NEON USER GUIDE TO LITTERFALL AND FINE WOODY DEBRIS SAMPLING (NEON.DP1.10033)

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CHANGE RECORD

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1 DESCRIPTION

1.1 Purpose

This document provides an overview of the data included in this NEON Level 1 data product, the quality controlled product generated from raw Level 0 data, and associated metadata. In the NEON data products framework, the raw data collected in the field, for example, the dry weights of litter functional groups from a single collection event are considered the lowest level (Level 0). Raw data that have been quality checked via the steps detailed herein, as well as simple metrics that emerge from the raw data are considered Level 1 data products.

The text herein provides a discussion of measurement theory and implementation, data product provenance, quality assurance and control methods used, and approximations and/or assumptions made during L1 data creation.

1.2 Scope

This document describes the steps needed to generate the L1 data product, Litterfall and fine woody debris sampling - the dry weight of litterfall and fine woody debris collected from litter traps by plant functional type - and associated metadata from input data. This document also provides details relevant to the publication of the data products via the NEON data portal, with additional detail available in the file, NEON Data Variables for Litterfall and Fine Woody Debris (NEON.DP1.10033) (AD[05]), provided in the download package for this data product.

This document describes the process for ingesting and performing automated quality assurance and control procedures on the data collected in the field pertaining to TOS Field and Lab Protocol for Litterfall and Fine Woody Debris (AD[07]). The raw data that are processed in this document are detailed in the file, NEON Raw Data Validation for Litterfall and Fine Woody Debris (NEON.DP0.10033) (AD[04]), provided in the download package for this data product. Please note that raw data products (denoted by 'DP0') may not always have the same numbers (e.g., '10033') as the corresponding L1 data product.

2   RELATED DOCUMENTS AND ACRONYMS

2.1   Associated Documents

AD[01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD[02]	NEON.DOC.000913	TOS Science Design for Spatial Sampling
AD[03]	NEON.DOC.002652	NEON Level 1, Level 2 and Level 3 Data Products Catalog
AD[04]	NEON.DP0.10033.001 _dataValidation.csv	NEON Raw Data Validation for Litterfall and Fine Woody Debris (NEON.DP0.10033)
AD[05]	NEON.DP1.10033.001 _variables.csv	NEON Data Variables for Litterfall and Fine Woody Debris (NEON.DP1.10033)
AD[06]	NEON.DOC.000914	TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index
AD[07]	NEON.DOC.001710	TOS Field and Lab Protocol for Litterfall and Fine Woody Debris
AD[08]	NEON.DOC.000913	TOS Science Design for Spatial Sampling
AD[09]	NEON.DOC.000913	TOS Science Design for Plant Diversity
AD[10]	NEON.DOC.000008	NEON Acronym List
AD[11]	NEON.DOC.000243	NEON Glossary of Terms
AD[12]	NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass
AD[13]	NEON.DOC.001709	TOS Protocol and Procedure: Measurement of Bryophyte Productivity
AD[14]	OS_Generic_Transitions .pdf	NEON Algorithm Theoretical Basis Document: OS Generic Transitions
AD[15]	Nicl Language.pdf	NEON's Ingest Conversion Language (NICL) specifications

2.2   Acronyms

Acronym	Definition
ANPP	Annual Net Primary Productivity
STRI/CTFS	Smithsonian Tropical Research Institute Center for Tropical Forest Science

3   DATA PRODUCT DESCRIPTION

The litterfall and fine woody debris sampling data products provide mass data for plant functional groups from individual sampling bouts. Litter and fine woody debris are collected from elevated and ground traps, respectively. All masses reported following processing are reported at the spatial resolution of a single trap and the temporal resolution of a single collection event.

Mass data for each collection event are measured separately for the following functional groups, to an accuracy of 0.01 grams. Weights < 0.01g are reported and may indicate presence of a given functional group, identified in the sorting process, but not present at detectable masses.

