



<i>Title:</i> TOS Standard Operating Procedure: APB – Measurement of Aboveground Productivity for Agricultural Crops		<i>Date:</i> 01/18/2023
<i>NEON Doc. #:</i> NEON.DOC.001714	<i>Author:</i> C. Meier	<i>Revision:</i> F

TOS STANDARD OPERATING PROCEDURE: APB – MEASUREMENT OF ABOVEGROUND PRODUCTIVITY FOR AGRICULTURAL CROPS

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	09/15/2016	ECO-04141	Initial release
B	07/12/2017	ECO-04624	<ul style="list-style-type: none"> Section 4, Timing: Clarified that 2+ harvests per plot are required if plot is planted with multiple crops per season, or is below <ul style="list-style-type: none"> for part of year and then planted. Section 6, Equipment: Added folding ruler, loppers, and spring scales. SOP B: Weighing of total fresh mass, creation of sub-sample, and weighing of subsample fresh mass now carried out in the field with spring scales, rather than lab, and can be employed for all crop-types. Prevents transport of large volumes of clipped mass.
C	02/16/2018	ECO-05405	<ul style="list-style-type: none"> Section 4.1, Sampling Frequency and Timing: Re-organized and added more examples to illustrate desired plot numbers based on learned experience at various sites. Section 4.2, Onset and Cessation of Sampling: Added guidance for crops that do not appear in Table 2, and for which USDA timing data are not available (e.g., millet in D02). Section 6.4, Estimated Time: Added updated standardized time estimates per SOP. SOP B: Updated text to reflect mobile app-based workflow and barcodes SOP D: Added optional workflow for using barcodes with samples SOP D.1, Drying and Weighing: Clarified that ovenStartTime and ovenEndTime are only recorded for initial drying period. Appendix A.1: Added LAJA specific guidance for sunflower crop.



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D	01/29/2019	ECO-06002	<ul style="list-style-type: none">• Added SOP A.2.1: Integration of Plant Belowground Biomass and Clip-Harvest at agricultural sites.• SOP B: Sampling areas for synchronized Plant Belowground Biomass sampling are rotated along with the crop clip-strip. SOP now matches training materials.• SOP B.1: Subsampling procedure for high-volume crops modified to reflect easier workflow developed in the field. Illustrations of workflow added.• SOP B.2: Added guidance when rows cannot be discerned for a portion of the plot.• Added SOP C.1 to specify Field record finalizing and auto-creation of lab records occurs after sort-checking
E	03/17/2021	ECO-06539	<ul style="list-style-type: none">• Updated to new template (NEON.DOC.002626vD).• SOP B.1: Changed boutNumber to weekBoutBegan to simplify bout naming convention.
F	01/18/2023	ECO-06908	<ul style="list-style-type: none">• Clarified the definition of agriculture cash crops, planted cover crops, and fallow.• Added spring scale calibration and validation.• Clarified that the Belowground Biomass sampling integration should be temporally aligned with the sampling of the largest number of agricultural plots if multiple crops exist across Tower plots.• Update to template Rev E



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1 DESCRIPTION

1.1 Overview

The Standard Operating Procedure (SOP) described in this document is an extension of the TOS Protocol and Procedure: Measurement of Herbaceous Biomass (RD[04]). For crop clip-harvesting in the field described here, the dimensions and orientation of typical Clip Strips used for ‘wild-type’ herbaceous biomass clipping are modified. In contrast to Clip Strips for ‘wild-type’ vegetation, crop Clip Strips adopt wider dimensions, and are oriented perpendicular to crop rows in order to account for the spatial structure introduced by crop row-planting. The field procedure for crops is also modified from RD[04] to include a subsampling routine. Because more area is sampled in the field, and crops can produce large amounts of biomass, the subsampling routine allows smaller amounts of biomass per sample to be transported back to the laboratory and placed into the drying ovens. Subsampling requires that additional fresh weight data are collected in the field so that subsample dry weights can be scaled back up to the entire sample collected in the field.

1.2 Purpose

This document outlines the procedure for measuring aboveground biomass in plots that have been planted with:

- Corn
- Soybean
- Sorghum, or
- Cereal crops (Wheat, barley, millet, triticale, rye, oat, etc.)

Other crops, such as squash, tomatoes, peppers, etc., are outside the scope of this SOP, and must be addressed on a case by case basis via NEON’s help ticket software.

1.3 Scope

This document provides a change-controlled version of an Observatory procedure. 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.

1.4 Applies To

The procedure described in this document is used in the following protocols:

Doc #	Title
NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass



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1.5 Acknowledgments

Quadrat dimensions for corn, soybean, and graminoid crops were taken from the Kellogg Biological Station LTER protocol for Aboveground Net Primary Productivity. Many thanks to: Greg Chapman for refining and streamlining the field subsampling routine in SOP B.



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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 and Productivity

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.014037	TOS Protocol and Procedure: HBP – Measurement of Herbaceous Biomass
RD[05]	NEON.DOC.001574	Datasheets for TOS Protocol and Procedure: Measurement of Herbaceous Biomass
RD[06]	NEON.DOC.001717	TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration
RD[07]	NEON.DOC.001025	TOS Protocol and Procedure: PLT – Plot Establishment
RD[08]	NEON.DOC.001271	AOS/TOS Protocol and Procedure: DMP – Data Management

2.3 Acronyms

Acronym	Definition
ddh	Diameter at decimeter height
NPP	Net Primary Productivity
ISO	International Organization for Standardization

All other acronyms used in this document are defined in RD[01].

2.4 Definitions

Agricultural Crop: Plant (e.g., corn or soybean) grown and harvested for profit or subsistence.

Brace roots: (Also called prop roots) Aerial roots originating along a corn stalk, above the soil surface (**Figure 1**).



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Cover Crop: Vegetation grown for protection or enrichment of the soil.

Ear: Pollinated female corn inflorescence comprised of cob, kernel, husk leaves and silk (style).

Fallow: Land that has been plowed but not planted for the growing/sampling season.

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

High-Volume Crop: Functionally, high-volume crops are those that, when sampled and brought back to the laboratory without subsampling, would overwhelm available oven space. Typically, it is not possible to process high-volume crops within the specified 5 d cold storage limit without subsampling. Because yields and growth rates can vary tremendously from year to year due to external factors, a crop may be high-volume one year, and low-volume the next (e.g., soy).

Low-Volume Crop: Functionally, samples from low-volume crops can be dried in their entirety without overwhelming available oven space, and all samples can be processed within the 5 d cold-storage limit without subsampling.

Non-crops: Weeds and other opportunistic herbaceous plants other than the crop or cover crop of interest

Pod: The elongated seed vessel of the soybean plant.

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

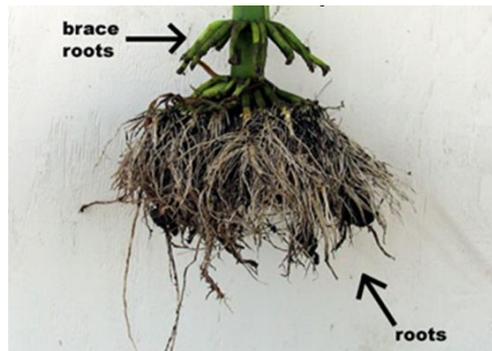


Figure 1. Base of corn stalk, including belowground roots and aboveground brace roots; the latter are also known as 'prop' roots.



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3 SAFETY

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

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

Agricultural Chemicals

Common agricultural chemicals include pesticides, insecticides, fungicides, and herbicides and residues of these chemicals may be found on active agricultural sites. Their hazards may remain after fields have been treated. These chemicals can be on plants, in soil, and sometimes in irrigation systems used to apply hazardous chemicals. Chemical residue cannot always be seen and may also be carried by the wind.

It is important to determine if it is safe to enter a field where pesticides have been applied prior to beginning work. Attempts should be made to determine pesticide application schedule and the restricted entry interval (REI) of applied pesticides prior to entering agricultural fields or areas where pesticide use is expected. When entering agricultural fields or other areas, check for posted warning signs at access roads, field borders adjacent to public areas and established walking routes where agricultural workers enter the area.

Pesticide Safety Training is required if entering/working in a field that has been sprayed within the last 30 days. The following precautions must be followed when re-entering areas within 30 days after expiration of restricted entry interval (REI):

- Wear full-length pants, long-sleeved shirts, a hat, socks, and non-leather gloves and work shoes. Leather can absorb chemicals from plants and the soil.
- Wash gloves and work boots/shoes prior to removing, if possible.
- Wash work clothes separately from other laundry using hot water and laundry detergent. Always wash clothes, boots, and gloves before wearing them again.
- Wash face, neck, hands, and arms as soon as possible, after potential exposure to agricultural chemicals.
- NEVER enter a field that has been posted with a “No Re-Entry” warning sign! Keep in mind sign verbiage may vary.



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- DO NOT smoke while working in a treated field, regardless of when the area was sprayed with the hazardous chemical.
- DO NOT carry food of any kind into treated work area.
- If exposed or if exhibiting any signs or symptoms of exposure:
 - Seek the Safety Data Sheet for the hazardous chemical that was used on the field. If medical assistance isn't immediately available, follow the first-aid directions on the label or included with the Safety Data Sheet.
 - Inform the Domain Manager of any suspected exposure. The DSF should have Safety Data Sheets on hand for chemicals used in the fields in which NEON plots are located.

Laser Rangefinder

A laser rangefinder/hypsometer/compass instrument may be used to navigate to clip cells within plots.

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.

Sharp Blades

Sharp-bladed pruners and/or loppers may be used to clip and subsample crop plants. Safety considerations for these tools include:

- Select the correct tool for the job.
- Use personal protective equipment, to include gloves, safety glasses, and work boots to minimize injuries in the field.
- Assure all personnel working in the area are aware of the use of the sharp tools, and keep all sharp blades safely away from others.
- Maintain good posture and do not twist or stretch body awkwardly while making cuts with a pruner or lopper.



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4 PERSONNEL

4.1 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.

Additional training is required for working in areas where agricultural chemicals have or may have been applied.

For the field component of this protocol, technicians must be trained in navigating to points in the field with a GPS and manual methods. Most critically, technicians must be trained to quickly identify common herbaceous species that inhabit agricultural fields within the region. Because different herbaceous functional groups can be sensitive indicators of ecosystem responses to global change (e.g., N deposition, warming, rising CO₂), it is very important that field technicians within a domain can accurately and quickly identify C3 and C4 graminoids as well as identify leguminous and non-leguminous forbs within that domain.

