



Title: TOS Protocol and Procedure: PLT – Plot Establishment and Maintenance		Date: 01/18/2023
NEON Doc. #: NEON.DOC. 001025	Author: R. Swanson	Revision: K

TOS PROTOCOL AND PROCEDURE: PLT – PLOT ESTABLISHMENT AND MAINTENANCE

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	01/10/2014	ECO-01139	Draft release
B	03/28/2014	ECO-01663	Production release, template change, and other changes as detailed in Appendix A
C	10/15/2014	ECO-02355	Migration to new protocol template
D	02/23/2015	ECO-02566	<ul style="list-style-type: none"> • GPS Receiver Setup edits; A-3.C and A-6 • Extraction of the Rangefinder section to NEON.DOC.001717 • Shifting and Offsetting Point Locations; SOP B.6 • Information located in boxes has been embedded in protocol text. • Added NEON Criteria for Wet Locations to Appendix D • Updated Appendix E: general workflow, tower workflow, mammal workflow. • Delineation steps where reformatted
E	01/29/2016	ECO-03061	<ul style="list-style-type: none"> • Replaced the word 'TruePulse' to rangefinder across the document. • Rewording in Section 1.1. • Additional details added about RRQRR sequence to section 3 in the Methods. • A.8 added site specific plot information. • Metadata collection was moved to B.4. • F.2 Lost Plot Markers section added. • G.1 Legend of figure was edited. • SOP H Plot Monumentation and Appendix I were added to clarify steps and safety concerns
F	03/20/2017	ECO-04429	<ul style="list-style-type: none"> • Added ear plugs to the equipment list • Appendix J- Base Station Workflow • Appendix A - Updated log sheets
G	03/16/2018	ECO-05482	<ul style="list-style-type: none"> • Update SOPF.2: Lost Plot Marker- Approved by Science and Ops IPT • Removed broken links • Appendix A- Fixed primary marker location in A.2 • Appendix B- Added base station table



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REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
H	01/08/2019	ECO-05961	<ul style="list-style-type: none"> Added instructions for SD card file transfer in sections A.5 and E1 Cleaned up graphics in Appendix D Added notes from FOPs for section F2
J	08/04/2020	ECO-06399	<ul style="list-style-type: none"> Updated to new template (NEON.DOC.050006vJ) Rangefinder with tripod and reflector on staff is preferred delineation method over tape Trimble instructions removed. Now in new SOP NEON.DOC.005221 Figures 2 and 9 updated to match new template
K	01/18/2023	ECO-06893	<ul style="list-style-type: none"> Updated to new template (NEON.DOC.050006vL) Added definitions to Section 2.4 Switch from recording metadata in Trimble Data Dictionaries to a Fulcrum Application. Added section G.1 about Plot Marker Priorities Updated Distributed Base Plot Delineation (C.3) to be based on which protocols will be sampled Clarified permanent, primary, and secondary maker definitions and standardization throughout the doc Organization updates: changed header class or order for Safety and Logistics Assessment, Replacing Lost Plot Markers, Collect GPS Coordinates, and Improving GPS Accuracies New Appendices added: Quick Reminders, Plot Verification, Southwest Corner Primary Markers



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1 OVERVIEW

1.1 Background

The National Ecological Observatory Network’s (NEON) goal is to improve understanding and forecasting of ecological change at continental scales over decades (Schimel et al. 2011). The design co-locates measurements of atmosphere, soil, water, select organisms and disease, and airborne observations at a hierarchy of spatial scales. Observing change by integrating measures of the drivers and ecological responses contributes to improved understanding of ecological cause and effect (Vitousek 1997, Keller et al. 2008, Luo et al. 2011). High-level requirements derived from the NEON goal and mission guide the architecture of the design and infrastructure for the Observatory (Schimel et al. 2011). The primary requirement-driven constraint of the design is that it must assemble sufficient data collected at points and local regions (400-km²) to enable extrapolation of these functional relationships to the scale of the continent over the course of several decades. The requirements framework permeates the NEON design, providing guidance for the design of observations and direct linkages back to the NEON mission.

A suite of data products collected across multiple temporal and spatial scales within each site describes the ecological parameters that the NEON design monitors through time. Fixed-wing aircraft measure the landscape across NEON sites with high-resolution remote sensing, and tower-based sensors capture temporally continuous fluxes over smaller spatial extents at each site. However, neither approach is sufficient for terrestrial biogeochemistry and organismal observations. A complete census of these measures at each site is biologically and financially impractical: microbes are ubiquitous and birds are mobile. Measurement of these types of ecological responses at sensor-like temporal frequencies is impossible, and even frequent observations at local scales would likely provide redundant information or, due to financial constraints, be limited in spatial extent. Hence, terrestrial organisms and soil are measured at discrete temporal and spatial units by human observers carrying out field-based observations.

The diversity of biogeochemistry and organismal measurements presents a formidable challenge to the integrated collection of data for the Observatory. Measurements include biodiversity, phenology, biomass, stoichiometry, prevalence of disease, and genomics of soil and organisms with a range of life histories and phylogenetic traits (Keller et al. 2008). Components of each are targeted for observation with a sample design (Thompson 2012). The design must collect data that capture spatial variability, facilitate the integration of observations, allow inference to unsampled populations, and contribute to ecological insight at the scale of the site and year, at a minimum. The Spatial Sampling Science Design (RD[15]) describes the proposed strategy: guided by NEON principles and requirements, the terrestrial sampling design provides a data collection framework that is statistically rigorous, operationally efficient, flexible, and readily facilitates integration with other data to advance the understanding of the drivers of and responses to ecological change. This protocol describes how to implement this design by establishing plots on the ground at NEON terrestrial sites where the observations that inform the Observatory are collected.



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1.2 Scope

This document provides a change-controlled version of Observatory protocols and procedures. Documentation of content changes (i.e. changes in particular tasks or safety practices) will occur via this change-controlled document, not through field manuals or training materials.

1.2.1 NEON Science Requirements and Data Products

This protocol fulfills Observatory science requirements that reside in NEON’s Dynamic Object-Oriented Requirements System (DOORS). Copies of approved science requirements have been exported from DOORS and are available in NEON’s document repository, or upon request.

Execution of this protocol procures samples and/or generates raw data satisfying NEON Observatory scientific requirements. These data and samples are used to create NEON data products, and are documented in the NEON Scientific Data Products Catalog (RD[03]).

1.3 Acknowledgments

This protocol relies heavily on advice and field experience provided by Dr. Benjamin Chemel with the Northern Rockies Conservation Cooperative.



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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

2.2 Reference Documents

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

RD[01]	NEON.DOC.000008	NEON Acronym List
RD[02]	NEON.DOC.000243	NEON Glossary of Terms
RD[03]	NEON.DOC.002652	NEON Data Products Catalog
RD[04]	NEON.DOC.001271	AOS/TOS Protocol and Procedure: DMP – Data Management
RD[05]	NEON.DOC.014049	TOS Protocol and Procedure: MOS – Mosquito Sampling
RD[06]	NEON.DOC.014045	TOS Protocol and Procedure: TCK – Tick and Tick-Borne Pathogen Sampling
RD[07]	NEON.DOC.014040	TOS Protocol and Procedure: PHE – Plant Phenology
RD[08]	NEON.DOC.000906	TOS Science Design for Terrestrial Biogeochemistry
RD[09]	NEON.DOC.000907	TOS Science Design for Plant Phenology
RD[10]	NEON.DOC.000908	TOS Science Design for Microbial Diversity
RD[11]	NEON.DOC.000909	TOS Science Design for Ground Beetle Abundance and Diversity
RD[12]	NEON.DOC.000910	TOS Science Design for Mosquito Abundance, Diversity and Phenology
RD[13]	NEON.DOC.000911	TOS Science Design for Vectors and Pathogens
RD[14]	NEON.DOC.000912	TOS Science Design for Plant Diversity
RD[15]	NEON.DOC.000913	TOS Science Design for Spatial Sampling
RD[16]	NEON.DOC.000914	TOS Science Design for Plant Biomass, Productivity, and Leaf Area Index
RD[17]	NEON.DOC.000915	TOS Science Design for Small Mammal Abundance and Diversity
RD[18]	NEON.DOC.000916	TOS Science Design for Breeding Bird Abundance and Diversity
RD[19]	NEON.DOC.001717	TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration
RD [20]	NEON.DOC.002649	NEON Configured Site List
RD[21]	NEON.DOC.005221	AOS/TOS Standard Operating Procedure: Trimble GeoXH Receivers Setup and Use
RD[22]	NEON.DOC.005247	AOS/TOS Standard Operating Procedure: NEON Aquatic and Terrestrial Site Navigation



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2.3 Acronyms

Acronym	Definition
CEA	Current Estimated Accuracy
HD	Horizontal Distance
MDD	Main Drop Down (menu icon in GPS receiver)
SDD	Sub Drop Down (menu icon in GPS receiver)
NLCD	National Land Cover Database
PPE	Personal Protective Equipment
GPS	Geographic Positioning System
RRQRR	Reverse Randomized Quadrant-Recursive Raster
GLONASS	Global Navigation Satellite System
OPUS	Online Positioning User Service
RINEX	Receiver Independent Exchange Format
RTK	Real-Time Kinematic
SN	Service Now

2.4 Definitions

Permanent Marker: All markers that have field GPS points collected and are entered into the named location database.

Primary Marker: Permanent markers that are topped with a stamped cap that includes the plot ID, point ID, and “NEON”. Primary markers are often aluminum rods with a steel cap.

Secondary Maker: Permanent markers with no stamped cap. Marker material is left to the discretion of the Domain Staff.

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

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



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3 METHOD

Plot establishment is an essential first-step in the development of the NEON Terrestrial Observation System (TOS) physical infrastructure. Accurate and precise plot locations that represent the target ecosystem components at each site facilitate reproducible data collection and spatial analysis for the life of the Observatory. All plot locations are created based on a spatially balanced random selection process (RRQRR, Theobald et al. 2007), and individual plots are then accepted or rejected based on an assessment by Field Ecologists (RD[15]). The RRQRR process results in a list of plots, each with a unique identifier called the Morton order. Following the Morton order list in ascending order (smallest to largest) within each plot type/NLCD class combination maintains the random selection process during plot establishment. This document outlines the procedures for location, evaluation, establishment, geospatial data collection and reporting for Tower Plots, Phenology Transects, Distributed Base Plots, Mammal Grids, Bird Grids, Tick Plots and Mosquito Point locations.

Distributed Plots are located throughout the dominant vegetation at each NEON site (dominant vegetation is defined as NLCD vegetation types with $\geq 5\%$ area at the site level). Individual Distributed Plots may be accepted or rejected based on a field assessment by Field Ecologists; potential plot locations are only accepted if the actual vegetation type is congruent with the vegetation type assigned by NLCD. Prior to plot establishment, each plot is subjected to an initial vegetation assessment. All NEON TOS sampling occurs at Distributed Plots, although not all TOS protocols are implemented at all Distributed Plots.

Tower Plots are located within or around the NEON tower airshed and are sampled for above and belowground plant biomass and productivity, plant biodiversity, foliar, litter, root, and soil biogeochemistry, and coarse downed wood volume. Individual Tower Plots may be accepted or rejected based on a field assessment by Field Ecologists. Tower Plots vary in size between sites depending on the stature of the dominant vegetation type. Low biomass, low stature vegetation such as that found in grasslands and homogeneous low diversity vegetation found in agricultural plots is monitored in 400 m² square plots, measuring 20 meters on a side. High-biomass, large-stature vegetation found in savannah and forest ecosystems is measured in 1600 m² square plots, 40 meters on a side. Larger 200 m x 200m square plant phenology transects are also located within the NEON primary 90% flux tower airshed. Within each site a subset of Tower plots is established with a hybrid Distributed Plot/Tower Plot design in order to support additional measurements of biogeochemistry and plant diversity; this subset is identified by Science. See **Figure 1** below for a generalized schematic of Distributed and Tower plots within a sampling boundary. Note the different NLCD layers and which plot types are near roads.

This Standard Operating Procedure identifies plot establishment activities required for all current TOS plot types. Site specific planning documents identify the location of plots within the site, specify which taxa are sampled at each of the identified plot locations, and provide lists of contingency plot locations to replace rejected plots. The initial establishment includes plot acceptance, plot delineation, the collection of high resolution coordinates for each marker point, the assignment of Unique Identifiers and the placement of permanent plot markers with corresponding identifiers. Maintenance of established



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points may be necessary in the event markers are lost or when markers are removed at the end of a sampling season due to site requirements. The annual marking of sampling points is achieved through the placement of temporary flagging or pin flags that may be removed following the final round of sampling for the field season.

High resolution GPS data are collected at permanent marker locations within each established plot. This SOP describes steps required to attain high accuracy at all coordinate locations (i.e., to within ≤ 30 cm accuracy). The procedure includes a detailed field planning phase, and field techniques that will assure the acquisition of the highest accuracy points given the tools available. The field planning requires the use of software (Trimble Pathfinder Office and Trimble Mission Planning packages) and careful assembly and use of a high-resolution GPS receiver (RD[21]). The post-field protocol constitutes a download of the collected data that are then post-processed by Science staff at headquarters (HQ).

Quality assurance procedures for plot establishment are conducted both by NEON Domain Field Science staff and HQ Science staff, and are an essential step in the plot-establishment process. Correct placement and documentation of plot markers at each plot enable Field Ecologists to re-locate and delineate plot boundaries precisely and to identify which type of sampling activities to conduct at each location.

Plot establishment errors are expensive to correct and may have long-lasting effects on data quality if not detected. For these reasons, it is very important to follow the procedures described in this protocol and collect high-quality plot-establishment data when plots are initially established.

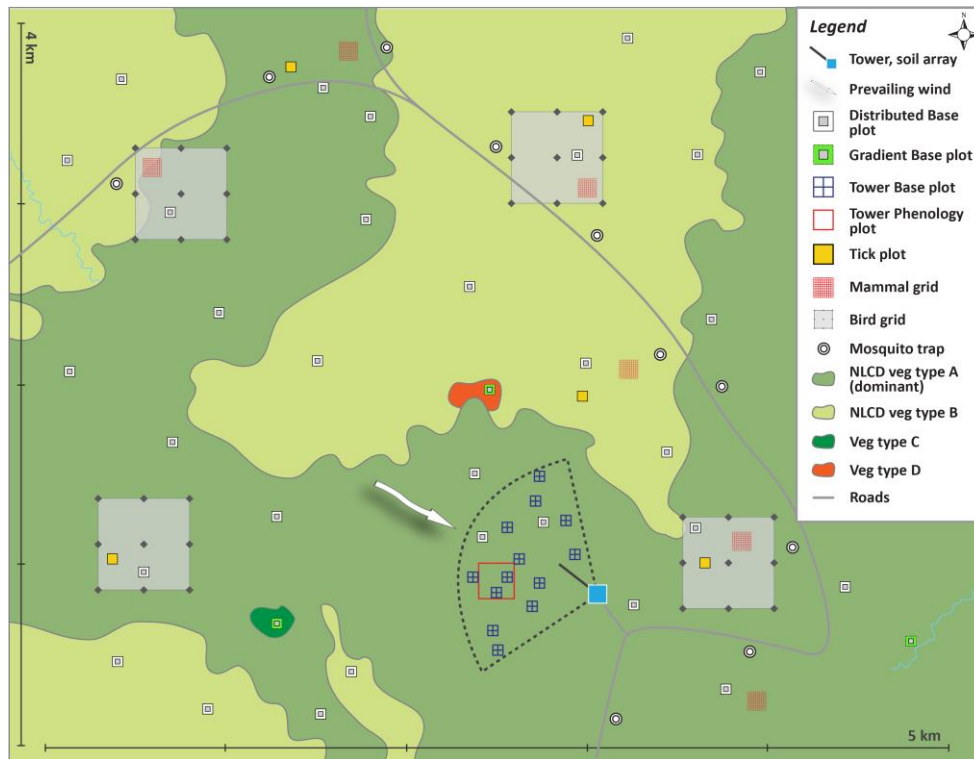


Figure 1. Generalized site-scale sampling schematic for the NEON Terrestrial Observation System (TOS).

3.1 NLCD Vegetation Classification

The NLCD is a continental scale land classification map (Fry et al. 2011). It spans the contiguous United States, as well as Hawaii, Puerto Rico and Alaska. The classification scheme is a two-tiered hierarchy, and our assessment focuses on the Level II categories (see NLCD Vegetation Classification Description in **Table 7**). The most commonly used vegetation types are in bold (**Table 1**).

Table 1. National Land Cover Database classification levels that inform NEON plot establishment.

Level I	Level II
1 Water	11 Open Water
	12 Perennial Ice/Snow
2 Developed	21 Developed, Open Space
	22 Developed, Low Intensity
	23 Developed, Medium Intensity
	24 Developed, High Intensity
3 Barren	31 Barren Land (Rock/Sand/Clay)
4 Forest	41 Deciduous Forest
	42 Evergreen Forest
	43 Mixed Forest
5 Shrubland	51 Dwarf Scrub*
	52 Shrub/Scrub



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Level I	Level II
7 Herbaceous	71 Grassland/Herbaceous
	72 Sedge/Herbaceous*
	73 Lichens*
	74 Moss*
8 Planted/Cultivated	81 Pasture/Hay
	82 Cultivated Crops
9 Wetlands	90 Woody Wetlands
	95 Emergent Herbaceous Wetlands

* Indicates Alaska only cover types

Definitions of each land cover type are available in Anderson’s land use and land cover classification systems (1976); also at <http://www.mrlc.gov/>.

Standard Operating Procedures (SOPs), in Section 7 of this document, provide detailed step-by-step directions, contingency plans, sampling tips, and best practices for implementing this sampling procedure. To properly collect and process samples, Field Ecologists **must** follow the protocol and associated SOPs. Use NEON’s problem reporting system to resolve any field issues associated with implementing this protocol.

The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. It is therefore essential that Field Ecologists carry out this protocol as outlined in this document. In the event that local conditions create uncertainty about carrying out these steps, it is critical that technicians document the problem and enter it in NEON’s problem tracking system.

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



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4 SAMPLING SCHEDULE

4.1 Sampling Frequency and Timing

Except where placement of permanent plot markers is prohibited by site managers, initial plot establishment and collection of high-resolution geospatial data ideally occurs once per site prior to scheduled TOS sampling.

Annual establishment and re-marking of permanent plots for visibility may occur each year of operations prior to seasonal field sampling. Replacing missing plot markers occurs as needed.

4.2 Criteria for Determining Onset and Cessation of Sampling

Initial plot establishment occurs before sampling begins. Plot maintenance and replacing missing plot markers takes place as needed throughout the year. **Table 6** documents which plot markers are required for each sampling protocol and should be utilized to prioritize sampling over plot maintenance activities when necessary.

4.3 Timing for Laboratory Processing and Analysis

This protocol generates no samples for laboratory analysis.

4.4 Sampling Timing Contingencies

Plot establishment should be completed prior to Operational sampling. Sites with deciduous leaf cover should prioritize plot delineation and GPS point collection to leaf off conditions.

Reasons to alter the timing of sampling include:

- Precipitation (rain or snow) that interferes with operation of the rangefinder or GPS receiver.
- Dense canopy cover that reduces the satellite reception.
- Periods of the day when satellites are less accessible.
- Challenges with host site allowing the process to complete, i.e. access issues or other problems with completing the process.

Table 2. Contingency decisions for plot establishment.

Delay/ Situation	Action	Outcome for Data Products
Precipitation or snow	Stop rangefinder work	No impact on data products as long as plots are established prior to sampling.
Insufficient satellite reception	Spend more time at each point, optimize time of day, or wait until leaf-off conditions.	No impact on data products as long as plots are established prior to sampling.

4.5 Estimated Time

The time required to implement a protocol will vary depending on a number of factors, such as skill level, system diversity, environmental conditions, and distance between sample plots. The timeframe provided below is an estimate based on completion of a task by a skilled two-person team (i.e., not the time it takes at the beginning of the field season). Use this estimate as framework for assessing progress. If a task is taking significantly longer than the estimated time, a problem ticket should be submitted. Please note that if sampling at particular locations requires significantly more time than expected, Science may propose to move these sampling locations.

Table 3. Estimated staff and labor hours required for implementation of plot establishment.

SOP	Estimated time	Suggested staff	Total person hours
SOP A: Preparing for Sampling	1 h	1	1 h
SOP B: Field Sampling- Plot Validation	0.25 h	2	0.5 h
SOP C: Field Sampling- Plot Delineation and Marking.	1-2.5 h (Base Plots and Tick Plots) 0.5-1 h (Mammal Grid and Phenology Plots) 0.1 h (Mosquito Point and Bird Grids)	2	2-5 h (Base Plots and Tick Plots) 1-2 h (Mammal Grid and Phenology Plots) 0.2 h (Mosquito Point and Bird Grids)
SOP D: Field Sampling- Collect GPS Coordinates	5 m per point (Open field or minimal canopy cover) 8-30 m per point (Semi-open and closed canopy)	1	5 m-45 m per plot (Open field or minimal canopy cover) 1.25-6.5h per plot (Semi-open and closed canopy)
SOP E: Data Entry and Verification	0.5 -1 h	1	0.5- 1h
SOP F: Improving GPS Accuracies	0.25 h- 1h (initial setup and real time network check) 0.25 h per point (if CEA meets threshold) 1-3 h per point (if re-delineation and GPS coordinate collection needed)	2	0.5 h- 2h (initial setup and real time network check) 0.5 h per point (if CEA meets threshold) 2-6 h per point (if re-delineation and GPS coordinate collection needed)
SOP G: Replacing Lost Plot Markers	0.25- 0.5 h per marker	2	0.5- 1 h per marker



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SOP	Estimated time	Suggested staff	Total person hours
SOP H: Primary Plot Marker Monumentation	0.25 h per marker	2	0.5 h per marker



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5 SAFETY

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

Personnel working at a NEON site must be compliant with safe field work practices as outlined in the Operations Field Safety and Security Plan (AD[02]) and EHSS Policy, Program and Management Plan (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Ecologist 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.