- Leaves
- Needles
- Twigs/branches
- Woody material (e.g. cones, bark, etc)
- Seeds
- Flowers and other non-woody reproductive structures
- Other (lichen, mosses, unidentifiable material, etc.)
- Mixed (unsorted material)

In this protocol, litter is defined as material that is dropped from the forest canopy and has a butt end diameter <2cm and a length <50 cm; this material is collected in elevated 0.5m^2 PVC traps. Fine wood debris is defined as material that is dropped from the forest canopy and has a butt end diameter <2cm and a length >50 cm; this material is collected in ground traps as longer material is not reliably collected by the elevated traps. Elevated PVC litter trap design is consistent with that used by the Smithsonian Tropical Research Institute Center for Tropical Forest Science (STRI/CTFS) (Muller-Landau and Wright 2010). Each is a 0.5m^2 square with mesh 'basket' elevated ~80cm above the ground. Ground traps are 3 m x 0.5 m rectangular areas. Muller-Landau and Wright (2010) employ square elevated litter and ground traps that are both 0.5 m^2, for sampling litter and fine woody debris production in a tropical forest. However, due to the spatially heterogeneous production of fine woody debris, and particularly for larger pieces of fine woody debris, larger rectangular ground traps may be more appropriate (Muller-Landau, personal communication).

Litterfall and fine woody debris data may be used to estimate annual Aboveground Net Primary Productivity (ANPP) and aboveground biomass at plot, site, and continental scales. They also provide essential data for understanding vegetative carbon fluxes over time.

3.1   Spatial Sampling Design

Litter and fine woody debris sampling is executed at terrestrial NEON sites that contain woody vegetation >2m tall. Along with most of NEON's plant productivity measurements, sampling for this product occurs only in tower plots (AD[06]). Locations of tower plots are selected randomly within the 90% flux footprint of the primary and secondary airsheds (and additional areas in close proximity to the airshed, as necessary to accommodate sufficient spacing between plots). In sites with forested tower airsheds, the litter sampling is targeted to take place in 20 40m x 40m plots. In sites with low-statured vegetation over the tower airsheds, litter sampling is targeted to take place in 4 40m x 40m tower plots (to accommodate co-located soil sampling) plus 26 20m x 20m plots. One

litter trap pair (one elevated trap and one ground trap) is deployed for every 400 m^2 plot area, resulting in 1-4 trap pairs per plot. In some cases, available space, plot spacing requirements, and/or the tower airshed size restricts the number of plots that can be sampled for litter below 20 (forested) or 30 (low-stature). Specifically, plot edges must be separated by a distance 150% of one edge of the plot (e.g., 40m x 40m Tower Base Plots must be 60m apart); plot centers must be greater than 50m from large paved roads and plot edges must be 10m from two-track dirt roads; plot centers must be 50m from buildings and other non-NEON infrastructure; streams larger than 1m must not intersect plots. See TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[06]), TOS Field and Lab Protocol for Litterfall and Fine Woody Debris (AD[07]), TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[08]) and TOS Science Design for Plant Diversity (AD[09]) for further details.

Trap placement within plots may be either targeted or randomized, depending on the vegetation. In sites with > 50% aerial cover of woody vegetation >2m in height, placement of litter traps is random and utilizes the randomized list of grid cell locations being utilized for herbaceous clip harvest and bryophyte sampling (Figure 1)(AD[12], AD[13]). This is an ordered list of all available sampling locations within a given plot, from which a **clipCell** is removed after being utilized for sampling in any one of the three sampling protocols. Removal precludes consideration of a **clipCell** for future sampling under all protocols. In sites with < 50% cover of woody vegetation, sites with heterogeneously distributed, patchy, vegetation, trap placement is targeted such that only areas beneath qualifying vegetation are considered for trap placement (Figure 2). Woody vegetation cover, as measured by NEON's Airborne Observation Platform and/or vegetation structure protocols, may be be used to scale up litterfall production from the point measurements included here.
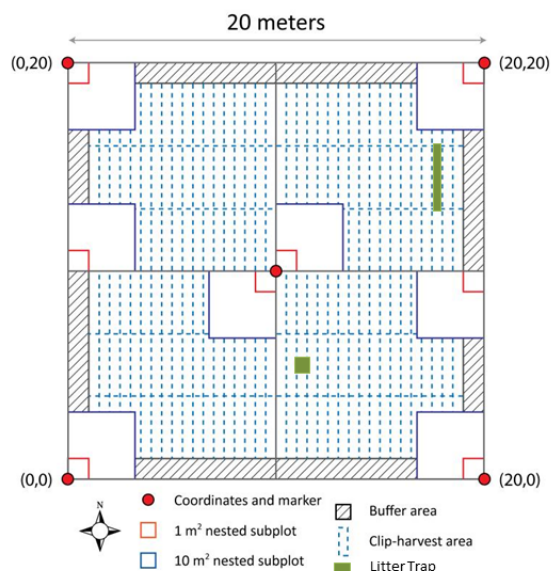

