TOS STANDARD OPERATING PROCEDURE: 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

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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: here, 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 laboratory 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 placed into the drying ovens. Subsampling for oven drying requires that additional fresh weight data are collected 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
- Soy
- Sorghum, or
- Cereal crops (Wheat, barley, triticale, rye, oat, etc.)

Other crops are outside the scope of this SOP, and must be addressed on a case by case basis via NEON's problem tracking software (currently JIRA).

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

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.

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.004316	Operations Field Safety and Security Plan
AD[02]	NEON.DOC.004300	EHSS Policy, Program and Management Plan
AD[03]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[04]	NEON.DOC.000914	TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index

2.2 Reference Documents

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

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
RD[04]	NEON.DOC.014037	TOS Protocol and Procedure: 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: Plot Establishment
RD[08]	NEON.DOC.001271	TOS Protocol and Procedure: Manual Data Transcription

2.3 Acronyms

Acronym	Definition
NA	NA

2.4 Definitions

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

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

Pod: The elongated seed vessel of the soybean plant.

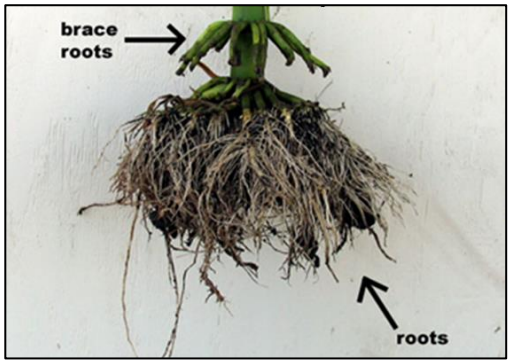

Figure 1. Base of corn stalk, including belowground roots and aboveground brace roots; the latter are also known as 'prop' roots.

3 METHOD

A combination of Distributed, Gradient, and Tower Plots may be used for collecting biomass and productivity data from agricultural crops. The timing of agricultural biomass sampling is managed on a per plot basis, is targeted to peak crop biomass, and is constrained by crop senescence, anticipated harvest date, or both. In addition, multiple clip harvests per season are required to capture agricultural crop productivity if farmers employ multiple crop rotations within a growing season (see Section 4 for more details).

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. The reason for variable Clip Strip dimensions is 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 (subsequently referred to in this document as '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 will be separated from non-crop biomass, and clipped non-crop biomass will be further sorted to herbGroup (i.e., CSG, WSG, LFB, etc.).

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. This subsampling step allows for more efficient drying and processing of large sample volumes. In addition, data collected via this SOP are entered via the same data ingest mechanism as RD[04].

4 SAMPLING SCHEDULE

4.1 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 given sampling year will need to be sampled for biomass in order to estimate the productivity of the site, and multiple sampling bouts are therefore required to capture the productivity of crops planted and harvested in different seasons. For these reasons, communicating and collaborating with the site host and/or farmer to determine and coordinate harvest dates and sampling activities is highly advantageous in agricultural systems. **Table 1** provides an overview of spatial and temporal sampling strategy for agricultural sites.

> ***Example:*** A north temperate site has 10 plots fallow, 10 plots planted with spring wheat, and 10 plots planted with corn. Plots planted with spring wheat would be harvested for bout1 (likely

late May or early June); fallow plots and corn plots would be harvested for bout2 (likely mid to late August). Fallow plots may be harvested on a different schedule than corn if a cover crop was planted that reaches peak biomass later than the corn harvest.

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 or Gradient	n=10 (min) n=20 (max)	Once per crop cycle	Annual	Beginning of crop senescence	Within 14d of sampling start
Tower	n=10				

4.2 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 Appendix D of 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).

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, UKFS	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

Domain	Site(s)	Crop	Harvest begin date	Harvest most active dates
		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	DCFS, 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

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**.

4.3 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; however, the large volume of some crops presents logistical challenges with respect to cold storage. Similar to RD[04], crop samples must be placed in the drying oven within 5 d of clipping in the field, and the following temporary storage methods are listed in order of preference:

- Keep samples in cold storage, same as in RD[04]. Feasible with relatively small-volume crops.
- Spread large volume crops out as much as possible, and air-dry (e.g., corn). A sunny, dry place free from rodents is best. If clip cells contain a mixture of crops and other non-crop herbaceous plants, place non-crop plants into cold storage as per RD[04].

Once samples are dry, timing considerations for weighing are identical to RD[04].

5 SAFETY

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

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[01]) and EHSS Policy, Program and Management Plan (AD[02]). 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.

