing Guidelines
	C:N (plastic vial) *Final minimum mass = 0.2 g*	**Lignin** (plastic vial) *Final minimum mass = 1 g*	**Archive** (glass vial) *Final minimum mass = 3 g*	
< 0.2 grams	-	-	-	Do not create subsample, discard all material.
0.2 – 2 grams	X	-	-	Do not grind, place entire sample in scintillation vial. Use gloved hand to crush if necessary to fit.
2 – 6 grams	X	X	-	Grind sample, distribute 1/4 sample to C:N* and 3/4 sample to lignin.
6 – 15 grams	X	X	X	Grind sample, distribute 1/4 to C:N*, 1/4 to lignin, 1/2 to archive.

*See Step 11, non-needle material may be further redistributed to facilitate grinding to 40 mesh

8. After grinding, collect material adhered to the glass cover or interior of the mill (common when grinding needles).
    a. Remove the glass face, loosen the screen, knock the screen into the collection jar 3-4 times, then wipe the inside of the grinding mechanism and glass plate with a paint brush to collect ground material. Vigorously flick material from the paint brush bristles between samples to clean.
9. Use an appropriately sized splitter or microsplitter to generate subsamples. Never use a scoop to subsample, only grind full splits. Using a splitter ensures particles of all sizes are split evenly, whereas using a scoop may lead to some subsamples having larger/smaller particles than other subsamples.
    a. Split the sample once:
        i. If dry mass is > 6 grams, one half will be the Archive sample.
        ii. If dry mass is < 6 grams, this first half will contribute to the Lignin sample. There will not be an archive sample.
    b. Split the remaining material in half again:
        i. Half will contribute to the Lignin sample. If dry mass is < 6 grams, combine with material from the first split.
        ii. The other half will be the C:N sample.

10. Verify the minimum mass is achieved for each sample (**Table 18**). If not, use the splitter to further redistribute material as needed. Always use full splits, never subsample with a scoop.
11. **For non-needle samples** that will be ground finer (next step), if the ¼ split for the C:N sample results in > 2 grams, split again with the splitter as many times as needed to achieve ~1 gram (roughly) for C:N. This should ensure sufficient, representative material is available for lab analyses without spending excessive time grinding extra material that the lab will not use.
    a. Do not subsample with a scoop, only use full splits.
    b. Add material from the other non-needed splits to the lignin or archive vials, or discard material if those vials are full.
12. **For non-needle samples**, take the material *from the C:N sample only* and re-grind it in the Wiley Mill with the 40-mesh attachment (0.42 mm mesh). Continue grinding until no more material is observed passing through the mill, grind another 30 seconds, then stop and consider the C:N subsample complete. Do not collect leftover material that is adhered to the mill.
    a. Needle C:N subsamples are not re-ground with the 40-mesh attachment given high resin content. Instead, label the scintillation vial cap with a red mark to alert the external lab facility that additional grinding is necessary before chemical analyses.
    b. If any of the non-leaf materials already have a fine, flour-like consistency after the first grind, it is not necessary to grind them to 40 mesh.
    c. **Do not re-grind lignin or chemistry archive subsamples**, only the C:N laboratory requires very finely ground material for analysis.
13. If an archive sample was generated, place a pre-labeled and barcoded glass scintillation vial on the balance and tare it, then transfer archive sample material to the vial and record **bgcArchiveMass** to the nearest 0.01 g.

Note: In low humidity conditions, static may impact efforts to transfer ground material to a plastic scint vial. Use of an anti-static gun may help manage static cling.

14. Place the remaining split sub-samples into 20 mL plastic scintillation vials with the barcode label already affixed and place a cryogenic label with the human readable sampleID vertically on the vial such that it does not interfere with the barcode label. If the vial is dusty with ground material, wipe it clean before adding the sampleID label so that it will be able to stick.
    a. SampleIDs are generated automatically by the mobile application. **Figure 24** outlines the relationships between samples and how sampleIDs are assigned. SampleIDs for leaf and needle samples are formatted as follows:
        - **massSampleID:** (from SOP E)
            - 'NEON.ltr.'clipID[no underscores].date.functional group code[just 'lvs' or 'ndl']
            - *Example:* 'NEON.ltr.OSBS025175.20151115.lvs'

- **massSampleMixtureID:** generated in step F.2
  - Remove the clip cell component from the **massSampleID**
  - *Example:* 'NEON.ltr.OSBS025.20151115.lvs'
- **cnSampleID:** massSampleMixtureID + '.cn'
  - *Example: '*NEON.ltr.OSBS025.20151115.lvs.cn'
- **ligninSampleID:** massSampleMixtureID + '.lig'
  - *Example: '*NEON.ltr.OSBS025.20151115.lvs.lig'
- **archiveSampleID:** massSampleMixtureID + '.ar'
  - *Example:* 'NEON.ltr.OSBS025.20151115.lvs.ar'

b. SampleIDs for all other functional groups are formatted as follows (**Figure 25**):

- **massSampleID:** (from SOP E)
  - 'NEON.ltr.'clipID[no underscores].date.functional group code
  - *Example:* 'NEON.ltr.TREE025175.20201015.sds'
  - This is only one of the many samples being pooled and will not be ingested
- **massSampleMixtureID**:
  - 'NEON.ltr.'+ yearBoutBegan + site + functional group for the samples being pooled
  - *Example:* 'NEON.ltr.2020.TREE.sds'
- **cnSampleID:** massSampleMixtureID + '.cn'
  - *Example: '*NEON.ltr.2020.TREE.sds.cn'
- **ligninSampleID:** massSampleMixtureID + '.lig'
  - *Example: '*NEON.ltr.2020.TREE.sds.lig'
- **archiveSampleID:** massSampleMixtureID + '.ar'
  - *Example:* 'NEON.ltr.2020.TREE.sds.ar'

15. Record which samples were created in the Fulcrum application.

a. For each subsample, select the **sampleID,** then scan the barcode label with the tablet (**Figure 26**).

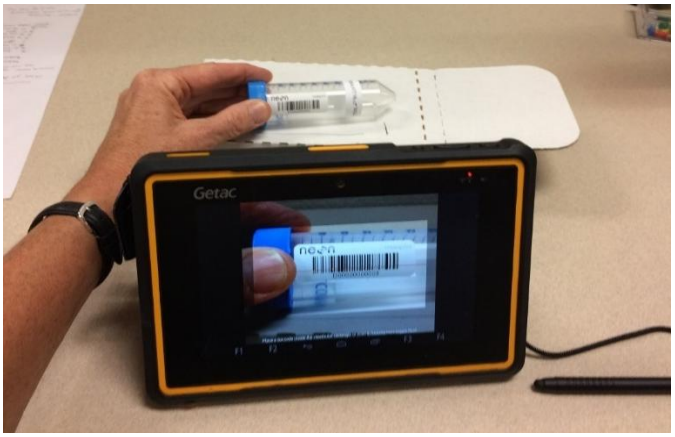

Figure 26. Barcode label scanning.

16. Clean the mill and all accessories in between grinding samples. Use canned air or a vacuum to remove coarse debris, followed by an ethanol wipe down to remove dust and resin. Clean the mill, all its metallic accessories (mesh, splitter), and any other equipment used in the grinding process (funnel, collection cup).
17. Repeat steps above for all samples.
18. Store subsamples in a dry location at ambient temperatures until they can be shipped to analytical facilities or the biorepository following the sample timing guidelines in **Table 4**.

SOP G Data Entry and Verification

G.1 Mobile Applications

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 field 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. Data collected on paper data sheets must be transcribed within 14 days of collection or the end of a sampling bout (where applicable). See RD[04] for complete instructions regarding manual data transcription.

Data are entered via the following Mobile or Desktop applications:

- **LTR: Trap Deployment**: Metadata describing trap placement.
- **LTR: Field Sampling**: Metadata describing individual sampling events on a per trap per eventID basis.
- **LTR: Lab Mass Data**: Oven-dried biomass data for each functional group per trapID per eventID, as well as weighing QA data.
- **LTR: BGC Sub-Sampling**: Lab processing for chemistry analysis and archive.

G.2 Sample Identifiers & Barcodes

By default, each (sub)sample produced by this protocol receives a sample identifier, which contains information about the location, date, and sample type. Each (sub)sample (leaf chemistry and archive samples) will also be associated with a scannable barcode, which will not contain information about sample provenance, but will improve sample tracking and reduce transcription errors introduced by writing sample identifiers by hand.

Adhesive barcode labels should be applied to dry, room temperature containers in advance of their use in the field (at least 30 minutes prior but may be applied at the start of the season). Barcodes are unique, but are not initially associated with a particular sample, thus it is encouraged to apply these in advance. Use the appropriate barcode label type with each container (i.e., cryogenic Type II barcode labels are only used for samples that are stored at -80°C, etc). Use Type I barcode labels for litter samples. Note that a barcode label is applied *in addition to* a sample identifier (hand-written or printed).

Barcodes are scanned into the data entry application when a sample is placed into a container; only one barcode may be associated with a particular sample. Do not reuse barcodes. If a barcode is associated with multiple samples, the data ingest system will throw an error and refuse to pull in entered data. If

multiple vials or containers are required to contain a sample from one trap, place the barcode on the outer container that will hold all vials associated with just that sample.

Data and sampleIDs must be entered digitally and quality checked prior to shipping samples to an external lab.

G.3 Entering and Uploading Field Data

1. For data collected on paper datasheets: Transcribe data into the appropriate data entry application in accordance with data entry and data QA/QC protocols (AD[05], RD[04]).
2. Use the LTR Data QA/QC Checklist and the "Catbird" LTR QC Shiny app, both linked via the SSL, to guide review of entered data.
3. Sync tablets daily to upload data collected via mobile applications to the NEON server.

   IMPORTANT: If tablets are not properly synced at the end of each field day there may be duplicate load attempts once it is synced and this will cause errors – i.e., a record with a load_status of 'LOADED' in Fulcrum will be reset back to 'NONE'.
4. If a trap had to be moved to a new location and data were recorded on paper data sheets, transcribe data from the '**Trap Deployment**' Datasheets to the "**LTR: Trap Deployment**" application.
5. If **trapMoved** = 'Yes' for a given field collection record, record data for new **clipID** in the trap deployment application.
   - **Reminder**: A ServiceNow request needs to be submitted for 'targeted' trap placement clipIDs to be loaded in the TOS: Clip List application.
6. Follow the procedure outlined in **SOP B.7** for remaining data entry for new traps.
7. Once all data from the most recent sampling bout have been collected and transcribed, submit data for ingest to the NEON database according to the guidelines provided in RD[04].

G.4 Quality Assurance

Data Quality Assurance (QA) is an important part of data collection and ensures that all data are accurate and complete. Certain QA checks can be conducted in the field (i.e., before a field team leaves a plot or site), while others can be conducted later in the office (typically within a week of collection). Field QA procedures are designed to prevent the occurrence of invalid data values that cannot be corrected later, and to ensure that data and/or sample sets are complete before the sampling window closes. Invalid metadata (e.g., collection dates, plotIDs) are difficult to correct when field crews are no longer at a sampling location.

Office QA procedures are meant to ensure that sampling activities are ***consistent*** across bouts, that sampling has been carried out to ***completion***, and that activities are occurring in a ***timely*** manner. The

Office QA will also assess inadvertently duplicated data and transcription errors to maintain data ***validity*** and ***integrity***. See the Data Management Protocol (RD[04]) for more discussion of QA measures.

Before samples ship to external facilities and/or their digital records load to the NEON database, the data must undergo thorough quality checks. The steps needed to accomplish this are outlined in the LTR QC Checklist, which is available on the NEON SSL.