Training for both the field and laboratory work must emphasize the importance of consistent, detailed labeling of all samples, including proper use of barcodes if barcodes are used. ***Improper or inconsistent labeling and sample tracking is the most common and problematic error associated with this work!***

4.2 Specialized Skills

The lead plant technician must possess the demonstrated ability to identify crops to species, and to identify non-crop species inhabiting cropped plots to functional group – either via visual inspection, or via visual inspection in combination with a dichotomous or polyclave key.

- Identification of all leguminous forbs to functional group, in the absence of flowers, is required.
- Identification to species is not required for non-leguminous forbs and woody stemmed plants.
- Identification to species is required for cool-season (C3) and warm-season (C4) graminoid functional groups. Technicians should be able to identify graminoids vegetatively.

To identify non-crop species, ideally each team member should know how to use diagnostic traits and a dichotomous or polyclave key.



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5 METHOD

The Herbaceous Biomass and Productivity (HBP) protocol, and this associated Agricultural Biomass SOP, are designed to contribute to plant biomass and productivity estimates for each NEON site. HBP sampling at Distributed plots, which are scattered across each site, occurs every five years to quantify site-wide variability in standing herbaceous biomass stocks. Sampling at Tower plots occurs annually or more frequently to quantify productivity. At many sites, Tower plots are generally representative of the biomass and productivity of the larger site. At agricultural sites, the ecological processes that result in productivity and biomass are dependent on management strategies. As such, at agricultural sites Tower plot productivity may not be representative of the larger site, and the timing of sampling for each plot – Tower or Distributed – must account for the crop type and anticipated harvest dates.

A combination of Distributed and Tower plots may be used for collecting biomass and productivity data from agricultural crops. There are multiple herbaceous biomass types that must be considered (also defined in Section 2.4):

- Agricultural crop – plant (e.g., corn or soybean) grown and harvested for profit or subsistence
- Cover crop – vegetation grown for protection or enrichment of the soil
- Fallow – land that has been plowed or harrowed but not planted for the growing/sampling season

The timing of agricultural biomass sampling is targeted to peak crop biomass and constrained by crop senescence, anticipated harvest date, or both. Each plot should be sampled according to the management to which it is subjected. A single clip harvest is required if - for the entire growing season - one crop is planted, if only a cover crop is planted, or if a plot is fallow and only non-crop vegetation is present. Multiple clip harvests per sampling season are required to capture multiple and successive agricultural crop rotations or the combination of both an agricultural crop and a cover crop (planted before or after the agricultural crop);

In the field, the primary distinction between the procedure for agricultural crops described here, compared to that presented in RD[04] for ‘wild’ herbaceous vegetation, is that crops require larger, variable Clip Strip dimensions, and Clip Strips are oriented perpendicular to crop rows. In contrast, ‘wild’ herbaceous vegetation uses a Clip Strip with fixed dimensions that is always oriented North/South. Variable Clip Strip dimensions are required because planting in rows introduces spatial structure to the biomass that is not adequately captured with a narrow Clip Strip.

Because agricultural plots may also support other herbaceous plants besides the crop of interest – i.e., ‘non-crops’ – clipped vegetation within these larger Clip Strips must still be sorted to functional group as in RD[04] if non-crops are present. For example, if a Clip Strip contains wheat, as well as other plants belonging to several of the herbGroups defined in RD[04], clipped wheat biomass is separated from non-crop biomass, and clipped non-crop biomass is further sorted to herbGroup (i.e., CSG, WSG, LFB, etc.).



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Because agricultural crops may attain relatively large stature, the laboratory procedure in this SOP differs from RD[04] by introducing a subsampling method prior to oven-drying clipped biomass of high-volume crops. This subsampling step allows for more efficient drying and processing of large sample volumes. Low-volume crops are processed identically to ‘wild’ herbaceous vegetation. In addition, data collected via this SOP are entered via the same HBP Fulcrum applications as RD[04].



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6 SAMPLING SCHEDULE

6.1 Sampling Frequency and Timing

Agricultural sites often practice crop rotation, which results in NEON plots located in different parcels, with each parcel supporting a crop-specific planting and harvest schedule that changes from year to year. Each crop that matures within the scheduled sampling year should be sampled for biomass to estimate the productivity of the site. To capture the biomass and productivity of crops planted and harvested in different growing/sampling seasons, the timing of sampling will not be the same for every plot – i.e., some plots will require multiple bouts. For these reasons, the following actions are highly advantageous in agricultural systems:

- Communicate and collaborate with the site host and/or farmer to determine and coordinate harvest dates and sampling activities,
- Monitor the Phenocam to determine crop maturation rates and potential harvest dates, and

Consult the Site Management application or NEON Portal data previously collected with this SOP for historical crop-specific harvest dates. Table 1 provides an overview of spatial and temporal sampling strategy for agricultural sites.

Fields Not Planted with Agriculture Cash Crops:

- Plots left fallow – i.e., not planted for an entire growing/sampling season – or planted with cover crops, should be sampled to adequately capture site-level productivity (see examples below).
- Non-crops or planted cover crops not intended for agricultural harvest that do not have an obvious row structure should be clipped with the standard 2.0m x 0.1m clip strip, oriented North/South.
- It is not necessary to schedule an additional bout for clipping non-crops that may sprout before the planting of or after the harvest of an agricultural cash crop or cover crop.

Table 1. Summary of clip harvest sampling frequency and timing guidelines by plot type for agricultural sites.

Plot Type	Plot Number	# Events per Sampling Year	Yearly Interval	Sampling Start	Sampling Stop
Distributed	n=10 (min)* n=20 (max)	Once per cash crop, planted cover crop, or if fallow for the entire	KONA and STER: Annual All other sites: 1x every 5 years	Beginning of crop senescence	Within 14d of sampling start



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Plot Type	Plot Number	# Events per Sampling Year	Yearly Interval	Sampling Start	Sampling Stop
Tower	n=10 per crop type (max)	growing season	Annual		

* If all Distributed plots are planted in the same crop type, a minimum of n=10 plots may be sampled (i.e., the first 10 plots in the Plot Prioritization list). If fewer than n=10 plots exist for a given crop type, all plots may be sampled. In the event that these rules result in > 20 plots that should be clipped, consult with Science. Only sample plots designated for HBP in the Plot Prioritization list. If 10 Distributed plots are in the Cultivated Crops NLCD class but only three are designated for HBP sampling, only sample those three plots.

Example Agricultural Clip Harvest Scenarios:

These examples convey the general concept that biomass produced by different crop and non-crop plants at different times of year should be accounted for with appropriately scheduled clip-harvest bouts. Not all possible scenarios are covered; if it is unclear how to schedule for your site, create an incident ticket and discuss with Science.

Multiple Crop Types Maturing at Different Times. A north temperate site has 10 plots planted with cover-crop (e.g., clover), 10 plots planted with a winter wheat cash crop, and 10 plots planted with a corn cash crop. Plots planted with winter wheat would likely be harvested late May or early June, approximately ISO week 22; cover-crop and corn plots would be harvested later, likely mid- to late-August at approximately ISO week 34. Cover-crop plots may be harvested on a different schedule than corn if the cover-crop reaches peak biomass later than the corn harvest.

Early-Season Fallow Followed by Crop. A plot (Distributed or Tower) is fallow and unplanted for the spring and has mixed non-crop plants growing opportunistically in it. The plot is then plowed and planted with a crop that matures in late summer or early autumn. Plots such as this require clip harvest sampling to capture the biomass associated with the cash crop in the autumn. It is not necessary to sample vegetation that grows opportunistically early in the season.

Early-Season Crop Followed by Fallow. A plot (Distributed or Tower) is planted with winter wheat that is harvested early to mid-summer. The plot is then left fallow and unplanted, and opportunistic non-crop plants grow that then senesce in the autumn. Plots such as this require a single bout for quantifying early-season crop biomass only, the opportunistic non-crop growth should not be clip harvested.

Early-Season Cash Crop Followed by Planted Cover Crop. A plot (Distributed or Tower) is planted with a winter wheat cash crop that is harvested early to mid-summer. The plot is then planted with a cover crop and these plants senesce in the autumn. Plots such as this require a first bout to quantify early-season winter wheat crop biomass, and a second bout for assessing the peak cover



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crop biomass (scheduled when greenness begins to decrease – i.e., when plants first begin to senesce).

Late-season planting that is not harvested. A plot is tilled and planted but the crop is left standing and not harvested. This plot would need to be sampled with clip harvesting at peak biomass. In the following growing season, if the plot is not tilled and planted with an agricultural crop or cover crop for the entire season, the plot would be sampled as a fallow plot, clipping whatever crop persists from the last planting and whatever non-crop vegetation has grown.

Multiple Crop Types and Desired Sample Size. At a site with n=30 Tower Plots, not all plots are planted in crops, and for plots with crops, plot numbers across crop types are not equal. For example, assume 3 Tower plots are planted with winter wheat, 14 Tower plots are planted with corn, and the remaining 13 Tower plots are located in perennial pasture/hay vegetation. In this scenario, one clip harvest bout would be scheduled early-season for all 3 winter wheat plots, another late-season bout would be scheduled to clip n=10 corn plots (the 10 lowest Morton Order plots), and a third bout would be scheduled according to the dates in RD[04] for the perennial pasture/hay vegetation. A similar strategy would be employed for Distributed plots planted the same way.

Pasture/Hay Harvests. Sampling should be scheduled to quantify productivity at Tower plots and biomass at Distributed plots. Distributed plots should be sampled once, prior to the hay harvest. Tower plots should be harvested prior to the hay harvest. If the growing season conditions are suitable for continued herbaceous production, the Tower plot may require a second sampling bout to account for the resulting compensatory growth that might precede an additional hay harvest. Service Now tickets should be generated to discuss the need and scheduling for these scenarios.

6.2 Criteria for Determining Onset and Cessation of Sampling

Sampling onset: Crop biomass typically peaks some time before plants begin to senesce, and a fraction of total peak biomass mass is lost as senescence proceeds. Peak greenness data provided in RD[04] may guide scheduling of sampling onset, but because multiple rotations are often planted within a site, MODIS data should be considered as a guide only. A more reliable indicator for sampling onset is to monitor plants for the beginning of senescence, and begin clipping as soon as the first leaves begin to dry or yellow. For corn and soybeans, drying and yellowing usually begins with the lower, older leaves.

Sampling cessation: As indicated in **Table 1**, sampling should be completed within 2 weeks of sampling onset. In the event of unforeseen delays, sampling must be completed before the farmer harvests the crop; if the farmer removes crop biomass before NEON clip harvest is complete, estimates of productivity for the site will be severely compromised. **Table 2** gives the earliest dates that farmers typically harvest specific crops within NEON sites (data provided by USDA).