A post driver and/or sledge hammer is used to drive the plot monuments into the ground. Safety considerations for this equipment include:

- Inspecting and wearing appropriate personal protective equipment (PPE). This may include impact gloves, hearing protection, and safety glasses.
- Maintaining appropriate posture while driving the monuments, including keeping the back straight, having a stance square to the monument, and maintaining a safe working height (e.g. working downhill of the monument and/or kneeling when appropriate).
- Using an appropriate driving technique to maintain control of the equipment prevents missed swings and minimizes the potential for injury.
- Using a Survey Monument Post Driver (30 inches or longer).

A hand or power saw is occasionally used to cut off a portion of the monument rod. Safety considerations for this equipment include:

- Inspecting and wearing appropriate PPE. This may include cut-resistant gloves, hearing protection, and safety glasses.
- Operating the equipment with a blade of the appropriate style and in good condition.
- Using an appropriate cutting technique to maintain control of the saw minimizes the potential for injury.



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6 PERSONNEL

6.1 Training Requirements

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

All Field Ecologists must have hands-on training with the GPS receiver with TerraSync software, antennae, laser rangefinder, and handheld compass with sighting mirror and declination prior to conducting field work. At least two technicians in each domain shall be trained and proficient in the use of GPS Pathfinder Office software and mission planning.

At sites where permanent markers often go missing Domains should train additional field staff to replace lost plot markers.

6.2 Specialized Skills

A team of two field technicians is required for plot establishment (delineation, marking and spatial data collection). Training will be provided for all specialized skills required for carrying out plot establishment (i.e. equipment use). Technicians are not required to have any additional skills other than those specified in the NEON Field Technician job description. Proficiency with compass and GPS receiver is useful and should be part of training to prepare to go into the field for this protocol.



7 STANDARD OPERATING PROCEDURES

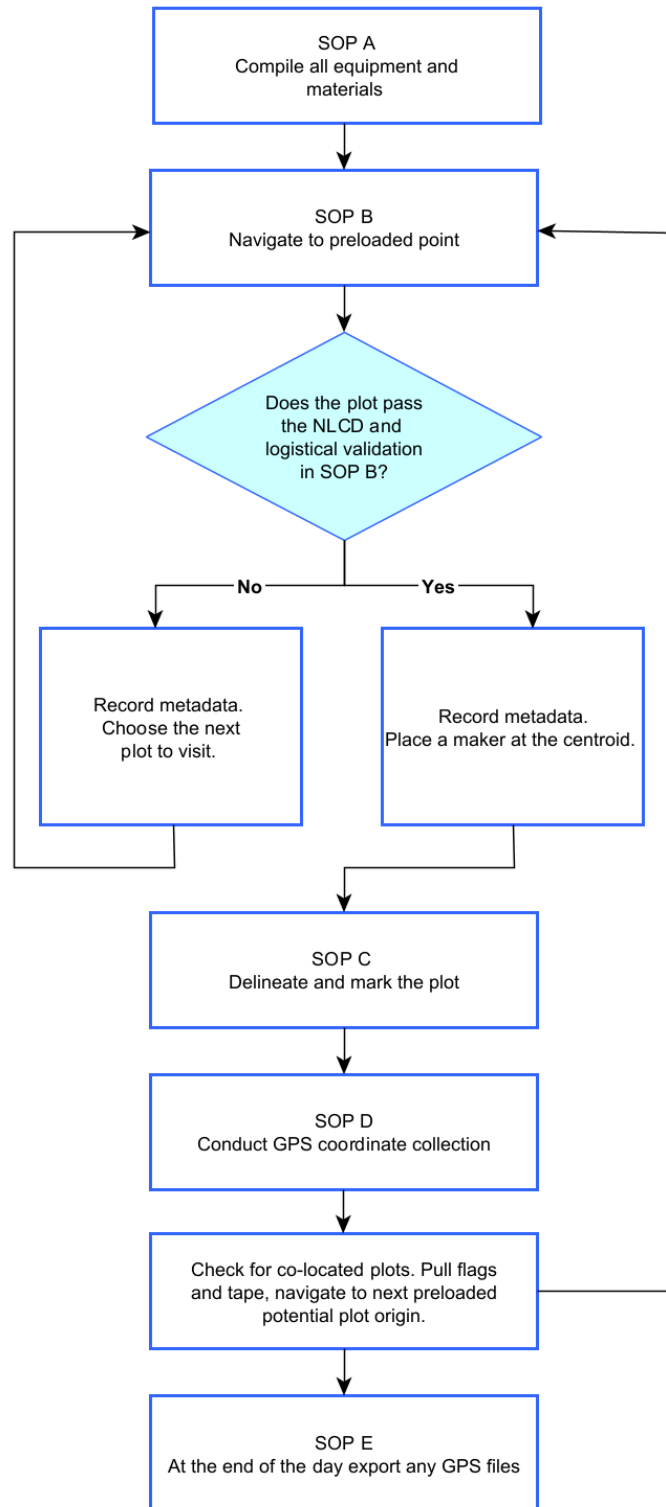


Figure 2. Overview workflow diagram for plot establishment.

SOP A Preparing for Sampling

COMPASS AND RANGEFINDER DECLINATION

Make sure the compass and rangefinder have their declination set appropriately for the geographic location. Declination changes through time so must be looked up annually for a given location. An incorrect declination will result in shifted plots that will need to be re-delineated. See TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration (RD[19]) for instructions.

Magnetic declination adjustment values are available at:

<https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination>

A.1 Preparing for Data Capture

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

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

Before plot establishment begins you will be provided with a NEON network location that serves as a communication gateway between the Science and Field Science teams; this network location also serves for source materials such as maps and files for the GPS receivers.

Table 4. Folder name, content, format, and purpose for file resources related to plot establishment.

Folder	Content	Format	Purpose
GPS_Pathfinder_Files	Contains all GPS data files (plot locations, roads, boundary and others)	.imp	Data files to be used by Field Science to collect plot data on the GPS receiver
Data_Dictionaries	Contains all data dictionaries	.ddf	A Data Dictionary is a Trimble digital form used to capture spatial data and photos. Data Dictionaries are uploaded to the GPS receiver prior to plot establishment.
Site_Information_&_Datasheets	Maps	.pdf	Maps to be used by Field Science.
	Plot layout and site information	.kmz	Layers to be used in google earth by Field Science



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Folder	Content	Format	Purpose
	XX_XXXX_TOS_Plots_Datasheet: Contains all Distributed plots, Morton Order, vegetation type, plot status and coordinates.	.xlsx	Datasheet to be used by Science and Field Science, must be regularly updated by Field Science.
	Contains site information and notes from previous remote and field (if applicable) validation	.docx	Background information about the site for Field Science
Established	Established point Trimble files	.imp	Point locations post processed from the field collected data. Used to navigate to plots for sampling and replace plot markers
ArcGIS Online	Post establishment shapefiles, csvs, and kmzs. Updated monthly.	multiple	Source for plot spatial data after plot establishment is complete
Sharepoint>Sample Support Library>	uniquePlotIDLists	.csv	List of what protocols are sampled at what locations. Also includes centroid and SW corner coordinate information to use in the Garmin units

A.2 GPS Receiver Setup and File Transfer

1. Set up the GPS Receiver following the standard instructions in SOP A in AOS/TOS Standard Procedure: Trimble GEOXH Receivers Setup and Use RD[21].
2. If needed, set up a new project in GPS Pathfinder Office. See RD[21] SOP B.1.
3. Import all the data dictionaries needed for Plot Establishment to the GPS receiver. See RD[21] SOP B.2.
 - a. Note: The data dictionaries are used as a guide for when photos and GPS logs should be taken per plot type. All other metadata is recorded in the Fulcrum Application.



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4. Import all the site specific background and datafiles needed for Plot Establishment to the GPS receiver. Be sure that the coordinate settings in GPS Pathfinder Office and the GPS receiver match and are correct for the site before importing. See RD[21] Section B.2.
 - a. Typical plot establishment background files include: site boundary, water bodies, roads, tower location, and existing research. Request site specific background layers from Science if needed.



SOP B Field Sampling - Plot Validation

Following the Morton order list, navigate to a plot centroid in the field. See RD[21] for how to open a datafile and navigate using the GPS receiver in the field.



- Turn on the unit in an open area for at least 5 min before entering a closed canopy system.
- Make sure the barometric pressure holes on the under-side of the Trimble are not obstructed.
- Always take an extra fully charged GPS battery.

B.1 Canopy Cover Assessment

Canopy cover assessment is based on the National Land Cover Database (NLCD) classification for all Distributed Plots (**Table 7**). Plot locations are only accepted if the actual vegetation type is consistent with the designated NLCD vegetation type. The DXX_SITE_TOS_Plots_Datasheets provided by Science lists the NLCD land cover type in the “nlcdClass” column.

1. Once within the plot, determine the location of the plot perimeter. You can run a tape across four cardinal directions (or use the range finder and reflector) and set up visual cues (it could be flagging tape, a rock, a tree etc.) that would indicate the perimeter of the plot.
 - a. Since Bird and Mammal Grids are so large and it is difficult to determine land cover type percentages err on the side of NLCD unless the classification is obviously off.
 - b. For Mosquito Points validate an area 40 m by 40 m with the point location as the centroid.
2. Determine plot Level 1 classification (e.g. Forest, Shrubland). Located in NLCD classification description (**Table 7**).
 - a. Remember: NLCD defines the dominant vegetation stratum by height since NLCD assesses canopy from satellite imagery (i.e., the tallest vegetation is “dominant”).
3. Within each Level 1 NLCD class, determine Level 2. For example, if the Level 1 classification is Forest, the next step is to determine if it is a Deciduous, Evergreen, or Mixed Forest.



IMPORTANT: Level 1 classification determines the total percent cover for the plot (e.g. 40% of the plot is forest); Level 2 is then assessed out of 100% of the Level 1 total (e.g. of the 40% of the plot that is forest, 50% of that forest area is deciduous, 50% of that forest area is evergreen, **NOT** 20% deciduous forest and 20% evergreen forest).

4. Evaluate the results of the Level 1 and Level 2 classification to determine whether the plot should be accepted or rejected.

In instances where the plot classification (either Level 1 or Level 2) is unclear due to borderline percent cover(s) (i.e. near the % cover cut-off described in E), acceptance or rejection should be



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based on group consensus. If disagreement persists, the plot should be rejected. For example, when validating a deciduous forest plot (Level 2) where more than 75% of the total forest cover in the plot should be deciduous to be accepted, if the sampling crew cannot agree because person 1 thinks plot deciduous forest cover is below the 75% threshold and person 2 thinks the plot is above this threshold, then the plot should be rejected.

If Level 1 classification is rejected, please assess both Level 1 and Level 2 classifications and record to the corresponding rejected plot metadata.

5. Begin metadata collection in Fulcrum, regardless of the results of the above assessment.

B.2 Safety and Logistics Assessment

In addition to the canopy cover assessment all plots are assessed for safety and logistical concerns.

A selected plot may be rejected by Field Ecologists if:

- Plot location is in a creek (wider than 10 m), is too wet (see 8Appendix D), or presents other geographical features that prevent sampling as specified in the associated TOS protocol(s).
- Field conditions are deemed unsafe by Field Ecologists.
 - Examples: steep slopes, dead standing trees, cliff exposures.
- Logistical reasons as determined by Field Ecologists; make sure the reasoning is outlined in the comments field of the plot's metadata.
 - Hiking distance is longer than 45 mins
 - Access to the plot goes through private property
- Tick plots may be rejected if more than 50% the plot perimeter (i.e., 80 m of the 160 m perimeter) is not amenable for tick sampling using the dragging or flagging method(s) (or both). For example, sections of the perimeter that run through dense patches of briars likely cannot be sampled by either method.
- A 4m offset is not enough to negotiate around an obstacle at the centroid of a base plot. See section B.4: Shifting and offsetting point locations for more information on offsets.

B.3 Metadata Collection

Metadata includes information about plot acceptance, vegetation type, and other plot characteristics. Record the metadata in the Fulcrum App following the Fulcrum manual for both accepted and rejected plots. Use the GPS receiver to collect photos (additional information about GPS file creation in Create a GPS File). Metadata only needs to be collected once per plot.

Accepted Plots:

1. If the plot is accepted based on the above assessments, place a temporary marker at the plot centroid (chaining pins, flag, etc.).
2. Record the metadata in Fulcrum.



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3. Proceed to Field Sampling- Plot Delineation and Marking.

Rejected Plots:

In all cases where a plot is rejected, record the rationale in the Fulcrum App. Do not record spatial location for rejected plots. After recording metadata, move on to the next plot location in sequence based on the Morton Order plot list. If the rejection of plots is so high that it is not possible to establish the desired number of plots at a given site, contact Science to provide additional plot locations.

To close the GPS file for the rejected plot and move on to the next location:

1. Make sure the file used to hike to the plot has been **Closed**; if it hasn't go to the **MDD > Data** and click **Done**.
2. Keep Type as the internal antenna option for your model and click **OK**, this will set the unit for hiking.
3. Select next location following the Morton Order.

B.4 Shifting and offsetting point locations

Determine plot centroid/origin

If a plot centroid/origin falls on a location where it is not feasible to place a permanent marker (e.g. a rocky outcrop), the Field Ecologists may shift the centroid to avoid an obstacle provided that the direction of the shift is selected to minimize the deviation from the provided point (i.e. the closest suitable location), within the specifications below.

Maximum distance of shifts by plot type:

- Distributed Base and Tower Base Plots can be shifted ≤ 3 meters (10% of the randomly generated RRQRR cell).
- Phenology Plots cannot be shifted
- Mammal and Bird Grids can be shifted 50 m and 150 m respectively but new locations **must** be approved by Science staff due to additional buffers.
- Tick Plots can be shifted 15 m but new locations **must** be approved by Science staff due to additional buffers.
- Mosquito Points can be shifted up to 10 m.

Record azimuth from True North, distance of shift, and rationale in the comments section of the Fulcrum Application.

Shift: used to describe how much a marker can be moved from the desired point so that it can be placed in the ground and coordinates collected at that shifted location.

Offset: used to describe placing of a marker at some recorded distance and direction from the desired point; the high resolution coordinates are collected at the original point, not at the offset. The azimuth



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and direction to the marked offset from the desired point must be recorded in the comment section of the metadata. Also record this information in a place that will be available to staff when they re-visit the plot. Offset information should also be written on the marker in the ground.

Centroid points

In the event that a plot centroid must be **shifted**, record the azimuth from True North and distance of the shift, and the rationale for the shift in the metadata; proceed to collect high resolution GPS point data for the new location. Build out the rest of the plot with the new centroid as a starting point. If the plot origin is shifted up to 3 meters and a marker still cannot be placed, you can keep the 3 meter shift and **offset** the marker up to 4 meters. If the offset is not enough to negotiate around an obstacle, reject the plot, record the rationale for rejection, and select the next available RRQRR generated contingency plot. Shifts and offsets can be used separately or in tandem depending on site conditions.

Points at corners and cardinal directions

If an obstacle prohibits placement (e.g. there is a rock or tree) of a corner or cardinal marker, **shift** the plot marker to a better location that is ≤ 0.5 m from the target location, record the rationale for the shift in the metadata comments field, and record high resolution GPS data for the new location. If a plot marker cannot be placed ≤ 0.5 m of the target location proceed to **offset** the marker up to 4 meters.

It is acceptable to increase this 4 m offset distance threshold; however, if there are more than 5 plots with an offset between 4 - 10 m or if at least 1 plot offset is more than 10 m, establish the offset and contact Science.

If the offset is not enough to negotiate around an obstacle, reject the plot, record the rationale for rejection, and select the next available RRQRR generated contingency plot.



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SOP C Field Sampling- Plot Delineation and Marking

The goal of plot delineation is to create plots of constant area when viewed from the air. The preferred method for plot delineation is by using the rangefinder. Be sure to bring the tape and compass as back up in case of equipment failures.

General Rules

- **Always use the rangefinder with a non-ferromagnetic tripod and reflective target on a staff** to reduce human error. See RD[19] for instructions on the correct setup and use.
- In dense vegetation set the rangefinder mode to **“Filter”** and use the **foliage filter**, see RD[19] for instructions.
- Always delineate in **increments of 10 m** or less. Greater distances will increase the effects of the rangefinder’s ± 1 degree azimuth accuracy. Verification measurements should be done in the smallest distances possible but can be greater than 10m.
- Always use the rangefinder in slopes over 20% or in areas of thick vegetation.
 - When establishing a plot where the slope of the ground is greater than 20%, measuring 10 m along this slope with a tape will yield a horizontal line that measures less than 10 m from the air. The same can be true if the tape must go around large trees or over/below brush, see obstruction methods in Appendix H if using the tape.
- **Always keep metal objects (including flags, chaining pins, cell phones, watches, jewelry etc.) at least 50 cm (20 in) from the rangefinder when using the internal compass.**
 - See the RD[19] for examples of metallic objects that may affect the compass performance
 - Be aware of sites with higher levels of mineral composition in the ground
- If you do use a sighting compass abide by the following rules to ensure accuracy:
 - Check to ensure the adjustable declination dial is set correctly.
 - Hold the compass at arms-length and keep all metal objects away.
 - Make sure the compass is held level to allow free movement of the magnetic needle.
 - Align the line in the mirror with the center of the needle while sighting your target.
 - Carefully align both sides and the points of the needle with the guides below it.

At each plot

- **Double check compass and rangefinder declination.** Make sure the compass and rangefinder have their **declination set appropriately for the geographic location.**
- **Calibrate the rangefinder internal compass.** Follow steps in the TruPulse Rangefinder Use and Calibration SOP (RD[19]).
 - Recalibrate the rangefinder at a plot if:
 - the rangefinder is dropped
 - batteries are changed
- Be sure the rangefinder is in the Horizontal Distance (HD) mode.



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Validation Rules

- Validate measurements with the rangefinder by measuring from different angles/locations. For example, checking the distance and direction between points 41 and 33.
 - ***It is required that validation measurements are within ± 1 degree for the azimuth and ± 0.3 meters for the distance.*** For example, if the instrument is validating a horizontal distance measured previously 10.0 m, the rangefinder values for validation should be between 9.7 and 10.3 meters to accept the validation.
 - Note: if the distance readout on the rangefinder includes a decimal point this means your target was “high quality”.
 - If there is not a decimal point you will need to change your target to something more reflective. Also check to make sure the mode is set to report in “meters” and not “feet” and if you are using the foliage filter to turn the filter “on”.
 - If the established point does not pass validation then repeat the delineation process.

NEON TOS sampling units are a variety of sizes, and all are created in the field according to two high-level workflows:

1. Delineated TOS Plots: Built out in the field using a rangefinder and high-accuracy target:
 - a. Tower Base Plots
 - b. Distributed Base Plots
 - c. Tick Plots
2. Established TOS Plots, Grids, and Points: markers are installed using a Trimble and pre-loaded GIS data):
 - a. Phenology Plots
 - b. Bird Grids
 - c. Mammal Grids
 - d. Mosquito Points

Procedure for Delineated Plots

The following procedure contains instructions followed by a bracketed number [#] that refers to the pointID. Plot pointID numbering is available in **Figure 19** and delineation schematics are in 8Appendix E. The instructions are broken down into generalized delineation steps that are then used in different combinations depending on plot type. These combinations are outlined in the sections below. Bring the Log Sheets and fill them out once a plot has been delineated.

The procedure for delineating TOS Plots with a rangefinder and high-accuracy target assumes a two-person crew:



- Person 1 uses the rangefinder on a tripod and measures angles and distances and
- Person 2 holds the reflector on a staff and carries flagging.

The numbers in brackets in below refer to the point IDs.

1. Delineating Cardinal Positions - 10 m  (Figure 3).

- a. Person 1 stands at the centroid [41] with the rangefinder directly over the marker.
- b. Using the rangefinder, Person 1 guides Person 2 until the reflector mounted on the staff is exactly North ($360/0^\circ$) and 10.0m away.
- c. Person 2 places a flag at the North point [50].
- d. To verify the position: Person 1 and Person 2 switch places so Person 1 is at the North point [50] with the rangefinder and Person 2 is at the centroid [41] with the reflector. Check both the distance (10.0m) and direction (180°).
- e. Repeat steps a-d for the remaining cardinal directions: South [32] 180° , East [42] 90° , West [40] 270° .