Common agricultural chemicals include pesticides, insecticides, fungicides and herbicides. Residues of these chemicals may remain after fields have been treated. These hazardous chemicals can be on plants, in soil and sometimes in irrigation systems used to apply hazardous chemicals. Residue can also be carried by the wind. Chemical residue can't always be seen, so skin should be covered, as much as possible, to prevent direct exposure which may cause rashes or burns. Prior to sampling in an exposed area, the employees should be provided a Safety Data Sheet for the products used on the crops. In accordance with Hazard Communication (2012 GHS), users are required to report all products and shall have readily available, a Safety Data Sheet for all hazardous chemicals used. Some of these hazardous chemicals remain poisonous for a period of time after they have been applied. The Safety Data Sheet will include the "Re-entry Period" for that particular chemical. Based on local law, type of chemical and type of work to be performed, this will vary. Employees should be trained in Hazard Communication 2012/Globally Harmonized System for Labeling and Classification (GHS).

All employees engaged in sampling of crop or non-crop products shall observe the following safe work practices:

- 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 "Re-Entry" warning sign!
- DO NOT smoke while working in a treated field, regardless of when the area was sprayed with the hazardous chemical.
- DO NOT carry lunch into treated work area.

- If exposed or if exhibiting any signs or symptoms of exposure, seek 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.

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.

6 PERSONNEL AND EQUIPMENT

6.1 Equipment

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

Table 3. Equipment needed to prepare for sampling.

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable Items					
MX102549	S	GPS receiver, decimeter accuracy (e.g. GEO XH 6000, 7X)	Navigate to sampling locations at sites where plot markers are absent	1	N
MX100703	S	GPS receiver, recreational accuracy	Navigate to sampling location at sites with plot markers	1	N
MX100322	S	Laser Rangefinder, ± 30 cm accuracy	Delineate plot boundaries, determine clip cell location	1	N
	R	USB Cable	Transfer data to GPS unit.	1	N
Consumable Items					
	R	All weather paper	Printing field datasheets	1	N

R/S = Required / Suggested

Table 4. Equipment needed for agricultural clip harvest sampling at one plot.

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable Items					
MX102549	S	GPS receiver, decimeter accuracy (e.g. GEO XH 6000, 7X)	Navigate to sampling locations at sites where plot markers are absent	1	N
MX100703	S	GPS receiver, recreational accuracy	Navigate to sampling location with plot markers	1	N
MX100722	R	Measuring tape, minimum 30 m	Locate clip-harvest strips within plots/subplots; measure and delineate dimensions of clip harvest strip.	1	N
MX100320	R	Compass with mirror and declination adjustment	Locate clip-harvest strips (with measuring tape)	1	N
MX100322	S	Laser Rangefinder, ± 30 cm accuracy	Delineate plot boundaries, determine clip cell location	1	N
	R	Pruning shear	Clip plants		N
	R	Cooler	Chill perishable samples in field	1	N
MX100358	R	Cold packs	Chill perishable samples in field		N
	R	Pre-marked string and stake sets; see RD[04] for more details	Delineate clip harvest strip		N
MX104361	R	Chaining pins or other suitable anchor	Anchor measuring tapes	2	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Survey marking flag, PVC or fiberglass stake	Delineate sampling area	4	N
	S	Work gloves	Protect hands	2	N
MX106656	R	Magnifier hand-lens, 10X	Aid in species identification (particularly for non-crops)	1	N
MX103211	R	Magnifier hand-lens, 20X	Aid in species identification (particularly for non-crops)	1	N
MX105089	R	Paper bags, #8[1]	Contain clipped herbaceous biomass, sorted to functional group	6[2]	N
	R	Large paper bags, yard waste type or equivalent (e.g., 30 gallon capacity)	Contain clipped crop biomass	1-4[2]	N
	R	Permanent marker	Label paper bags	2	N
	S	CR123A battery	Spare battery for laser rangefinder	2	N
	S	AA battery	Spare battery for GPS receiver	2	N
Resources					
RD[05]	R	Herbaceous Biomass Field Datasheets	Record sampling metadata		N
	R	Per plot or subplot Clip Lists	Identify random Clip Strip locations	As needed	N

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Field guide, regional flora reference guide and/or key	Identify leguminous forbs and graminoids to species	1	N

R/S = Required / Suggested

[1] Bag size may be adjusted as necessary based on size/bulk of plants being clipped. For example, sites with tall grasses will require larger bags.
[2] Quantity may be adjusted as necessary based on field experience at a given site.

Table 5. Equipment needed for post-field sampling tasks.