Occasionally, farmers will plant specialty crops for which USDA has not compiled harvest date data – e.g., millet planted at the D02 BLAN and D10 STER sites. In this event, to complete NEON Ag Clip Harvest



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sampling activities before the farmer harvests the crop, opportunistically monitor crop maturation through time while conducting other sampling, and/or maintain communication with the farmer about anticipated harvest dates.

Dates listed in **Table 2** may be used for hiring and high-level scheduling purposes if Field Operations obtains information from the farmer with respect to which crops will be planted in the coming year. However, with respect to scheduling the exact week in which clip harvests will take place for a particular crop once the growing season is underway, bear in mind that weather can cause significant deviations from the averages presented in **Table 2**.

Table 2. Anticipated earliest harvest dates for unique site by crop combinations likely at NEON agricultural sites. Data come from long-term USDA records aggregated at the state level. Sites with crops other than those listed here are covered in the site-specific modification appendix at the end of this document (e.g., D04 LAJA).

Domain	Site(s)	Crop	Harvest begin date	Harvest most active dates
D02	BLAN	Corn for grain	8/25	9/5 – 10/25
		Corn for silage	8/5	8/30 – 10/1
		Soybeans	10/5	10/25 – 11/25
		Wheat, winter	6/5	6/20 – 7/15
	SERC	Soybeans	10/5	10/18 – 11/15
D03	JERC	Corn for grain	7/25	8/15 – 9/5
		Soybeans	10/1	11/1 – 11/25
		Wheat, winter	5/20	6/1 – 6/15
D06	KONA	Barley, fall	6/10	6/15 – 7/1
		Barley, spring	6/20	6/25 – 7/1
		Corn for grain	9/5	9/20 – 10/20
		Sorghum for grain	9/15	10/10 – 11/5
		Soybeans	9/20	10/5 – 10/25
		Wheat, winter	6/15	6/20 – 7/10
D09	NOGP	Barley, spring	7/30	8/8 – 8/23
		Corn for silage	8/31	9/12 – 9/28
		Corn for grain	9/29	10/10 – 10/27
		Soybeans	9/16	9/26 – 10/11
		Wheat, durum	8/9	8/21 – 9/9
		Wheat, spring	8/4	8/14 – 9/1
D10	STER	Barley, spring	6/10	7/25 – 9/5
		Corn for silage	9/1	9/10 – 9/30
		Corn for grain	10/1	10/15 – 11/10
		Sorghum for grain	9/25	10/10 – 11/15
		Sorghum for silage	9/1	9/5 – 9/20
		Wheat, winter	6/25	7/10 – 7/20



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6.3 Timing for Laboratory Processing and Analysis

Because clipped biomass continues to be biologically active after clipping and before drying (i.e. plant cells continue to respire and therefore lose mass), it is important to place clipped samples into the drying oven as soon as possible after clipping occurs. For Herbaceous Biomass (RD[04]), clipped plants are kept in cold storage after clipping and until samples can be placed in the drying oven. Similar to RD[04], freshly clipped crop samples or subsamples must be placed in the drying oven within five days of clipping in the field, and crop biomass must be kept in cold storage, same as in RD[04]. Once samples are dry, timing considerations for weighing are identical to RD[04].



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7 STANDARD OPERATING PROCEDURES

Standard operating procedures provide specific instruction and suggestions for the generation of data that is aligned with the goals of this document (**Figure 2**).



Figure 2. Overview of the SOPs needed to collect agricultural biomass and productivity data.



SOP A Preparing for Sampling

A.1 Sampling Equipment Preparation and Checklist

- See RD[04] for equipment preparation.
- Use of the laser rangefinder is only necessary at agricultural sites if plot markers are not present, and full plot delineation is required.

A.2 Early-season Preparation at Agricultural Sites

- Check with the Domain Manager to ensure that the farmer (or site host) has approved implementation of this SOP within target plots.
- If density of mature vegetation precludes easy navigation and Clip Strip delineation (e.g., in mature corn crops), marking of plot corners and delineation of Clip Strips may occur earlier in the season while plants are young and line-of-sight is not obscured.
 - Temporarily record GPS coordinates for locations marked in this manner to enable re-location during sampling.

A.2.1 Integrating Plant Belowground Biomass and Clip-Harvest at Agricultural Sites

Delineation and flagging of sampling areas for both Plant Belowground Biomass Sampling and the Agricultural Biomass SOP should be carried out at the same time regardless of which protocol is executed first. In the event that Tower plots are planted with different crop types that are harvested at different times or some of the Tower plots are not in agriculture, the Plant Belowground Biomass Sampling should occur when the majority of Tower plots are sampled and at or near peak biomass.

1. Bring a 3 m long folding ruler, or equivalent rigid measuring device, and 0.5m x 0.5m frames used to lay out the belowground biomass sampling areas.
2. Locate the SW corner of the clip cell. When integrating Plant Belowground Biomass and clip-harvest at agricultural sites, *the Clip List coordinate will serve as the SW corner of the clip cell rather than the clip strip*. For example, the left-most flag in **Figure 3** is placed at the coordinate provided in the Clip List.
 - a. Clip List coordinates at Agricultural sites have the standard meaning when Plant Belowground Biomass sampling is NOT integrated with the Ag clip-harvest.
3. Rotate clockwise until you are facing perpendicular to crop rows (**Figure 3**).
4. Use the rigid measuring stick to lay out the 3 m long left side of a 3.0m x 0.5m clip cell.
5. Use the 0.5m x 0.5m frames to layout the plant belowground biomass sampling areas at either end of the clip cell. Flag the lower-left corner of the cell and the upper-right corner of the cell.



- a. Flagging should remain if soil sampling occurs prior to agricultural clip harvest and allowed by the site host.
 - b. Note that the clip-strip may be wider than 0.5 m for some crop types.
6. Delineate a clip strip of the appropriate dimensions; the long edge of the clip strip should remain perpendicular to crop rows.

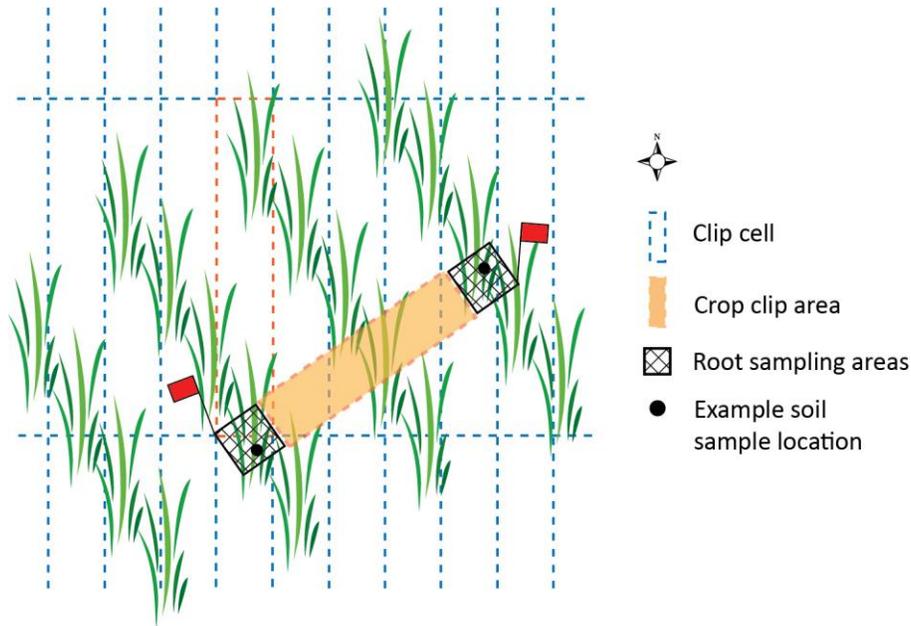


Figure 3. Modified clip cell layout when integrating plant belowground biomass sampling and herbaceous biomass clip harvest at agricultural sites. Orange dashes indicate the rotated clip cell. The red flag on the left is placed at the coordinate provided in the Clip List.

A.3 Calibrating Spring Scales

Calibration Procedure: This process ensures that scales are calibrated to register accurate weights and have not been inadvertently adjusted.; it should be completed in the lab prior to each sampling bout.

1. Place a weight around the mid-point of the scale’s range into a bag. Note that this does not need to be a calibration weight – it can be any object around the mid-point of the weight range for the scale (e.g., measured bags of seed).
2. Weigh the bag plus the weight to the nearest 0.1 g on the laboratory balance and record this reference weight.
3. With nothing clipped to the spring scale, turn the knob to adjust the scale to zero.
4. Clip the bag plus the weight to the spring scale and record the registered current weight. Ensure the scale is held vertically so the spring hangs freely and is not stuck.



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5. Check that the spring scale registers the weight \pm the stated accuracy of the scale (e.g., $\pm 5\%$). If the scale is not registering within this tolerance, do not use this scale in the field.

Testing Scale Integrity: An additional ‘scale integrity’ test should be conducted once per year. This process ensures that scales are able to accurately register weights across their range. As the springs in the scales age there will be a point when they are no longer accurate enough for field use.

1. Perform the calibration procedure above with a weight at the mid-point of the scale range.
2. Perform the calibration procedure above, but this time with a weight in the lower 25% of the scale’s weight range (e.g., for a 100g scale use ~25g weight).
3. Perform the calibration procedure a third time with a weight in the upper 75% of the scale’s weight range (e.g., for a 100g scale use ~75g weight).
4. Discard and replace any calibrated spring scales registering weights that diverge from the true weight by more than $\pm 5\%$ (e.g., for a calibrated scale that is measuring a weight that is 80g, the scale passes the integrity test if it registers a value between 76-84g).

A.4 Sample Labels and Identifiers

By default, this procedure considers each clip cell harvested on a unique date to be a sample, and each herbGroup/crop is a subsample. Subsamples are labeled with the location, date, and herbGroup of the collected subsample. In addition to labeling the subsample with human readable information, each subsample may also be associated with an optional scannable barcode.

Barcode Workflow:

Use of barcodes for this SOP is highly recommended. Barcodes may improve sample tracking, and reduce transcription errors associated with writing sample and subsample identifiers by hand. Barcodes may also speed entry of data into the HBP: Lab Masses [PROD] application. Until they are linked with a subsample, barcodes do not contain information specific to sample provenance.