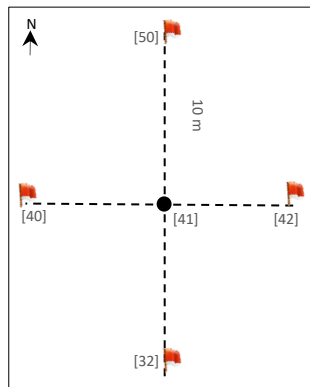



Figure 3. Delineating the 10m cardinal positions (red flags, pt IDs in brackets) starting at the centroid (black circle, pt 41).

2. Delineating Cardinal Positions - 20 m  (Figure 4).

- a. Complete Step 1, Delineating Cardinal Positions – 10m, steps a-d.
- b. Person 1 remains at the North 10m point [50] with the rangefinder and guides Person 2 until they are exactly an additional 10m North [59].
- c. Person 2 places a flag at the 20m North pt [59].
- d. Once again, switch places and verify the position by shooting the rangefinder South from pt 59 to pt 50.
- e. Repeat steps a-d for the remaining cardinal directions: South [23] 180° , East [43] 90° , West [39] 270° .



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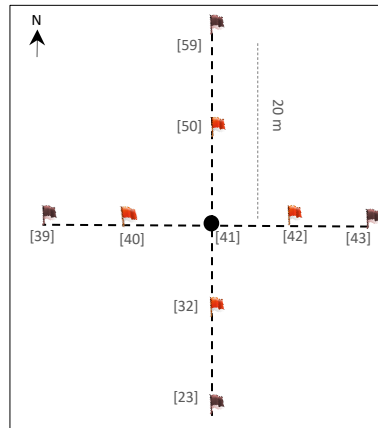


Figure 4. Delineating the 20m cardinal positions (purple flags, pts 39, 59, 43, 23) building on the 10m cardinal positions, see **Figure 3**.

3. Delineating **20 m x 20 m corners** 🚩 (Figure 5)

- a. To delineate the Northwest 20m point [49], determine which path has a better line of sight:
 - 1) North point [50] to the Northwest point [49] or
 - 2) West point [40] to the Northwest point [49]
- b. Person 1 stands at the flagged location determined above and guides Person 2 either West or North exactly 10 m.
- c. Person 2 places a flag at the 20m Northwest corner point [49].
- d. Verify by checking either:
 - 1) Option 1 or 2 from step a that was not used to delineate the point or
 - 2) The diagonal from the centroid [41] to the 20m Northwest plot corner [49]. The diagonal should measure 14.14m and 315°.
 - 3) Choose based on which path has the better line of sight. If they are equal then choose option 1 since it is a smaller distance.
- e. Repeat steps a-d for the remaining corners: Northeast [51], Southwest [31], Southeast [33]
 - 1) Appendix F has useful plot diagrams with angles for diagonal verifications.

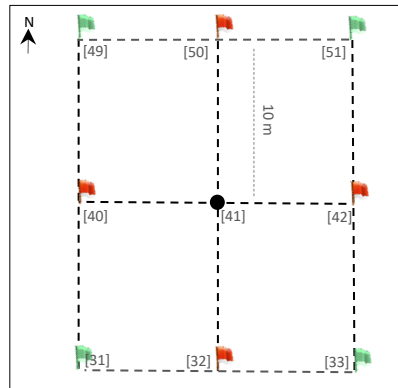


Figure 5. Delineating the 20m corners (green flags, pts 49, 52, 33, 31) building on the 10m cardinal positions, see **Figure 3**.

4. Delineating 40 m x 40 m corners (Figure 6)

- a. To delineate the Northwest 40m point [57], determine which path has a better line of sight:
 - 1) North 10m from point 49 and then West 10m from point 58 or
 - 2) West 10m from point 49 and then North 10m from point 48 or
 - 3) North 20m from point 39 (in two 10m increments) or
 - 4) West 20m from point 59 (in two 10m increments)
- b. Person 1 stands at the flagged location determined above and guides Person 2 either North or West exactly 10m.
- c. Person 2 places a flag.
- d. Person 1 stands at the newly flagged location and guides Person 2 to the Northwest 40m point [57].
- e. Verify by checking the diagonal from the Northwest 20m point [49] to the Northwest 40m point [57]. The diagonal should measure 14.14m and 315°.
 - 1) If line of sight is an issue select a path from option 1-4 from step a that was not used to delineate the point.
- f. Repeat steps a-e for the remaining corners:
 - 1) Northeast 40m point [61]
 - 2) Southwest 40m point [21]
 - 3) Southeast 40m point [25]



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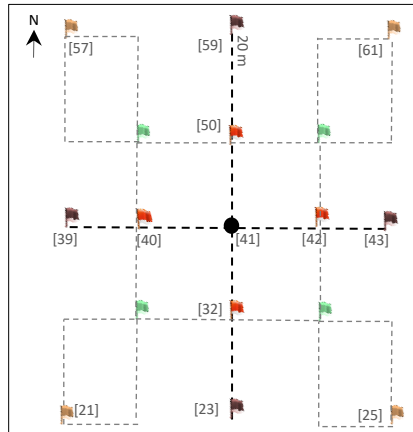


Figure 6. Delineating the 40m corners (orange flags, pts 57, 61, 25, 21) building on the 10m cardinal positions (Figure 3) and 20m corners (Figure 5).

C.1 Tower Base Plots

Tower plot dimensions depend on vegetation type and will be listed on the site datasheet (see **Table 4**). See B.4 for guidance on offsetting markers and Tower Plot Workflow for diagrams. Tower Base Plots are delineated.

20 m x 20 m Tower Plot

1. Follow: Delineating Cardinal Positions - 10 m (Step 1).
2. Follow: Delineating 20 m x 20 m corners (Step 3).
3. Leave markers and collect GPS points at [41], [49], [51], [31], [33].
4. Use the GPS to take photos facing toward center from points [49], [51], [31], [33].
5. Fill out log sheet (Tower Plot Log Sheet- 40 m by 40 m8Appendix A).

20 m x 20 m Tower Plot with 40 m corners for Soil Sampling

1. Follow: Delineating Cardinal Positions- 10 m (Step 1).
2. Follow: Delineating 20 m x 20 m corners (Step 3).
3. Follow: Delineating 40 m x 40 m corners (Step 4).
4. Leave markers and collect GPS points at [41], [49], [51], [31], [33], [57], [61], [21], [25]. See SOP B.4 for guidance on offsetting markers.
5. Use the Trimble GPS to take photos facing toward center from points [49], [51], [31], [33].
6. Fill out log sheet (Tower Plot Log Sheet- 20 m by 20 m8Appendix A).

40 m x 40 m Tower Plots

1. Follow: Delineating Cardinal Positions - 20 m (Step 1 and 2).



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2. Follow: Establishing Delineating 20 m x 20 m corners (Step 3).
 - Suggestion: Flags may be left at all 20 x 20 m corners within 40 m tower plots (where sites permit), until tower plots with plant diversity sampling are accepted.
3. Follow: Delineating 40 m x 40 m corners (Step 4).
4. Leave markers and collect GPS points at [41], [57], [59], [61], [43], [25], [23], [21], [29]. See SOP B.4 for guidance on offsetting markers.
5. Use the Trimble GPS to take photos facing toward center from points [57], [61], [21], [25].
6. Fill out log sheet (Tower Plot Log Sheet- 40 m by 40 m).

40 m x 40 m Tower Plots with 20 m corners for Plant Diversity Sampling

1. Follow: Delineating Cardinal Positions - 20 m (Step 1 and 2).
2. Follow: Delineating 20 m x 20 m corners (Step 3).
3. Follow: Delineating 40 m x 40 m corners (Step 4).
4. Leave markers and collect GPS points at [41], [49], [51], [31], [33], [57], [59], [61], [43], [25], [23], [21], [29]. See SOP B.4 for guidance on offsetting markers.
5. Use the GPS to take photos facing toward center from points [57], [61], [21], [25].
6. Fill out log sheet (Tower Plot Log Sheet- 40 m by 40 m).

C.2 Tower Phenology Plot

Located within the tower airshed (RD[09]). See diagrams in Appendix E. Tower Phenology Plots are established using the Trimble and pre-loaded GIS data.

1. **Primary Phenology Plot:** 8 points every 100 meters around square transect.
 - a. Navigate to preloaded points with GPS receiver.
 - b. Place primary markers at the Southwest and Northeast points, the remaining points require secondary markers.
 - c. Collect GPS points (refer to SOP D)
 - d. Use the GPS to take photos in a clockwise direction at all points
 - e. Marker type and labeling instructions located in Appendix E. See B.4 for guidance on offsetting markers.
 - f. Fill out log sheet (Phenology Plot Log Sheet&Appendix A).
2. **Secondary Phenology Plot:** line contains three points. Not applicable for all sites (refer to tower data sheet in FOPS folder).



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- a. Navigate to preloaded points. Place primary marker at SW corner, remaining points require secondary markers.
- b. Collect GPS points.
- c. Use the GPS to photos in a clockwise direction at all points
- d. If possible, place temporary flags as needed along transect to visually guide phenology sampling efforts. For more details, refer to RD[09].
- e. Marker type and labeling instructions located in Appendix E. See SOP B.4 or guidance on offsetting markers.
- f. Fill out log sheet (Phenology Plot Log Sheet&Appendix A).

C.3 Distributed Base Plot

Distributed Base Plots are delineated, see B.4 for guidance on offsetting markers and Distributed Base Plot Workflow for a diagram. Communicate with Science via ServiceNow to determine which protocols will be sampled at each Distributed Base Plot since this will determine the plot size. If unsure, start out with steps 1&2 below to build a 20m by 20m plot. The outer 40m by 40m corners can be added later at Beetles and Soil sampling plots.

1. Follow: Delineating Cardinal Positions - 20 m (Step 1 and Step 2).
2. Follow: Delineating 20 m x 20 m corners (Step 3).
3. If the plot will be sampling Beetles, Soils, or Birds, then 40m corners are needed. For Assignable Asset work: Follow Delineating 40 m x 40 m corners (Step 4).
 - a. Note: Bird sampling requires delineation only to point 21.
4. Leave markers and collect GPS points at [41], [49], [51], [33], [31].
 - a. For plots that sample Beetles, Soils, or 40m corners are needed for Assignable Asset work also leave permanent markers and collect GPS points at [61], [25], [21], [57].
 - b. For plots that sample Birds leave a permanent marker and collect GPS points at [21].
5. Use the GPS to take photos facing toward center from points [49], [51], [31], [33].
6. Fill out log sheet (Distributed Base Plot Log Sheet&Appendix A).

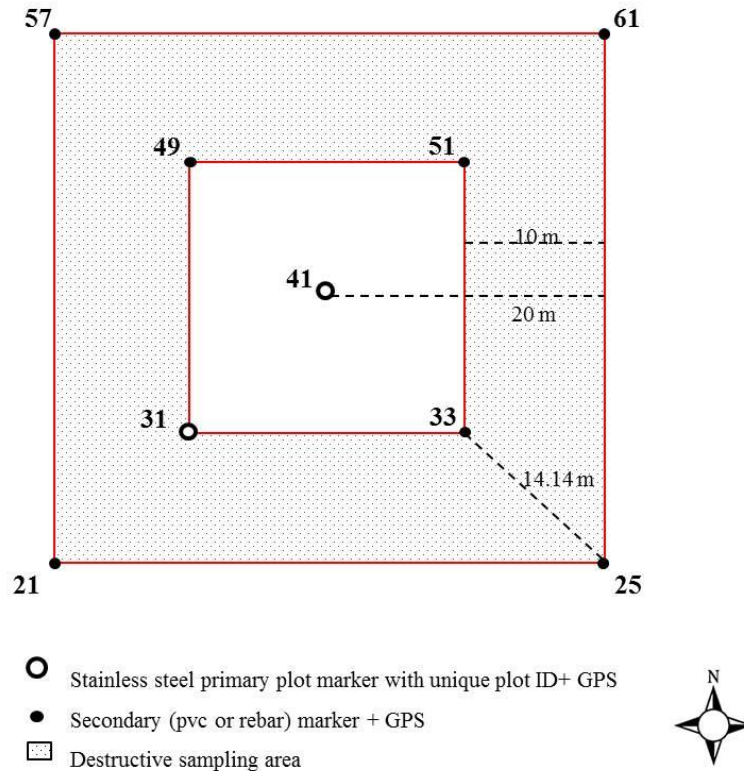


Figure 7. Schematic of a Distributed Base Plot illustrating the point IDs (numbers), distances between features (dashed lines), types of markers, and the destructive sampling area.

C.4 Distributed Tick Plot

Once at the plot verify that at least 50% of the plot perimeter (i.e., 80 m of the 160 m perimeter) is amenable for tick sampling using the dragging or flagging method(s) (or both). For example, sections of the perimeter that run through dense patches of briars likely cannot be sampled by either method. Additional information can be found in RD[06]. Distributed Tick Plots are delineated.

See B.4 for guidance on offsetting markers and Distributed Tick Plot Workflow for a diagram.

1. Follow: Delineating Cardinal Positions- 20 m (Step 1 and Step 2).
2. Follow: Delineating 20 m x 20 m corners (Step 3).
3. Follow: Delineating 40 m x 40 m corners (Step 4).
4. Leave markers and collect GPS points at [41], [57], [61], [25], [21].
5. Fill out log sheet (Tick Plot Log Sheet&Appendix A).

C.5 Distributed Mammal Grid

See B.4 for guidance on offsetting markers and Distributed Small Mammal Grid Workflow for a diagram. Distributed Mammal Grids are established using the Trimble and pre-loaded GIS data.



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1. **Locate pt E5** with GPS receiver, using pre-loaded waypoints and/or data files.
2. **Mark the pt E5.**
3. **Locate the plot corner** with the GPS receiver, using pre-loaded waypoints and/or data files.
4. **Mark plot corner**
5. **Repeat steps 3-4 for remaining corners.**
6. **Set up grid before sampling** as outlined in Small Mammal protocol.
 - a. Note: The plot corner flags are meant to act as a guide when setting up the grid and do not indicate the final position of the traps.
7. Fill out log sheet (Small Mammal Grid Log Sheet&Appendix A).

C.6 Distributed Bird Grid

See B.4 for guidance on offsetting markers and Distributed Bird Grid Workflow for a diagram. Distributed Bird Grids are established using the Trimble and pre-loaded GIS data.

1. **Locate the desired plot centroid** with GPS receiver, using pre-loaded waypoints and/or data files.
2. **Mark the plot centroid.**
3. **Collect GPS point**
4. **Bird Grid preloaded points will be provided for use when sampling.**
5. Fill out log sheet (Bird Grid Log Sheet&Appendix A).

C.7 Distributed Mosquito Point

See B.4 for guidance on offsetting markers and Distributed Mosquito Point Workflow for a diagram. Distributed Mosquito Points are established using the Trimble and pre-loaded GIS data.

1. **Locate the point** with GPS receiver, using pre-loaded waypoints and/or data files.
2. **Validate the point**
 - a. **Point** must be at least 5 m from a road and a maximum distance of 45 m.
 - b. **Shift the point** within 10 m in any direction if needed to find an acceptable hanging structure and/or increase distance from the road. For more details, refer to RD[05]
 - c. **Validate the vegetation** within a 40 m by 40 m box around the point following the canopy cover assessment of SOP B. Exclude the road during this assessment, for example if 30% of the 40 x 40 m plot is road, exclude this 30% and assess the plot based on the remaining 70%.
 - d. **Fill out** the metadata.



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3. **If accepted, mark** the point with a primary marker, use a temporary marker if primary marker is not yet available.
4. **Collect the GPS point**
5. Fill out log sheet (Mosquito Point Log Sheet).



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SOP D Field Sampling- Collect GPS Coordinates

After a plot has been delineated and plot markers are in the ground, the next step is to record the spatial locations for each marker. This step can occur independently of delineation.

D.1 Create a GPS File

Create a new datafile in the GPS receiver to collect spatial data and photos. Data Dictionaries are used to ensure data collection occurs at the right points per plot type.

1. Make sure the file used to hike to the plot has been **Closed**; if not, navigate to **MDD > Data** and click **Done** and then **Close**.
2. When establishing plots, create a new data file for each unique plot. Go to **MDD > Data**, and then go to the **SDD** menu and select **New (T)**.
3. Keep the settings on **File type** (Rover) and **Location** (Default); Click on the **File Name** field and choose an appropriate name.

Filename begins with the letter D, followed by the two digit number for the domain, followed by an underscore: e.g. **D01_**

- a. Add the four letter site ID followed by an underscore: e.g. **D01_HARV_**
- b. Add the value denoting Morton Order plot number followed by an underscore: e.g. **D01_HARV_1_**, **D01_HARV_1234020_**
- c. Add a letter to indicate the plot type followed by an underscore: e.g. **D01_HARV_1_T_**.
Plot type letters are:
 1. "T" to indicate a "Tower" Plot.
 2. "H" to indicate a "PHenology" Plot.
 3. "R" to indicate a "DistRibuted Base" Plot.
 4. "K" to indicate a "TicK" Plot.
 5. "M" to indicate a "Mammal" Grid.
 6. "B" to indicate a "Bird" Grid.
 7. "Q" to indicate a "MosQuito" Point.
- d. If the plot is accepted, add the letters "GPS" to the end to indicate the file contains GPS data: e.g. **D01_HARV_1_T_GPS**

Each time a plot is visited to collect GPS points a new file must be created. Follow the same naming convention outlined above and add V # to the end of the file name. E.g. **D01_BART_199_R_GPS_V4** if it is your fourth time collecting GPS points at a plot.

4. Change the **Location** to "Storage Card". This setting can also be changed after the file is collected.
5. In **Dictionary Name** choose the GPS data dictionary that is appropriate for the given plot (Distributed Base Plot, Tower Base Plot, Mammal Grid, etc) and task (soil sampling at 20 m by 20



m Tower Base Plots, Plant Diversity sampling at 40 m by 40 m Tower Base Plots, etc).Click **Create**.

- a. Note: If Data dictionaries have not been imported, use the default “generic point” data dictionary and create one file per point location. Add the pointID to the datafile name after the module letter.
6. Change antennae height to **2.000 m**
7. Select Type as **antenna model 2** and click **OK** (Do not set up the antenna at this point).
8. **Open** the appropriate GPS data dictionary based on the plot type you are currently in. Make sure the receiver is active by going to the **MDD>Setup**. If the satellite icon is not visible: click **on the GNSS box which should be in upper right side of the screen. If the receiver is NOT** active you will see a satellite icon to the right of the MDD menu. If the receiver is already active the following message should appear:



Are you sure you want to disconnect from GNSS receiver? Click on NO to maintain the receiver’s active status

D.2 Collect GPS Logs

GPS coordinate and photo collection follows plot delineation. To collect highly accurate coordinates, set up a surveyor style standing GPS system as described in RD[21] (**Figure 8**). Follow **Table 5** to determine which points at which plots must have GPS records collected and photos taken.



Figure 8. GeoXH 6000 set up for high accuracy data collection.



Table 5. Number of GPS points to be collected at each plot type; point ids are in brackets next to point descriptions.

Plot_Type	Sub_Type	Module	Provided by Science	GPS points collected by Field Science for Post Processing	Total Points
Distributed	Base	Base – only samples plant protocols	Centroid	Centroid [41] Four 20 m corners [49,51,33,31]	5
Distributed	Base	Base – samples plant protocols and/or beetles and soils	Centroid	Centroid [41] Four 20 m corners [49,51,33,31] Four 40m corners [57,61,25,21]	9
Distributed	Base	Base – plant protocols and bird point sampling	Centroid	Centroid [41] Four 20 m corners [49,51,33,31] Outer SW corner [21]	6
Distributed	Collocated	Mammal	E5, corners	E5	1
Distributed	Collocated	Bird	Centroid, 9 pt grid (includes centroid)	Centroid [41]	1
Distributed	Collocated	Mosquitoes	Centroid	Centroid [41]	1
Distributed	Collocated	Ticks	Centroid, 4 Corners	Centroid [41] Four 40m corners [57,61,25,21]	5
Tower	Type A	Tower-40 m x 40 m	Centroid	Centroid [41] Four 40m corners [57,61,25,21] Four 40m cardinal points [59,43,23,39]	9
Tower	Type A	Tower- 40 m x 40 m with plant diversity	Centroid	Centroid [41]	13



Plot_Type	Sub_Type	Module	Provided by Science	GPS points collected by Field Science for Post Processing	Total Points
				Four 20 m corners [49,51,33,31] Four 40m corners [57,61,25,21] Four 40m cardinal points [59,43,23,39]	
Tower	Type A	Tower-20 m x 20 m	Centroid	Centroid [41] Four 20 m corners [49,51,33,31]	5
Tower	Type A	Tower- 20 m x 20 m with DSA corners	Centroid	Centroid [41] Four 20 m corners [49,51,33,31] Four 40m corners [57,61,25,21]	9
Tower	Type B	Phenology 1H	8 pts on transect	8 points along transect [N, NE, E, SE, S, SW, W, NW]	8
Tower	Type B	Phenology 2H	3 pts	3 pts [SE, S, SW]	3

Connect to the Antenna

1. Make sure that the Antenna **Height** is at 2 m, and the **Type** refers to the Antenna Model. Keep setting on “measure to bottom of receiver”; then click **OK** on “confirm antenna height” pop-up.
 - a. If the antenna type you are using is not in the drop down menu select “unknown external”



Tip: To check if the external antenna is properly connected, navigate to the status screen (the one that shows the current coordinates). Move the Trimble unit but not the antenna to see if the coordinates change.