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable Items					
MX103211	S	Magnifier hand-lens, 20X	Aid in non-crop species identification	1	N
MX106656	S	Magnifier hand-lens, 10X	Aid in non-crop species identification	1	N
	R	Cooler	Chill perishable non-crop and low-volume crop samples	1	N
	R	Cold packs	Chill perishable non-crop and low-volume crop samples	Variable	
Resources					
RD[05]	R	Completed Herbaceous Biomass Field Datasheets	Contains field-collected sampling metadata	Variable	N
	R	Field guide, regional flora reference guide and/or key	Aid in distinguishing morphologically similar species to functional groups	1	N

R/S = Required / Suggested

Table 6. Equipment needed for processing agricultural biomass clip harvest samples in the laboratory.

Item No.	R/S	Description	Purpose	Quantity	Special Handling
Durable Items					
MX100230	R	Drying oven	Dry samples at 65 ˚C	2 (typically)	N
MX100265	R	Balance, 0.01 g accuracy	Weigh dried subsamples	1	N
	R	Large capacity scale, 10 g accuracy; shipping or spring type	Weigh total fresh weight of clipped crop samples up to 20 kg total weight		
MX100689	S	Weigh boats, large	Contain dried non-crop samples while weighing	Variable	N
MX103931	R	Plastic tray or equivalent	Contain crop samples and subsamples while weighing	1	N
Consumable Items					
RD[05]	R	Datasheets: • Lab Drying QC Datasheet • Lab Weighing Datasheet	Recording dry weight of herbaceous biomass	As needed	N

R/S = Required / Suggested

6.2 Training Requirements

All technicians must complete required safety training and procedure-specific training for safety and implementation of this procedure as required in Field Operations Job Instruction Training Plan (AD[03]).

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 CO_2), 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. ***Improper or inconsistent labeling is the most common and problematic error associated with this work!***

6.3 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.

6.4 Estimated Time

An experienced two-person team will require approximately 1 hour to perform clip-harvest sampling of an agricultural crop within a given Clip Strip. This time range includes identifying an acceptable clip-harvest location, delineating the Clip Strip, and clipping the crop and any non-crop plants present. Lab work for an agricultural Clip Strip should require approximately 1 hour, and this time includes effort required for sorting, drying, and weighing clipped agricultural biomass.

7 STANDARD OPERATING PROCEDURES

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.

SOP B Field Sampling Aboveground Biomass of Agricultural Crops

At agricultural sites, clip harvesting produces estimates of total crop biomass on a per crop basis, as well as the biomass 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].

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

HELPFUL HINT: COORDINATING WITH PLANT DIVERSITY PROTOCOL

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 m^2 nested subplots used for Plant Diversity % cover measurements.

B.1 Sample Collection in the Field

1. Navigate to the selected plot, using the GPS if necessary.
    - Should the farmer harvest the crop prior to scheduled Agricultural Clip Harvest sampling, record 'Crop harvest preceded NEON sampling' in the **remarks** field.
2. As described in RD[04], use the plot- or subplot-specific Clip List to identify and locate the target clip cell for sampling (steps 2 – 7 in RD[04]).
    - When these steps are complete, you should have placed a pin flag at what is defined as the SW corner of the Clip Strip in wild-type vegetation. This flag is referred to as 'Flag1' below (**Figure 2**), and will NOT necessarily be the SW corner in an Ag Clip Strip.
3. Record required plot-level field sampling information:
    - **boutNumber**; use *XX* format, where XX is the bout number assigned by Field Operations, e.g. '01'. Values of **boutNumber** reset every year (typically the end of the farming season). Multiple bouts will be required if crop rotation is in practice at the site.
    - **clipCellNum**; as provided in Clip List; use last 3 numbers from the clipID, e.g. for BLAN_001_0126, record '126'
    - **clipDate**; use *YYYYMMDD* format
    - **exclosure**; this is typically 'N' for agricultural clip harvests
4. Select the appropriate crop-specific dimensions for the Clip Strip (**Table 7**), and record:
    - **clipDimension**: The length (L) and width (W) of the Clip Strip, in meters; e.g., *'1.5 x 0.65'*.

5. 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 2**). 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.

    b. Extend a meter tape outward and away from yourself the required 'Length' distance specified in **Table 7**, and mark this distance with another pin flag – 'Flag2'.

    c. Stretch a string and stake set between Flag1 and Flag2 to mark one long edge of the Clip Strip.

    d. Standing over Flag1 again, look down the length of the string toward Flag2, and use the meter tape to place two more pin flags X cm to the right of Flags1 and 2, where X is the 'Width' distance (**Table 7**, **Figure 2**).