SOP H Sample Shipment

Only subsamples from litterfall collection bouts selected for chemistry and archive are shipped to external facilities.

1. Follow sample shipping timelines in Section 4 to maintain appropriate sample hold times and storage conditions.
    a. Discrepancies between this protocol document and the Shipping Protocol should be communicated to Science.
2. Follow instructions in the NEON Protocol and Procedure: SCS – Shipping Ecological Samples, Sensors, and Equipment to ship samples to external laboratories or the biorepository (RD[20])

8 REFERENCES

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APPENDIX A QUICK REFERENCES

A.1 Delineating the Clip Cells for Litter Trap Placement

LOCATE AND ASSESS POTENTIAL SAMPLING CELL

STEP 1 – Locate southwest corner of sample plot - plot coordinate (0,0)

STEP 2 – If no woody vegetation is present in the plot, record targetTaxaPresent = "No"

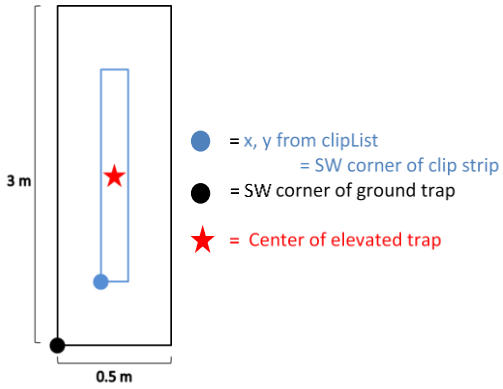
STEP 3 – Select the first available sampling cell from the *LTR: Trap Deployment* app.

STEP 4 – Use Appendix G to determine the x-y coordinates for the trap.

STEP 5 – Locate the Y-coordinate with the laser rangefinder in HD mode (azimuth 0°) and place a pin flag.

STEP 6a – For an elevated trap: Locate the sampling cell centroid.

STEP 6b – For a ground trap: Locate the sampling cell SW corner.



STEP 7 – Assess the suitability of the sampling cell for litterfall sampling. Reject if not suitable.

DELINEATE 0.5 M X 3 M SAMPLING CELL

STEP 1 – Place one stake in the SW corner of the sampling cell.

STEP 2 – Use the laser rangefinder or a handheld compass to determine the azimuth and use a tape to measure the distance between points to locate the remaining three corners of the cell.

STEP 3 – Check the distance between all four corners with a ruler or tape measure. Use a handheld compass to check the N/S orientation.

STEP 4 – Monument the corners of the sampling cell with aluminum stakes.

A.2 Litter Trap Status Codes

Elevated

Code	Description
OK	Litter collected - Trap in good shape, no issues
TE	Litter not collected – Trap empty
HO	Litter not collected - Holes large enough for leaves to pass through. Holes near the base of the screen (the lowest hanging point) are of greater concern than holes on the side of the screen.
TB*	Litter not collected – trap blocked. Large branches or leaves (especially palm fronds) present in or above the trap, which may have prevented the trap from collecting litter or diverted falling litter away from the trap.
TT	Litter not collected – trap tilted ≥ 10° (use clinometer on compass to measure)
RE	Litter not collected – trap broken
PF	Litter collected – Trap previously flooded

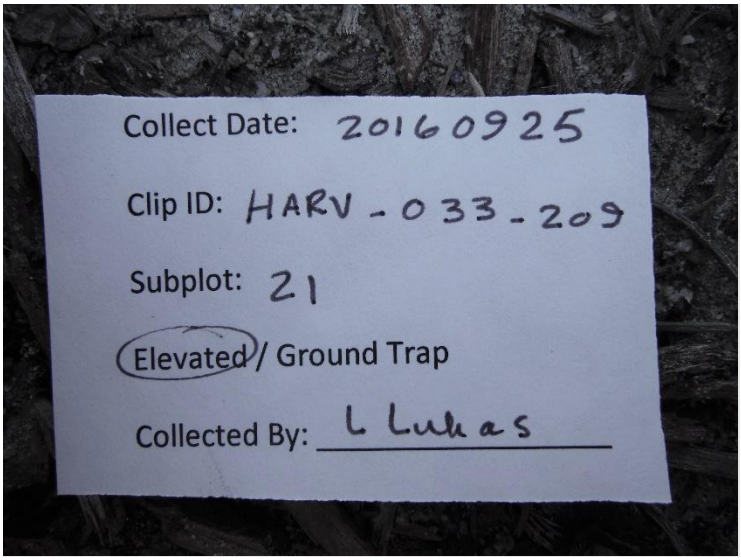
* Do not use "TB – trap blocked" for traps with too much snow mounded to confidently collect all material, instead create a samplingImpractical record for the trap (**Table 7**).

Ground

Code	Description
OK	Litter collected - Trap in good shape, no issues
TE	Litter not collected – Trap empty
TB*	Litter not collected – trap blocked. Large branches or tree > 10 cm diameter have fallen over the trap which may have diverted falling litter away from the trap.
PF	Litter collected – Trap previously flooded

* Do not use TB – trap blocked for traps with too much snow mounded to confidently collect all material, instead create a samplingImpractical record for the trap (**Table 7**).

A.3 Example Field Collection Label



APPENDIX B REMINDERS

Before leaving the DSF, double check that you have:

- ☑ Plot map
- ☑ Trap repair supplies
- ☑ Uniquely numbered cloth bags
- ☑ Labels for cloth bags
- ☑ Devices
- ☑ Clipboard w/ datasheets and protocol
- ☑ Measuring tools for diameter and length of twigs
- ☑ Rubber bands to seal cloth bags
- ☑ Nitrile gloves (if BGC year)
- ☑ Writing devices
- ☑ Compass (declination corrected)

After completing field collection:

- ☑ Inventory all samples, make sure your count of bags matches the number of records for successfully collected traps.
- ☑ Place all bags in the refrigerator or hang to dry if wet.
- ☑ Place all bags in the freezer if sorting will be delayed for more than 1 week,, ensure they are no longer wet first.

Before sorting:

- ☑ Pre-label several paper bags with the fieldSampleID prior to sorting.
- ☑ Add functional group designator once sorting is complete and functional groups are known.

Before weighing:

- ☑ Weigh samples within 1 hr. of removing from the oven.
- ☑ If weighing is delayed, then return samples to oven for 24 hr. before weighing.

Before grinding for chemistry analyses and archive:

- ☑ In a BGC year, use the Litter QC app to determine which bout should be kept per functional group.
- ☑ Remember to wear nitrile gloves during any handling of litter samples processed for BGC.

APPENDIX C ESTIMATED DATES FOR ONSET AND CESSATION OF SAMPLING

The dates in the table below are estimated from satellite MODIS-EVI phenology data averaged from 2012-2021 (Didan 2023), with the exception that dates for D04 and D20, which are relatively invariant with respect to greenness, are derived from precipitation data. Dates presented here are only a guide and are derived according to the logic presented in Section 4.2. Because individual years may vary widely from the average dates provided below, 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.

The 'average Greenness Increase' date is a proxy for the beginning of spring. At seasonal sampling sites, this indicates when collection of winter litterfall should occur and the beginning of the regular sampling season. Beginning and average end of senescence indicate the period of time during which leaf fall occurs and fall sampling interval is necessary at sites dominated by deciduous vegetation. NLCD vegetation classification listed is based on the dominant vegetation found in the tower airshed.

Sampling schedules may be modified based on local conditions, for example, if the NLCD vegetation class is identified as 'Mixed Forest' but plots are almost entirely coniferous trees, sampling may be shifted to 'Monthly, Year-round' even though the table specified 'Spring + Senescence' or 'Hybrid' sampling schedule. Dates are only listed for sites with forests where intensive sampling during fall senescence is anticipated; all other sites are sampled once a month all year or not at all. If the sampling schedule or dates in **Table 19** below no longer reflects what is occurring in the field, an incident should be created to discuss with Science staff so that modifications can be made.

Non-forested sites with estimated < 25% cover may be subject to additional vegetation surveys to determine mean cover of woody vegetation > 2 m across all tower plots (see RD[17]).

Table 19. Site-specific sampling schedule and strategy, and estimated sampling dates.

Domain	Site code	Primary Airshed NLCD	Trap Location Selection	Suggested Sampling Schedule	Average Greenness Increase	Beginning of Senescence	Average End of Senescence	Ground trap Collection	Remarks
01	BART[±]	Mixed Forest	Random	Hybrid	28-Apr	9-Aug	10-Nov[§]	May	
	HARV	Mixed Forest	Random	Hybrid	22-Apr	7-Aug	7-Nov	April	
02	BLAN	Deciduous Forest/ Pasture Hay	Random	Spring + Senescence	13-Mar	9-Aug	7-Nov	April	
	SCBI	Deciduous Forest	Random	Spring + Senescence	27-Mar	3-Aug	19-Nov	April	
	SERC	Deciduous Forest	Random	Spring + Senescence	17-Mar	9-Aug	21-Nov	March	
03	DSNY	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
	JERC[§]	Mixed Forest	Random	Hybrid	23-Mar	10-Sep	29-Dec	February	Sample schedule: 8-week interval during non-senescence, 4-week interval from beginning of senescence until senescence midpoint, then 2-week interval until dormancy
	OSBS	Evergreen Forest	Random	Monthly, Year-round				March	
04	GUAN	Evergreen Forest	Random	Monthly, Year-round				October	
	LAJA	Cultivated Crops		None					Schedule survey for qualifying vegetation every 5 y.

Domain	Site code	Primary Airshed NLCD	Trap Location Selection	Suggested Sampling Schedule	Average Greenness Increase	Beginning of Senescence	Average End of Senescence	Ground trap Collection	Remarks
05	STEI	Deciduous Forest	Random	Spring + Senescence	29-Apr	12-Aug	30-Oct[§]	May	
	TREE	Deciduous Forest	Random	Spring + Senescence	27-Apr	12-Aug	30-Oct[§]	May	
	UNDE	Deciduous Forest	Random	Spring + Senescence	30-Apr	13-Aug	30-Oct[§]	May	
06	KONA	Cultivated Crops		None					
	KONZ	Grassland Herbaceous	Targeted	Spring + Senescence	02-Apr	11-Aug	7-Nov	November	Recheck targetTaxaPresent= 'No' annually for qualifying vegetation
	UKFS	Deciduous Forest	Random	Spring + Senescence	22-Mar	11-Aug	12-Nov	November	
07	GRSM	Deciduous Forest	Random	Spring + Senescence	2-Apr	9-Aug	11-Nov	September	
	MLBS	Deciduous Forest	Random	Spring + Senescence	17-Apr	11-Aug	8-Nov	September	
	ORNL	Deciduous Forest	Random	Spring + Senescence	17-Mar	24-Jul	13-Nov	April	
08	LENO[§]	Woody Wetlands	Random	Hybrid	9-Mar	25-Jul	17-Nov	July	Sample schedule: 8-week interval during non-senescence, 4-week interval from beginning of senescence until senescence midpoint, then 2-week interval until dormancy

Domain	Site code	Primary Airshed NLCD	Trap Location Selection	Suggested Sampling Schedule	Average Greenness Increase	Beginning of Senescence	Average End of Senescence	Ground trap Collection	Remarks
	DELA	Woody Wetlands	Random	Spring + Senescence	1-Mar	17-Jul	11-Nov	August	Sampling discontinued after the 2025 season due to site decommissioning
	TALL	Evergreen Forest	Random	Monthly, Year-round				May	
09	DCFS	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
	NOGP	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
	WOOD	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
10	CPER	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
	RMNP	Evergreen Forest	Random	Monthly, Year-round				October	
	STER	Cultivated Crops		None					
11	CLBJ***	Grassland Herbaceous	Random	Hybrid	27-Feb	21-Jul	17-Dec	January	
	OAES	Grassland Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.
12	YELL*	Shrub Scrub	Random	Monthly, Year-round				September	
13	MOAB	Shrub Scrub	-	None					Schedule survey for qualifying vegetation every 5 y.