Figure 1: Arrangement of clip cells within a 20mx20m plot; a 1m buffer around the edge of the plot and all nested subplots are excluded from consideration for sampling to avoid interfering with plant diversity measurements, vegetation structure measurements and areas subject to high traffic around the edge of the plot. See AD[12] for details about clip cell design.

3.2 Temporal Sampling Design

Ground traps are sampled once per year. Target sampling frequency for elevated traps varies by vegetation present at the site, with frequent sampling (1x every 2weeks) in deciduous forest sites during senescence, and infrequent year-round sampling (1x every 1-2 months) at evergreen sites. See TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index (AD[06]), and the TOS Field and Lab Protocol for Litterfall and Fine Woody Debris (AD[07]). At sites with deciduous vegetation or limited access during winter months, litter sampling of elevated traps may be discontinued for up to 6 months during the dormant season.

3.3 Variables Reported

All variables reported from the field or laboratory technician (L0 data) are listed in the file, NEON Raw Data Validation for Litterfall and Fine Woody Debris (NEON.DP0.10033) (AD[04]). All variables reported in the published data (L1 data) are also provided separately in the file, NEON Data Variables for Litterfall and Fine Woody Debris (NEON.DP1.10033) (AD[05]).

Field names have been standardized with Darwin Core terms (http://rs.tdwg.org/dwc/; accessed 16 February 2014), the Global Biodiversity Information Facility vocabularies (http://rs.gbif.org/vocabulary/gbif/; accessed 16 February 2014), the VegCore data dictionary (https://projects.nceas.ucsb.edu/nceas/projects/bien/wiki/VegCore; accessed 16 February 2014), where applicable. NEON Terrestrial Observation System (TOS) spatial data employs the World Geodetic System 1984 (WGS84) for its fundamental reference datum and GEOID09 for its reference gravitational ellipsoid. Latitudes and longitudes are denoted in decimal notation to six decimal places, with longitudes indicated as negative west of the Greenwich meridian.

Some variables described in this document may be for NEON internal use only and will not appear in downloaded data.

3.4 Temporal Resolution and Extent

The finest resolution at which temporal data are reported is the **daysOfTrapping**, the range between **setDate** and **collectDate**.

collectDate (date an individual trap was collected) → **daysOfTrapping** → **annual production**

3.5 Spatial Resolution and Extent

The finest resolution at which spatial data are reported is a single trap (Figure 2).

trapID (unique ID given to the individual trap, based on location within the plot) → **subplotID** (ID of one of four subplots within a plot; ground and elevated traps are paired at the subplot level) → **plotID** (ID of plot within site) → **siteID** (ID of NEON site) → **domainID** (ID of a NEON domain.
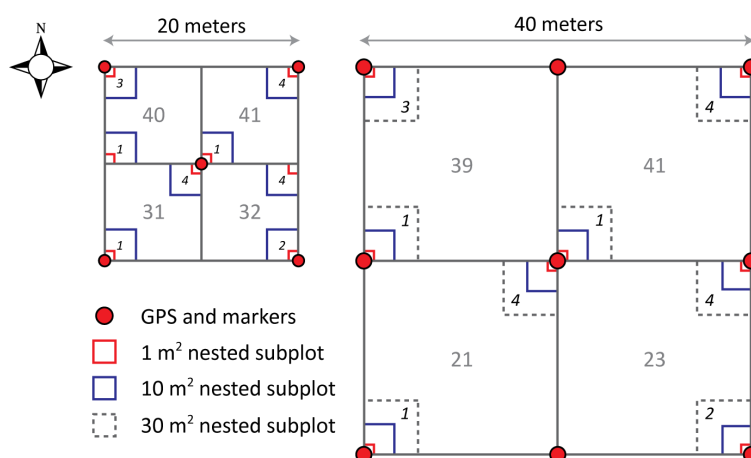
Figure 2: Plot, subplot and nested subplot layout in 20mx20m and 40mx40m Tower plots