Collect GPS logs




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1. Move the monopole setup so it is directly over the plot maker.
2. Open the point feature that matches your location.
3. Check the measurement values below to ensure High-Accuracy Logging. These measurements are located on the bottom right of the **MDD > skyplot** in the TerraSync software on the Trimble unit.
 - a. Position Dilution of Precision (PDOP) is ≤ 6 .
 - b. The Signal to Noise Ratio (SNR) should be ≥ 4 .
 - c. Number of satellites used ≥ 4 .
4. Log the GPS positions (note the logging symbol in the upper right side of the screen). You may need to click “log”.
5. Depending on the canopy cover choose the appropriate number of logs:
 - **Open field or minimal canopy cover:** record GPS data for at least 120 logs using the accuracy-based logging feature.
 - If the data collection of each point takes over 20 minutes, disable logging feature (see below) and collect the 120 logs regardless of accuracy.
 - **Semi-open and closed canopy:** record GPS data for at least 300 logs using the accuracy-based logging feature.
6. If the data collection of each point takes between 5 and 10 minutes, disable the logging feature (see Box 1) and collect the 300 logs regardless of accuracy.



Use your judgment in regards to exactly how long to wait at each point (always a minimum of 5 minutes). Create your judgment by assessing potential permanent obstructions like canopy cover, boulders, mountains etc., and based on any preceding results from post processed data received from Science (when available).

Box 1. Disabling the Accuracy-Based Logging Feature

1. Go to MDD > Setup
2. Click on Logging Settings
3. Under Logging Settings click on the wrench  to the right of the screen.
4. Scroll down and in the Use Accuracy-based Logging click No
5. Click Done for the two following windows and,
6. To go back to the data collection go to MDD>Data + SDD>Existing File.

By disabling this feature, the GPS will collect data of any accuracy.

7. For all canopy conditions:



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- a. Verify that carrier lock and a minimum estimated accuracy of 0.5 m is maintained for the duration of the logging. If accuracy drops check that the skyplot information is following high accuracy standards. To view carrier lock scroll to **Status** in the upper left drop down and the scroll to **Receiver** in the lower left drop down menu.
 - b. Following the completion of the first day of collection under closed canopy or semi-open canopy conditions, notify HQ to verify that the accuracy requirements are being met. *Note:* it takes 24-48 hours to post-process data. After the post-processing accuracy check, you may be required to log more data to meet accuracy; this depends upon plot conditions.
8. Tap **Done** to store data. Close the feature but **NOT** the data file.
9. If a picture is required (this is plot and point dependent, see the diagrams in Appendix E):
- a. Take the picture while the GPS is attached to the monopole.
 - b. Make sure pictures are always taken facing the center of the plot.
 - i. For phenology plots take the photo clockwise towards the next point on the transect.
 - c. To take a picture open the photo feature:
 - i. Tap on the photo icon to the right of the blank box.
 - ii. Be sure that photos are clear and portray the landscape only (i.e. no technicians or backpacks).
 - iii. Tap on the physical camera button located towards the bottom center of the GPS underneath the screen.
 - iv. Tap OK/Done if the picture follows the above criteria or follow step iii above to re-take.
10. Move the monopole setup to the next point for GPS log collection and repeat steps 1-9 until all features have had spatial data and photos collected.
11. Once the last point in the plot is collected **Close** the file and **Save** all changes. Collect all equipment and hike to the next plot.
- a. *Optional:* To quickly verify that all required points have been collected, before closing the file:
 - i. Use the MDD to view the Map.
 - ii. Zoom to the area where your plot is located.
 - iii. Visually confirm that all features have been collected (each logged feature will be displayed as an “X” on the map). See **Table 5** for complete list of point IDs to be completed per plot type.



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- iv. Photo icons will only be displayed if logs were taken while the photo feature is open, which will not always be the case



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SOP E Data Entry and Verification

The importance of thorough, accurate data entry cannot be overstated; the value of field efforts are only manifested once the data are properly entered for publication via the NEON Data Portal.

Mobile applications are the preferred mechanism for data entry. Whenever possible, data should be entered into the TOS: Plot Establishment and Maintenance [PROD] Fulcrum application as they are being collected in order to minimize data transcription errors and improve data quality. Mobile devices should be synced at the end of each field day, where possible; alternatively, devices should be synced immediately upon return to the Domain Support Facility.

As a best practice, field data collected on paper datasheets should be digitally transcribed and transferred to the shared folder for post-processing by Science staff as soon as possible following plot establishment. Ideally this will occur daily at sites where internet access is available. However, given logistical constraints, the maximum timeline for entering data is within 14 days of collection. See RD[04] for complete instructions regarding manual data transcription.

Once back from the field, make sure to:

1. Transfer data from GPS handheld to computer (see section SOP F in RD[21]).
2. Update the plot establishment datasheet to mark what plots were accepted or rejected and field comments.
3. If it is the first day of collection under a closed or open canopy forest, notify Science that there is data available for post processing through Service Now.
4. Sync the tablet.

E.1 Data Verification

Data Quality Control (QC) is a very important task for all data entered into a Fulcrum Application. Use the Plot Establishment and Maintenance 'QC Checklist' documents linked via the SSL to guide and focus QC activities. Below is a high-level summary of important QC activities:

1. For metadata in the Fulcrum Application:
 - a. Make sure the plot ID or Morder is correct.
2. If GPS files were collected:
 - a. Make sure that the data file is correctly named.
 - b. Make sure the spatial location of the point ID is accurate.
3. For Plot Establishment Only:
 - a. Fill in the datasheet saved in the shared network drive with which plots were accepted/rejected.



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SOP F Improving GPS Accuracies

If a point does not meet the required accuracy after the initial GPS data collection event, the following steps will be used either separately or in combination during subsequent re-measurements. If applicable, a list of points that must be re-measured can be found on the second tab in the site-specific datasheet. In most cases Field Science will be asked to attempt re-measurement up to 3 times.

1. Wait until canopy leaf-off.
 - a. If the point that needs to be collected is under deciduous leaf canopy, the best solution is to wait until the leaves drop and there is no longer any canopy cover.
2. Double or triple the number of logs collected. In some cases this could be as many as 800 to 1000 logs per high-accuracy point.
3. Utilize mission planning. Timing collection such that one or two additional satellites is/are available can make a huge difference in accuracy.
4. Utilize the carrier time technique. This method utilizes open canopy areas for satellite communication before collecting logs in the closed canopy. Staff will either need two GPS units (one for logging, one for navigating) or be able to re-locate the re-measurement point from an open canopy location without the use of a GPS unit.
 - a. In open canopy make a new file, click create, confirm the antenna height, and choose point generic.
 - b. Without logging points wait until you have at least two minutes of carrier lock. To view carrier lock scroll to Status in the upper left drop down and the scroll to Receiver in the lower left drop down menu.
 - i. Note: Two minutes of carrier time might take longer than two minutes to acquire.
 - c. Once you reach two minutes, hike to the point that will be re-measured without closing the file you just created.
 - d. At the point log the appropriate number of logs and pause the logging.
 - e. Without clicking “done” or closing the file return to the open canopy area and wait until two minutes of carrier time is obtained.
 - f. Close the file.

At certain sites it is not possible to meet the science accuracy requirements through the current workflow due to factors entirely out of the control of Field Ecologists collecting the data (e.g. rugged topography, blocked horizons, a lack of CORS stations by which to post-process). Work with Science staff to determine the best path forward for your site. Some indications that a base station may be necessary are:

- If your re-measurement rate is over 30%



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- If entire plots are requiring re-measurement
- Post processed accuracies are routinely above 1m
- There are no CORs or state base stations within 200 km of the site

While these indicators are not always available to operators working in the field, should Field Science find that a site requires an extremely high rate of re-measurement there should be communication with Science.



SOP G Replacing Lost Plot Markers

If markers cannot be located on subsequent visits to the plot after establishment has occurred, use the steps below to re-mark the plots.

The goal is to maintain sampling from a replicable location over the lifetime of the plot. When cell phone service is available, re-delineation of lost markers will take advantage of real-time navigation. When cell phone coverage is absent, re-delineation relies on a combination of the remaining plot markers and vegetation structure tags.

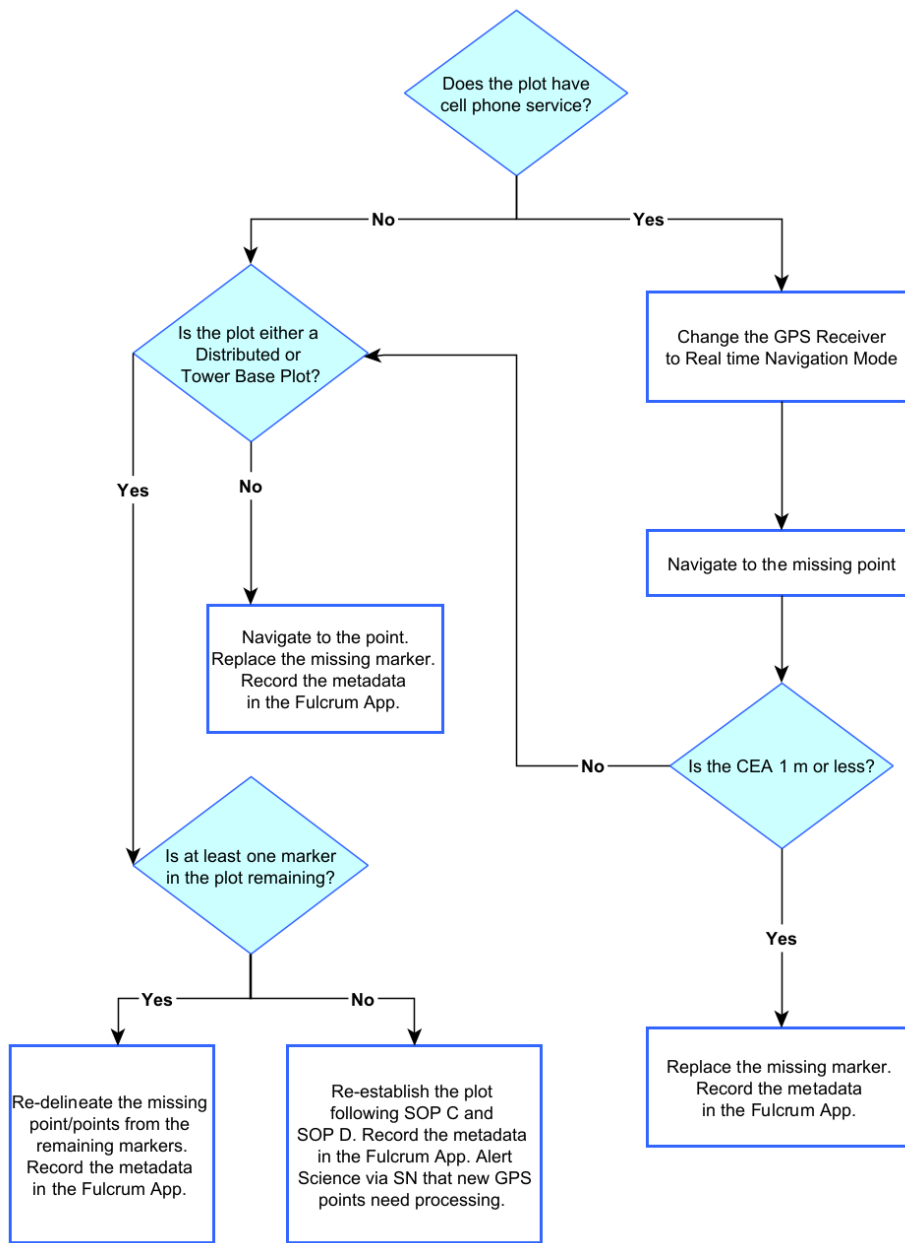


Figure 9. Lost plot marker workflow. Note: CEA = Current Estimated Accuracy



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Equipment: Cell phone coverage can be inconsistent across a site, so be prepared to re-establish markers utilizing all methods. See the Field Equipment Table for a list of all materials (

Table 10).

Before heading into the field be sure to import the post-establishment GPS receiver files provided by Science (**Table 4**).

GPS Files: GPS data should rarely need to be collected when replacing missing plot markers. If a plot marker is replaced following the steps for real-time navigation using RTK, or delineating from existing markers, then the assumption is the replaced plot location is close enough to the original position and versioning the spatial data is not necessary. The only time GPS coordinates need to be collected is if:

- No plot markers were left at a plot and the entire plot required re-establishment.
- A Tower Phenology Plot Marker is replaced and there is no RTK available, the RTK CEA is 1 m or more, or there are no tagged plants within 20m of the missing point.
 - Tower Phenology Markers are spaced too far apart to use delineation techniques.
- A plot maker has been purposefully moved from its original location.
 - See Appendix Plot verification Workflow for workflows dealing with repairing plot shape and verifying plot locations

GPS file names should include the unique plot ID. Be sure the point ID is available either in the file name (if just one location per file) or in the comments section. If GPS data is collected, alert Science via ServiceNow that new spatial files are available and need to be processed.

Metadata: Regardless of the plot marker re-establishment method used, use the Fulcrum Application and Fulcrum Manual to record descriptive metadata associated with the lost marker.

Replacing Plot Marker Types: If a point frequently requires re-delineation due to a missing marker, work with your domain manager to determine if a different marker type would work better in that location. Thresholds for switching to a new marker type are site and event specific. For example, a site that has routine prescribed burns vs a one-time wildfire require different approaches if markers are affected. In general, if markers go missing for the same reason at a site, then a new marker type should be evaluated. For example:

- Fire disturbance- Replace plastic markers with aluminum.
- Cow disturbance- Replace above ground markers with below ground markers.

Be sure to check with permitting and the site host to see if there are any restrictions on marker type.

Other Plot Maintenance Activities: See Appendix K: Plot verification Workflow for additional instructions for verifying a plot’s size and shape. Note that these activities are less common than missing plot markers.



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G.1 Plot Marker Priorities

Implementation of a given protocol may not require the presence of all markers. If time is short, replace only those markers required for the scheduled sampling activity. Missing markers and maintenance should be documented in the *TOS: Plot Establishment and Maintenance* Fulcrum Application.

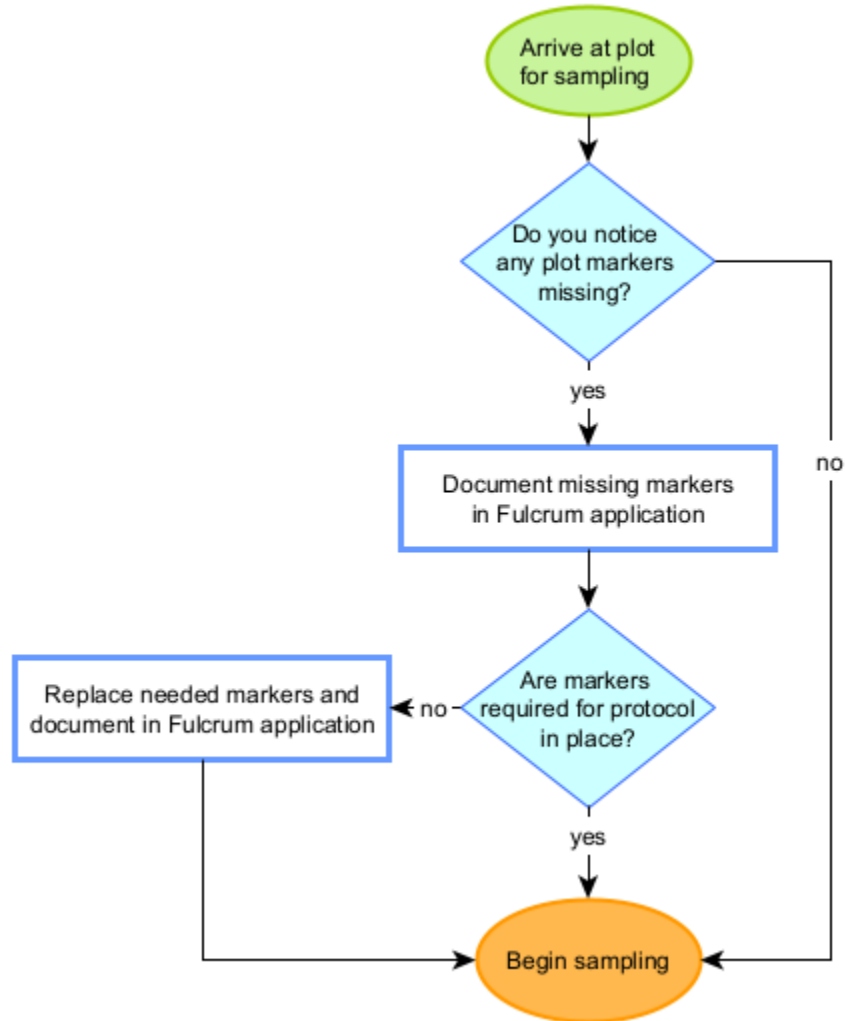


Figure 10. Checking for plot maker priorities workflow.

Note: Plots that support Assignable Assets (AA) projects may require additional markers.

Table 6. Required plot markers per protocol for the Terrestrial Observation System.

Plot Type	Plot Size	Subtype	Protocol	Marker Requirements
tower	40m x 40m	basePlot	bbc	Points required: 21,23,39,41
tower	20m x 20m	basePlot	bbc	Points required: 31, 33, 41, 49, 51
distributed	40m x 40m	basePlot	bet	Centroid (41) or at least 2 corner markers (21, 57, 61, 25) required
distributed/ tower	40m x 40m	basePlot	bgc	All permanent plot markers should be available to allow to the nearest monumented marker to be used but only pt 21 is absolutely necessary for sampling.
distributed	40m x 40m	basePlot	brd	Points required: 21
distributed	500m x 500m	birdGrid	brd	Points required: B2
distributed/ tower	40m x 40m	basePlot	cdw	Points required: 41
distributed/ tower	20m x 20m	basePlot	cdw	Points required: 41
distributed/ tower	40m x 40m	basePlot	cfc	Identical to VST for mapping woody stems, or HBP for delineating clip strips
distributed/ tower	20m x 20m	basePlot	cfc	Identical to VST for mapping woody stems, or HBP for delineating clip strips
distributed/ tower	40m x 40m	basePlot	dhp	Points required: 41
distributed/ tower	20m x 20m	basePlot	dhp	Points required: 41
distributed/ tower	40m x 40m	basePlot	div	Points required: 31, 33, 41, 49, and 51
distributed/ tower	40m x 40m	basePlot	hbp	Points required: 21,23,39,41
distributed/ tower	20m x 20m	basePlot	hbp	Points required: 31
tower	40m x 40m	basePlot	ltr	Points required: 21,39,41,43,57,59,61
distributed	90m x 90m	mammalGrid	mam	Points required: E5
distributed		mosquitoPoint	mos	Points required: 41
tower	200m x 200m	phenology	phe	Points required: SW, S, SE, W, E, NW, N, NE



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Plot Type	Plot Size	Subtype	Protocol	Marker Requirements
tower	200m x 200m	phenology - phenocam	phe	Points required: SW, S, SE
distributed/ tower	40m x 40m	basePlot	sme	All permanent plot markers should be available to allow to the nearest monumented marker to be used but only pt 21 is absolutely necessary for sampling.
distributed	40m x 40m	tickPlot	tck	3 of 4 corner markers required for sampling (21, 57, 61, 25)
distributed/ tower	40m x 40m	basePlot	vst	Points required at large stature tower base plots: 21,23,25,39,41,43,57,59,61. Points required at large stature distributed base plots: 31, 33, 41, 49, 51
distributed/ tower	20m x 20m	basePlot	vst	Points required: 31, 33, 41, 49, 51

G.2 Real -Time Navigation

When possible, use Real Time Navigation to navigate back to the missing marker location. To ensure the best possible precision, use the full GPS receiver setup including antenna and tripod. Note that use of real-time navigation requires some office setup and should be tested before heading into the field. See the Trimble SOP (RD[21]) for more information.

- See SOP C.4 in RD[21] for instructions on setting up Real-Time Navigation and navigating in the field.
- Use the .imp files in the established folder (**Table 4**) when navigating to plot marker locations.
- When navigating to a lost plot marker, if the CEA and the x are “jumping” around wait up to five minutes for the signal to settle. It is problematic when the CEA has large fluctuations of 10 cm or greater.
- After navigating to the lost plot marker location, install the new plot marker.

G.3 Delineation Using Remaining Plot Markers and Vegetation Structure Tags

If the plot does not have cell phone service, or if the CEA is too high, utilize the remaining NEON plot infrastructure to determine the missing point location. Plot markers, vegetation structure tags, or a combination of the two can be used. When possible, use at least **two** remaining features in the plot to perform delineation.

When re-delineating, use the rules described for initial plot establishment (Field Sampling- Plot Delineation and Marking). Always use the rangefinder and tripod.