Domain	Site code	Primary Airshed NLCD	Trap Location Selection	Suggested Sampling Schedule	Average Greenness Increase	Beginning of Senescence	Average End of Senescence	Ground trap Collection	Remarks
	NIWO**	Evergreen Forest	Targeted	Monthly, Year-round				September	Recheck targetTaxaPresent= 'No' annually for qualifying vegetation
14	JORN	Shrub Scrub	-	None					Schedule survey for qualifying vegetation every 5 y.
	SRER	Shrub Scrub	Targeted	Monthly, Year-round				April	
15	ONAQ	Shrub Scrub	-	None					Schedule survey for qualifying vegetation every 5 y.
16	ABBY§	Evergreen Forest	Random	Monthly, Year-round				October	
	WREF	Evergreen Forest	Random	Monthly, Year-round				May	
17	SJER	Evergreen Forest	Targeted	Monthly, Year-round				November	Recheck targetTaxaPresent= 'No' annually for qualifying vegetation
	SOAP	Evergreen Forest	Targeted	Monthly, Year-round				August	Trap location selection changed from random to targeted in 2023 after 2 wildfires substantially altered forest structure
	TEAK	Evergreen Forest	Random	Monthly, Year-round				September	
18	BARR	Sedge Herbaceous		None					Schedule survey for qualifying vegetation every 5 y.

Domain	Site code	Primary Airshed NLCD	Trap Location Selection	Suggested Sampling Schedule	Average Greenness Increase	Beginning of Senescence	Average End of Senescence	Ground trap Collection	Remarks
	TOOL	Dwarf Scrub		None					Schedule survey for qualifying vegetation every 5 y.
19	BONA	Mixed Forest	Random	Hybrid	13-Mar	3-Aug	1-Oct	July	
	DEJU**	Evergreen Forest	Random	Monthly, Year-round				May	
	HEAL**	Shrub Scrub	Targeted	Monthly, Year-round				May	Recheck targetTaxaPresent= 'No' annually for qualifying vegetation
20	PUUM	Evergreen Forest	Random	Monthly, Year-round				September	

* *Litter sampling at YELL is suspended March 10 – July 1 each season due to annual closure of the Bear Management Area within the Tower Airshed.*

** *Litter sampling is not scheduled during wintertime months when site access is restricted due to heavy snow.*

*** *High production period in January, 2-week sampling interval employed during this peak.*

§ *Dates updated based on Field Ecologist request to better represent Tower plot phenology.*

± *Bout 01 is scheduled before greenness increase date (roughly week 15 or early April) to perform trap maintenance and collect litter from traps after wintertime snow.*

APPENDIX D SITE-SPECIFIC INFORMATION

D.1 Optimization Analysis

An analysis was conducted by NEON science staff in 2019 to determine whether a reduction in sampling scope was warranted for the litterfall and fine woody debris protocol. Statistical analyses were conducted using previously collected litter data to determine whether litter and fine woody debris measurements were sufficiently spatially homogeneous to reduce sampling or processing intensity, eliminate redundant sampling effort when possible, and maintain robust site-level litter production estimates and the ability to detect temporal trends.

Elevated Traps: Based on an analysis of sites that had a minimum of three years of data per site, reduction of sampling effort is supported at a subset of sites (**Table 20**).

Ground Traps: Production of fine woody debris that qualifies for ground trap collection is spatially and temporally heterogeneous; currently, reduction of ground trap number is not supported at any site.

Table 20. Elevated trap plot reduction optimization analysis results.

Domain	Site Code	Pre- 2020 Elevated Trap Number	2020-present Optimized Elevated Trap Number
D01	BART	40	20
D01	HARV	40	20
D02	SCBI	40	20
D02	SERC	40	20
D03	JERC	40	20
D05	TREE	40	30
D05	UNDE	40	20
D07	GRSM	40	20
D07	ORNL	40	20
D08	TALL	40	20

Use the Plot Prioritization list available on the Sharepoint Sampling Support Library or the TOS Spatial Data Fulcrum application to identify the priority plots to continue sampling elevated traps based on the Optimized Elevated Trap Number listed here.

D.2 Prescribed Burns

The following procedure should be followed at sites with prescribed burns:

1. Prior to a scheduled burn, collect litter samples as if conducting a regular sampling bout, even if a bout is not scheduled, or if collecting before the anticipated burn will occur “ahead” of schedule; include a remark describing why traps were collected early.
2. Remove traps from the plot so they do not burn.
3. Replace traps to their original location as soon as possible following completion of the burn. This date will be the new setDate.

a. Dates of removal of litter traps do not need to be recorded, as no litter production is expected during this period.

4. Resume the prescribed sampling schedule once traps are reset, even if the setDate for burned plots differs from non-burned plots (and the trapDuration may be less than the standard number of days).

   - If a trap cannot be reset before the next scheduled bout, and therefore that collection event will have been missed, then record a samplingImpractical record for the trap, and include a remark describing why the trap could not be reset.
   - Submit a SN incident ticket to notify HQ staff which plots and traps were affected by the prescribed burn and include details if biogeochemistry samples were impacted.
     - Best practice is to also create a site management and event reporting record as well.

   If traps are inadvertently burned before FS staff could remove them, and they are a non-biogeochemistry collection bout, and there is no damage to trap or screen that would otherwise prevent collection, then follow collection procedures as schedule but include a remark.

Burn sites include, but may not be limited to, the following:

Table 21. Field sites that regularly have prescribed burns.

Domain	Site Code	Site Name
D03	JERC	Jones Ecological Research Center
D03	OSBS	Ordway-Swisher Biological Station
D06	KONZ	Konza Prairie Biological Station
D08	TALL*	Talladega National Forest
D09	WOOD	Woodworth
D11	CLBJ	LBJ National Grassland

* At TALL, a raking method is deployed instead of removing the traps from the entire tower airshed before a scheduled burn. Crews lightly rake the litter around and underneath the trap away from the trap (12-18 inches), this acts as a fire break, and prevents the traps from burning/damage.

D.3 Fine Needled Species

Mesh size on elevated trap assembly kits is 1 mm. Particles < 1 mm diameter may be capable of passing through the standard mesh and may be underestimated in dry mass measurements, though field crews will attempt to collect material that passes through the trap mesh during collection activities.

Sites with known coniferous species with needles < 1mm diameter or at which needles have been observed to pass through elevated trap mesh during collection are summarized in **Table 22**.

Table 22. Sites with fine needled species capable of passing through 1mm mesh.

Domain	Site Code	Site Name	Species with needle width < 1mm
D01	HARV	Harvard Forest	*Picea mariana, Tsuga canadensis*
D01	BART	Bartlett Experimental Forest	*Picea rubrum, Tsuga canadensis*
D05	STEI	Steigerwaldt Land Services	*Larix laricina*
D05	UNDE	UNDERC	*Larix laricina*
D05	TREE	Treehaven	*Larix laricina*
D16	ABBY	Abby Road	*Tsuga heterophylla, Pseudotuga menziesii* var. *mensiesii*
D16	WREF	Wind River Experimental Forest	*Tsuga heterophylla, Pseudotuga menziesii var. mensiesii*
D19	DEJU	Delta Junction	*Picea mariana, Larix laricina*
D19	HEAL	Healy	*Picea mariana, Larix laricina*
D19	BONA	Caribou Creek - Poker Flats Watershed	*Picea mariana, Larix laricina*

APPENDIX E 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 23. Equipment list – Initial trap deployment, SOP B.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
	N	Non-oxidizable metal rods (e.g. aluminum, galvanized stainless steel, or equivalent) ~1 m length	Anchor trap to sampling location	4 per trap
Yardandpool.com #MYLS	N	Aluminum stake	Mark corners of ground traps	4 per trap
Ben Meadows #100952 Forestry Suppliers #39167	N	Chaining pins or other suitable anchor	Anchor measuring tapes	2
	N	Coin	Randomize selection of patches at sites with targeted selection	1
Ben Meadows #213379 Forestry Suppliers #37184 #37036	N	Compass with mirror and declination adjustment	Locate X, Y coordinates of within-plot trap location; alternative to high-accuracy laser rangefinder (with less precise rangefinder)	1
#EG07670000	Y	Elevated litter trap assembly	Collect litter sample	40-50
Greenhouse Megastore #SN-SC	N	PVC Snap Clamps	Secure screen to elevated litter trap	4 per trap
Compass Tools #703512 Forestry Suppliers #90998	Y	Foliage filter	Allow laser rangefinder use in dense vegetation	2
Forestry Suppliers #91567	Y	Laser Rangefinder, ½ foot accuracy	Locate X, Y coordinates of within-plot trap location	1

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
B&H #SISOK12601	Y	Laser Rangefinder, 1 yard accuracy	Measure distances. May be used, in conjunction with handheld compass, as an alternative to TruPulse	1
Ben Meadows #122731 Forestry Suppliers #40108 #39943	N	Measuring tape, minimum 30 m	Locate clip-harvest strips within plots/subplots. Plot slope < 10 deg; grassland, savannah	1
Grainger #3CYN7	N	PVC pipe cutter	Cut PVC to length	1
Home Depot #EM81.9	N	Torpedo bubble level	Check the angle of the elevated trap	1
Grainger #1F017	N	White reflector or reflective tape	Reflective target for laser rangefinder; aids in measuring distance to target accurately	1
Grainger #2RUV1	N	CR123A battery	Spare battery for laser rangefinder	2
	N	PVC pipe glue	Permanently attach PVC from the elevated trap kits	1 jar
Forestry Suppliers #33790 #3JVC4	N	Survey marking flag, PVC or fiberglass stake	Delineate sampling area	4 per trap
RD[05]	Y	Datasheets for Litterfall and Fine Woody Debris	Record required data and metadata	Variable
	Y	Per plot or subplot Clip Lists	Identify random clip-strip locations	
	N	Random number list	Randomize selection of patches at sites with targeted selection	1

Table 24. Equipment list – Field sampling elevated and ground litter traps, SOP C.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
Grainger #12U275 Grainger #2PRP6 Amazon #B001OK8MM8	N	Nylon rope	Delineate ground trap	1, 8 m
Yardandpool.com #MYLS	N	Aluminum stake	Replace stakes on damaged ground traps	4
Amazon #B016V82RKA	N	Cotton bags, uniquely numbered [1]	Carry fresh, potentially wet, litter samples	2 per trap pair
#EG07670000	Y	Elevated litter trap assembly	Replace damaged traps	2
	N	80 cm long, 0.5 in diameter PVC pipe	Replace damaged elevated trap leg pieces	As needed
	N	65.5 cm long, 0.5 in diameter PVC pipe	Replace damaged elevated trap frame pieces	As needed
	N	PVC right angle out, 3-way elbow, 0.5 in	Replace damaged elevated trap corner pieces	As needed
	N	122 cm x 122 cm, 1mm polyester window screen	Replace or repair damaged elevated trap screen	As needed
	N	6 in long, UV resistant zip-ties	Replace damaged elevated trap zip ties	As needed
	N	PVC slip coupling	Replace damaged elevated trap leg spacers	As needed
Compass Tools #703512 Forestry Suppliers #90998	Y	Foliage filter	Allow laser rangefinder use in dense vegetation	2
	N	Handheld caliper, 0.1 cm precision	Measure branch diameters	1
Forestry Suppliers #91567	Y	Laser Rangefinder, ½ foot accuracy	Locate X, Y coordinates of trap if thick brush prevents visual trap location	1