The basic spatial data included in the data downloaded include the latitude, longitude, and elevation of the centroid of the plot where sampling occurred + associated uncertainty due to GPS error and plot width. Shapefiles of all NEON Terrestrial Observation System sampling locations can be found here: http://www.neonscience.org/science-design/field-sites/maps-spatial-data

To derive a more precise estimate of the location of each trap, there are two options:

- Use the def.calc.geo.os function from the geoNEON package, available here: https://github.com/NEONScience/NEON-geolocation

- Or follow these steps to perform the same calculation:

1. The namedLocation field in the data is the named location of the plot; more precise geographic data require the named location of the subplot. Construct the named location of the subplot of each record in ltr_pertrap by concatenating the fields for namedLocation and subplotID as: namedLocation + '.' + subplotID, e.g. subplotID '41' of namedLocation 'HARV_052.basePlot.ltr' has a complete named location of 'HARV_052.basePlot.ltr.41'.

2. Use the API (http://data.neonscience.org/api; e.g. http://data.neonscience.org/api/v0/locations/HARV_052.basePlot.ltr.41) to query for elevation("locationElevation"), easting("locationUtmEasting"), northing("locationUtmNorthing"), coordinateUncertainty ("Value for Coordinate uncertainty"), elevationUncertainty ("Value for Elevation uncertainty"), and utmZone ("locationUtmZone") as inputs to the next step.

3. Calculate the clipCellNumber of each trap (last 3 digits of trapID).

4. Use the clip cell lookup table, available here: http://data.neonscience.org/api/v0/documents/clipCellNumber_lookup (clicking on link will initiate download), to find the offsets for each clipCellNumber and subplot (=pointID), and use the offsets to adjust the UTM values downloaded in step 2.

5. Increase coordinateUncertainty by an appropriate amount to account for error introduced by navigating within plots. Technicians may shift elevated trap up to 1 meter to either the north or south within a se-

lected clip cell to avoid obstacles. Additional error may be introduced due to tape stretching to navigate to locations within plots.

3.6 Associated Data Streams

massSampleID, **cnSampleID**, **ligninSampleID**, and **archiveSampleID** are linking variables that tie specific samples and associated metadata to the Litter Chemical Properties data product (NEON.DP1.10031) and the Litter Stable Isotopes data product (NEON.DP1.10101). Additional information about woody vegetation present in the plot, contributing to litter production, is available in the NEON Woody Plant Vegetation Structure data product (NEON.DP1.10098). Users are advised to leverage data from vegetation structure to provide context to litter data. Additional information about herbaceous vegetation present in the plot is available in the NEON Herbaceous Clip Harvest data product (NEON.DP1.10023).

3.7 Product Instances

There are a maximum of 12 litterfall collection bouts per year, with litter collected from no more than 40 elevated traps per bout. Each elevated litter trap will yield no more than 7 dry mass values (one for each functional group). Each elevated litter trap is paired with a ground trap, resulting in a maximum of 40 ground traps/site. Each ground trap may have up to two functional groups and is sampled once per year, yielding no more than 80 mass values per year. Thus, no single site should ever exceed 3,440 data product instances in a given calendar year.