When using barcodes, adhesive barcode labels should be applied to dry, room temperature bags or envelopes 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; if using barcodes, it is encouraged to apply these in advance. See RD[04] for the appropriate barcode label type for this procedure. Note that a barcode label is applied *in addition to* labeling the subsample with human-readable information (hand-written or printed).

Barcodes are scanned into the mobile application when the subsample (i.e., herbGroup) is placed into the bag; only one barcode may be associated with a particular subsample. Do not reuse barcodes. If a barcode is associated with multiple subsamples, the data ingest system will throw an error and refuse to pull in entered data.



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SOP B Field Sampling Aboveground Biomass of Agricultural Crops

At agricultural sites, clip harvesting produces estimates of total crop biomass production on a per crop basis, as well as the biomass production of any non-crop herbaceous plants growing with the crop. Crop biomass is separated from non-crop biomass, and non-crop biomass is further sorted to herbGroup as in RD[04] (Figure 4).

In the procedure below, it is assumed that technicians have a working knowledge of SOP B in the TOS Protocol and Procedure: HBP - Measurement of Herbaceous Biomass (RD[04]).

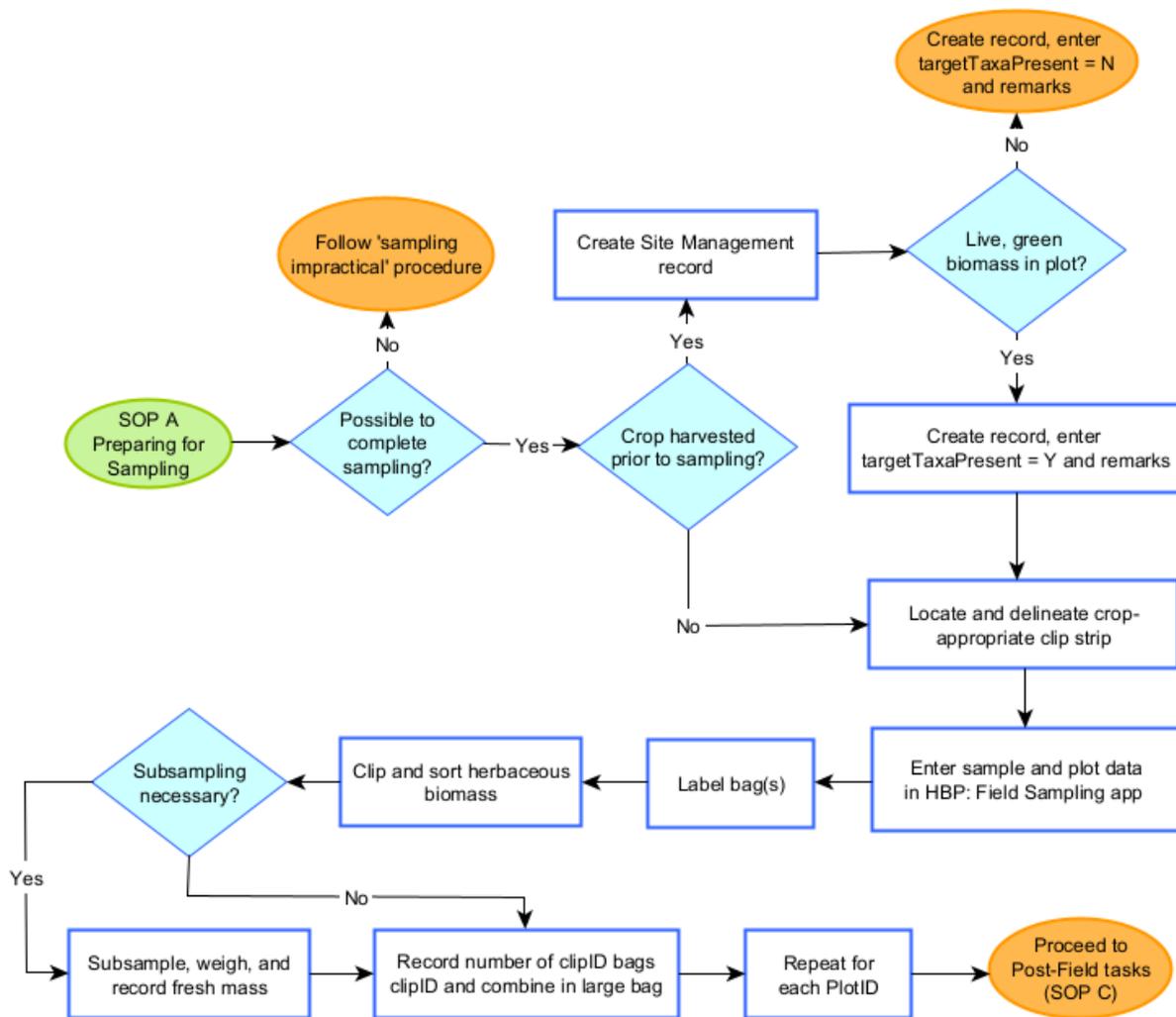


Figure 4. Expanded workflow diagram for field sampling the aboveground biomass of agricultural crops (SOP B). Diagram supports and does not replace protocol text; most common workflow is outlined.



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HELPFUL HINT: COORDINATING WITH OTHER PLANT PROTOCOLS

Plant Diversity:

- If plant diversity sampling is scheduled to occur prior to crop clip-harvest sampling in a given sampling year, it may be helpful to identify and demarcate a suitable Clip Strip prior to performing diversity sampling. This will ensure that the Clip Strip is not trampled during diversity sampling.
- Should clip-harvest occur before diversity sampling, take care to avoid trampling 1 m² nested subplots used for Plant Diversity % cover measurements.
- Reject the clip cell if rotation required for sampling causes the desired clip cell to overlap with nested subplots used for Plant Diversity (applicable only in Distributed plots and those Tower plots that support Plant Diversity).

Plant Belowground Biomass:

- Plant Belowground Biomass soil samples should be collected according to the standard protocol from 0.5m x 0.5m sampling areas.
 - Soil sampling areas for belowground biomass are rotated along with the crop clip strip and 'book-end' the clip strip on each narrow end, similar to standard North/South clip strips. See **Figure 3**.
-

B.1 Sample Collection in the Field

1. Navigate to the selected plot, using the GPS if necessary. Should the farmer harvest the crop or till a cover crop plot prior to scheduled Agricultural Clip Harvest sampling:
 - Create a record in the Site Management application describing the management activity that occurred, and estimate the date of occurrence.
 - If live, green weeds or other non-crop plants are still growing in the plot:
 - Create a record for the **clipID** in the Herbaceous Clip Harvest Field Sampling application, and indicate **targetTaxaPresent** = 'Y'.
 - In the **biophysicalCriteria** field: Record 'Crop harvest preceded NEON sampling' or 'Plot tilled before NEON sampling'.
 - Perform subsequent steps below.
 - Else if no weeds or non-crop plants are growing:
 - Create a record for the **clipID**, and indicate **targetTaxaPresent** = 'N'.
 - In the **biophysicalCriteria** field: Record 'Crop harvest preceded NEON sampling' or 'Plot tilled before NEON sampling'.
 - Proceed to the next plot.



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2. As described in RD[04], use the plot- or subplot-specific Clip List to identify and locate the target clip cell for sampling.
 - When these steps are complete, you should have placed a pin flag at the SW corner of the Clip Strip. This flag is referred to as ‘Flag1’ below (**Figure 5**). Because Ag Clip Strips are commonly rotated, Flag 1 will not necessarily be the SW corner as it is for the standard Clip Harvest.
 - On the Clip List, record the clip cell that was used as the starting point for clip cell delineation. Because agricultural clip strips are often oriented off the typical north/south axis, they will typically intersect > 1 clip cell, and there is no need to determine exactly which clip cells an angled clip strip intersects.
3. Select the appropriate crop-specific dimensions for the Clip Strip (**Table 3**).
4. Delineate the accepted Clip Strip for harvesting. Clip Strip orientation **is not the same as in RD[04]**. For agricultural crops, clip strips are oriented perpendicular to crop rows in order to consistently account for the spatial structure introduced by row planting (see **Figure 5**). Crop row orientation, and therefore Clip Strip orientation, may change from year to year.
 - a. Stand over the top of ‘Flag1’ facing North, and rotate clockwise until you are perpendicular to the crop rows. A compass may help ensure you are consistently perpendicular to the rows.
 - b. Extend a meter tape or measuring stick outward to the required ‘Length’ (L) distance specified in **Table 3**, and mark this distance with another pin flag – ‘Flag2’.
 - c. Stretch a string and stake set or lay the measuring stick between Flag1 and Flag2 to mark one long edge of the Clip Strip.

Note: For crops in **Table 3** that require Clip Strips with length < 2 m, use the folding measuring stick instead of a string/stake set.
 - d. Standing over Flag1 again, look down the length of the string toward Flag2, and use the meter tape or measuring stick to place two more pin flags X cm to the right of Flags1 and 2, where X is the ‘Width’ (W) distance (**Table 3, Figure 5**).
 - A folding meter stick may be used to create an accurate right-angle help determine the correct location of Flags 3 and 4.
 - e. Stretch a second string and stake set between these two new flags. The second string should be parallel to the first, and the strings and flags should delineate a rectangular Clip Strip with the dimensions shown in **Table 3**.

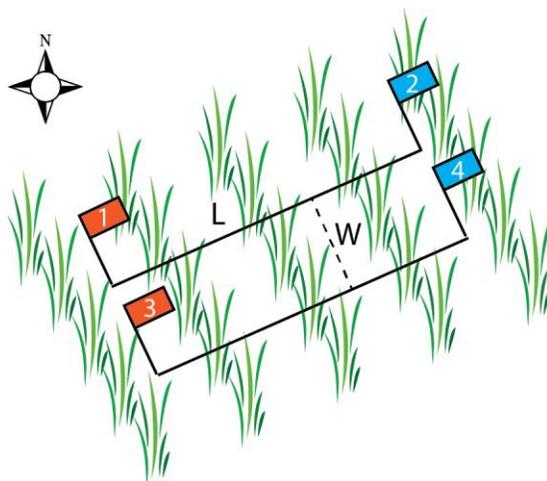


Figure 5. Clip Strip establishment in an agricultural row crop. Numbered flags correspond to those referenced above in step (5); ‘Flag 1’ corresponds to the SW corner of the Clip Strip that is provided in the Clip List. Values for the length (L) and width (W) of the Clip Strip are crop-specific and are provided in the **Table 3** below.

Table 3. Clip Strip dimension required for crops expected at NEON agricultural sites. Row spacing is for typical plantings and may vary from listed value.