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
Grainger #3KMZ6 Forestry Suppliers #71166	N	Measuring stick, 1 m^2	Measure and identify/discard litter > 50 cm	1
Home Depot #300450094	N	Pruning lopper, heavy duty	Cut branches up to 2 cm diameter	1
Home Depot #EM81.9	N	Torpedo bubble level	Check the angle of the elevated trap	1
Fastenal #294561	N	Flush cut clippers	Cutting screen material or zip ties	1
	N	Screen patch kit (pieces of 1 mm screen, wire, window screen repair tape, wirecutters)	Repair minor holes in screen material	1
Amazon #B0D7ZTHK7V #B0CQL42BZK	N	Adhesive-backed screen repair patches	Repair small holes in screen material with a patch	As needed
Grainger #2RVU2	N	CR123A battery	Spare battery for laser rangefinder	2
Herbarium Supply #361	N	General Purpose Tags, may use rite in-the-rain	Label collection bags	2 per trap pair
Camcode: Metalphoto® XHT Barcode	Y	Anodized aluminum field barcode treated with XHT for fire resistance	(Optional) Barcode for traps that can withstand fire and temperatures up to 1200°F	1 per elevated trap
Camcode: Durable Tracking and Identification Tags MP XHT 2-Holes RC or MP XHT 4 -Holes RC	Y	Secondary option for anodized aluminum field barcode with fire resistance	(Optional) Barcode for traps that can withstand fire and temperatures up to 1200°F	1 per elevated trap
Express, Inc. Asset labels	Y	Anodized aluminum field barcode for trap	(Optional) Barcode for traps, come in a sheet of 100	1 per elevated trap

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
	N	Adhesive	(Optional) To glue trap barcode to pigtail stake (if applicable)	As needed
	N	Pigtail stake	(Optional) To affix trap barcode and put in ground next to trap leg (if applicable)	As needed
ULINE #S-21339	N	Sample warning pictogram label	Identify acute toxins that may cause serious eye or skin irritation. Samples contain *Toxicodendron* spp.	1 per container
	N	Nitrile gloves, powderless	Handle small-mass samples that will be processed for chemistry and archive	
	N	Work gloves, clean	Handle samples in traps that may be processed for chemistry and archive	
Grainger #12U275 Grainger #2PRP6 Amazon #B001OK8MM8	N	Nylon rope	Delineate ground trap	1, 8 m

[1] recommended size ~ pillowcase dimensions
[2] May also mark 50cm on plot frame with permanent marker.

Table 25. Equipment list – Laboratory processing and analysis SOPs E & F.

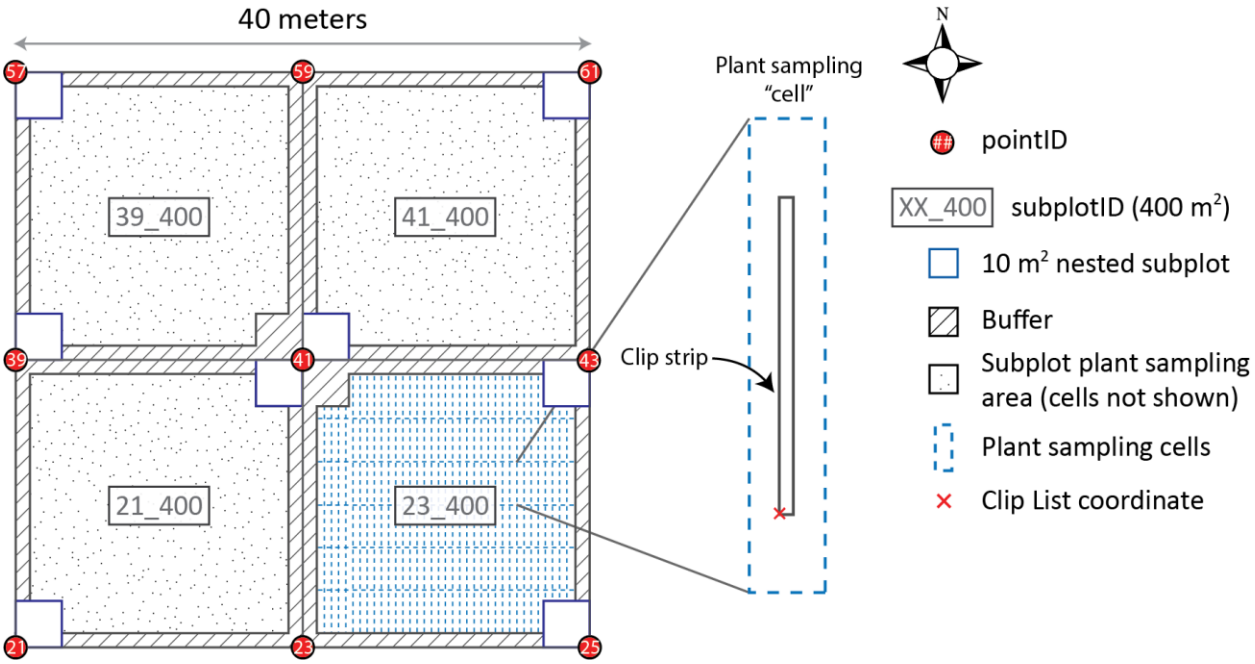
Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
Grainger #1TTX2 #2AJP4	N	Paintbrushes, assorted sizes	For use in sorting litter	4
Fisher #S90203 #02-401-7	N	Timer	Track sorting time and limit to one hour per field sample	1
	N	Domain specific litter sorting guide	Assist with identification of litter functional groups	1
Fisher #8732115	N	Weigh boats, assorted sizes	For weighing sorted material	4

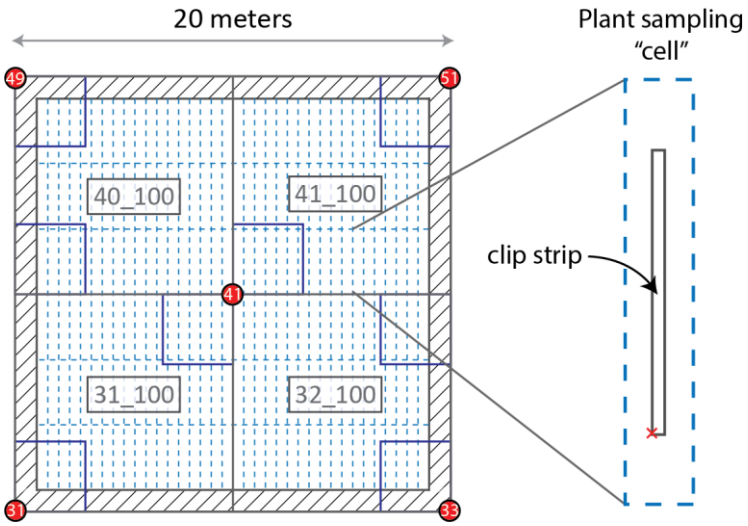
Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
#8732112				
Fisher #NC0516918	N	Hy back pan	Receive sub-samples generated by splitter	2 per splitter
Fisher #NC9052925	Y	Sample microsplitter, small capacity	Subsample from small volumes of ground sample. Little litter mass per litterCode per trap	1
Fisher #040G-010	Y	Sample splitter, large capacity	Subsample from large volumes of ground sample. Useful with fibrous leaves. Large litter mass per litterCode per trap	1
ULINE #S-7798 #S-6285 #S-14719 #S-6286 #S-14720 #S-5623 #S-11485 #S-12775 #S-17208 #S-11486 #S-17209 #S-11487	N	Paper coin envelopes, assorted sizes	Contain very small masses of sorted litter for drying	20
Grainger #12R027 #12R024 ULINE #S-7630 #S-13236 #S-11538 #S-13241	N	Paper bags, assorted sizes	Contain litter, sorted to functional group	50
ULINE #S-15706	N	12 x 18 blank newsprint paper	Clean, sharp contrast surface for sorting	As needed
Fisher #03-337-23C	N	Plastic scintillation vials with caps, 20 mL	Contain samples for shipment for chemical analysis	As needed
	N	Glass scintillation vials with caps, 20 mL	Contain samples for shipment to archive	As needed

Supplier/ Item No.	Exact Brand	Description	Purpose	Quan-tity
Fisher #19-176-550	N	Ethanol wipes	Quickly clean gloves, buckets, sample splitter, etc. between samples	
Fisher #15-930-C	Y	Adhesive cryo-labels (0.5 x 1.25 in)	Labeling sample containers with bgc sampleID labels	1 sheet
	Y	Type I adhesive barcode labels	Labeling sample containers with barcode-readable labels	1 sheet
Amazon #B0033SHDSS	N	Anti-static gun	Remove static charge from scint vials to prevent cling	1
	N	Nitrile gloves, powderless	Handle samples that will be processed for chemistry analyses	

APPENDIX F PLOT MAPS

40m x 40m (top) and 20m x 20m (lower) Tower Plots showing the location of 0.5m x 3m plant sampling cells (dashed blue lines). Subplot IDs are listed in gray for the 40m x 40m plot. The clip-strip coordinates provided to domain staff in the Fulcrum TOS: Clip List application are supplied on a per subplot basis (red 'X' in the figures). For sampling cell centroids, navigate 1 m North and 5 cm East from this point. To locate the clip cell / ground trap SW corner, navigate 0.5 m South and 20 cm West from the provided coordinates. Adjusted offsets, specific to litter sampling, are also available in Appendix G. Exclusion areas in 40m x 40m Tower Plots selected for Plant Diversity sampling are consistent with a 20m x 20m plot centered on the plot centroid. Sampling cells that overlap 10 m^2 nested subplots are not included in the randomized lists provided by NEON Science.





APPENDIX G CLIP CELL NUMBER COORDINATES AND MAPS

Targeted deployment of ground and elevated litter traps (SOP B) in habitats with non-continuous cover (< 50% of the plot area) of woody vegetation requires locating Clip Strips within "patches" of vegetation with overstory species ≥ 2 m. To identify trap location within woody "patches," first map out the location of patches within a selected subplot, use a random selection procedure to pick an individual patch then use the appropriate map in this Appendix to determine which clipCellNumber should be sampled. Use **Table 26** to find the easting and northing values associated with that Clip Strip so that it can be delineated at a known location relative to the SW corner of the 20m x 20m plot / subplot.