3.8 Data Relationships

The protocol dictates that each trap is established once (one expected record per trapID in ltr_pertrap). A record from ltr_pertrap may have zero or more child records in ltr_fielddata.trapID, depending on the date range of the data downloaded; a given ltr_fielddata.trapID is expected to be sampled zero or one times per collectDate (local time). A record from from ltr_fielddata may have zero (if no litter present) or more child records in ltr_massdata depending on the functional groups contained in the trap and whether reweighing occurred for QA purposes. A record from from ltr_massdata may have zero (if not sent for chemistry analyses) or one child records in ltr_chemistrySubsampling. Duplicates and/or missing data may exist where protocol and/or data entry abberations have occurred; users should check data carefully for anomalies before joining tables.

ltr_pertrap.csv - > One record expected per trapID for all time

ltr_fielddata.csv - > One record expected per trapID per collectDate (day of year, local time) combination, generates a single fieldSampleID if litter is present in the trap

ltr_massdata.csv - > One record expected per fieldSampleID per functionalGroup, generates a single massSampleID. Duplicate instances of a single massSampleID are expected to exist where qaDryMass = 'Y'; these are samples that are reweighed for quality assurance purposes.

ltr_chemistrySubsampling.csv - > One record expected per massSampleMixtureID, which is a mixture of massSampleID's (listed in massSampleIDList). Generates samples used in Litter chemical properties

(NEON.DOM.SITE.DP1.10031) and Litter stable isotopes (NEON.DOM.SITE.DP1.10101). Not all massSampleID's contribute to mixtures; some are discarded.

sampleIDs and **sampleBarcodes** will be generated for each collection event and functional group within a sample. Unless the collection event has been selected for biogeochemical analyses and archive, the physical sample will be discarded following measurement. Once every five years at a site, one round of sampling (either the October event or that occurring during peak senescence) will be selected for additional processing and analysis by external labs. Within this sampling event, material from one elevated trap and two functional groups (leaves and needles) per plot will be sent for chemical analyses, resulting in no more than 60 samples/site/5 yrs. Material from all other functional groups from the selected sampling event will be weighed and discarded.

4 DATA QUALITY

4.1 Data Entry Constraint and Validation

Many quality control measures are implemented at the point of data entry within a mobile data entry application or web user interface (UI). For example, data formats are constrained and data values controlled through the provision of dropdown options, which reduces the number of processing steps necessary to prepare the raw data for publication. An additional set of constraints are implemented during the process of ingest into the NEON database. The product-specific data constraint and validation requirements built into data entry applications and database ingest are described in the document NEON Raw Data Validation for Litterfall and Fine Woody Debris (NEON.DP0.10033), provided with every download of this data product. Contained within this file is a field named 'entryValidationRulesForm', which describes syntactically the validation rules for each field built into the data entry application. Also included in this file is a field named 'entryValidationRulesParser', which describes syntactically the validation rules for each field that is performed upon ingest of the data into the NEON Cyberinfrastructure, based on a standardized data validation language (Nicl) internal to NEON. Please see AD[15] for more information about the Nicl language.

4.2 Automated Data Processing Steps

Following data entry into a mobile application of web user interface, the steps used to process the data through to publication on the NEON Data Portal are detailed in the NEON Algorithm Theoretical Basis Document: OS Generic Transitions (AD[14]).

4.3 Data Revision

All data are provisional until a numbered version is released; the first release of a static version of NEON data, annotated with a globally unique identifier, is planned to take place in 2020. During the provisional period, QA/QC is an active process, as opposed to a discrete activity performed once, and records are updated on a rolling basis as a result of scheduled tests or feedback from data users. The Change Log section of the data product readme, provided with every data download, contains a history of major known errors and revisions.

4.4   Quality Flagging

The **dataQF** field in each data record is a quality flag for known errors applying to the record. There are currently no dataQF codes in use in this data product.

fieldName	value	definition
dataQF	legacyData	Data recorded using a paper-based workflow that did not implement the full suite of quality control features associated with the interactive digital workflow

5   REFERENCES

Muller-Landau, H. C., and S. J. Wright. 2010. Litterfall Monitoring Protocol. The Center for Tropical Forest Science Global Forest Carbon Research Initiative (http://www.forestgeo.si.edu/).