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1. If using vegetation structure tags previously mapped from the missing marker, use the data in Fulcrum to determine the stem distance and stem azimuth. To access the data in Fulcrum:
 - a. Navigate to the *VST: Mapping and Tagging [PROD]* app on the tablet.
 - b. Go to “view records” and be sure the following columns are visible (click on the three red vertical lines to the right of the search bar): siteID, plotID, tagID, subplotID, and morphospeciesID.
 - c. Filter by siteID first by using the drop down arrow in the “siteID” column.
 - d. Search by plot ID or vegetation structure tag ID in the search bar.
 - e. Click on the record that matches the corresponding plot ID and tag ID to the individual being used for re-delineation.
 - f. Scroll to the Stem Data section.
 - g. Confirm that the individual was measured from a particular point by matching the pointID to the marker that is missing.
 - h. A lost marker should only be re-delineated from vegetation structure tags that were originally mapped from the lost marker.
 - i. Use the stemDistance and the opposite of the stemAzimuth (add or subtract 180 degrees to the listed value) to determine the location of the missing plot marker.
2. Delineate from one remaining feature and place a temporary marker.
3. Delineate from the second remaining feature and place a temporary marker.
4. If there is a discrepancy between the two delineation points place the new plot marker halfway between the two (i.e. split the difference). Record the difference in the Fulcrum app.
5. If the difference between the two delineation points is more than 3 m, delineate from a third plot feature. Use the two closest delineation points when you split the difference.

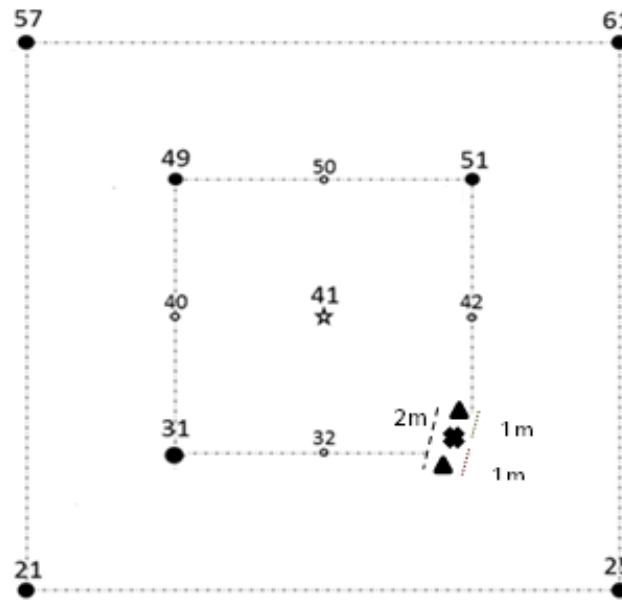


Figure 11. Plot schematic showing how to split the difference between two delineation points. Each triangle is the delineated location from 2 remaining markers. The difference is 2m apart. The new marker (the X) will be placed at the halfway point, 1 m from each triangle.

6. If there is only one marker or vegetation structure tag to use delineate from that point twice to serve as a check.
7. For phenology plots use plant tags if available. Contact Science if the distance between remaining plant tags and plot markers is too far to delineate.
8. Record the metadata in the *TOS: Plot Establishment and Maintenance* Fulcrum App.

See **Figure 12** below for a schematic that includes distances and azimuths between points. Plot layout, distances, and azimuths are the same for all Base and Tick Plots. Additional figures can be found in Plot Establishment Workflows

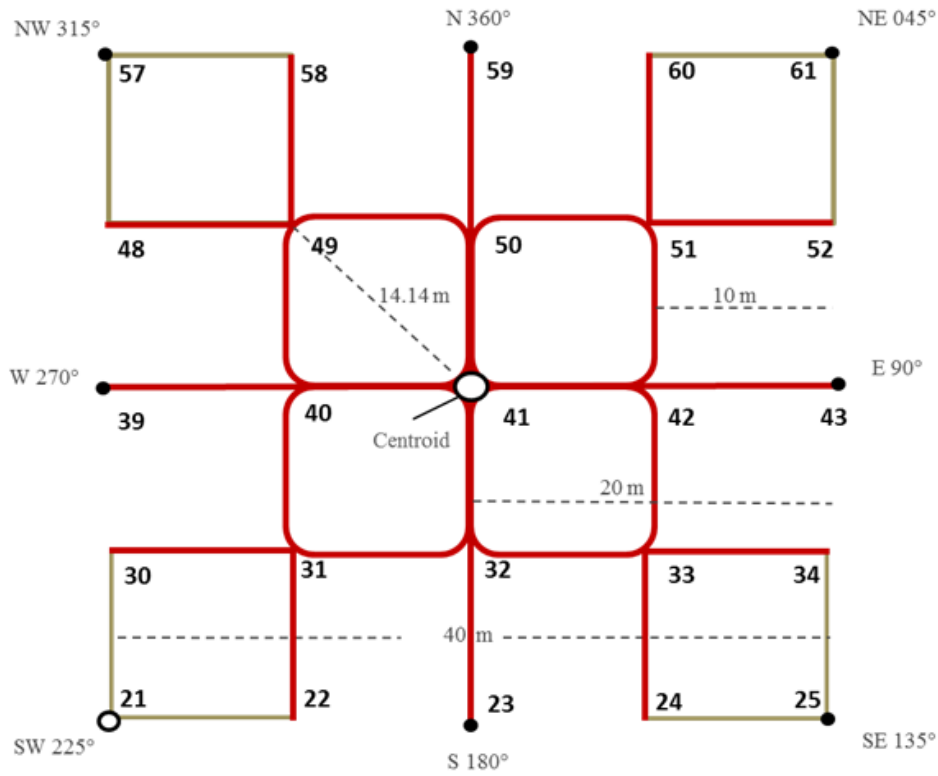


Figure 12. Distances and azimuths between points of a 40m by 40m Tower Base Plot.

G.4 Navigation to Mammal Grids, Bird Grids, Tick Plots, and Mosquito Points in areas without cell phone service or areas with high real time navigation CEA values

Plots that do not support plant protocols have a larger acceptable uncertainty value.

- If cell phone service is available, continue to use the real time navigation even if the CEA value is over 1 meter.
 - If cell phone service is not available, use the post processing CEA value (click on the CEA to toggle back and forth between the real time navigation and post processing value).
1. Navigate to the missing point using the Trimble and place the marker in the ground.
 - a. Be sure to use the established '.imp' file since tick, mammal, mosquito, and bird points often shift during plot establishment.
 2. Record the metadata in the *TOS: Plot Establishment and Maintenance* Fulcrum App.

G.5 Navigation to Phenology Points in areas without cell phone service or areas with high real time navigation CEA values

1. Navigate to the missing marker location.



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- a. If cell phone service is available, continue to use the real time navigation even if the CEA value is over 1 meter.
 - b. If cell phone service is not available, use the post processing CEA value (click on the CEA to toggle back and forth between the real time navigation and post processing value).
2. Place the marker in the ground.
 3. Record the metadata in the *TOS: Plot Establishment and Maintenance* Fulcrum App.
 4. Collect and export GPS points following steps in Field Sampling- Collect GPS Coordinates and export the files following steps in the Trimble SOP (RD[21]).
 5. Alert Science via SN that new spatial files are available and need to be processed.

G.6 No Plot Markers or Vegetation Structure Tags Remain

If there is nothing from which to delineate, and there is no cell phone service, then re-establish the plot following the steps from initial plot establishment.

1. Be sure to use the established '.imp' file to navigate to the centroid location (using real time navigation if possible).
2. Re-establish following the Field Sampling- Plot Delineation and Marking and Field Sampling- Collect GPS Coordinates workflows.
3. Record the metadata in the *TOS: Plot Establishment and Maintenance* Fulcrum App.
4. Collect and export GPS points following steps in Field Sampling- Collect GPS Coordinates and export the files following steps in the Trimble SOP (RD[21]).
5. Alert Science via SN that new spatial files are available and need to be processed.



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SOP H Primary Plot Marker Monumentation

Primary (capped) monuments are used at one to two locations per plot, dependent on plot type and plot size. In general, plot centroids and southwest corners are marked with primary monuments.

Due to discrepancies in figures in the Plot Establishment protocol over the years, some sites have the primary capped monument at point 21 (outer 40m SW corner) and some at point 31 (inner 20m SW corner) at the 40m by 40m Distributed Base Plots. See the table in Southwest Corner Primary Marker Location By Site. Any new plots should follow the site specific practices; if both occur at a site, use point 31.

Generally, primary markers are comprised of aluminum rods topped with a stamped cap. Sites may have differing requirements for the length of monument rod needed for primary installations, usually determined by the depth of the frost line or unique substrates. Primary marker depth should be determined by Field Science personnel in conjunction with Science.

H.1 Primary Marker Installation

1. If primary monuments are not installed as part of plot establishment, begin by navigating to the target plot and corner using a map, rangefinder, GPS, compass, and/or tape measures as needed. Refer to Appendix L for instructions on which plot corners require primary monuments at each site. If temporary plot markers are present, use a pry bar to remove them.



Figure 13. Removing a pre-existing temporary plot marker with a pry bar.

2. Assemble the monument by threading a driving point on one end of a rod. Using the supplied threaded connection pins, add the driving adapter on the opposite end. Pliers can be used to ensure a tight connection between the different sections. Place the monument assembly with the driving point down into the hole left by the temporary plot marker. At plots without a



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preexisting temporary plot marker, lightly tap the monument assembly a few inches into the soil before proceeding.

3. Proceed to drive the monument into the soil using the post driver. This is a deceptively hazardous action requiring cautious attention. See the Safety section and be sure to use the required PPE. In particular, pay attention to several factors:
 - a. Occasionally the rod assembly sections may slightly separate while driving the monument into the ground as the connections tend to move a little counterclockwise during each hit (**Figure 14**). Because damage can occur to a rod section or threaded connection pin if a gap forms between the monument assembly sections, frequently pause while driving the monument assembly into the ground (approximately every 10-20 strikes) to check for and tighten any loose connections.



Figure 14. Picture of rod assembly sections separating while driving the monument, be sure to tighten before continuing.

- b. Do not lift the post driver too high during the striking motion as this may allow the bottom of the post driver to rise above the top of the monument assembly. This situation is dangerous as the worker could miss the monument on the down stroke of the striking motion and potentially hit a leg with the post driver or hit a hand against the top of the monument assembly (**Figure 15**). If the worker can see scored line about 1 inch below the driving adapter at any point during the striking motion, they are probably raising the post driver too high.



Figure 15. Demonstration of a dangerous method using the post driver. If the post driver is raised above the rod during the upward swing (first picture), it can miss the rod (second picture), and injure the worker’s hand or leg (third picture).

- c. Adjust body position as needed – e.g., from standing to a kneeling stance – as the top of the monument is driven closer to the ground. Operating the post driver above your body reduces control of the driver, while operating the post driver below your body may allow the driver to strike the worker in the head.
4. When the monument has been driven far enough into the soil so that A) the post driver almost hits the ground at the bottom of the striking motion or B) the worker is making the striking motion at an uncomfortable height/angle and the required monument rod length has not been reached, unthread the driving adapter from the top of the monument, thread another monument rod section onto the top of the monument assembly in the ground, and thread the driving adapter onto the top of the new monument rod section. Repeat step 3 and 4 until the required depth has been reached.
5. When the monument has been driven far enough into the soil so the post driver almost hits the soil surface at the bottom of the striking motion and the final monument rod section needed to reach the required depth has already been attached, finish driving the monument assembly close to the final height by repeating step 4 using a spare 2’ monument rod section threaded above the final monument section. Repeat step 3 until the top of the final monument rod section is a few inches above the soil surface, at which point the driving adapter and spare monument rod section are removed.



6. Place the monument cap on top of the final rod section. Use a sledgehammer to seat the monument cap squarely on the final monument rod section and drive the final monument assembly to the final desired position (**Figure 16**). Ensure the cap is secure after work has been performed.
 - a. Monument caps cannot be ordered until plot acceptance is done and the unique plot IDS created. Plot IDS are created by Science staff after the final list of accepted plots is available.



Figure 16. Use a sledgehammer to seat the cap and drive the rod to the desired position.

H.2 Cutting a Monument Stake

Occasionally a monument is driven to refusal (i.e. the bottom has reached an impenetrable barrier) before reaching the site specific preferred or minimum length, which leaves a length of rod still above ground which must be cut off or removed.

1. If the minimum monument length has been reached, use a hand or power saw to remove any extraneous monument rod.
 - a. Use a marker to make a mark at the desired final height of the monument rod.
 - b. Pierce the center of a paper plate and push the plate down the monument rod through this hole so the plate is resting on the ground with the plate lids facing up. This plate will serve as a containment area for any metal shavings generated during the cutting process. Properly dispose of the shavings after work has been completed (i.e. at the support facility).



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- c. Slowly and carefully saw horizontally through the monument at the height mark, being cautious near the end of the cut to maintain control of the saw and prevent large burrs on the rod.

- d. Place the monument cap on top of the final rod section. Use a sledgehammer to seat the monument cap squarely on the final monument rod section and drive the final monument assembly to the final desired position (**Figure 16**).



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SOP I Sample Shipment

This protocol generates no samples for shipment.



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APPENDIX A QUICK REFERENCES

New Plot Establishment

- Step 1** – Import the potential plot locations into the GPS receiver.
- Step 2** – Navigate to the plot and verify the plot meets safety, logistical, and canopy cover criteria.
- Step 3** – Record metadata (both accepted and rejected plots).
- Step 4** – Delineate the accepted plot to the appropriate size.
- Step 5** – Collect GPS coordinate information at all permanent plot marker locations.
- Step 6** – Verify data collected and upload any GPS files at the end of the day.
- Step 7** – Install primary capped markers at the plot once unique plot ids are assigned.

Lost Plot Markers

- Step 1** – Import the established point locations into the GPS receiver.
- Step 2** – At Base and Phenology Plots- if you have cell phone service: Navigate using RTK and place the new marker in the ground if the CEA is less than 1m.
- Step 3** – At Base and Phenology Plots- if there is no cell phone service or if CEA is over 1 m: Re-delineate the plot using existing markers.
- Step 4** – At Base Plots - if no markers exist: Re-delineate the entire plot and collect GPS coordinates.
- Step 5** – At fauna plots - navigate and replace markers regardless of CEA. Use real time navigation when possible.
- Step 6** – Record required metadata in the *TOS: Plot Establishment and Maintenance* Fulcrum app.
- Step 7** – Create a SN ticket if GPS files were collected (rare).

For directions on using the laser rangefinder, see TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration (RD[19])

For directions on using the Trimble, see TOS Standard Operating Procedure: Trimble GeoXH Receivers Setup and Use (RD[21])



APPENDIX B REMINDERS

Preparing for Sampling

- ✓ Be sure the GPS receiver and Pathfinder Office are in the correct coordinate system before transferring files.
- ✓ Double check that the files are correctly loaded before heading into the field.
- ✓ Check that both batteries are charged.

Field Sampling

- ✓ If the GPS Receiver is not connecting to satellites tap on the connect icon on the top of the tool bar.



Connect icon

When the TerraSync software is trying to connect to a receiver, the connect icon appears instead of the satellite icon. If the TerraSync software cannot connect to the GPS receiver, the connect icon flashes.

- ✓ Turn on the unit and TerraSync in an open area for at least 5 min before entering a closed canopy system.
- ✓ For NLCD classification- Level 1 classification determines the total percent cover for the plot (e.g. 40% of the plot is forest); Level 2 is then assessed out of 100% of the Level 1 total (e.g. of the 40% of the plot that is forest, 50% of that forest area is deciduous, 50% of that forest area is evergreen, NOT 20% deciduous forest and 20% evergreen forest).
- ✓ Following the mOrder list maintains the random spatial integrity of the sampling design.
- ✓ Use a non-ferromagnetic tripod and reflective target on a staff when using the rangefinder.
- ✓ If you are collecting GPS logs be sure the real time navigation setting are turned off . Also make sure the accuracy settings tab is set to “PostProcessed” and “GPS and GLONASS” or “Multi constellation”.
- ✓ When in doubt collect more GPS logs.

Data Entry and Verification

- ✓ Data should be transferred daily to reduce chance of file corruption and allow for Science to post process and report any issues.



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APPENDIX C LOG SHEETS

C.1 How to use the Mission Planning/Assignment Sheet

The Mission Planning/Assignment Sheet provides a standardized format for tracking each plot establishment team’s progress on a daily basis:

- As the day’s activities are being planned, each team can write down the plots they should (or might possibly) visit. When possible, it is useful to list the plots in the order they are to be visited so that the team can simply work their way down the list. Fill in as many details about each plot as are necessary to do the work: Morton order number, plot type, NLCD class, etc. If the task list includes a revisit to collect more GPS data, write down the points to be re-logged and the file version to be used (V2, V3, etc.).
- In the field, the team can use the checkboxes and note fields to record progress and any deviations from the expected plan. If the work was carried out according to plan, simply check off the “Task Completed” box. If the team was not able to finish the planned tasks, check “Task Partially Completed” and take notes on what work remains to be done. If the plot is rejected, check off the “Plot Rejected” and record why.
- At the end of the day, the team should finalize any notes and check off “Not Visited” for any plots the team did not make it to. Then use the log sheet to update the “plots datasheet” on the GIS drive and any master checklist or progress map that domain staff may have developed.
- Later on, these log sheets are available as resources to plot establishment coordinators as they try to troubleshoot and track down loose ends, for example: “I have a question about plot X; which technician should I talk to about it?” Or, “I thought we had re-visited that plot to re-log point 23 but I can’t find the file. Was that work never done in the field or did we just miss a file during the data upload? Which GPS unit was used, anyway?”



Plot Information			Task Information			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			
Mort. Order/PlotID	Plot Type <input type="checkbox"/> Tower <input type="checkbox"/> Phenology <input type="checkbox"/> Base <input type="checkbox"/> Bird	<input type="checkbox"/> Mammal <input type="checkbox"/> Mosquito <input type="checkbox"/> Tick <input type="checkbox"/> _____	NLCD Class	Task(s) <input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> GPS Revisit <input type="checkbox"/> Other =====>	More Details 	Outcome(s) <input type="checkbox"/> Plot Accepted/Task Completed <input type="checkbox"/> Plot Rejected <input type="checkbox"/> Task Partially Completed <input type="checkbox"/> Not Visited
Location Notes/Directions			Completion Comments			



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C.2 How to use Plot Maintenance Logs

Plot Maintenance Logs provide a long-term record of plot-specific details that are not otherwise tracked under this protocol. Side one (plot type specific; A.2- A.9) is for documenting the initial plot acceptance/delineation visit. It contains a diagram showing the plot’s configuration and fields for metadata such as Morton order number, personnel who did the work, etc. Side two (marker installation; A.10) contains fields for notes on subsequent visits (for example, to install permanent markers or to seasonally break down/re-establish the plot). The teams performing this later work can either take the original with them and update it in the field (suggestion: scan/photocopy the original first to ensure there is a backup) or update the log sheet in the office at the end of the day.

During plot establishment, each plot acceptance team should carry enough of these sheets to cover all possibilities for the day. Once a plot is accepted, the team can record:

- type(s) of markers used
- location of any offset markers
- locations of streams, boulders, trails, or any other features that might complicate sampling
- suggested route to plot
- metadata such as personnel who accepted and delineated the plot

Many of these details can simply be sketched onto the plot diagram, providing a visual record (see example, **Figure 17**). In terms of workflow, a good time to fill out the Plot Maintenance Log might be at the end of the delineation process, when one team member is finishing up the GPS work and other team members are unoccupied.

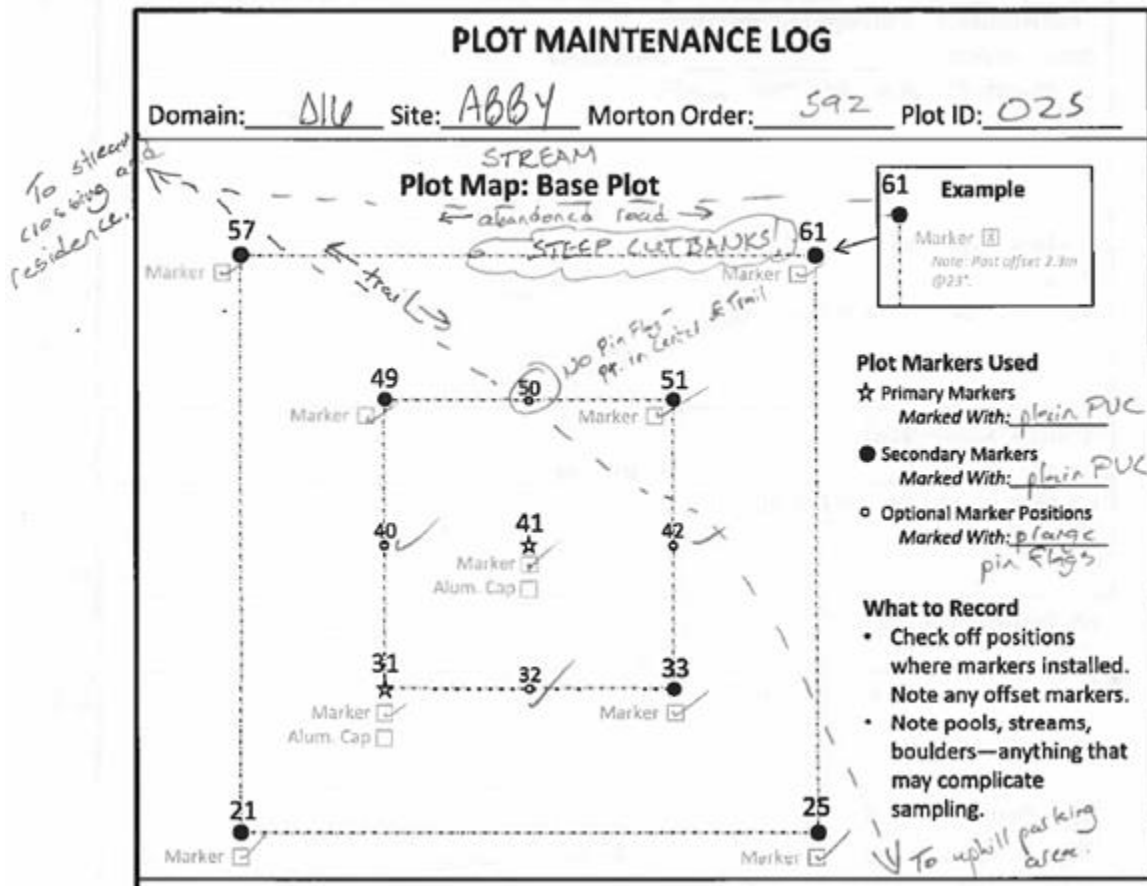


Figure 17. Example of a completed plot maintenance log sheet with relevant contextual details.