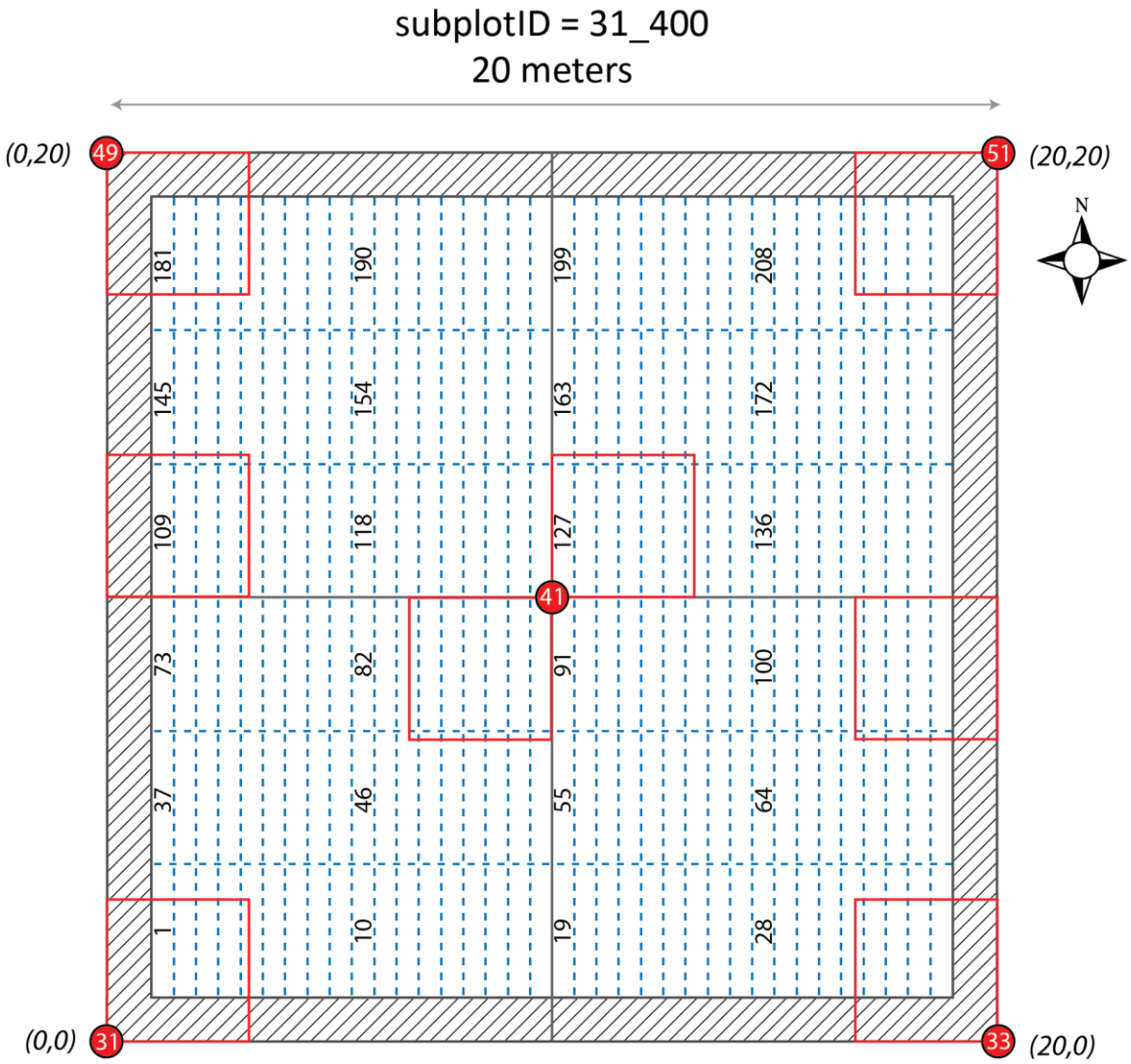


Figure 27. Map of clipCellNumbers in a 20m x 20m base plot (**subplotID = 31_400** in provided Clip Lists). Red squares indicate nested subplots used for diversity sampling; clip cells that significantly overlap red squares are not used for litter sampling. However, clip cells with minimal overlap (e.g., 48-54, 68-72, 145-149) are considered for litter sampling. Red circles with white numbers represent plot markers with associated pointIDs.

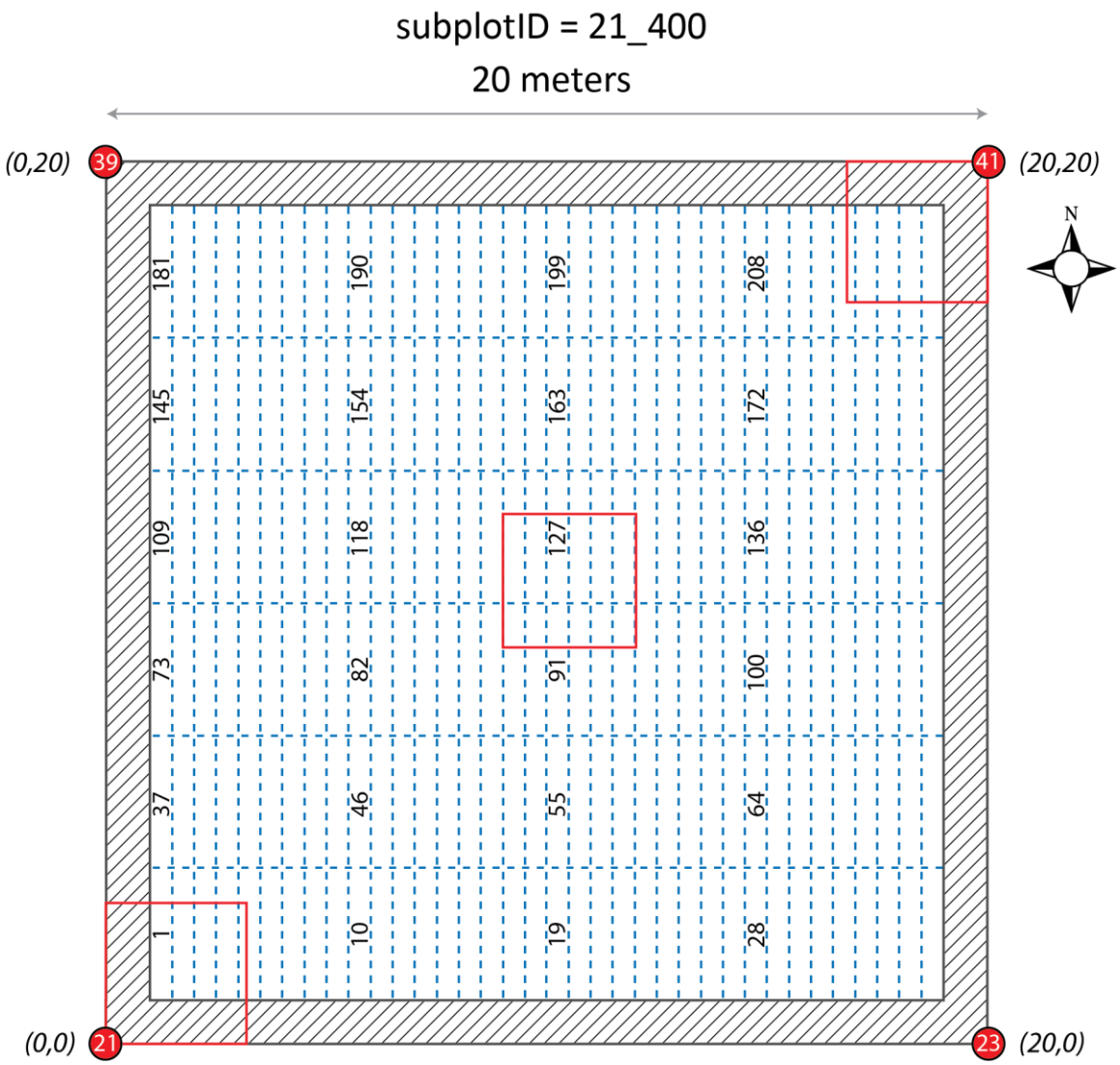


Figure 28. Map of clipCellNumbers for **subplotID = 21_400** in a 40m x 40m Tower base plot. Clip cells that overlap nested subplots indicated by red squares are not used for litter sampling. Red circles with white numbers represent plot markers with associated pointIDs.

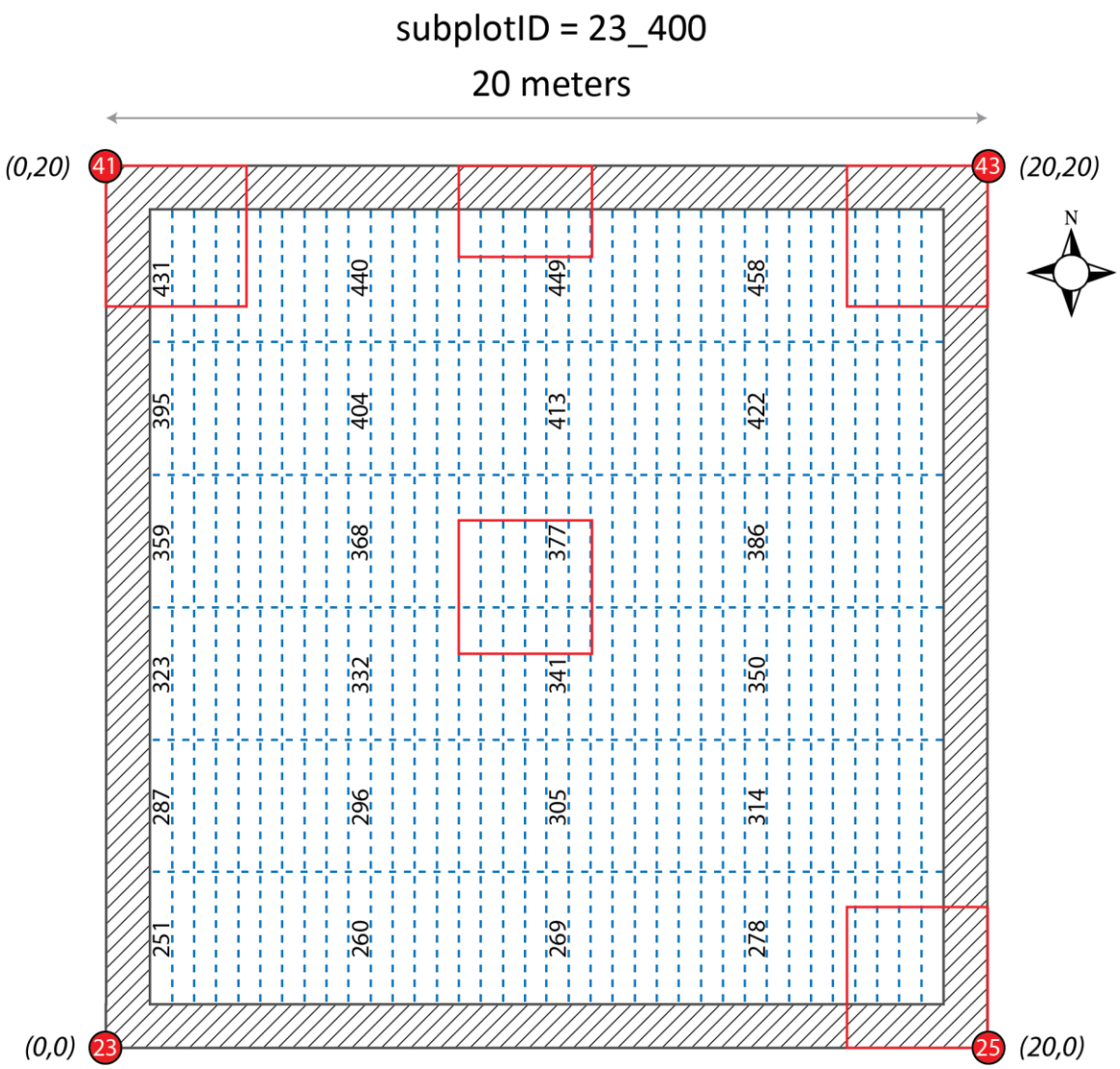


Figure 29. Map of clipCellNumbers for **subplotID = 23_400** in a 40m x 40m Tower base plot. Clip cells that overlap nested subplots indicated by red squares are not used for litter sampling. Red circles with white numbers represent plot markers with associated pointIDs.