Crop	Row spacing	Quadrat dimensions, L x W (m)
Barley	18 cm (7 in)	2.0 x 0.5
Corn	38 or 76 cm (15 or 30 in)	1.5 x 0.65
*Millet	18 cm (7 in)	2.0 x 0.5
Sorghum	38 or 76 cm (15 or 30 in)	1.5 x 0.65
Soybeans	38 cm (15 in)	1.5 x 0.65
Wheat	18 cm (7 in)	2.0 x 0.5

* Millet is a generic term for a number of different crop plants. Submit a help ticket if observed spacing is different from that listed here.

ROW SPACING



- If row spacing differs from that listed in **Table 3** for a given crop by > 25%, submit a help ticket to determine whether a different quadrat dimension is warranted.
- An early season reconnaissance may be helpful to detect potential crop spacing, and address Clip Strip dimension issues prior to scheduled sampling.

5. Create a record in the HBP: Field Sampling [PROD] application for the sampled **plotID**, and enter required plot-level field sampling information:

- **Sampling Impractical;** ‘OK’ or a reason sampling was not completed (RD[04]).



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- **biophysicalCriteria**; ‘OK – no known exceptions’ or a reason sampling did not occur during intended conditions (RD[04]).
 - **domainID**; the NEON domain from which the data are generated.
 - **siteID**; the NEON site from which the data are generated.
 - **plotID**; the NEON plot from which the data are generated. **collectDate**; use YYYYMMDD format.
 - **collectTime**; use HH:MM format.
 - **weekBoutBegan**; the ISO week number in which sampling began. If a bout duration exceeds a single week, enter the ISO number of the week the bout began. Multiple bouts per season will be required if crop rotation is practiced at the site. **samplingCellNumber**; as provided in Clip List; use last 3 numbers from the clipID, e.g. for BLAN_001_126, record ‘126’.
 - **samplingCellDimensions**; The length (L) and width (W) of the Clip Strip, in meters; e.g., ‘1.5 x 0.65’.
 - **targetTaxaPresent**; If there is no biomass in a Clip Strip (i.e., neither crop nor non-crop biomass is present), AND the Clip Strip is deemed representative of the plot, record ‘targetTaxaPresent = N’. **samplingProtocolVersion**; the version of the protocol that guided the collection.
 - **hbptype**; select ‘Agricultural’ if there is a cash crop or cover crop, or ‘fallow’ if the field is fallow. **measuredBy**; identity of the person making the field measurements.
 - **Field Sub Samples Created**; indicated if the subsampling procedure was applied to the sample. If ‘yes’ enter
 - **freshMass (g)**; the fresh mass of the entire sample.
 - **subsampleFreshMass (g)**; the fresh mass of the subsample.
 - **cropType**; select the appropriate crop from the drop-down list. Submit an incident ticket if the required crop type is not in the list.
 - **herbGroups**; indicate ‘Present/Not present’ for all non-crop herbGroups. The HBP: Lab Masses [PROD] application will require a **dryMass** value for all ‘Present’ herbGroups.
6. Using a permanent marker, label an appropriately sized paper bag with the information below (use large yard-debris paper bags for high-volume crops like corn). Remember that you will need to clip and sort any non-crop biomass into the **herbGroups** (RD[04]), so label additional smaller 8# or 25# craft paper bags for this biomass, if present.

Note: To improve sample tracking, bags should be labeled with pre-affixed barcodes.

- **weekBoutBegan**; use ISO week format, e.g., ‘47’



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- **collectDate**; use YYYYMMDD format
 - **samplingCellID**; e.g. BLAN_001_126
 - **herbGroup**; for crops, this will simply be the crop type (e.g., ‘corn’, ‘soy’, etc.), and for non-crop biomass, herbGroup values are identical to those in RD[04].
 - **bagCount**; the total # of bags generated from a given clipID (for Field Ops tracking purposes only).
7. Clip and sort all crop and herbaceous non-crop biomass rooted within the Clip Strip. Recall that an individual must be $\geq 50\%$ rooted within the Clip Strip to be counted as ‘in’ for clipping.

General guidelines:

- For corn brace roots (**Figure 1**), clip all brace roots for an individual if it is $\geq 50\%$ rooted within the Clip Strip.
- Do **NOT** clip vegetation that passes through/leans over the Clip Strip but is not rooted in the strip.
- **DO** include leaves and stems in the harvest that exit the strip, but originate from stems rooted within the strip.
- When subsampling is required, use the **Subsample Fresh Mass Target Calculator** in the HBP: Sampling [PROD] application.

SOP B.1.1 Guidelines for high-volume crops with large seeds

- See Definitions (Section 2.4) for high- vs. low-volume crops, and note that it is always preferable to avoid subsampling if possible. The high-volume procedure for crops with large seeds is suitable for corn and other large-seeded crops.
- For steps that require the use of a spring-scale, always select the scale that allows the greatest precision possible for the mass being weighed. Remember that spring scales must be calibrated in the lab prior to each bout (SOP A.3).

Step-by-Step Sub-sampling Procedure (Figure 6)

1. Prepare two bags:
 - a. A large bag for the entire fresh sample (yard waste type, no label required), and
 - b. A smaller, labeled bag for the subsample (typically a #25 bag).
2. Tare bags on spring scales:
 - a. Tare both bags together; a 10 kg spring-scale is typically adequate for corn but smaller scales may be necessary for low-yield plots.
 - b. Tare the smaller subsample bag alone on a 5 kg spring-scale.



3. Separate ears or seed pods from the vegetative stalks/leaves, placing the ears/pods into the smaller subsample bag and the stalks/leaves into the large bag.
 - a. If harvesting corn, leave ears intact.
 - b. Use hand pruners or long-handled loppers to break up large stems and leaves.
4. Weigh the combined total mass of the content of both bags. To prevent tearing, double over the top of the bag before passing the spring-scale hook through the paper. Bag tops may also be reinforced with tape and then hole-punched.
 - a. Record the **Fresh Mass** to the greatest precision afforded by the spring-scale (nearest 50 g for a 10 kg scale).
5. Weigh the ears/pods separately on the 5 kg spring-scale.
 - a. Record the **Seed Fresh Mass** to the greatest precision possible.
6. Calculate the 'Seed Mass:Fresh Mass' ratio by dividing **Seed Fresh Mass** by **Fresh Mass** (done automatically by the Calculator in the Fulcrum application).
7. Select a representative ear or handful of pods and leave in the small bag to weigh. The remaining ears/pods may be discarded.
 - a. Record the **Sub Sample Seed Fresh Mass** to the greatest precision possible.
8. Calculate the **Subsample Fresh Mass Target** by dividing the **Sub Sample Seed Fresh Mass** by the **Seed to Fresh Mass Ratio** (done automatically by the Calculator in the Fulcrum application).
9. Add representative handfuls of vegetative biomass from the large bag to the smaller subsample bag until the target **Sub Sample Fresh Mass** is achieved (± 100 g).
 - a. Make sure the proportion of stalks/leaves is roughly maintained when adding vegetative mass to the subsample bag.
10. Weigh and record the *actual* **subSampleFreshMass** to the greatest precision possible.
11. Place the subsample into cold storage as soon as possible (e.g., cooler with re-usable cold packs), and transport back to the laboratory for drying.

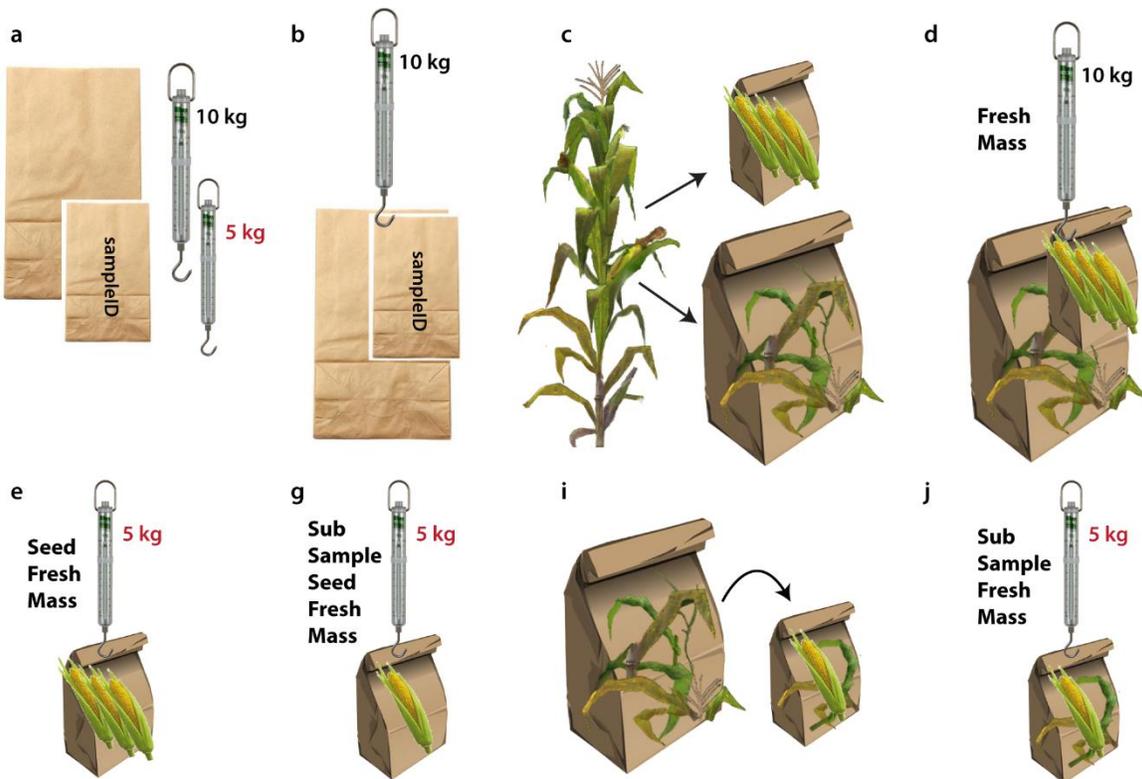


Figure 6. Subsampling routine for high-volume crops with large seeds (e.g., corn). Letters (a-j) correspond to protocol steps.