C.3 Distributed Base Plot Log Sheet

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
<p style="text-align: center;">Plot Map: Distributed Base Plot</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>61 Example</p> <p>Marker <input checked="" type="checkbox"/></p> <p>Note: Post offset 2.3m @23°.</p> </div> <p>Plot Markers Used</p> <ul style="list-style-type: none"> ★ Primary Markers Marked With: _____ ● Secondary Markers Marked With: _____ ○ Optional Marker Positions Marked With: _____ <p>What to Record</p> <ul style="list-style-type: none"> Check off positions where markers installed. Note any offset markers. Note pools, streams, boulders—anything that may complicate sampling.
<p>Initial Establishment Visit</p> <p>Date Accepted: _____ Field Crew: _____</p> <p>Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Comments:</p>	
<p><i>Please be detailed about any GPS points not logged/delineation work still to be done.</i></p>	



C.4 Tick Plot Log Sheet

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
<div style="text-align: center;">Plot Map: Tick Plot</div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> 61 Example Marker <input checked="" type="checkbox"/> <i>Note: Post offset 2.3m @23°.</i> </div> <p>Plot Markers Used</p> <ul style="list-style-type: none"> ★ Primary Markers Marked With: _____ ● Secondary Markers Marked With: _____ <p>What to Record</p> <ul style="list-style-type: none"> Check off positions where markers installed. Note any offset markers. Note pools, streams, boulders—anything that may complicate sampling.
<p>Initial Establishment Visit</p> Date Accepted: _____ Field Crew: _____ Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N Tick Drag/Flag Evaluation (<input type="checkbox"/> Y / <input type="checkbox"/> N) : <i>Field technicians will be able to drag and/or flag at least 50% of plot perimeter. (If the answer is "N", reject the plot!)</i> Comments: _____	
<p><i>Please be detailed about any GPS points not logged/delineation work still to be done.</i></p>	



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C.5 Small Mammal Grid Log Sheet

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
Plot Map: Small Mammals Grid	
	<p>Plot Markers Used</p> <ul style="list-style-type: none"> ★ Primary Markers Marked With: _____ ● Secondary Markers Marked With: _____ <p>What to Record</p> <ul style="list-style-type: none"> Check off positions where markers installed. Note any offset markers. Note pools, streams, boulders—anything that may complicate sampling. Corner points (A1, J1, A10, J10) will be provided in imps, no delineation is done in the field.
<p>Initial Establishment Visit</p> <p>Date Accepted: _____ Field Crew: _____</p> <p>Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Comments:</p>	
<p><i>Please be detailed about any GPS points not logged/delineation work still to be done.</i></p>	



C.6 Bird Grid Log Sheet

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
Plot Map: Bird Grid Centroid	
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>A1 ☼</p> <p>B1 ☼</p> <p>C1 ☼</p> </div> <div style="text-align: center;"> <p>A2 ☼</p> <p>B2 ★ Marker <input type="checkbox"/> Alum. Cap <input type="checkbox"/></p> <p>C2 ☼</p> </div> <div style="text-align: center;"> <p>A3 ☼</p> <p>B3 ☼</p> <p>C3 ☼</p> </div> </div>	<p>Plot Markers Used</p> <p>★ Primary Markers Marked With: _____</p> <p>☼ No marker. Not visited during plot establishment.</p> <p>What to Record</p> <ul style="list-style-type: none"> • Check box(es) when marker(s) installed. Note any offset markers. • Note pools, streams, boulders—anything that may complicate sampling.
<p>Initial Establishment Visit</p> <p>Date Accepted: _____ Field Crew: _____</p> <p>Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Comments:</p> <p style="font-style: italic; font-size: small;">Please be detailed about any GPS points not logged/delineation work still to be done.</p>	



C.7 Mosquito Point Log Sheet

PLOT MAINTENANCE LOG

Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____

Plot Map: Mosquito Sampling Point

Plot Markers Used

★ Primary Markers
Marked With: _____

What to Record

- Check off when markers installed. Note any offset markers.
- Sketch road location and give approx. distance.
- If possible, the point should be difficult to see from the road. Note any obstructions (big trees, boulders, etc.) that also may serve as landmarks to help find the sampling point.

Marker ★
Alum. Cap

Initial Establishment Visit

Date Accepted: _____ Field Crew: _____

Trimble GPS Used: _____ All GPS Points Attempted? Y / N

Plot Nickname: _____ Plot Delineation Completed? Y / N

Comments:

Please be detailed about any GPS points not logged/delineation work still to be done.



C.8 Tower Plot Log Sheet- 40 m by 40 m

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
<p style="text-align: center;">Plot Map: 40m by 40m Tower Base Plot</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p>61 Example</p> <p>Marker <input checked="" type="checkbox"/></p> <p>Note: Post offset 2.3m @23°.</p> </div> <p>Plot Markers Used</p> <ul style="list-style-type: none"> ★ Primary Markers Marked With: _____ ● Standard Secondary Markers Marked With: _____ ▲ Additional Secondary Markers for Div./Soils Tower Plots Marked With: _____ ○ Optional Marker Positions Marked With: _____ <p>What to Record</p> <ul style="list-style-type: none"> • Check off positions where markers installed. Note any offset markers. • Note pools, streams, boulders—anything that may complicate sampling.
<p>Initial Establishment Visit</p> <p>Date Accepted: _____ Field Crew: _____</p> <p>Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Comments:</p>	
<p><i>Please be detailed about any GPS points not logged/delineation work still to be done.</i></p>	



C.9 Tower Plot Log Sheet- 20 m by 20 m

PLOT MAINTENANCE LOG

Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____

Plot Map: 20m by 20m Tower Base Plot

61 Example

Marker

Note: Post offset 2.3m @23°.

Plot Markers Used

- ★ Primary Markers
Marked With: _____
- Standard Secondary Markers
Marked With: _____
- ▲ Additional Secondary Markers for Div./Soils Tower Plots
Marked With: _____
- Optional Marker Positions
Marked With: _____

What to Record

- Check off positions where markers installed. Note any offset markers.
- Note pools, streams, boulders—anything that may complicate sampling.

Initial Establishment Visit

Date Accepted: _____ Field Crew: _____

Trimble GPS Used: _____ All GPS Points Attempted? Y / N

Plot Nickname: _____ Plot Delineation Completed? Y / N

Comments:

Please be detailed about any GPS points not logged/delineation work still to be done.



C.10 Phenology Plot Log Sheet

PLOT MAINTENANCE LOG	
Domain: _____ Site: _____ Morton Order: _____ Plot ID: _____	
<p style="text-align: center;">Plot Map: Phenology Plot</p>	<p>Plot Markers Used</p> <ul style="list-style-type: none"> ★ Primary Markers Marked With: _____ ● Standard Secondary Markers Marked With: _____ <p>What to Record</p> <ul style="list-style-type: none"> • Check off positions where markers installed. For secondary phenocam transects this will be 3 markers max. Note any offset markers. • Note pools, streams, boulders—anything that may complicate sampling. • The Phenocam Plot only needs markers at the SW, S, and SE points
<p>Initial Establishment Visit</p> <p>Date Accepted: _____ Field Crew: _____</p> <p>Trimble GPS Used: _____ All GPS Points Attempted? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Plot Nickname: _____ Plot Delineation Completed? <input type="checkbox"/> Y / <input type="checkbox"/> N</p> <p>Comments:</p>	
<p><i>Please be detailed about any GPS points not logged/delineation work still to be done.</i></p>	



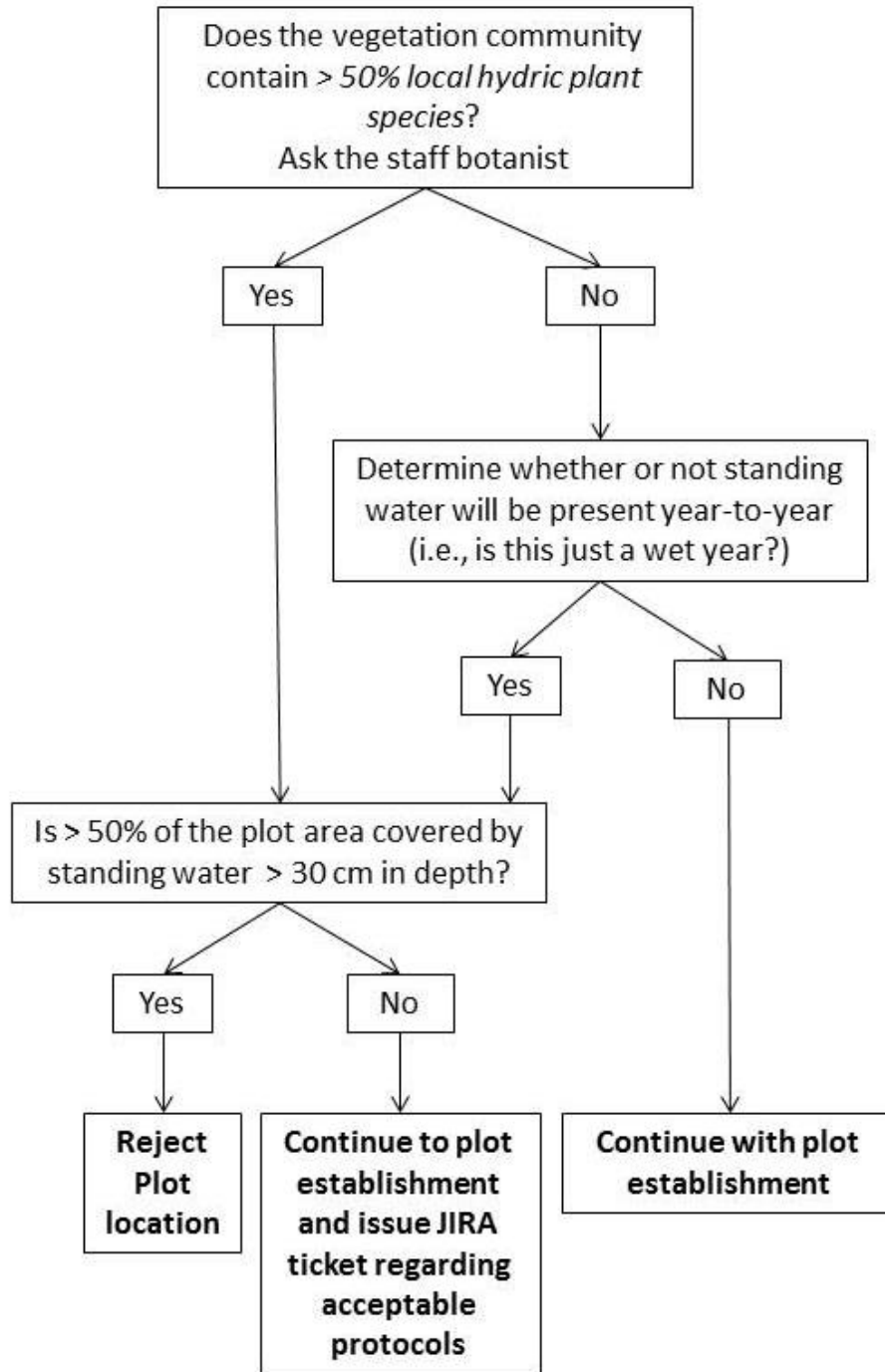
Title: TOS Protocol and Procedure: PLT – Plot Establishment and Maintenance		Date: 01/18/2023
NEON Doc. #: NEON.DOC. 001025	Author: R. Swanson	Revision: K

C.11 Marker Installation Log Sheet

<p>“Permanent” Marker Installation Date Installed: _____ Field Crew: _____ Comments (for example, offsets used?):</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>
<p>Maintenance Visit Date: _____ Field Crew: _____ Maintenance Issue and Resolution:</p>



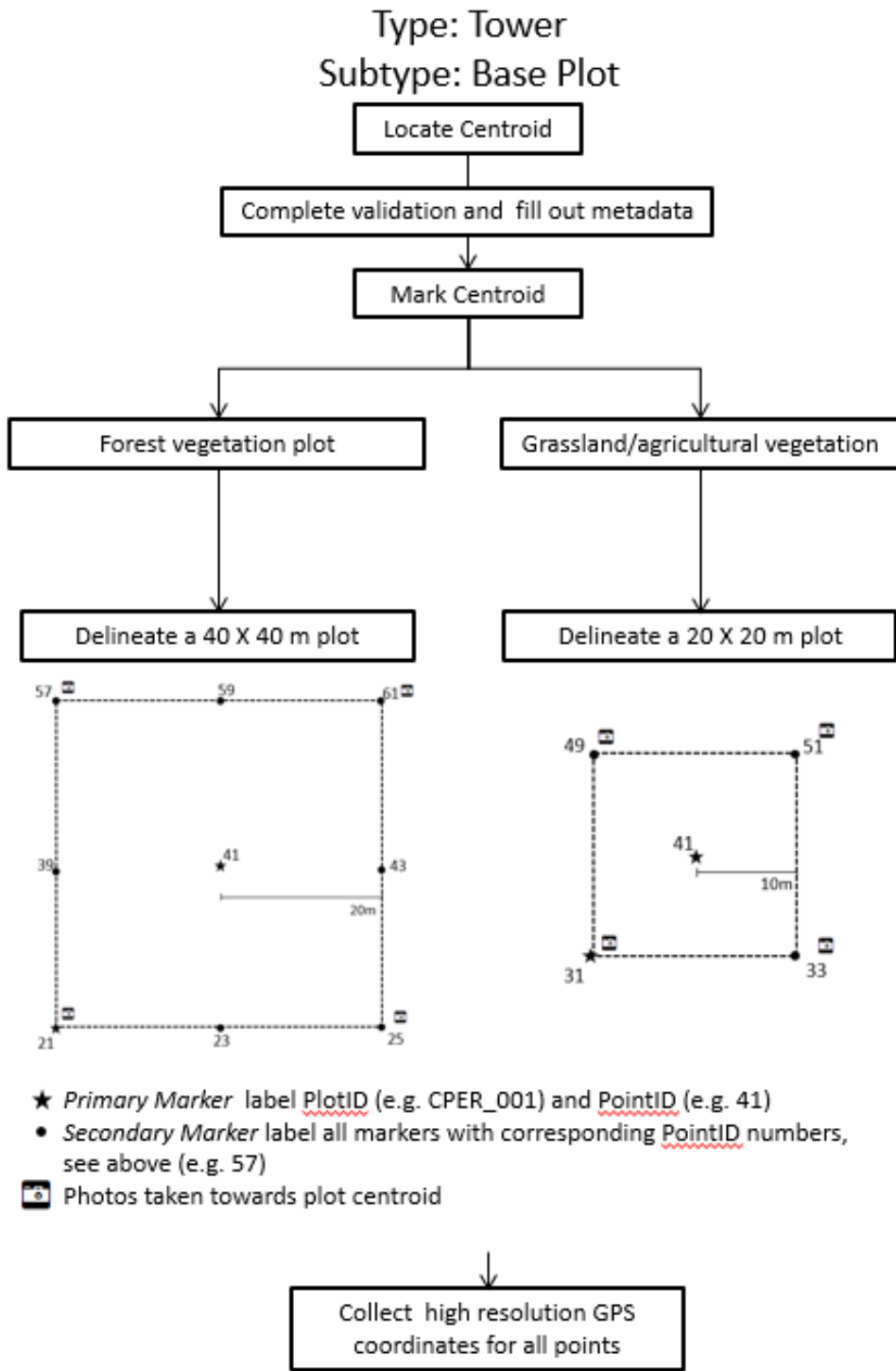
APPENDIX D CRITERIA FOR PLOT ESTABLISHMENT IN WET LOCATIONS





APPENDIX E PLOT ESTABLISHMENT WORKFLOWS

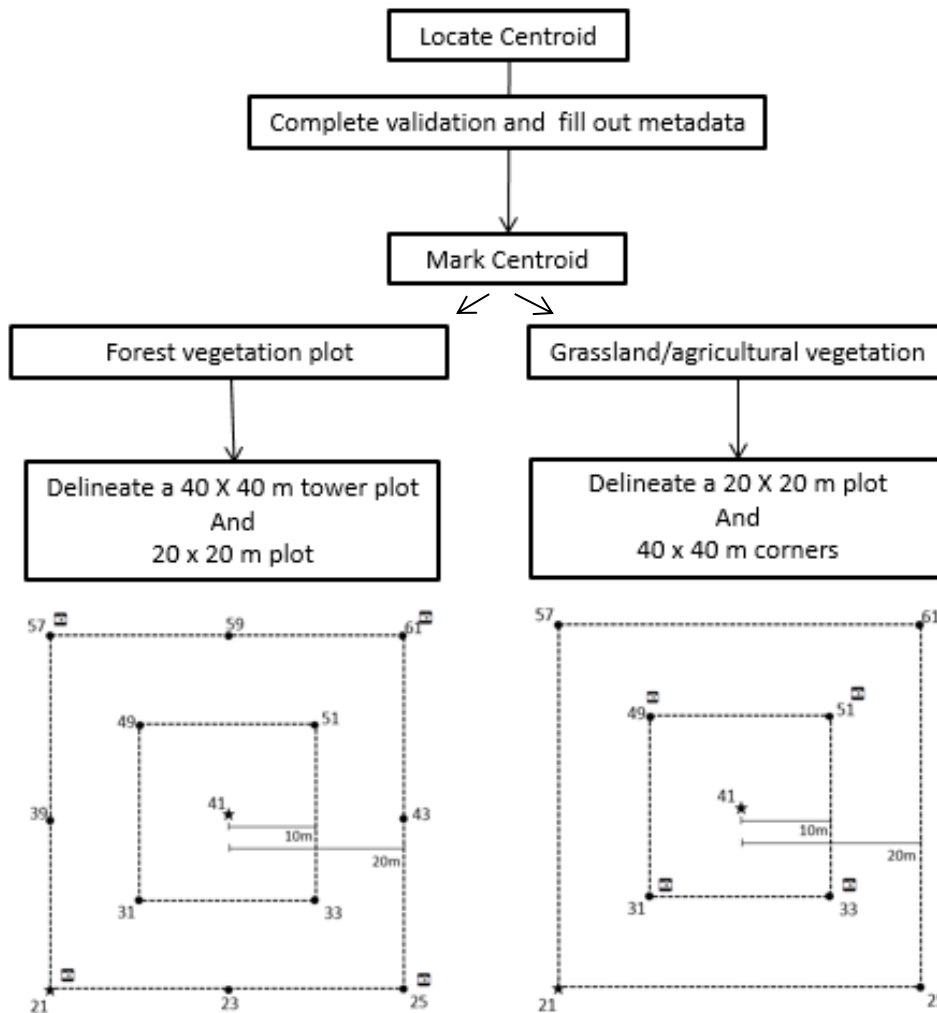
E.1 Tower Plot Workflow





Type: Tower
Subtype: Base Plot

Only for **a subset of tower plots** that will measure: *Biogeochemistry, Microbe, Plant Diversity and Plant Productivity*



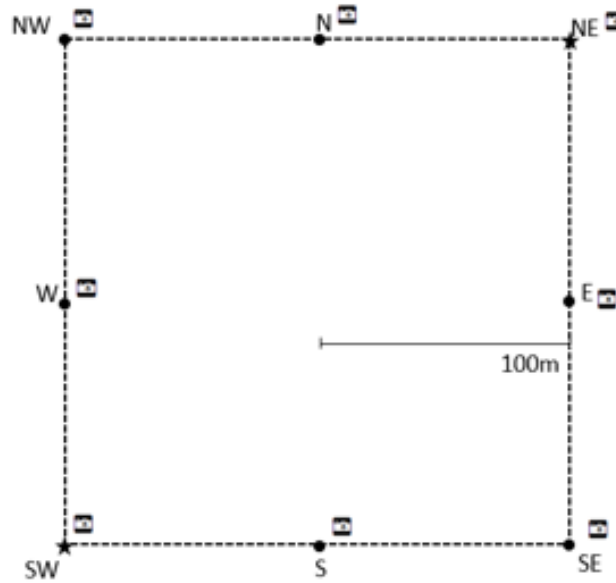
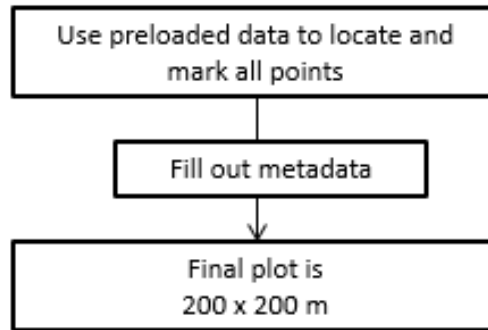
- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (e.g. 41)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)
- 📷 Photos taken towards plot centroid

