

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

## TOS PROTOCOL AND PROCEDURE: PLOT ESTABLISHMENT

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See configuration management system for approval history.

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Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
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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"> <li>• GPS Receiver Setup edits; A-3.C and A-6</li> <li>• Extraction of the Rangefinder section to NEON.DOC.001717</li> <li>• Shifting and Offsetting Point Locations; SOP B.6</li> <li>• Information located in boxes has been embedded in protocol text.</li> <li>• Added NEON Criteria for Wet Locations to Appendix D</li> <li>• Updated Appendix E: general workflow, tower workflow, mammal workflow.</li> <li>• Delineation steps where reformatted</li> </ul>

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**TABLE OF CONTENTS**

**1 OVERVIEW .....1**

1.1 Background ..... 1

1.2 Scope..... 2

1.2.1 NEON Science Requirements and Data Products ..... 2

1.3 Acknowledgments..... 2

**2 RELATED DOCUMENTS AND ACRONYMS .....3**

2.1 Applicable Documents ..... 3

2.2 Reference Documents..... 3

2.3 Acronyms ..... 4

2.4 Definitions..... 4

**3 METHOD .....5**

3.1 NLCD Vegetation Classification ..... 6

**4 SCHEDULE .....8**

4.1 Frequency and Timing..... 8

4.2 Criteria for Determining Establishment Dates..... 8

4.3 Timing for Laboratory Processing and Analysis ..... 8

4.4 Sampling Timing Contingencies ..... 8

**5 SAFETY .....9**

**6 PERSONNEL AND EQUIPMENT.....10**

6.1 Equipment..... 10

6.2 Training Requirements..... 14

6.3 Specialized Skills..... 14

6.4 Estimated Time ..... 14

**7 STANDARD OPERATING PROCEDURES FOR TOS PLOTS.....15**

7.1 Workflow of Field Activities..... 16

**SOP A PREPARING FOR ESTABLISHMENT.....17**

**SOP B PLOT ACCEPTANCE .....24**

**SOP C PLOT DELINEATION AND MARKING.....34**

**SOP D COLLECT GPS COORDINATES .....43**

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**SOP E DATA ENTRY AND VERIFICATION .....48**

**SOP F RE-MEASURING GPS LOCATIONS .....53**

**SOP G SAMPLE SHIPMENT .....54**

**8 REFERENCES .....55**

**APPENDIX A LOG SHEETS .....56**

**APPENDIX B GPS RECEIVER SETUP .....66**

**APPENDIX C SITE-SPECIFIC INFORMATION .....69**

**APPENDIX D CRITERIA FOR PLOT ESTABLISHMENT IN WET LOCATIONS.....73**

**APPENDIX E PLOT ESTABLISHMENT WORKFLOWS .....74**

**APPENDIX F NLCD VEGETATION CLASSIFICATION DESCRIPTION .....84**

**APPENDIX G PLOT DELINEATION LAYOUT .....86**

**APPENDIX H SCHEMATIC OF COMPLETE GRID USED TO LABEL PLOT POINTS .....88**

**APPENDIX I TROUBLESHOOTING .....89**

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**LIST OF TABLES AND FIGURES**

**Table 1.** The NLCD land use and land cover classification system for use with remote sensing data. .... 6

**Table 2.** Contingent decisions..... 8

**Table 3.** Equipment list – A crew of two technicians preparing for establishment of one plot..... 10

**Table 4.** Equipment list – A crew of two technicians performing field establishment of one plot..... 11

**Table 5.** Materials provided for use of FOPs and FSU..... 17

**Table 6.** Points to be logged by FOPs (also see workflow for each plot type in Appendix D)..... 44

**Table 7.** Base stations and Geographic Coordinate System properties ..... 69

**Figure 1.** Generalized site-scale sampling schematic for the NEON TOS ..... 15

**Figure 2.** Pathfinder Office project ..... 22

**Figure 3.** Plot Delineation step 1 ..... 35

**Figure 4.** Plot Delineation step 2 ..... 36

**Figure 5.** Plot Delineation Step 3 ..... 37

**Figure 6.** Plot Delineation Step 4 ..... 37

**Figure 7.** Plot layout and marker positions for 40 m by 40m Distributed Base Plots..... 41

**Figure 8.** GeoXH 6000 set up for high accuracy data collection. .... 43

**Figure 9.** The Obstructions tool within the Trimble Mission Planning web-based software ..... 50

**Figure 10.** Adding an obstruction observed in the field within the Trimble Mission Planning software... 51

**Figure 11.** GPS receiver Geo XH 6000..... 66

**Figure 12.** Schematic of the point ID grid used in plot establishment. .... 88

**Figure 13.** Alternative strategy when obstructions are in line of sight during plot delineation. .... 90

**Figure 14.** Hypotenuse option to verify plot delineation measurements ..... 91

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

# 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. Observing change by integrating measures of the drivers and ecological responses will contribute 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 national 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-km<sup>2</sup>) 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.

Observations will describe the ecological status and future trends NEON is designed to detect with a suite of measurements that cross diversity of spatial and temporal scales. Fixed-wing aircraft census vegetation across NEON sites with high-resolution remote sensing, and tower-based sensors capture temporally continuous fluxes over smaller spatial extents. 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 will be 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 will be 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 large spatio-temporal scales. 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 creating plots on the ground at NEON sites where the observations that inform the Observatory will be made.