Example:

- The Fresh Mass of a corn Clip Strip is 5000 g (leaves/stalks + ears), and the Seed Fresh Mass is 2000 g (ears only). The Seed:Fresh ratio is $2000/5000 = 0.4$
- One representative ear is selected for the subsample, with Sub Sample Seed Fresh Mass = 500 g. The target Sub Sample Fresh Mass = $\text{Sub Sample Seed Fresh Mass} / \text{Seed:Fresh} = 500/0.4 = 1250$ g.
- Add vegetative mass to the existing ear until the total mass is 1250 ± 100 g. This is the **Sub Sample Fresh Mass** to place in the cooler and take back to the laboratory.

SOP B.1.2 Guidelines for high-volume crops with small seeds

- See Definitions (Section 2.4) for high- vs. low-volume crops. The high-volume procedure for crops with small seeds is suitable for grains and other small-seeded crops.

Step-by-Step Sub-sampling Procedure (Figure 7)

1. Prepare and label two bags as above for high-volume crops with large seeds.



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2. Tare bags separately on spring-scales. Spring-scale sizes below are for typical plots; a smaller scale may be necessary for low-yield plots:
 - a. Tare the large bag on a 10 kg spring-scale.
 - b. Tare the smaller bag on a 5 kg spring-scale.
3. Place all clipped biomass into the large bag, and do NOT separate seed heads from vegetative stalks/leaves.
4. Weigh and record the **Fresh Mass** to the greatest precision afforded by the spring-scale (nearest 50 g for a 10 kg scale).
5. Create a subsample in the smaller bag and visually maintain the existing proportion of seeds/leaves/stalks.
 - a. This is most easily done by selecting whole, representative plants for subsampling.
 - b. The subsample should be 20% – 30% of the initial **Fresh Mass**.
6. Weigh and record the **Sub Sample Fresh Mass** to the greatest precision possible (i.e., to the nearest 25 g with the 5 kg spring-scale).

SOP B.1.3 Guidelines for low-volume crops (e.g., some cereals)

1. Place the entirety of the clip-harvested crop sample into the bag from step (7).
2. Place the bagged sample into cold storage as soon as possible, and transport back to the laboratory for drying.
3. Select 'Fresh Sub Samples Created' = No
4. The **Fresh Mass** and **Sub Sample Fresh Mass** fields are not required (these fields are automatically hidden by the Fulcrum application).

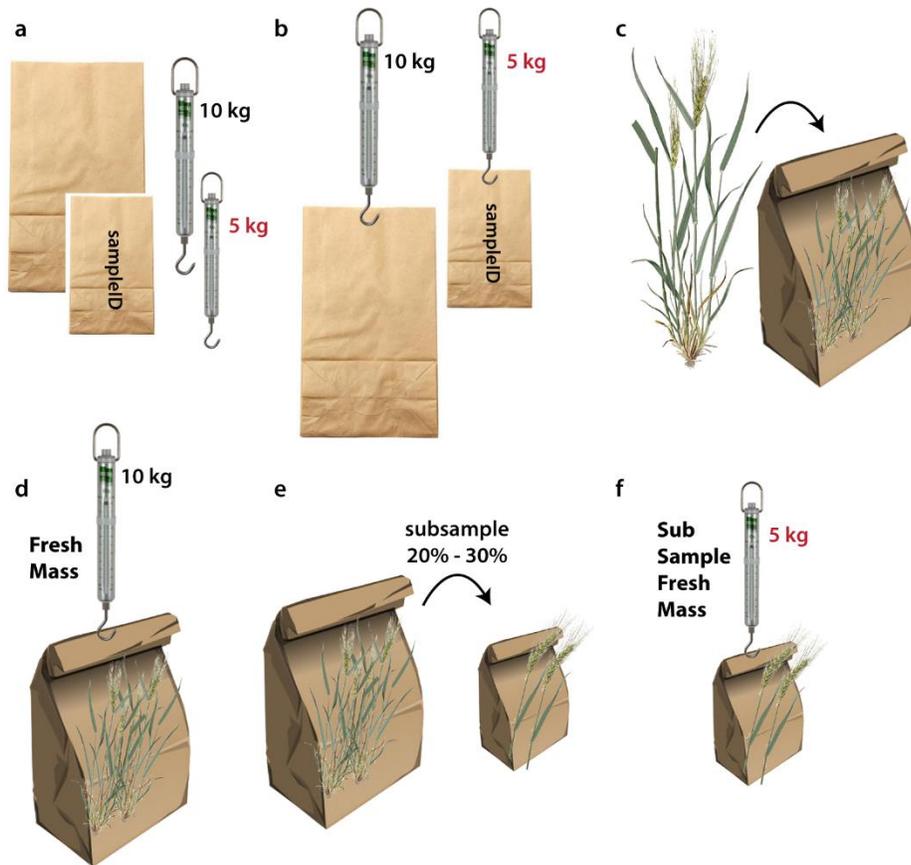


Figure 7. Subsampling routine for high-volume crops with small seeds (e.g., cereals). Letters (a-f) correspond to protocol steps.

SOP B.1.4 Completing Field Sampling

1. Record the total number of bags from the Clip Strip on the bags, and record the **collectTime** bags will be placed in the cooler in the HBP:Field Sampling [PROD] application (estimate to the nearest 30 min).
 - A value for **collectTime** is still required for the record even if there are no samples placed in the cooler.
2. **If using barcodes:** Link barcodes from each bag with subsamples in the Field Sampling application (subsamples = crop and herbGroups present).
3. Save the Field Sampling record. Records are finalized in a later step after sort-checking of non-crop biomass is completed.
4. When clipping is finished, group any small 8# bags from non-crop samples from the clipID together into a 25# bag, label with the clipID and date, and place in cold storage.



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- If cold storage space is insufficient for the crop volume, seal paper bags containing the sample, and keep at ambient temperature while still in the field.
5. If a high-volume crop was subsampled, dispose of any excess fresh biomass that will not be brought back to the laboratory outside the plot.
 6. Return to step (1) for the next plotID.

B.2 Sampling Non-Standard Agricultural Plots

Table 2. Additional guidelines for field conditions that required special handling or consideration.

Field condition	Guidelines
Plot planted in more than one crop type	Accept a random Clip Strip that falls within the dominant crop, as visually assessed by % cover (Figure 8). Reject other Clip Strips. Note that rejected Clip Strips are not rejected permanently as are un-representative Clip Strips in RD[04], due to the fact that crop cover changes regularly (just skip over these strips in the list).
Non-target crop is present but rare amongst target crop – e.g., a few corn stalks grow in a field of wheat	Select cropType for the dominant, target crop (e.g., wheat). Assign the non-target crop to the appropriate herbGroup and treat as non-crop biomass.
Wind thrown corn with multiple root points, at least one of which is in the Clip Strip	Only clip biomass associated with rooting points located within the strip.
Stubble from previously harvested crop is present (e.g., wheat stubble)	If the plot was harvested by the farmer before the scheduled NEON Clip Harvest bout: Clip stubble only if stubble biomass was produced in the current season, and from the biophysicalCriteria field select, “Crop harvest preceded NEON sampling.” Do NOT clip stubble produced in a previous growing season.
Rows cannot be discerned for a portion of the plot due to non-crop growth	Visually assess the plot with respect to % cover (rows can vs. cannot be discerned). If rows cannot be discerned for > 50% of the plot, then move forward with a standard N/S clip strip, and reject cells where rows <i>can</i> be discerned.



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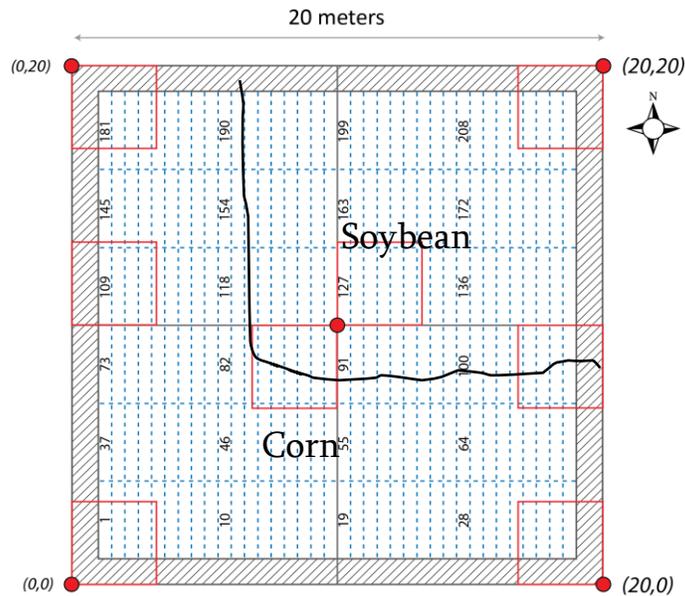


Figure 8. Rough percent cover map of plot planted in both corn (dominant crop) and soybeans (subdominant crop). The map may be used to reject potential clip strip locations that fall within the ‘soybean’ area without navigating to them.

B.3 Sample Preservation

- Keep paper bags with clipped vegetation in a cooler with cold packs to minimize wilting and biomass loss.
- Change cold packs for fresh ones every 12 h or transfer to a 4 °C refrigerator if a drying oven is not immediately available.
- Return to the laboratory for drying within 24 h of clipping, if possible.
- Transfer bags of clipped biomass to the drying ovens as soon as possible after field sampling, and monitor drying progress with the “Lab Drying” data sheet.
- Remember that samples must be dried within 5 days of clipping.

!!! IMPORTANT: Record the **collectDate** and **collectTime** in the HBP: Field Sampling [PROD] application AND **ovenStartDate** and **ovenStartTime** on both the sample bags and in the HBP: Lab Masses [PROD] application so that the number of hours the bags were stored cold can be automatically calculated.



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SOP C Post-Field Sampling Tasks

The workflow following field work is largely similar to the analogous activity in the protocol (RD(04): checking biomass bags and sorting (**Figure 9**).