↓
Collect high resolution GPS coordinates for all points

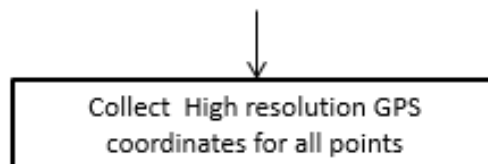


E.2 Phenology Plot- Primary

Type: Tower Subtype: Phenology Plot



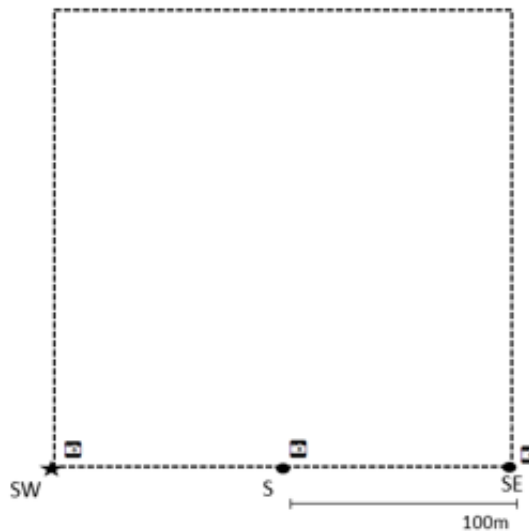
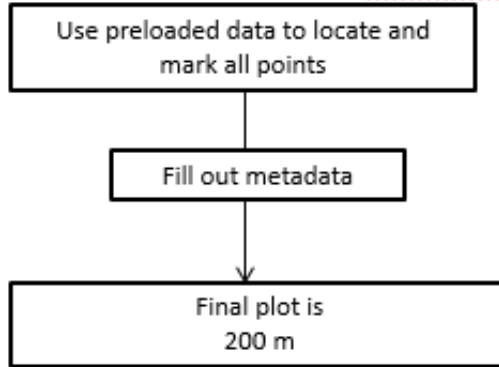
- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (SW, NE)
- *Secondary Marker* label all markers with corresponding PointID cardinal directions, see above (e.g. NW)
- 📷 Take photos towards next point on transect in a clockwise direction



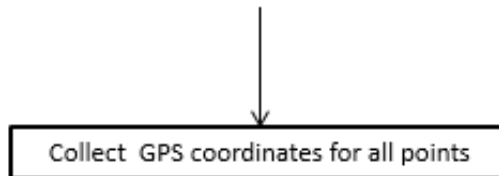


E.3 Phenology Plot- Phenocam

Type: Tower
Subtype: Phenology Plot
Secondary Plot if applicable- Phenocam



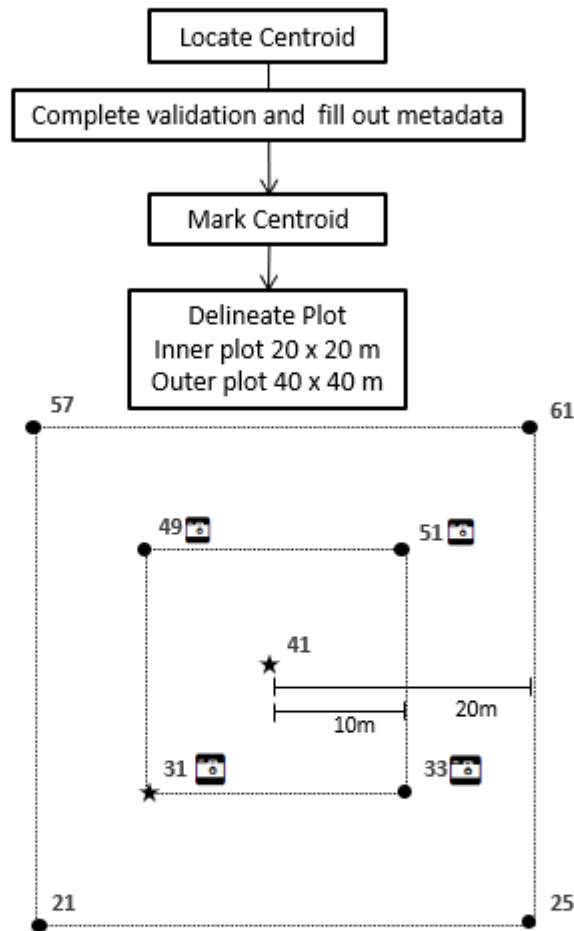
- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (SW)
- *Secondary Marker* label all markers with corresponding PointID cardinal directions, see above (e.g. S)
- 📷 Take photos towards next point on transect in clockwise fashion. SW photo taken towards S point.





E.4 Distributed Base Plot Workflow

Type: Distributed
Subtype: Base Plot



- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (e.g. 41)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)
- 📷 Photos taken towards the centroid

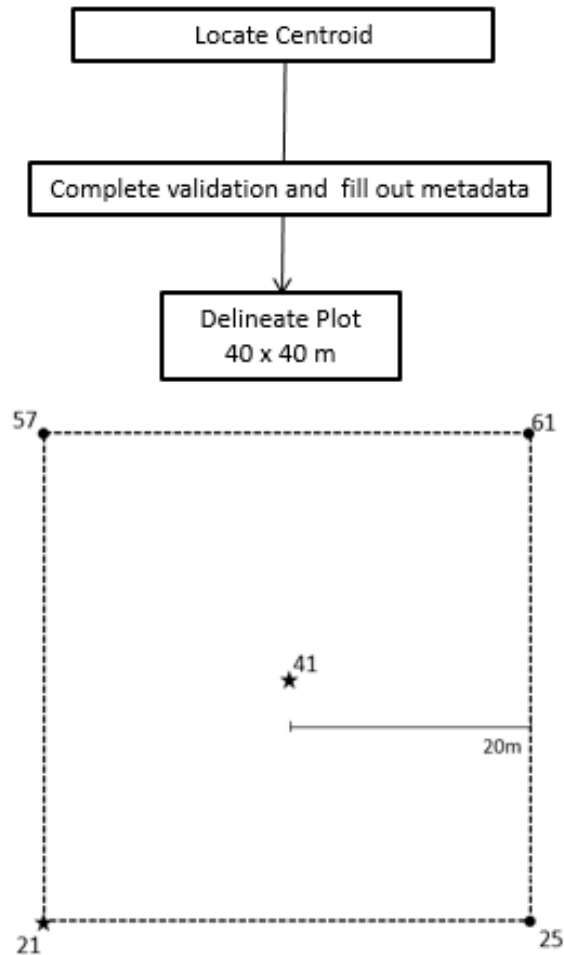
Note: outer 40m corners only need to be installed at plots that support beetle, soil, or assignable asset work. Point 21 should be installed at all plots that support bird sampling.

Collect GPS coordinates for all points

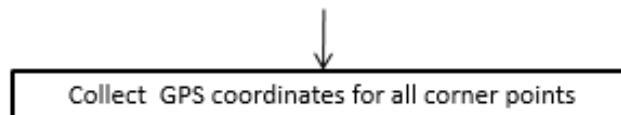


E.5 Distributed Tick Plot Workflow

Type: Distributed
Subtype: Tick Plot



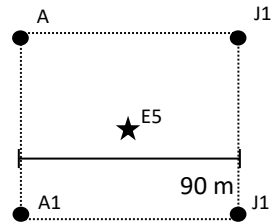
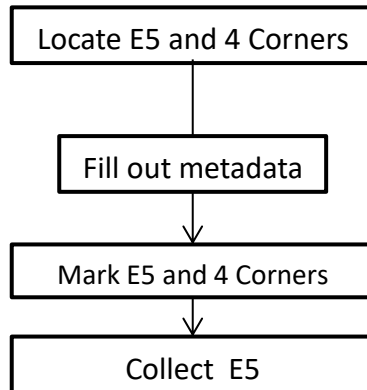
- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (41, 21)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)



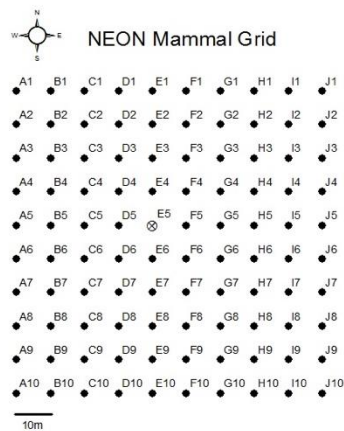
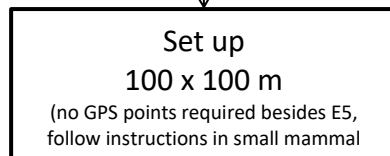


E.6 Distributed Small Mammal Grid Workflow

Type: Distributed Subtype: Mammal Grid



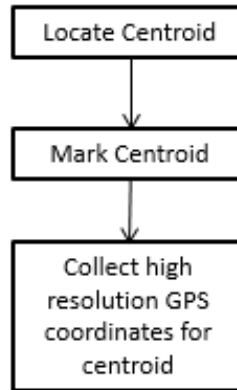
- ★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (E5)
- *Secondary Marker* label PointID (e.g. A1)





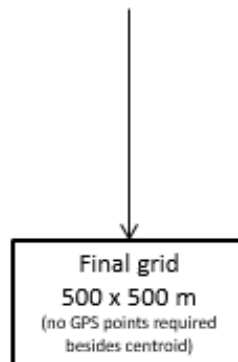
E.7 Distributed Bird Grid Workflow

Type: Distributed
Subtype: Bird Grid



B2 ★

★ *Primary Marker* label PlotID (e.g. CPER_001) and PointID (B2)

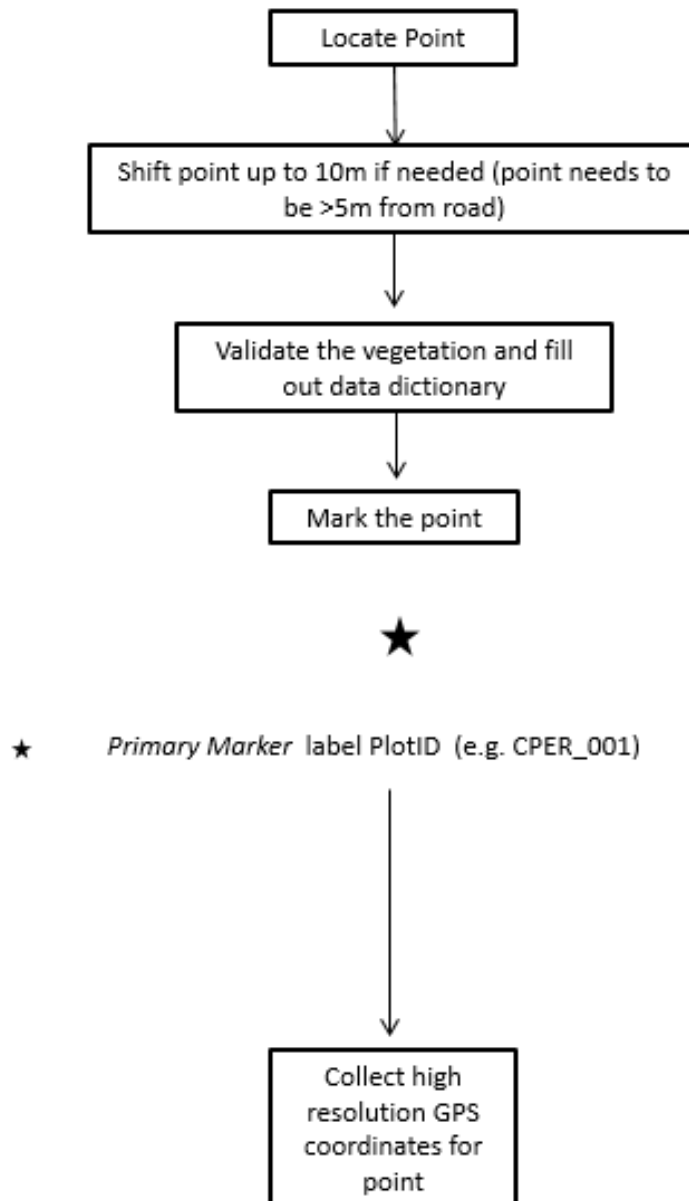


If the site is bird point sampling at a subset of Distributed Base Plots no additional markers are necessary



E.8 Distributed Mosquito Point Workflow

Type: Distributed Module: Mosquito Point





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APPENDIX F NLCD VEGETATION CLASSIFICATION DESCRIPTION

Table 7. The NLCD classification definitions

Class/Value	Classification Description
Water	<i>areas of open water or permanent ice/snow cover.</i>
11	Open Water - areas of open water, generally with less than 25% cover of vegetation or soil.
12	Perennial Ice/Snow - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	<i>areas characterized by a high percentage (30% or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc.).</i>
21	Developed, Open Space - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	Developed, Low Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	Developed, Medium Intensity - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	Developed High Intensity -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	<i>areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the green vegetated categories; lichen cover may be extensive.</i>
31	Barren Land (Rock/Sand/Clay) - areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	<i>areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 5 meters tall); tree canopy accounts for 20% to 100% of the cover.</i>
41	Deciduous Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	Evergreen Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	Mixed Forest - areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.



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Class/Value	Classification Description
Shrubland	<i>areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 5 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.</i>
51	Dwarf Scrub - Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	Shrub/Scrub - areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	<i>areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75% to 100% of the cover.</i>
71	Grassland/Herbaceous - areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.
72	Sedge/Herbaceous - Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73	Lichens - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	Moss - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	<i>areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75% to 100% of the cover.</i>
81	Pasture/Hay - areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	Cultivated Crops - areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	<i>areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al., (1979).</i>
90	Woody Wetlands - areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.



APPENDIX G PLOT DELINEATION LAYOUT

Use the following schematics in the field to keep track of your progress, place diagram in page protector, and mark off points with a dry erase as you locate them.

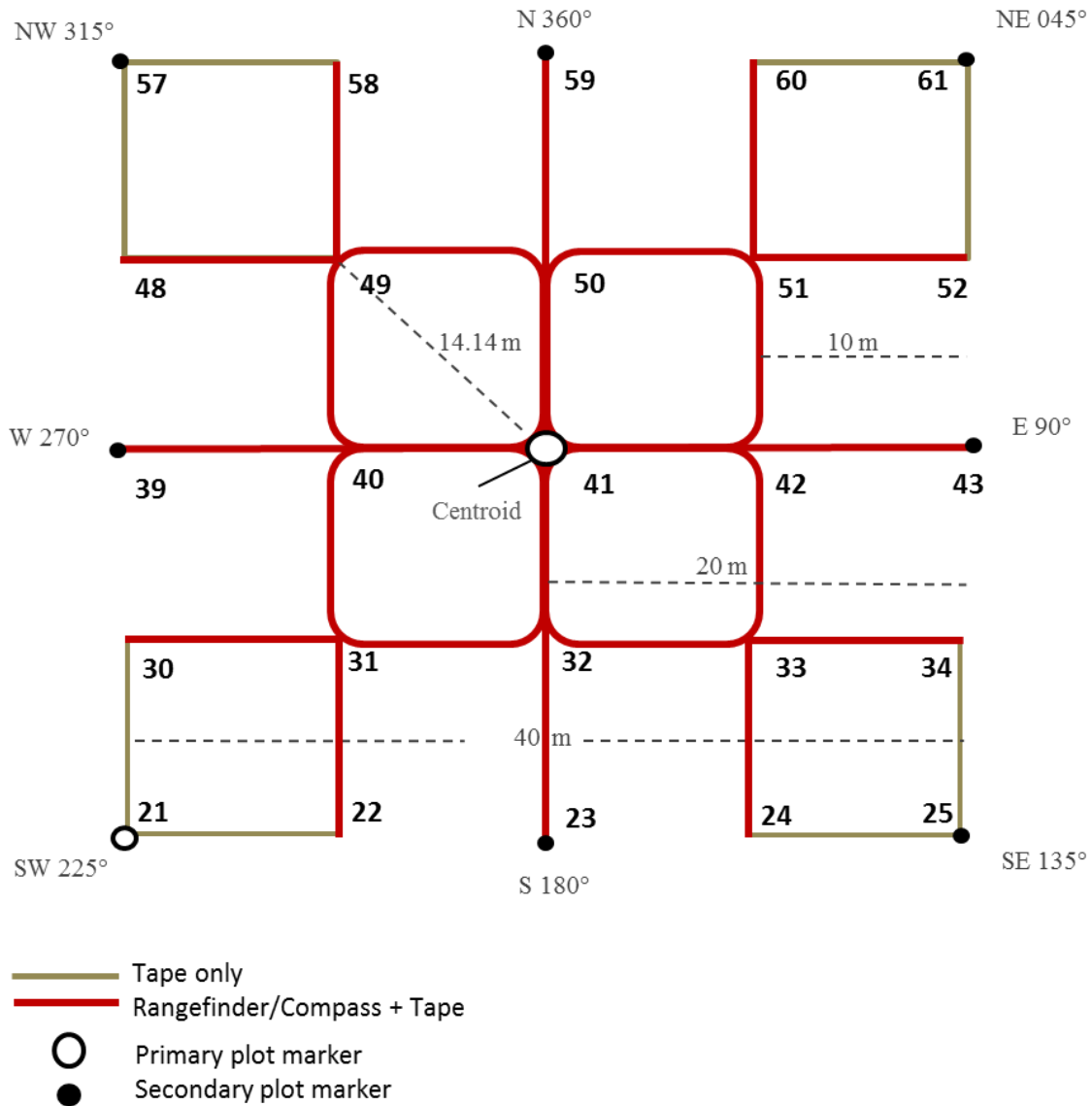


Figure 18. Schematic of a 40m by 40m Tower Base Plot. Note that layout, distances, and azimuths are the same for all Base and Tick plots.



APPENDIX H SCHEMATIC OF COMPLETE GRID USED TO LABEL PLOT POINTS

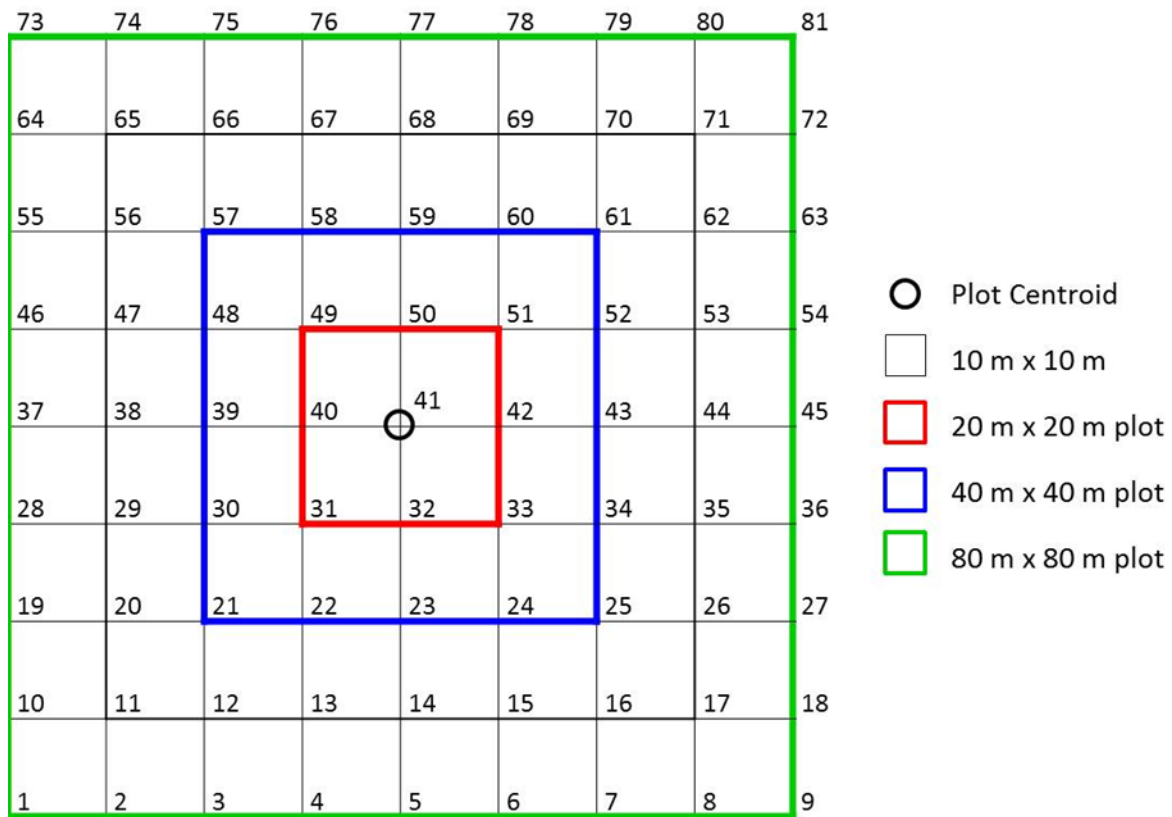


Figure 19. Schematic of the standardized grid used for Distributed Base Plots, Distributed Tick Plots, Distributed Mosquito Points, and Tower Base Plots. The point ids are assigned by the numbers in the grid, for example the plot centroid (circle) is point id 41.