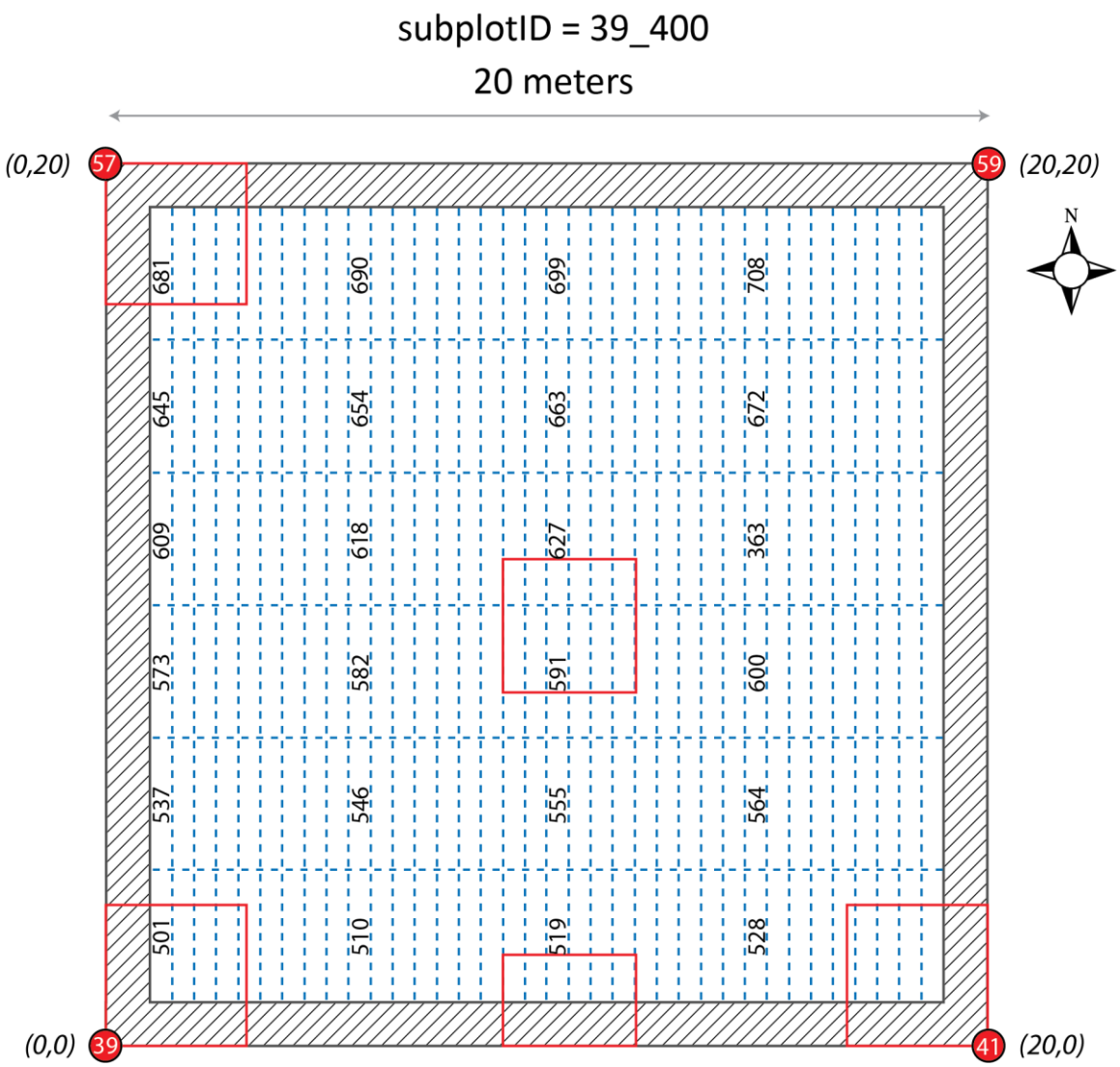


Figure 30. Map of clipCellNumbers for **subplotID = 39_400** in a 40m x 40m Tower base plot. Clip cells that overlap nested subplots indicated by red squares are not used for litter sampling. Red circles with white numbers represent plot markers with associated pointIDs.

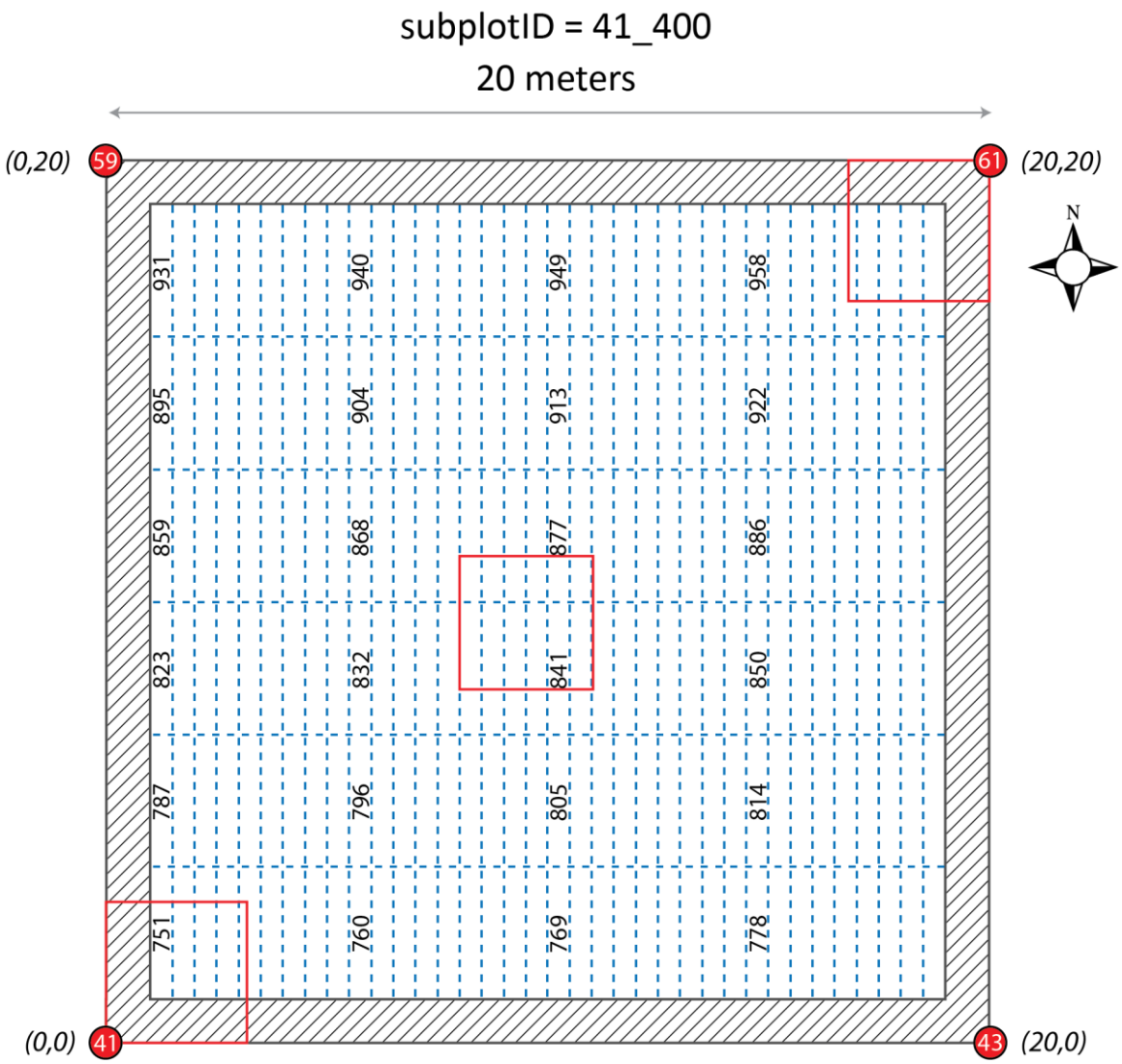


Figure 31. Map of clipCellNumbers for **subplotID = 41_400** in a 40m x 40m Tower base plot. Clip cells that overlap nested subplots indicated by red squares are not used for litter sampling. Red circles with white numbers represent plot markers with associated pointIDs.

G.1 Coordinates for Litter Trap Placement by clipCellNumber and subplotID

Coordinates correspond to the either 1) SW corner of the 0.5m x 3m ClipCell for ground trap placement, or 2) the centroid of the clip cell over which an elevated trap would be placed. Offsets indicate the distance in meters relative to the SW corner of the plot (subplotID = 31_400) or subplot. These are **not** the same coordinates used in the herbaceous clip harvest protocol. Print this Appendix separately for use with this protocol.

Table 26. List of clipCell coordinates by subplotID.

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
1	1	251	501	751	1	1	1.25	2.5
2	2	252	502	752	1.5	1	1.75	2.5
3	3	253	503	753	2	1	2.25	2.5
4	4	254	504	754	2.5	1	2.75	2.5
5	5	255	505	755	3	1	3.25	2.5
6	6	256	506	756	3.5	1	3.75	2.5
7	7	257	507	757	4	1	4.25	2.5
8	8	258	508	758	4.5	1	4.75	2.5
9	9	259	509	759	5	1	5.25	2.5
10	10	260	510	760	5.5	1	5.75	2.5
11	11	261	511	761	6	1	6.25	2.5
12	12	262	512	762	6.5	1	6.75	2.5
13	13	263	513	763	7	1	7.25	2.5
14	14	264	514	764	7.5	1	7.75	2.5
15	15	265	515	765	8	1	8.25	2.5
16	16	266	516	766	8.5	1	8.75	2.5
17	17	267	517	767	9	1	9.25	2.5
18	18	268	518	768	9.5	1	9.75	2.5
19	19	269	519	769	10	1	10.25	2.5
20	20	270	520	770	10.5	1	10.75	2.5
21	21	271	521	771	11	1	11.25	2.5
22	22	272	522	772	11.5	1	11.75	2.5
23	23	273	523	773	12	1	12.25	2.5
24	24	274	524	774	12.5	1	12.75	2.5
25	25	275	525	775	13	1	13.25	2.5
26	26	276	526	776	13.5	1	13.75	2.5
27	27	277	527	777	14	1	14.25	2.5
28	28	278	528	778	14.5	1	14.75	2.5
29	29	279	529	779	15	1	15.25	2.5
30	30	280	530	780	15.5	1	15.75	2.5
31	31	281	531	781	16	1	16.25	2.5

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
32	32	282	532	782	16.5	1	16.75	2.5
33	33	283	533	783	17	1	17.25	2.5
34	34	284	534	784	17.5	1	17.75	2.5
35	35	285	535	785	18	1	18.25	2.5
36	36	286	536	786	18.5	1	18.75	2.5
37	37	287	537	787	1	4	1.25	5.5
38	38	288	538	788	1.5	4	1.75	5.5
39	39	289	539	789	2	4	2.25	5.5
40	40	290	540	790	2.5	4	2.75	5.5
41	41	291	541	791	3	4	3.25	5.5
42	42	292	542	792	3.5	4	3.75	5.5
43	43	293	543	793	4	4	4.25	5.5
44	44	294	544	794	4.5	4	4.75	5.5
45	45	295	545	795	5	4	5.25	5.5
46	46	296	546	796	5.5	4	5.75	5.5
47	47	297	547	797	6	4	6.25	5.5
48	48	298	548	798	6.5	4	6.75	5.5
49	49	299	549	799	7	4	7.25	5.5
50	50	300	550	800	7.5	4	7.75	5.5
51	51	301	551	801	8	4	8.25	5.5
52	52	302	552	802	8.5	4	8.75	5.5
53	53	303	553	803	9	4	9.25	5.5
54	54	304	554	804	9.5	4	9.75	5.5
55	55	305	555	805	10	4	10.25	5.5
56	56	306	556	806	10.5	4	10.75	5.5
57	57	307	557	807	11	4	11.25	5.5
58	58	308	558	808	11.5	4	11.75	5.5
59	59	309	559	809	12	4	12.25	5.5
60	60	310	560	810	12.5	4	12.75	5.5
61	61	311	561	811	13	4	13.25	5.5
62	62	312	562	812	13.5	4	13.75	5.5
63	63	313	563	813	14	4	14.25	5.5
64	64	314	564	814	14.5	4	14.75	5.5
65	65	315	565	815	15	4	15.25	5.5
66	66	316	566	816	15.5	4	15.75	5.5
67	67	317	567	817	16	4	16.25	5.5
68	68	318	568	818	16.5	4	16.75	5.5
69	69	319	569	819	17	4	17.25	5.5
70	70	320	570	820	17.5	4	17.75	5.5
71	71	321	571	821	18	4	18.25	5.5