    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 7**.

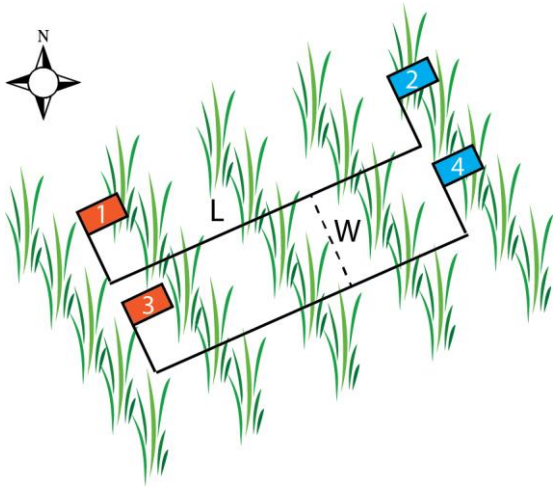

Figure 2. Clip Strip establishment in an agricultural row crop. Numbered flags correspond to those referenced above in step (5); 'Flag 1' corresponds to the SW corner of the Clip Strip that is provided in the Clip List. Values for the length (L) and width (W) of the Clip Strip are crop-specific and are provided in the table below.

Table 7. 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 (in)	Quadrat dimensions, L x W (m)
Barley	7	2.0 x 0.5
Corn	15 or 30	1.5 x 0.65

Sorghum	15 or 30	1.5 x 0.65
Soybeans	15	1.5 x 0.65
Wheat	7	2.0 x 0.5

ROW SPACING

- If row spacing differs from that listed in **Table 7** for a given crop, submit a JIRA 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. For example, you may check on crop rows during plant phenology sampling).

6. If there is no herbaceous biomass in a Clip Strip, AND the Clip Strip is deemed representative of the plot:
    - Record 'targetTaxaPresent = N' for the plotID in question.
7. 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** listed in Table 8 of RD[04], so label smaller 8# or 25# craft paper bags for this biomass, if present.
    - **boutNumber**
    - **date**; use *YYYYMMDD* format
    - **clipID**; e.g. BLAN_001_0126
    - **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).
8. Clip and sort all crop and herbaceous non-crop biomass rooted within the Clip Strip, and collect into the bags labeled above. Recall that an individual must be ≥ 50% rooted within the Clip Strip to be counted as 'in' for clipping.
    - For large volume crops (e.g., corn), use the hand pruners to break up large stems and leaves into small 6-12" sections. Do not break up corn ears into pieces.
    - For corn brace roots (**Figure 1**), clip all brace roots for an individual if it is ≥ 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.

9. When clipping is finished, group any small 8# bags from the clipID together into a 25# bag, and place in cold storage. In addition:
    - If clipping relatively low-volume crops (e.g., barley or wheat), place clipped crop into cold storage as well.
    - 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.
10. Record the total number of bags from the Clip Strip in the **bagCount** field, and the time the bags were placed in the cooler in the **time** field of the "Field" ingest table.
11. If there is no biomass associated with one or more 'herbGroups' defined in RD[04], record in the **remarks** field so it is clear that all 'herbGroups' have been assessed.
    - In the **remarks** field, record 'present = XXX, YYY' etc., where XXX and YYY are the 3-letter codes for the herbGroups that were present.
12. Return to step (1) for the next plotID.

B.2 Points of Confusion

Table 8. 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. 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.
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.

B.3 Sample Preservation

- For low-volume crops and non-crop biomass, 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.
- For high-volume crops: If the site is remote, and it is not possible to return to the laboratory within 24 h for subsampling and drying, clipped crops may be spread out in a warm, dry place for air-drying (non crop mass should stay in cold storage).
    - Some air movement will speed the drying process, but exposure to windy conditions and rodents and other herbivores is not desirable. If an appropriate location cannot be identified, keep the clipped biomass in large paper bags and do NOT spread out.
    - Be sure to keep samples organized and track labels appropriately if you take this step.
- Transfer bags of clipped biomass to the drying ovens as soon as possible after field sampling, and monitor drying progress with the “Lab Drying QC” data sheet.

IMPORTANT: Record the **clipDate** and **time** on the “Field” datasheet AND **ovenInDate** and time on both the sample bags and the “Lab Weighing” ingest table so that the number of hours the bags were stored cold can be automatically calculated.

SOP C Post-Field Sampling Tasks

C.1 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)
  - Paper bags, 8# and 25# kraft (or the necessary size given site vegetation stature)
  - Rite-in-the-Rain paper for printing field datasheets
  - Permanent markers for labeling bags in the field
- Return cold packs to the -20 ˚C freezer to refresh.