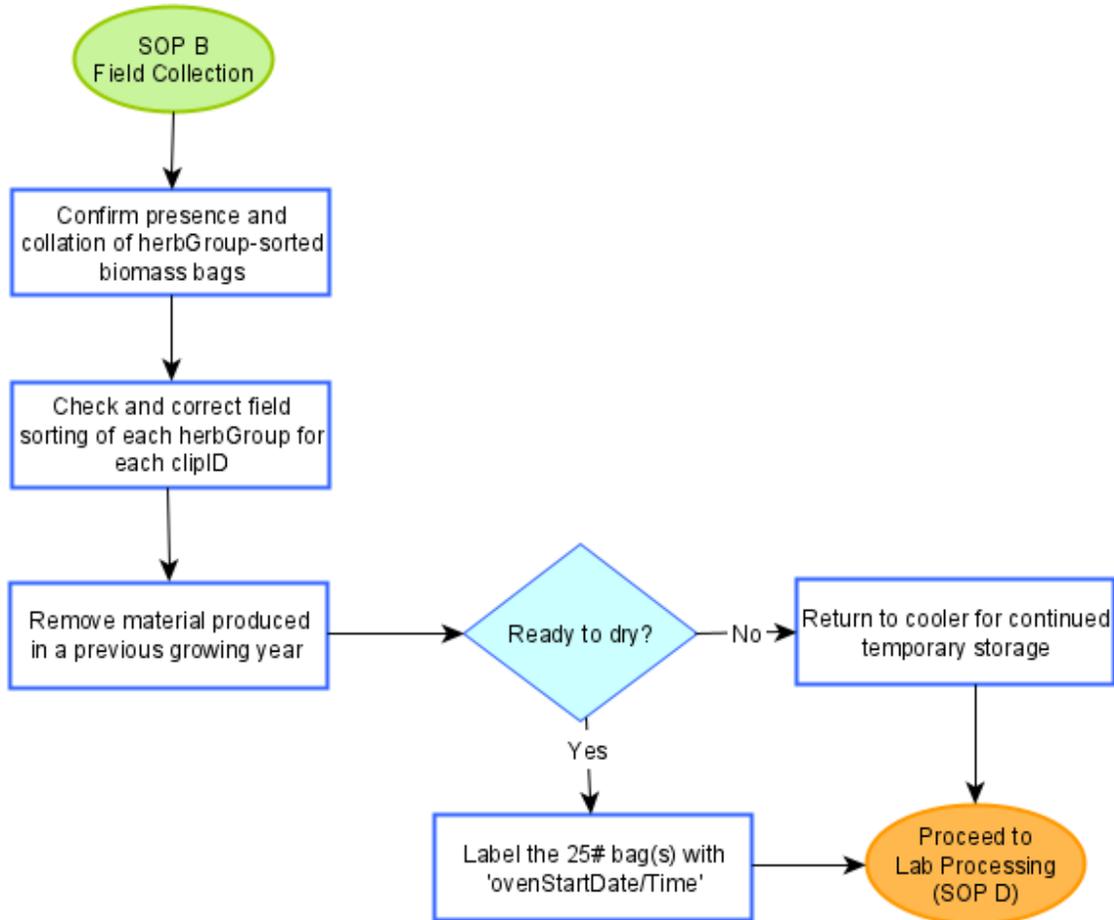


Figure 9. Expanded workflow diagram for sort-checking field-collected agricultural biomass prior to oven-drying in the laboratory (SOP C). Diagram supports and does not replace protocol text; most common workflow is outlined.

C.1 Sort-Checking Non-Crop Biomass

1. Sort-check non-crop biomass to ensure accurate herbGroup classification. Use the procedure outlined in RD[04].
2. Update and save herbGroup presence/absence in the HBP: Field Sampling [PROD] application (if necessary).



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C.2 Refreshing the Sampling Kit

- Make sure the following consumables are available in sufficient quantity for the next round of clip-harvests:
 - Large ‘yard waste’ style paper bags, 30 gallon capacity (high volume crops). Bags may be re-inforced with tape and hole punched at this time, if desired.
 - Paper bags, 8# and 25# kraft (or the necessary size given site vegetation stature)
 - All-weather paper for printing field datasheets
 - Permanent markers for labeling bags in the field
- Return cold packs to the -20 °C freezer to refresh.

C.3 Equipment Maintenance and Cleaning

- Clean blades of hand clippers with an appropriate solvent (oil, ethanol, water), and dry thoroughly.
- Recharge batteries for the GPS unit (if necessary).
- Recharge batteries for the TruPulse (if applicable).

C.4 Data Management

1. After sort-checking non-crop biomass (above), finalize and save all records in the HBP: Field Sampling [PROD] application.
 - Finalizing records will auto-generate corresponding records for each Clip Strip (parent) and Herb Group (child) in the HBP: Lab Masses [PROD] application.
2. Sync all tablets. Tablets should be synced before any additional Lab Mass edits are made.
3. See RD[08] for additional Data Management guidelines that pertain to this procedure.



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SOP D Laboratory Processing of Agricultural Biomass Samples

Overview

Oven dried ‘dryMass’ values are generated for crops and herbaceous non-crop plants from the same clip strip. Drying and weighing of clip-harvested crop biomass is very similar to that described for herbaceous biomass in RD[04], with the exception that high-volume crop biomass is subsampled prior to oven drying. A subsampling approach ensures the drying ovens are not monopolized by a small number of high-volume samples. Because of the subsampling approach used for high-volume crops, data are entered into the HBP:Lab Masses [PROD] application differently for high-volume crop versus low-volume crop and non-crop herbaceous biomass (**Figure 10**):

- High-Volume Crop biomass (SOP D.1):
 - Set Field Sub Samples Created to ‘Yes’
 - Values for **Fresh Mass**, and **Sub Sample Fresh Mass** are recorded in the field (SOP B).
 - Record **Sub Sample Dry Mass** in the HBP: Lab Masses [PROD] Fulcrum application.
 - Values of **Dry Mass** are calculated automatically.
- Low-Volume Crop and Non-crop Herbaceous Biomass (SOP D.2):
 - Set Field Sub Samples Created to ‘No’
 - Record measured **Dry Mass** of entire clipped sample.

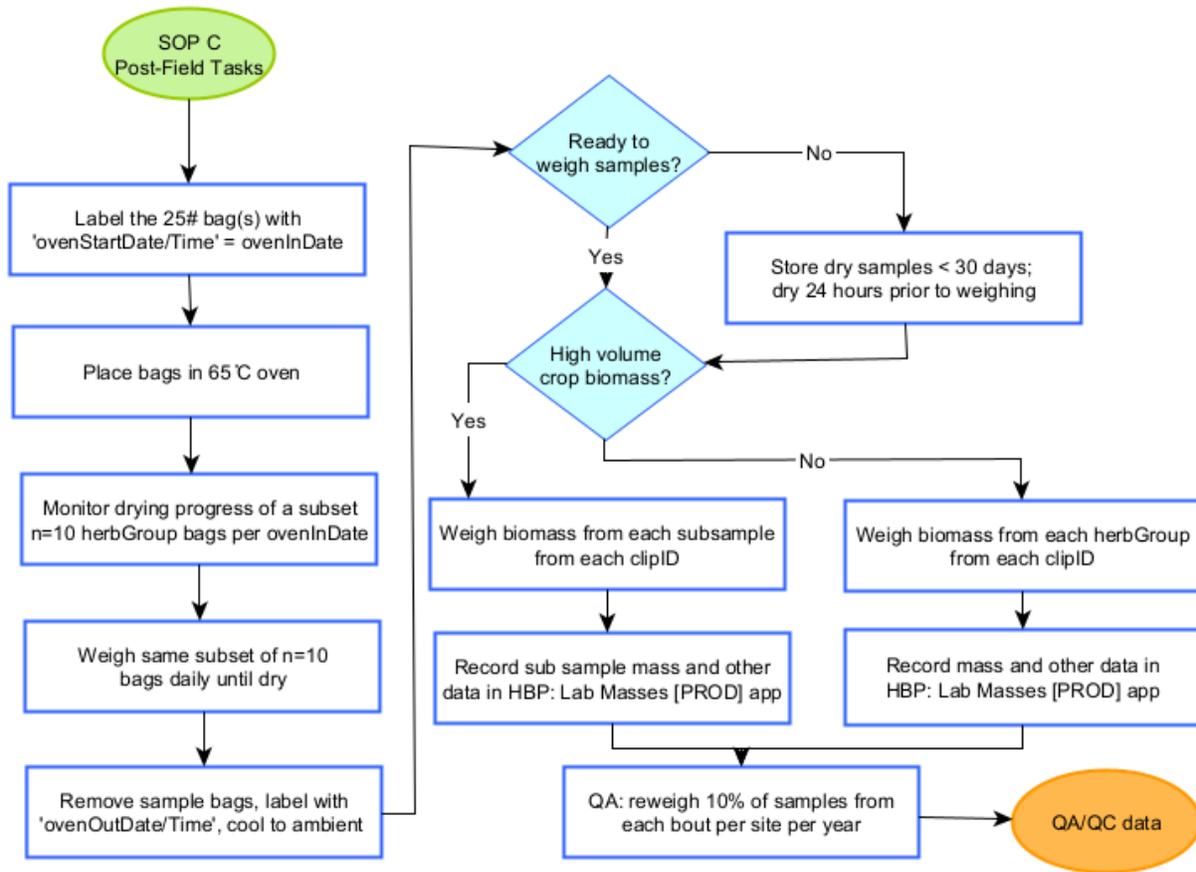


Figure 10. Expanded workflow diagram for drying and weighing clipped, sort-checked agricultural biomass (SOP D). Diagram supports and does not replace protocol text; most common workflow is outlined.

D.1 Drying and Weighing Clipped High-Volume Crop Biomass

Most of the crops to which this SOP applies will be high-volume crops, and clipped biomass from all plots will therefore not readily fit into NEON’s drying ovens. Certain cereals may be low-volume crops; if all of the clipped crop samples can fit into the drying ovens, use the low-volume crop biomass approach (SOP D.2, below).

1. Place labeled 25# subsample bags into a 65 °C drying oven for 48h – 120h (2d – 5d).
 - Some crop samples may take significantly longer to dry, make sure there is adequate oven space.
2. After placing all bags from one clipDate in the oven, check the drying progress of clipped biomass using a subset of 10 bags, and the “Lab Drying” datasheet.
 - a. Check the weight of the same selected subset of 10 bags per clipDate after day 1, 2, 3, etc. Record these weights each day on the “Lab Drying” datasheet.



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- b. Calculate the difference in weight between the latest two time points for each bag.
- c. Subsamples are dry when the average weight difference between the last two time points = 0 (averaged across all 10 bags, ± 0.1 g or $\pm 1.0\%$ of the previous timepoint mass, whichever is larger).