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
72	72	322	572	822	18.5	4	18.75	5.5
73	73	323	573	823	1	7	1.25	8.5
74	74	324	574	824	1.5	7	1.75	8.5
75	75	325	575	825	2	7	2.25	8.5
76	76	326	576	826	2.5	7	2.75	8.5
77	77	327	577	827	3	7	3.25	8.5
78	78	328	578	828	3.5	7	3.75	8.5
79	79	329	579	829	4	7	4.25	8.5
80	80	330	580	830	4.5	7	4.75	8.5
81	81	331	581	831	5	7	5.25	8.5
82	82	332	582	832	5.5	7	5.75	8.5
83	83	333	583	833	6	7	6.25	8.5
84	84	334	584	834	6.5	7	6.75	8.5
85	85	335	585	835	7	7	7.25	8.5
86	86	336	586	836	7.5	7	7.75	8.5
87	87	337	587	837	8	7	8.25	8.5
88	88	338	588	838	8.5	7	8.75	8.5
89	89	339	589	839	9	7	9.25	8.5
90	90	340	590	840	9.5	7	9.75	8.5
91	91	341	591	841	10	7	10.25	8.5
92	92	342	592	842	10.5	7	10.75	8.5
93	93	343	593	843	11	7	11.25	8.5
94	94	344	594	844	11.5	7	11.75	8.5
95	95	345	595	845	12	7	12.25	8.5
96	96	346	596	846	12.5	7	12.75	8.5
97	97	347	597	847	13	7	13.25	8.5
98	98	348	598	848	13.5	7	13.75	8.5
99	99	349	599	849	14	7	14.25	8.5
100	100	350	600	850	14.5	7	14.75	8.5
101	101	351	601	851	15	7	15.25	8.5
102	102	352	602	852	15.5	7	15.75	8.5
103	103	353	603	853	16	7	16.25	8.5
104	104	354	604	854	16.5	7	16.75	8.5
105	105	355	605	855	17	7	17.25	8.5
106	106	356	606	856	17.5	7	17.75	8.5
107	107	357	607	857	18	7	18.25	8.5
108	108	358	608	858	18.5	7	18.75	8.5
109	109	359	609	859	1	10	1.25	11.5
110	110	360	610	860	1.5	10	1.75	11.5
111	111	361	611	861	2	10	2.25	11.5

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
112	112	362	612	862	2.5	10	2.75	11.5
113	113	363	613	863	3	10	3.25	11.5
114	114	364	614	864	3.5	10	3.75	11.5
115	115	365	615	865	4	10	4.25	11.5
116	116	366	616	866	4.5	10	4.75	11.5
117	117	367	617	867	5	10	5.25	11.5
118	118	368	618	868	5.5	10	5.75	11.5
119	119	369	619	869	6	10	6.25	11.5
120	120	370	620	870	6.5	10	6.75	11.5
121	121	371	621	871	7	10	7.25	11.5
122	122	372	622	872	7.5	10	7.75	11.5
123	123	373	623	873	8	10	8.25	11.5
124	124	374	624	874	8.5	10	8.75	11.5
125	125	375	625	875	9	10	9.25	11.5
126	126	376	626	876	9.5	10	9.75	11.5
127	127	377	627	877	10	10	10.25	11.5
128	128	378	628	878	10.5	10	10.75	11.5
129	129	379	629	879	11	10	11.25	11.5
130	130	380	630	880	11.5	10	11.75	11.5
131	131	381	631	881	12	10	12.25	11.5
132	132	382	632	882	12.5	10	12.75	11.5
133	133	383	633	883	13	10	13.25	11.5
134	134	384	634	884	13.5	10	13.75	11.5
135	135	385	635	885	14	10	14.25	11.5
136	136	386	636	886	14.5	10	14.75	11.5
137	137	387	637	887	15	10	15.25	11.5
138	138	388	638	888	15.5	10	15.75	11.5
139	139	389	639	889	16	10	16.25	11.5
140	140	390	640	890	16.5	10	16.75	11.5
141	141	391	641	891	17	10	17.25	11.5
142	142	392	642	892	17.5	10	17.75	11.5
143	143	393	643	893	18	10	18.25	11.5
144	144	394	644	894	18.5	10	18.75	11.5
145	145	395	645	895	1	13	1.25	14.5
146	146	396	646	896	1.5	13	1.75	14.5
147	147	397	647	897	2	13	2.25	14.5
148	148	398	648	898	2.5	13	2.75	14.5
149	149	399	649	899	3	13	3.25	14.5
150	150	400	650	900	3.5	13	3.75	14.5
151	151	401	651	901	4	13	4.25	14.5

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
152	152	402	652	902	4.5	13	4.75	14.5
153	153	403	653	903	5	13	5.25	14.5
154	154	404	654	904	5.5	13	5.75	14.5
155	155	405	655	905	6	13	6.25	14.5
156	156	406	656	906	6.5	13	6.75	14.5
157	157	407	657	907	7	13	7.25	14.5
158	158	408	658	908	7.5	13	7.75	14.5
159	159	409	659	909	8	13	8.25	14.5
160	160	410	660	910	8.5	13	8.75	14.5
161	161	411	661	911	9	13	9.25	14.5
162	162	412	662	912	9.5	13	9.75	14.5
163	163	413	663	913	10	13	10.25	14.5
164	164	414	664	914	10.5	13	10.75	14.5
165	165	415	665	915	11	13	11.25	14.5
166	166	416	666	916	11.5	13	11.75	14.5
167	167	417	667	917	12	13	12.25	14.5
168	168	418	668	918	12.5	13	12.75	14.5
169	169	419	669	919	13	13	13.25	14.5
170	170	420	670	920	13.5	13	13.75	14.5
171	171	421	671	921	14	13	14.25	14.5
172	172	422	672	922	14.5	13	14.75	14.5
173	173	423	673	923	15	13	15.25	14.5
174	174	424	674	924	15.5	13	15.75	14.5
175	175	425	675	925	16	13	16.25	14.5
176	176	426	676	926	16.5	13	16.75	14.5
177	177	427	677	927	17	13	17.25	14.5
178	178	428	678	928	17.5	13	17.75	14.5
179	179	429	679	929	18	13	18.25	14.5
180	180	430	680	930	18.5	13	18.75	14.5
181	181	431	681	931	1	16	1.25	17.5
182	182	432	682	932	1.5	16	1.75	17.5
183	183	433	683	933	2	16	2.25	17.5
184	184	434	684	934	2.5	16	2.75	17.5
185	185	435	685	935	3	16	3.25	17.5
186	186	436	686	936	3.5	16	3.75	17.5
187	187	437	687	937	4	16	4.25	17.5
188	188	438	688	938	4.5	16	4.75	17.5
189	189	439	689	939	5	16	5.25	17.5
190	190	440	690	940	5.5	16	5.75	17.5
191	191	441	691	941	6	16	6.25	17.5

clipCell Number subplotID = 31_400	clipCell Number subplotID = 21_400	clipCell Number subplotID = 23_400	clipCell Number subplotID = 39_400	clipCell Number subplotID = 41_400	Ground Trap SW corner easting Offset	Ground Trap SW corner northing Offset	Elevated Trap centroid easting Offset	Elevated Trap centroid northing Offset
192	192	442	692	942	6.5	16	6.75	17.5
193	193	443	693	943	7	16	7.25	17.5
194	194	444	694	944	7.5	16	7.75	17.5
195	195	445	695	945	8	16	8.25	17.5
196	196	446	696	946	8.5	16	8.75	17.5
197	197	447	697	947	9	16	9.25	17.5
198	198	448	698	948	9.5	16	9.75	17.5
199	199	449	699	949	10	16	10.25	17.5
200	200	450	700	950	10.5	16	10.75	17.5
201	201	451	701	951	11	16	11.25	17.5
202	202	452	702	952	11.5	16	11.75	17.5
203	203	453	703	953	12	16	12.25	17.5
204	204	454	704	954	12.5	16	12.75	17.5
205	205	455	705	955	13	16	13.25	17.5
206	206	456	706	956	13.5	16	13.75	17.5
207	207	457	707	957	14	16	14.25	17.5
208	208	458	708	958	14.5	16	14.75	17.5
209	209	459	709	959	15	16	15.25	17.5
210	210	460	710	960	15.5	16	15.75	17.5
211	211	461	711	961	16	16	16.25	17.5
212	212	462	712	962	16.5	16	16.75	17.5
213	213	463	713	963	17	16	17.25	17.5
214	214	464	714	964	17.5	16	17.75	17.5
215	215	465	715	965	18	16	18.25	17.5
216	216	466	716	966	18.5	16	18.75	17.5

APPENDIX H COLLECTING LITTERFALL FROM *TOXICODENDRON* SPECIES

This appendix deals with protocol-specific mitigation strategies for dealing with *Toxicodendron* during litterfall and fine woody debris sampling. General strategies for preventing *Toxicodendron* exposure are described in detail in the *Toxicodendron* SOP (RD[13]).

H.1 Equipment and Materials

Table 27. Equipment and materials required for a team of two to minimize exposure to toxic oils from *Toxicodendron* spp. during litter collection.

Description	Purpose	Example Item	Quantity
Small paper bags, pre-weighed, labeled with bag weight	*Toxicodendron* biomass never handled directly again after it is placed in pre-weighed bag if not being processed for archive and chemistry analysis	8# or lunch sack type	Variable
Cotton gloves, single use	Prevent oil contact with skin.	http://www.globalindustrial.com/p/safety/hands/cotton-canvas-gloves/anchor-4501v-8-oz-cotton-canvas-knit-wrist-1110	Box of 12
Disposable PPE outerwear	Prevent oil contact with skin, normal clothing.	Coverall; http://disposable-garments.com/shop/koolguard/koolguard-coveralls/	Case of 24
Large, single-use plastic bags	Transport used gloves and PPE and minimize toxic oil transfer.	Trash bag or large Ziploc type bag	Box
Cleanser, urushiol-specific	Clean equipment and surfaces after use.	Tecnu or equivalent; http://www.teclabsinc.com/products/poison-oak-ivy/tecnu	1
Sample warning pictogram label	Identify acute toxins that may cause serious eye or skin irritation. Samples contain *Toxicodendron* spp.	ULINE #S-21339	

H.2 Minimizing Exposure to Toxic Oil in the Field and Lab

Plot locations with *Toxicodendron spp.* present require a modified sampling strategy to collect and weigh litter dry mass. There are two approaches to collection, either of which is acceptable from a science perspective.