C.2 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).

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 'Lab Weighing' ingest table differently for high-volume crop versus low-volume crop and non-crop herbaceous biomass:

- High-Volume Crop biomass (SOP D.1):
    - Record **freshMass, subsampleFreshMass,** and **subsampleDryMass.**
    - Values of **dryMass** are calculated automatically.
- Low-Volume Crop and Non-crop Herbaceous Biomass (SOP D.2):
    - Leave **freshMass, subsampleFreshMass,** and **subsampleDryMass** blank.
    - Record measured **dryMass** of entire clipped sample.

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. Using a large-capacity scale (either spring or shipping type), weigh the total 'fresh' mass of the pre-oven sample.
    - It does not matter if the sample has been air-dried, or is otherwise not technically 'fresh.' The goal here is to record the pre-oven 'fresh' weight, and use a subsample to generate a fresh weight:dry weight ratio so that the whole sample does not have to be placed in the oven.
    - Record the **freshMass** in the 'Lab Weighing' ingest table; minimum precision required is nearest 10 g, record greater precision if scale allows (1 g, 0.5 g, etc.)
    - For corn, record the total pre-oven fresh weight of any ears separately in the **remarks** field of the ingest (i.e., ears = XXX g).
2. Create a representative subsample for oven drying.

a. Label a 25# bag with **boutNumber**, **clipDate**, **clipID**, and the current date and time the sample will be placed in the oven. These latter two data will be the **ovenInDate** and time required during data entry.

- ***Critical step:*** Labeling bags allows assessment of how long different batches of bags have been in the drying oven, and are used to assess drying progress.

b. Mix the sample thoroughly, grab 2-3 handfuls for the subsample, and place the subsample into the bag labeled in the step above.

For corn: Use the ear mass recorded in the **remarks** above to ensure that ears comprise the same proportion of the subsample mass as they do the total sample mass. This is necessary because ears may have very different moisture content than leaves/stems.

For all other crops: Visually assess that seeds / grain form roughly the same proportion of the subsample mass as they do the total sample mass.

3. Use an analytical balance and a plastic tray, and weigh the fresh subsample. Record:

- **subsampleFreshMass**; nearest 0.01 g

4. Place labeled 25# subsample bags into a 65 ˚C drying oven for 48h – 120h (2d – 5d).

5. 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 QC" 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 QC" datasheet.

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).

DRYING TIPS

- A spreadsheet calculator is useful for calculating the average weight difference. Ask your Domain Manager for the calculator already created by Field Operations staff.
- To save time, plant material may be weighed WITH the bag.
- Focus on the heaviest bags, as these will likely take the longest to dry.

6. 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.

7. Weigh crop subsamples from each clipID using an electronic scale, and a plastic tray or weigh boat.

    - Record **subsampleDryMass** in the "Lab Weighing" ingest table; 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.

8. Record required metadata for each subsample in the "Lab Weighing" ingest table:

    - **weighDate**; date subsample was weighed in the laboratory, *YYYYMMDD* format
    - **plotID**; *SITE_XXX* format
    - **clipCellNum**; last three digits of the clipID
    - **clipDate**; date sample was clipped in the field, *YYYYMMDD* format
    - **ovenInDate / Time**; date and time (24-h format) subsample was placed in oven
    - **ovenOutDate / Time**; date and time subsample was removed from oven
    - **herbGroup**; select 'corn', 'wheat', 'soy', 'sorghum', etc.

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. In the "Lab Weighing" ingest table, 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.)
    - **dryMass**; total dry mass of the entire sample, nearest 0.01 g, plant material ONLY (without the bag).

D.3 Data Verification and QA

- QA sample weighing is not performed high-volume crop samples.

- 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 "Lab Weighing" ingest table.

SOP E Data Entry

Data entry uses the Herbaceous Biomass ingest, and is identical to that described in SOP G of RD[04].

APPENDIX A SITE-SPECIFIC CROP SAMPLING

A.1 D04 LAJA

Crops present (Distributed Plots):

- Tomatoes
- Peppers
- Squash
- Sunflowers
- Mangoes
- Others

Distributed Plot sampling strategy:

- 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.
- Disrupting small-scale academic research is not desired, and plots located within these crop types should not be clip-harvested.
    - Record `targetTaxaPresent = X` in the **remarks**, where 'X' is one of the crops listed immediately above.

Crops present (Tower Plots):

- None. Tower Plots are grazed.