APPENDIX I TROUBLE SHOOTING

I.1 Plot Establishment Obstructions

If there are obstructions (i.e. large tree, rocks...) between Person 1 & Person 2 when using the rangefinder to place a marker or make measurements:

- Use the rangefinder in HD mode to accurately measure 10.0 m of horizontal distance along the slope. Depending on the degree of slope, using the transect tape could result in moving the flag to 10.5 m instead of 10 m. If this is performed along the center line, this adjustment should be propagated through the remaining points on that line (i.e. 20.5, 30.5 etc.). Using the rangefinder in filter mode and shooting at a reflector can help determine where exactly to place the flag.
- Both people can step to the side up to 3 times away from the point or use an alternative standardized measurement to get a clear reading. Once a clear reading is acquired move back to the original point and place marker.

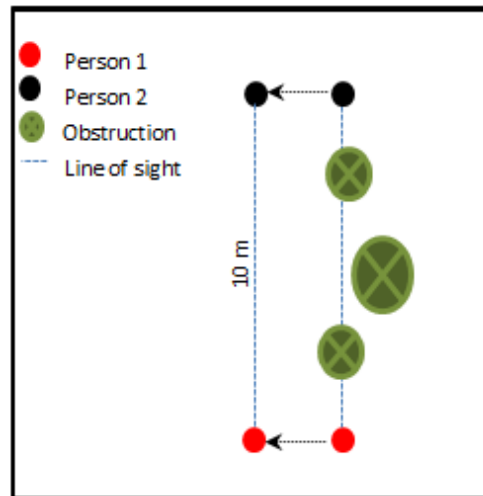


Figure 20. Alternative strategy when obstructions are in line of sight during plot delineation. Person 1 (red) and person 2 (black) can move in the same direction at the same azimuth (arrows).



I.2 Plot verification obstructions

- When looking for a line of sight for verification, if the initial suggested diagonal line of sight is obstructed, use the Pythagorean Theorem $c^2 = b^2 + a^2$ to find the unobstructed hypotenuse of a right triangle within the plot to complete the verification. For example, if there is a line of obstruction for verification of point 49 from point 41 when delineating a 20 x 20 meter plot, there are several hypotenuse options (**Figure 21**). Select the one that is clear of obstructions and use it to verify point. Calculate the hypotenuse distance with the base and the height of the right triangle; in this case using the right triangle between points 49, 31 and 32 the hypotenuse “c” would be:

$$\begin{aligned}c^2 &= b^2 + a^2 \\c &= \sqrt{(20^2 + 10^2)} \\c &= \sqrt{(500)} \\c &= 22.36 \text{ meters}\end{aligned}$$

In order to verify point 49 from point 32 the distance measured with both the tape and the range finder should be 22.36 meters.

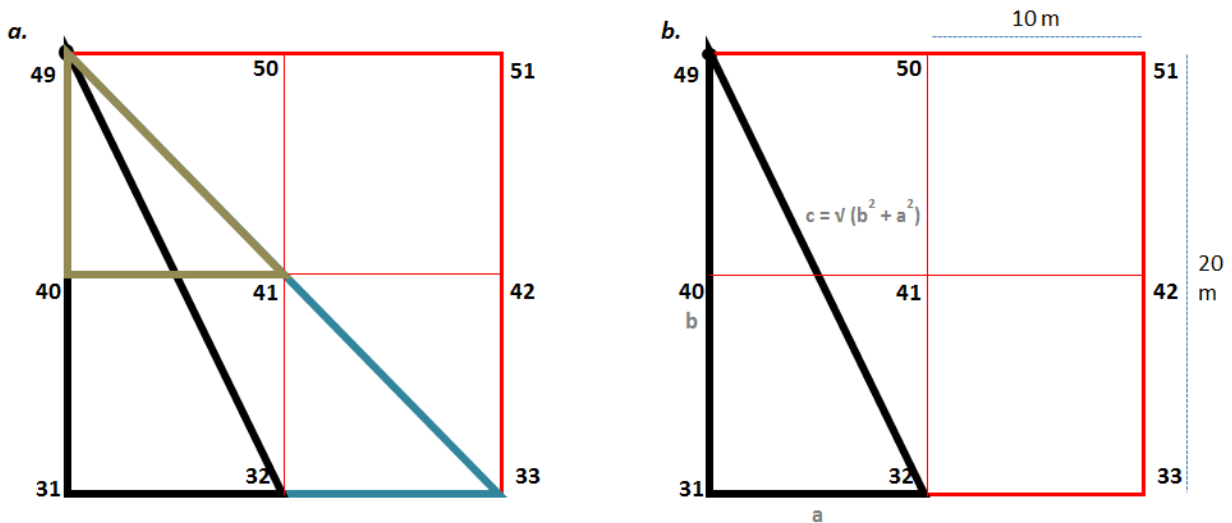


Figure 21. Schematic of hypotenuse options to verify plot delineation measurements.



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APPENDIX J PLOT MONUMENT INSTALLATION JSA

DESCRIPTION OF JOB TASK: As required in the TOS Protocol and Procedure for Plot Establishment, up to two primary monuments will be installed at all distributed and tower plots where the site host has approved such monumentation. The primary markers generally consist of one or more sections of aluminum rods, a top cap stamped with information related to the point and plot, and a bottom spike to facilitate driving the rod into the ground.

Item	JOB STEP SEQUENCE	POTENTIAL HAZARDS	RECOMMENDED SAFE PRACTICE
1	Travel to jobsite. Before work begins, review steps of this procedure with workers. Inspect worksite for hazards.	Improper use or failure of equipment can cause serious injury or property damage. Driving, Bees/Wasps, Ice, Trips, etc.	Before the work starts, the crew must be aware of the potential hazards associated with the task. The team must also be aware of the intended safe procedures and the appropriate PPE to be worn during the operation. Journey Management and Vehicle safety best practices should be followed.
2	Inspect and put on personal protective equipment.	Failure to identify worn PPE. Improper use of PPE.	Personnel should inspect PPE before use. It is the end user’s responsibility to ensure PPE is in functional condition before beginning work.
3	Remove old temporary markers.	Strain on back.	Use crowbar to gain leverage to reduce strain on back.
4	Build Permanent Marker segments.	Segments could loosen, causing marker to bend, leading to a missed blow with the T-post driver.	Use pliers or a wrench with teeth to tighten each segment and driving adapter before being to pound marker with T-post driver.
5	Drive Permanent Marker into the ground.	Loud noise, blisters on hand, crushing of hands, strain on back.	Ear protection must be worn by both people on the plot. Thick, impact gloves must be worn by the person using the T-post driver. DO NOT lift the T-post driver above the scored marking line on the top section of the Permanent Marker while using the T-post driver. The second person on the plot should be watching the person using the T-post driver to ensure this does not happen. After every 6-12 blows with the T-post driver, check the connections of the marker segments



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Item	JOB STEP SEQUENCE	POTENTIAL HAZARDS	RECOMMENDED SAFE PRACTICE
			and the driving adapter segments and the driving stud.
6	Attach additional Permanent Marker segments until needed depth is reached.	Strain on back.	Do not continue to operate the T-post driver once the Permanent Marker has reached an uncomfortable position. Attach a new segment of marker to reduce back strain.
7	Permanent Marker may need to be cut, if bedrock or difficult soil substrate is encountered. A battery powered reciprocating saw or hacksaw are the appropriate tools for this.	Cutting off finger, loud noise, hot metal shards in eyes or on hands.	Both people on the plot must wear safety glasses, gloves and hearing protection. When assembling the hand or power saw, be sure to have parts secured before beginning to cut the Permanent Marker. The second person on site should verify this before cutting begins. If both people are not comfortable using the sawzall then a hacksaw will be used instead.
8	Install Marker Cap	Strain on back, crushing hands.	Once the Permanent Marker has reached needed depth, remove excess segments installed to reduce back strain. Then install Marker Cap with a plastic sledge hammer



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APPENDIX K PLOT VERIFICATION WORKFLOW

Although less common than missing plot markers, sometimes markers need to be verified in the field to ensure that their locations match what is currently recorded, or to check on plot size and shape. Ensuring the plots on the ground are in fact square (as viewed from the air) and match as closely as possible to the predicted area is important for derived data products that depend on area to correctly scale – e.g., plot-level biomass estimates.

Work with Science via SN to determine if plot verification needs to occur. Often the need for plot verification activities occurs when Science runs a check on plot area or Field Science notices a discrepancy between the plot location in the named location database and the position in the field.

Plots may not be square on the ground or appear to be square when viewing the field GPS data due to:

1. A challenging environment for plot delineation
 - a. Slopes
 - b. Vegetation
 - c. Iron in rocks affecting compass readings
2. Errors during plot delineation
 - a. incorrect azimuth/distance used
 - b. compass or rangefinder declination errors
 - c. missing plot markers replaced incorrectly
3. Challenging GIS collection environment
 - a. dense canopy
 - b. canyons
 - c. large trees
4. GPS point uncertainties
 - a. horizontal uncertainty associated with each GPS point generally ranges from 0.1-3m
 - b. horizontal uncertainty values are estimates and less reliable under canopy environments

K.1 Verify a Plot Marker's Position

If it is suspected that a plot marker has been replaced improperly and is no longer in the correct position, follow the workflow below to verify its location matches the one saved in the named location database.

1. With the Trimble (and cell phone service):



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- a. Use real time navigation and navigate to the spatial database location in the field (when the x is in circle on the Trimble)
 - i. If no cell phone service, skip to step 4.
 - b. Record the current estimated accuracy (CEA) and place the Trimble on the ground on that location with the center of the Trimble screen over the point
 - i. Wait until the CEA is relatively static.
 - c. If the CEA is over 1m skip to step 3
 - d. Using tape, measure how far away the plot marker is from the center of the Trimble screen.
 - e. If the distance is less than or equal to the CEA, leave the marker in place
 - i. For example, if the CEA at the point is 0.5m and the marker is 0.45m from the trimble it is within the acceptable accuracy and can be left in place
 - f. If the distance is greater than the CEA, move the marker to the location of the Trimble screen
 - i. For example, if the CEA at the point is 0.5m and the marker is 0.55m from the trimble the plot marker needs to be moved.
 - g. For plots with known “wonkiness” double check the distance/azimuth and fix/re-log if necessary.
 - h. For Phenology points- if the distance is greater than the CEA then do not move the plot marker but re-log the points instead
 - i. For each point, record plot, point, date, CEA, moved (Y/N); if moved = Y, additionally measure (quickly) the distance the marker was moved.
2. If CEA over 1 m: Since the CEA is too high to provide an accurate enough location, the point will need to be re-delineated.
- a. If you have 2 or more markers from which to perform delineation, you do not need to re-log.
3. If no cell service:
- a. Use the Trimble to make sure the centroid is reasonably in the right location (not 10m away).
 - b. Using the rangefinder, start at the centroid and check the distance and azimuth for the plot markers.
 - i. “Good” equals within 0.3m for distance, 1 degree plus or minus for azimuth.
 - c. For any points that moved, log the location(s).



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- d. For any points that pass the rangefinder test, no logs necessary.

K.2 Verify a Plot's Shape

So called “wonky plots” were identified programmatically as those plots or subplots that deviate from the prescribed area by greater than 10-12% depending on the plot size. The wonky plot threshold considered known instrument uncertainty. Field Science was asked to verify each plot/subplot on the list and fix plot markers when necessary.

1. Field Ecologists visit each plot/subplot on the ‘wonky plot’ list.
 - a. Plots with deciduous leaf cover should wait for leaf off conditions to check the plot to allow for easier delineation.
 - b. If a plot requires plot marker movement, GPS collection must occur in leaf off conditions.
2. At each plot Field Ecologists check the distance and bearing between plot markers using the rangefinder:
 - a. When using the rangefinder to verify distances be sure to use a non-ferromagnetic tripod and reflective target on a staff to reduce human error.
 - b. Be aware of the known instrument errors (± 0.3 m for distance, ± 1 degree for azimuth), and always verify declination.
 - 1) Note: if the distance readout on the rangefinder includes a decimal point this means your target was “high quality”. If there is not a decimal point you will need to change your target to something more reflective.
 - c. Assume the centroid is in the correct location and use it as an “anchor” to check the other points.
 - 1) Check the smallest distances possible (for example, check the distance between points 21 and 39 instead of points 41 and 21).
 - 2) The 14.14m hypotenuse check is works well at Distributed Base Plots, 20m by 20m Tower Base Plots, and 40m by 40m Tower Base Plots that sample DIV.
 - 3) At 40m x 40m Tower base plots, check the N,S,E, and W cardinal points first, then check the corner points.
 - d. Write down the verified distances and bearings on the fieldDataSheet.
 - 1) The data sheet is found under the “wonky plot” category in the Field Science collaboration Sharepoint page.
 - 2) If there is a large tree or other obstacle next to a marker that could interfere with GPS point collection make a note.



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3. If plot markers need to be moved:
 - a. Follow the Plot Establishment Protocol for delineation steps and recommendations.
 - b. Use the laser rangefinder if the slope is over 20%.
 - c. Move the plot marker.
 - 1) If you are at plot where visibility has decreased since plot establishment and there is a concern about making the plot even wonkier, place temporary “corrected” markers and leave the original markers in place. Science will process the data and check if the plot area is better before making a final plot marker change.
 - d. When correcting a wonky subplot in a 40m x 40m plot, be aware that a change of one plot marker position may affect other plot markers not part of the original wonky subplot.
 - e. Collect GPS points following the steps in the Plot Establishment Protocol and the Trimble GPS Receivers SOP.
 - 1) If under deciduous canopy, GPS collection must occur in leaf off conditions.
 - 2) Collect of a minimum of 500 logs.
 - 3) Be sure real time navigation is turned off when collecting logs.
 - f. Record on the fieldDataSheet which markers were moved.

APPENDIX L SOUTHWEST CORNER PRIMARY MARKER LOCATION BY SITE

Due to discrepancies in figures in the Plot Establishment protocol over the years, some Distributed base plots at some sites have the inscribed cap monument at point 21 (outer 40m SW corner) and some at point 31 (inner 20m SW corner). Below is a table outlining the location per site. Any new plots should follow the site-specific locations; if both marker locations occur, use point 31.

Table 8. Site specific location of the southwest primary maker at Distributed Base Plots.

Domain	Site	Point ID	Additional Notes
D01	HARV	31	
D01	BART	31	
D02	SERC	31	
D02	SCBI	31	
D02	BLAN	31	
D03	JERC	31	
D03	DSNY	31	
D03	OSBS	31	
D04	GUAN		No metal markers. PVC stakes, yellow plastic stakes, or pin flags
D04	LAJA		No monuments due to farming activities
D05	STEI	31	
D05	UNDE	31	
D05	TREE	31	
D06	UKFS	31	
D06	KONZ	31	
D06	KONA		No monuments due to farming activities
D07	MLBS	31	
D07	GRSM	31	
D07	ORNL	31	
D08	TALL	31	
D08	LENO	31	
D08	DELA	31	
D09	NOGP	21	
D09	DCFS	21	
D09	WOOD	21	
D10	RMNP	31	
D10	CPER	31	
D10	STER		No monuments due to farming activities
D11	OAES	31	A few plots are monumented at point 21
D11	CLBJ	31	Some plots are monumented at point 21 or both 21 and 31
D12	YELL	21	



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Domain	Site	Point ID	Additional Notes
D13	NIWO	31	
D13	MOAB	31	
D14	SRER	31	
D14	JORN	31	
D15	ONAQ	31	
D16	WREF	31	
D16	ABBY	31	
D17	SJER	31	Paint marks used at locations with insufficient soil
D17	TEAK	31	Paint marks used at locations with insufficient soil
D17	SOAP	31	Paint marks used at locations with insufficient soil
D18	TOOL		No plots monumented yet
D18	BARR	31	Plot monumentation ongoing effort, not all plots monumented
D19	BONA	21	
D19	HEAL	21	
D19	DEJU	21/31	roughly 50/50 spilt between which SW point at Distributed Base Plots
D20	PUUM	31	Additional capped monument at pt 21 at Base Plots that sample birds

APPENDIX M 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.
- Item quantities are provided for a single team of two people collecting the data.
- Trimble GPS equipment should be bought by a local provider.

Table 9. Equipment list – Preparing for Sampling (SOP A).

Supplier / Item No.	Exact Brand	Description	Purpose	Quantity
	Y	Trimble GPS receiver, decimeter accuracy (e.g. GEO XH 6000, 7X)	Loading data to GPS that will locate plots and generate spatial locations of plot points	1
Forestry Suppliers 91567	Y	TruPulse 360R Laser Rangefinder, 30cm accuracy	Measure distance and azimuth between objects	1
	Y	Trimble GPS Pathfinder Office Software NEON	Importing and exporting Trimble GPS data	1
	N	SD Memory Card	Transfer files from GOPS receiver to a computer	1

Table 10. Equipment List – Plot establishment in the field (SOP B:D, F:G).

Supplier / Item No.	Exact Brand	Description	Purpose	Quantity
	Y	Trimble GPS receiver, decimeter accuracy (GEO XH 6000, 7000)	Locate plots and generate spatial locations of plot points	1
	Y	Extra battery for GPS receiver	Extend field GPS collection time	1
	Y	Range Pole Bracket	Secure range pole to GPS	1
	Y	Range pole with bi-pod attachment	Hold antenna	1
	Y	Antenna	Receive satellite information	1
	Y	Antenna Cable	Connect antenna to GPS	1
Forestry Suppliers 91567	Y	TruPulse 360R Laser Rangefinder, 30cm accuracy	Lay out the plot in proper dimension	1



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Supplier / Item No.	Exact Brand	Description	Purpose	Quantity
Compass Tools 703512; Forestry Suppliers 90998	Y	TruPulse 360R Foliage filter	Allow laser rangefinder use in dense vegetation	1
	N	CR123A battery	Spare battery for laser rangefinder	
	N	Lens cleaning cloth	Cleaning rangefinder lens	1
Grainger 5B317	N	Reflective tape or bicycle reflector	Sight rangefinder	1
Compass Tools 7024901	N	Tripod, non-magnetic	Hold laser rangefinder directly over plot marker	1
	N	Plumb bob	Attach to center of tripod to ensure the laser rangefinder is centered over the intended point	1
	N	Staff/Pole	Use with the reflective tape or bicycle reflector	1
Ben Meadows 213379	N	Compass with mirror and declination adjustment	Verify rangefinder compass calibration	2
	N	Site Maps	Navigation to plot	1
	N	Secondary markers (e.g. PVC pipe)	Raw material for secondary markers	Variable
	N	Additional material to label markers (e.g. spray paint)	Label flags, PVC and/or other secondary markers	Variable
	N	Log Sheets (See Appendix A)	Record information/notes	1
	N	Definitions of Land Use and Land Cover Classification (Appendix E)	Field-based validation	1
	N	Field Science datasheet with a list of potential plots	Reference	1
	N	GPS receiver, recreational accuracy with fully charged batteries	Back up navigation around the site if needed. Do not use to navigate exact plot location or collect GPS data.	1
	R	GPS Pathfinder Office Software	Transfer and process spatial data	1

¹ Secondary and temporary marker quantities will vary depending on plot type and site-specific plot monumentation strategies, which will be dependent upon local conditions and site host restrictions.



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Table 11. Equipment List – Plot Monumentation (SOP G).

Supplier / Item No.	Exact Brand	Description	Purpose	Quantity
	N	PVC pipe cutter	Cutting secondary markers	1
	N	Survey Monument Post Driver (30 inches or longer)	Install primary markers	1
	N	Survey Monument Driving Pin Adapter	Install primary markers	1
	N	Impact gloves 	Protect Hands from the potential force of the driver striking the post.	1 pair per staff
	N	Ear Plugs	Protect ears and hearing from loud noises while driving monument rods into the ground	1 pair per staff
	N	Sledge hammer	Driving monument rods	1
	N	4.5" x 0.75" stainless steel driving adapter	Driving monument rods	1
	N	Hacksaw with appropriate blade or battery powered reciprocating saw	Removal of excess rod	1
	N	Pliers	Tightening sections	1
	N	Crow or pry bar	Removal of temporary plot marker	1
	N	2.5" flat survey cap, stamped	Monument component	variable
	N	1' x 0.75" aluminum monument rod sections	Monument component	variable
	N	3' x 0.75" aluminum monument rod sections	Monument component	variable
	N	3' x 0.75" aluminum monument rod sections	Monument component	variable
	N	6" x 0.75" aluminum driving rod section	Monument component	variable



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Supplier / Item No.	Exact Brand	Description	Purpose	Quantity
	N	Blades specified to cut metal for hacksaw or reciprocating saw	Removal of excess rod	1
	N	Paper plate	Catchment for saw debris	1
	N	Additional materials to label markers (e.g. spray paint)	Label flags, PVC and/or other secondary markers	2
	N	Pencils	Record information/notes	3