Option A: sort all litter material in the field.

Field processing litter requires extra time in the field but all functional groups from the trap can then be treated in an equivalent manner to *Toxicodendron*. That is, weighed and discarded without removing material from bags.

Option B: sort non-*Toxicodendron* material in the lab

Sort *Toxicodendon* from the trap, bulk the remainder in a cloth collection bag, sort in the lab with disposable cotton gloves (optionally on butcher paper) then decontaminate all surfaces with Urushiol-specific cleanser.

Label all sample bags with warning sticker.

The following are best-practice techniques for minimizing exposure to *urushiol* oils during litterfall collection of *Toxicodendron* species.

1. Prior to field work:
    - Count out bags for storing and drying *Toxicodendron* biomass **and** other functional groups (include enough for collection of leaves, fruit and stems in separate bags). Don't mix *Toxicodendron* biomass with any other biomass.
    - Pre-weigh (to nearest 0.01 g) and label each paper bag that will be used for storing and drying litter material from traps that include *Toxicodendron* biomass. Once the weight of each empty bag is included on the bag label, the biomass inside the bag will never have to be touched after it is initially placed in the bag unless collected during a chemistry bout.
2. To handle *Toxicodendron* biomass in the field:
    - Wear cotton gloves and dispose after single use. Toxic oils can pass through nitrile or latex gloves.
    - Bring a clean, new plastic bag to the field for storing and transporting contaminated gloves after use.
    - Wear a thin outer layer of disposable PPE over clothes and shoes.
3. After field work is complete, wash clothing and collection bags according to these guidelines or similar:
    - While handling and loading unwashed clothing exposed to toxic oils, wear gloves or use a clean cloth to prevent direct contact between your skin and the clothing.
    - Wash with ordinary laundry detergent at the highest recommended water temperature.
    - Do not overload the machine; the clothes must be allowed to agitate freely.
4. To process *Toxicodendron* biomass for dryMass measurement in the laboratory:
    - Wear cotton gloves while handling *Toxicodendron* or any litter material that may have come in contact with *Toxicodendron* litter in traps, including sorting of non-*Toxicodendron* material.
    - Disinfect all tools and lab surfaces used in the sorting process with Tecnu. Discard gloves.

- Minimize potential spread of toxic oil by putting *Toxicodendron* biomass bags into the same drying oven every time.
- When drying is complete, clean drying oven shelves used for drying *Toxicodendron* biomass bags with hot water and Tecnu. Wear appropriate PPE when cleaning.
- Record weight dried biomass, minus weight of the bag, to nearest 0.01 g. Dried *Toxicodendron* biomass should never leave the bag.
- After weighing, if the bout is not being processed for archive and chemistry analyses, dispose of all biomass bags from traps that contained *Toxicodendron*.

5. **Do not grind samples that may include *Toxicodendron*.** To process *Toxicodendron* biomass for Chemistry and Archive:

- If sample contains *Toxicodendron spp.* or was collected from a trap that also contained *Toxicodendron*, no grinding takes place. However, subsampling for chemical analyses and archive will still occur.
- Conduct all subsampling activities in a clean fume hood. Use caution when handling the sample so as not to expose yourself or others to leaves containing toxic oils.
- Wear single-use cotton gloves as described in RD[13] and follow the guidelines in RD[13] to clean any equipment, clothing, or skin that comes in contact with foliage.
- For the leaves sample, combine *Toxicodendron* and non-*Toxicodendron* material.
- Homogenize the sample prior to manual subsampling by crushing/shaking the contents of the brown paper sample bag(s). It may be helpful to transfer sample to a larger-size paper bag first if it is held in a small paper bag.
    - If the sample is very large (> 20 g), haphazardly subsample ~ 20 g first, then use this for further subsampling. The rest may be discarded.
- Split the homogenized foliar material into three subsamples. Try to ensure that the splits are representative but with minimal handling of the foliage.
- Sample mass < 10 g: follow guidelines in section 0 to apportion material for the different subsample types. Use forceps to avoid having to touch the material where possible.

- Do not grind the archive subsample.
- Label all samples with the warning sticker.

APPENDIX I TROUBLESHOOTING

Sampling Challenge	Proposed Solution

Plot is seasonally inundated	*Deployment*
	• Initial deployment of traps cannot occur while plots are inundated.
	• If a site experiences areas of seasonal flooding, deployment may occur in all dry plots prior to deployment in inundated plots.
	• Trap deployment is not all or nothing though it is preferable, once all traps are deployed, to sample all plots at the same time.
	• Production is reported as per/year mass/area so there is wiggle room on collection dates.
	• Tracking is easier if everything is on the same schedule.
	
	Trap modifications
	• Though PVC is not buoyant, a sealed frame of an elevated trap could be lifted and moved by water in the plot.
	• If it appears likely that a plot may occasionally experience periods of inundation act preemptively by weighing the elevated traps (consider bricks or large rocks) or drilling a couple small holes in the top of the frame to allow air to escape, minimizing float potential.
	
	Ground trap collection
	• Even though ground traps are cleared of all woody material during deployment, inundation will undoubtedly move litter laterally across the landscape and potentially deposit in the ground trap location.
	  ○ In this case, total annual production of fine woody debris will be overestimated since material > 1yr will float into the trap area.
	  ○ It is not practical to attempt to distinguish new litter from old, so all qualifying litter present in the trap area should be collected; record trapCondition = PF to indicate that the trap location was previously flooded.
	  ○ This enables a user to be able to identify those records where estimates of annual production are affected by flooding.

Sampling Challenge	Proposed Solution
Atypical structures in litter samples slow down sorting time	• At sites with high diversity of species, it may be difficult to identify structures that are only occasionally encountered in litter samples. One solution may be to create a reference collection to make sorting more efficient. Collections may include pollen cones, seed cones, seeds, or flower parts. • For distinguishing structures from flowers vs. fruits, one approach may be to use phenological cues to sort unattached flower/seed structures into the appropriate functional group. • Creation of a litter reference collection is at the discretion of domain staff and is not a requirement imposed by Science.
Quarantine in effect at site	• Discontinue sampling, document quarantine issues via a problem ticket. ○ Coordinate with Domain Manager, HQ Permitting, and regulatory agency to determine how sampling should proceed.
Unexpected material collected in litter trap	• All qualifying plant material present in the elevated traps should be collected. • Galls, for example, shouldn't be removed from litter but should be sorted with the functional group from which the source tissue originates; a gall on a twig should be sorted with twigs and branches, a gall on a leaf should be sorted with leaves. • Plant material that may not originate from overhanging vegetation but does qualify according to the guidelines provided in this protocol should be collected. ○ For example, nest material including grass, twigs, herbaceous plants, and moss, collected elsewhere and transported to the trap by birds or mammals still represents material produced within a given year, presumably from the plot or nearby areas. ○ Nest material likely contains many different tissue types some of which may not be identifiable, it is therefore acceptable to sort all nest material in the 'other' category. • Remember, material growing up through the mesh from below an elevated trap should be excluded and trimmed back as part of regular trap maintenance before reaching the height of the trap. • Seeds from fruits consumed elsewhere then deposited by birds represent plant material produced in the current year that would otherwise have landed in the 0.5m2 patch of ground, these seeds should be collected and sorted in the 'seeds' category. • An exception to collection is made for sap.

Sampling Challenge	Proposed Solution
	○ Do not place pieces of sap or any other plant exudate, in the drying ovens, under heat, these materials will be lost to melting or pose safety concerns due to natural flammability. ○ Exudates are not explicitly accounted for in net primary productivity calculations. ○ Small amounts of sap bound in woody seed cones does not generally pose a fire hazard. ○ However, if the volume of exudate is great enough to saturate a paper bag or there is any risk of sap dripping and collecting on heating elements in the oven, exclude the material from the sample and record # of female cones were discarded. • Non-plant material, including invertebrates and animal by-products, found in a field trap should be removed when collected and discarded within or near the plot where it was found. • Dead vertebrates found in the trap should be collected and processed according to the guidelines in the State Collection Permit.
Elevated traps overtopped by plant growth	• Manually remove plants growing up and on elevated litter traps, as well as plants growing beneath and immediately around the trap that are likely to grow up trap legs. • Ground tarps may be used to minimize growth of particularly aggressive plants beneath elevated traps. • Additionally, adding weights (or a rock) to the screen may help traps remain upright if vegetation does threaten to disturb the trap between maintenance bouts.
Snow in elevated trap	• If snow is present in an elevated trap at collection, collect all snow and litter; do not attempt to separate snow from litter while in the field. If snow is mounded such that disturbing the pile would result in snow falling outside of trap, or the volume of snow is > the volume of your collection bag, do not collect. • In the case where there is too much snow to collect, skip the trap, record sampling impractical = 'location snow covered'. The set date for the current, unsampled collection event will be the setDate for the subsequent collection. • Melt snow at the DSF and air dry before sorting.
Trap incorrectly constructed or incorrectly marked	• If the trap dimensions are not correct and the area is < 15% different from intended trapSize, fix the trap to the correct dimensions and continue sampling the selected location.

Sampling Challenge	Proposed Solution
	• If the trap dimensions and the area are > 15% different from the intended trapSize, drop the sampling location, move to the next random clip cell, and construct a new trap with the correct dimensions. • Submit a data update request to enter a non-standard trapSize for old data.

APPENDIX J ALTERNATIVE TRAP MATERIALS

Based on site conditions, it may be necessary to modify materials used in construction of the elevated litter trap.

Here are suggestions employed by some NEON domains to address specific issues:

- **Destruction by bears or cattle.** Trap frame material. The design specifies PVC but at some sites, this material may be attractive to bears resulting in widespread damage to traps. Wood traps and galvanized conduit traps constructed at the domain office are an approved alternative (**Figure 32**, **Figure 33**, and **Figure 34**). Additionally, larger anchors such as t-posts may be employed to discourage animals from attempting to move and destroy elevated litter traps.
    - Conduit traps are deployed at YELL tower plots and are constructed using the following materials:
        - 1-3/4" x 3-1/2" x 5' Green Steel Fence T-Posts
        - 3/4" Electric Metallic Tube (EMT) Conduit
        - 3/4" 3-way through canopy roof fitting
- Metals with potential to oxidize and leach into the soil may only be used in plots not scheduled for soil biogeochemistry sampling.

Figure 32. PVC elevated trap destroyed by bears at SCBI.

Figure 33. Conduit trap from D17- San Joaquin.

Figure 34. Conduit trap from D17- San Joaquin.

- **Destruction by rodents.** Application of a non-toxic capsaicin rodent deterrent spray on trap surfaces may render the trap material un-palatable without causing undue harm to surrounding vegetation or wildlife. Spray must be re-applied to maintain efficiency. If zip ties are targeted, mesh may be secured to trap with the aluminum wire used to attach numbered tags to shrubs and saplings.
- **Removal of material by wind.** Traps may be weighted by placing baseball-size rocks in the elevated trap to prevent wind from disturbing the mesh and forcing collected material out of the trap. Additionally, using a larger piece of mesh than the 4ft x 4ft piece provided in the kits to create more sag, a deeper bowl (i.e., >20 cm specified in SOP A) that may trap material more effectively in windy conditions.

Elements that may **not** be modified:

- Trap shape, elevated traps must be square.

- Trap size, elevated traps must be 0.5m^2 (70.7 cm x 70.7 cm) – measured from the outside edge of the trap.

Use of non-oxidizing materials in plots scheduled for soil biogeochemistry sampling, if metal is used for any portion of the trap, it must be resistant to rust (aluminum, stainless steel).