AGRICULTURAL BIOMASS DRYING TIPS

- A spreadsheet calculator is useful for calculating the average weight difference. A link is provided in the ‘Supporting Documents’ section of the Field Ops Sampling Support Library on Sharepoint.
 - To save time, plant material should be weighed WITH the bag to prevent loss of material during drying.
 - Focus on the heaviest bags, as these will likely take the longest to dry.
 - Additional drying tips in RD[04] also apply.
-
3. Remove bags of dried biomass from the drying oven, and label bags with **ovenOutDate/Time**.
 - Dried plant material should be weighed immediately after removing from the drying oven, as it will absorb moisture from the air if left in ambient room conditions (particularly in humid environments).
 - If using this method, it is helpful to remove bags from the oven and weigh one at a time.
 - Dried subsamples may also be stored for up to 30 days in ambient room conditions prior to weighing. Subsamples treated in this manner must be returned to the drying oven for 24 h prior to weighing, and must be weighed as above after removal from the oven.
 - If samples have been initially dried and kept in storage, it is not necessary to record any additional drying times.
 4. Record and/or check required metadata for each subsample in the HBP: Lab Masses [PROD] Fulcrum application in the parent and child levels and check the Fulcrum manual for further details:
 - **herbGroup**; ‘corn’, ‘wheat’, ‘soy’, ‘sorghum’, etc.
 - **plotID**; *SITE_XXX* format
 - **collectDate**; date collection was made in the field
 - **sampleID**; unique identifier for the sample
 - **ovenStartDate / ovenStartTime**; date and time (24-h format) subsample was placed in oven (initial drying only)



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- **ovenEndDate / ovenEndTime**; date and time subsample was removed from oven (initial drying only)
5. Weigh crop subsamples from each clipID using an electronic scale, and a plastic tray or weigh boat.
 - If using optional barcodes:
 - Open the HBP: Lab Masses [PROD] application, and scan the barcode on the bag to bring up the record associated with the plotID.
 - Select the appropriate crop/herbGroup subsample that matches the bag, and choose 'Edit'.
 - Record **subSampleDryMass**; nearest 0.01 g, plant material ONLY (without the bag).
 - Avoid splitting the subsample into subgroups for weighing, as uncertainty values from weighing must be added each time a subgroup is created.
 - Do NOT record **finalDryMass**. This will be calculated automatically by the Fulcrum application.
 6. Save the herbGroup level child record, and when all child-records have been updated with **finalDryMass** values, save the parent plotID record.

D.2 Drying and Weighing Clipped Low-Volume Crop and Non-crop Herbaceous Biomass

Low-volume crop biomass and non-crop herbaceous biomass is dried and weighed as described in RD[04]. In contrast to high-volume crop biomass processing above (SOP D.1), no subsampling is employed here: Dry and weigh the entire sample, as in RD[04].

1. Enter required data into the Herbaceous Clip Harvest: Lab Mass application.
 - If using optional barcodes:
 - Open the Lab Masses application, and scan the barcode on the bag to bring up the record associated with the plotID.
 - Select the appropriate crop/herbGroup child record that matches the bag, and choose 'Edit'.
 - Record **herbGroup**; for low-volume crop, select 'wheat', 'barley', etc.; for non-crop biomass select the appropriate herbGroup described in RD[04] (i.e., cool-season graminoid, leguminous forb, etc.)
 - Record **Dry Mass**; total dry mass of the entire sample, nearest 0.01 g, plant material ONLY (without the bag).



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- Save the herbGroup level child record, and when all child-records have been updated with **Dry Mass** values, save the parent plotID record.

D.3 Data QA

- QA sample weighing is not performed for high-volume crop subsamples.
- For low-volume crop samples and non-crop herbaceous biomass, QA sample weighing is performed as in RD[04].
- Record QA weight data to the nearest 0.01 g in the **qaDryMass** field of the HBP: Lab Masses [PROD] Fulcrum application.



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SOP E Data Entry and Verification

The Aboveground Productivity for Agricultural Crops SOP uses the Herbaceous Biomass data entry and verification workflow and ingest, and is identical to that described in SOP F of RD[04]. Consult the Data Management protocol for Herbaceous Biomass data quality procedures (RD[08]).



APPENDIX A EQUIPMENT

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

Table 4. Equipment list – Equipment needed to prepare for sampling.

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
Compass Tools	Y	GPS receiver, decimeter accuracy (e.g. Trimble GEO XH 6000, Trimble GEO 7X, or equivalent); Range pole, and antenna	Navigate to sampling locations at sites where plot markers are absent	1
Amazon Cabela’s REI	N	GPS receiver, recreational accuracy	Navigate to sampling location at sites with plot markers	1
Forestry Supplier	Y	TruPulse 360R Laser Rangefinder, ± 30 cm accuracy	Delineate plot boundaries, determine clip cell location	1
		USB Cable	Transfer data to GPS unit.	1
		All weather paper	Printing field datasheets	1
		Adhesive barcode labels (Type I)	Labeling sample containers with barcode-readable labels	1 sheet

Table 5. Equipment list – Equipment needed for a 2-person team to perform agricultural clip harvest sampling at one plot.

Supplier/Item No.	Exact Brand	Description	Purpose	Quantity
Compass Tools	Y	GPS receiver, decimeter accuracy (e.g. Trimble GEO XH 6000, Trimble GEO 7X, or equivalent); Range pole, and antenna	Navigate to sampling locations at sites where plot markers are absent	1
Amazon Cabela’s REI	N	GPS receiver, recreational accuracy	Navigate to sampling location with plot markers	1



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Supplier/ Item No.	Exact Brand	Description	Purpose	Quantity
Ben Meadows Forestry Supplier	N	Measuring tape, minimum 30 m	Locate clip-harvest strips within plots/subplots; measure and delineate dimensions of clip harvest strip.	1
Ben Meadows Forestry Supplier	N	Compass with mirror and declination adjustment	Locate clip-harvest strips (with measuring tape)	1
Forestry Supplier	Y	TruPulse 360R Laser Rangefinder, ± 30 cm accuracy	Delineate plot boundaries, determine clip cell location	1
	N	Pruning shear	Clip plants	2
	N	Loppers, long-handled	Clip and cut corn	1
Forestry Suppliers	N	Spring scale, 10 kg capacity, tareable	Weigh total fresh mass of high-volume crops (e.g., corn)	1
Forestry Suppliers	N	Spring scale, 5 kg capacity, tareable	Weigh subsample fresh mass of high-volume crops (e.g., corn)	1
Forestry Suppliers	N	Spring scale, 2.5 kg capacity, tareable. Note: Unit has English and metric gradations. Data should be recorded in metric.	Weigh subsample fresh mass for graminoid crops (e.g., wheat)	1
Forestry Suppliers	N	Spring scale 1000 g capacity, tareable. Note: Unit has English and metric gradations. Data should be recorded in metric.	Weigh low mass subsamples	
	N	Cooler	Chill perishable samples in field	1
Fisher Grainger	N	Cold packs	Chill perishable samples in field	
	N	Pre-marked string and stake sets; see RD[04] for more details	Delineate clip harvest strip for small-stature crop types (measuring stick may be easier if vegetation is thick)	2
Forestry Suppliers, Tent Pole	N	Measuring stick, minimum 2 m length, folding; or equivalent such as tent pole frames or similar	Delineate clip harvest strip for crops (may be easier to push through thick vegetation than using string sets)	1



Supplier/ Item No.	Exact Brand	Description	Purpose	Quantity
Technologies or other				
Ben Meadows Forestry Suppliers	N	Chaining pins or other suitable anchor	Anchor measuring tapes	2
	N	Survey marking flag, PVC or fiberglass stake	Delineate sampling area	4
	N	Work gloves	Protect hands	2
Forestry Suppliers	N	Magnifier hand-lens, 10X	Aid in species identification (particularly for non-crops)	1
Forestry Suppliers	N	Magnifier hand-lens, 20X	Aid in species identification (particularly for non-crops)	1
ULINE	N	Paper bags, #8 ¹	Contain clipped herbaceous biomass, sorted to functional group	6 ²
	N	Large paper bags, yard waste type or equivalent (e.g., 30 gallon capacity)	Contain clipped crop biomass	1-4 ²
	N	Permanent marker	Label paper bags	2
	N	CR123A battery	Spare battery for laser rangefinder	2
	N	AA battery	Spare battery for GPS receiver	2
	N	Field notebook	Calculation of seed: fresh ratio when using paper data sheets.	1
RD[05]	NA	Herbaceous Biomass Field Datasheets	Record sampling metadata	
	NA	Per plot or subplot Clip Lists	Identify random Clip Strip locations	As needed
	NA	Field guide, regional flora reference guide and/or key	Identify leguminous forbs and graminoids to species	1



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Table 6. Equipment list – Equipment needed for post-field sampling tasks.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quantity
Forestry Suppliers	Y	Magnifier hand-lens, 10X	Aid in non-crop species identification	1
Forestry Suppliers	N	Magnifier hand-lens, 20X	Aid in non-crop species identification	1
	N	Cooler, size dependent on anticipated crop volume	Chill perishable non-crop and low-volume crop samples	As needed
	N	Cold packs	Chill perishable non-crop and low-volume crop samples	Variable
RD[05]	NA	Completed Herbaceous Biomass Field Datasheets	Contains field-collected sampling metadata	Variable
	NA	Field guide, regional flora reference guide and/or key	Aid in distinguishing morphologically similar species to functional groups	1

Table 7. Equipment list – Equipment needed for processing agricultural biomass clip harvest samples in the laboratory.

Supplier/ Item No.	Exact Brand	Description	Purpose	Quantity
Fisher	N	Balance, 0.01 g accuracy	Weigh dried subsamples	1
Fisher	N	Weigh boats, large	Contain dried non-crop samples while weighing	Variable
Fisher	N	Plastic tray or equivalent	Contain crop samples and subsamples while weighing	1
RD[05]	NA	Datasheets: <ul style="list-style-type: none"> • Lab Drying QC Datasheet • Lab Weighing Datasheet 	Recording dry weight of herbaceous biomass	As needed



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APPENDIX B SITE-SPECIFIC CROP SAMPLING

B.1 D04 LAJA

Crops present (Distributed plots):

- Mangoes (not sampled)
- Peppers (not sampled)
- Squash (not sampled)
- Sunflowers (sampled)
 - Clip Strip dimensions: 1.5m x 0.65 m
 - Crop Type: High-volume; see SOP B.1, step 8, section (1)
 - Row Spacing: TBD
- Tomatoes (not sampled)
- Others (consult with Domain Manager and Science)

Distributed Plot sampling strategy:

- Only clip those plots planted in pasture hay once per year in October, and keep the annual clip harvest bout.
- Many of the plots planted with the above crops are located in small-scale experimental parcels of an Agricultural Experimental Station, and support Master's experiments, etc.
- Do not sample crops listed as 'not sampled.' Instead:
 - Record `targetTaxaPresent = Y` for the plot/clipID.
 - In the **remarks**, record 'Experimental Crop: X, not sampled', where X is one of the crops listed immediately above.

Crops present (Tower plots):

- None: Tower plots are grazed