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

## 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.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## 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.001155	NEON Training Plan
AD[05]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD[06]	NEON.DOC.014051	Field Audit Plan
AD[07]	NEON.DOC.000824	Data and Data Product Quality Assurance and Control 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.005003	NEON Scientific Data Products Catalog
RD[04]	NEON.DOC.001271	NEON Protocol and Procedure: Manual Data Transcription
RD[05]	NEON.DOC.014049	TOS Protocol and Procedure: Mosquito Sampling
RD[06]	NEON.DOC.014045	TOS Protocol and Procedure: Tick and Tick-Borne Pathogen Sampling
RD[07]	NEON.DOC.014040	TOS Protocol and Procedure: 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



<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

### 2.3 Acronyms

Acronym	Definition
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

### 2.4 Definitions

None given.

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

### 3 METHOD

Plot establishment is an essential step in the development of the NEON Terrestrial Observation System (TOS). Accurate and precise plot locations that represent the target ecosystem components at each site will facilitate reproducible data collection and spatial analysis for the life of the Observatory. This document outlines the procedures for location, evaluation, establishment, geospatial data collection and reporting for Tower Plots, Phenology Transects, Distributed Base Plots, small mammal grids, bird grids, tick transects and mosquito locations.

Tower Plots are located within or around the NEON tower airshed and will be sampled for above and belowground plant biomass and productivity, plant biodiversity, foliar and wood biogeochemistry, and soil biogeochemistry. All plot locations are created based on a spatially balanced random selection process, and individual plots are then accepted or rejected based on an assessment by field technicians (RD[15]). Tower plots will vary in size between and within sites. Between sites plots will vary depending on the dominant vegetation type and heterogeneity. Low biomass, low stature vegetation such as that found in grasslands and homogeneous low diversity vegetation found in agricultural plots will be monitored in 400 m<sup>2</sup> square plots, measuring 20 meters on a side. Forested sites require larger plots to accurately measure plant biomass and productivity than sites dominated by herbaceous plants and shrubs. High biomass vegetation, found in forest will be measured in 1600m<sup>2</sup> square plots, 40 meters on a side. Plant phenology transects are also located within the NEON primary 90% flux tower airshed. Within each site there will be a subset of tower plots that require a hybrid approach because they contain additional measurements of biogeochemistry and plant diversity, this subset will be specified and directed by TOS.

Distributed Plots may be located throughout the NEON site, and selection of their location is based on a spatially balanced random selection process (RRQRR). During plot establishment, individual Distributed Plots may be accepted or rejected based on a field assessment by field technicians; potential plot locations are only accepted if the actual vegetation type is congruent with the assumed NLCD vegetation type. Prior to plot establishment, each plot has been subjected to an initial vegetation assessment. All sentinel taxa sampling will occur at Distributed Plots, although not all taxa will be measured at all Distributed Plots.

The Standard Operating Procedures in this document outlines the specifications for establishing each taxa-specific sampling plot. Site specific planning documents will identify the location of plots within the site, specify which taxa will be sampled at each of the identified plot locations and provide lists of contingency plot locations to replace rejected plots. This Standard Operating Procedure identifies plot establishment required for all current TOS plot types. The initial establishment includes plot acceptance, 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. Annual maintenance of established 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

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

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.

Several high resolution coordinates will be taken at several locations within each established plot. In order to attain high accuracy (i.e. to within  $\leq 30\text{cm}$  accuracy) at all points within each plot, a procedure has been developed. This 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 will require the use of software (Trimble Pathfinder Office and Trimble Mission Planning packages) and a detailed GPS receiver accuracy setup. The field work will require attention to detail when following all procedures and the use of best practices. The post-field protocol constitutes a download of the data that will be post-processed by the Fundamental Sentinel Unit (FSU) at HQ.

### 3.1 NLCD Vegetation Classification

The NLCD is a continental scale land classification map. 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 (Table 1). The most commonly used vegetation types are in bold.

**Table 1.** The NLCD land use and land cover classification system for use with remote sensing data.

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	<b>41 Deciduous Forest</b>
	<b>42 Evergreen Forest</b>
	<b>43 Mixed Forest</b>
5 Shrubland	51 Dwarf Scrub*
	<b>52 Shrub/Scrub</b>
7 Herbaceous	<b>71 Grassland/Herbaceous</b>
	72 Sedge/Herbaceous*
	73 Lichens*
	74 Moss*
8 Planted/Cultivated	<b>81 Pasture/Hay</b>
	82 Cultivated Crops
9 Wetlands	<b>90 Woody Wetlands</b>
	95 Emergent Herbaceous Wetlands

\*Alaska only

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

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. The value of NEON data hinges on consistent implementation of this protocol across all NEON domains, for the life of the project. To properly collect and process samples, field technicians **must** follow the protocol and associated SOPs. 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. Use NEON’s problem reporting system to resolve any field issues associated with implementing this protocol.

The procedures described in this protocol will be audited according to the Field Audit Plan (AD[06]). Additional quality assurance will be performed on data collected via these procedures according to the NEON Data and Data Product Quality Assurance and Control Plan (AD[07]).

Quality assurance procedures for plot establishment will be conducted by NEON Domain Field Operations staff and are an essential step in the establishment process. Correct placement and documentation of plot markers at each plot enable future field crews to locate and delineate plot boundaries precisely and identify which type of sampling activities to conduct at each location.

If errors originating in field establishment are detected in a future review, they may be very expensive to correct and will have a lasting effect on all sampling data associated with plot location. Field audits should be performed early in the initial field establishment process, to ensure problems are detected and corrected before an error is propagated across many plots. NEON will use a system of hot and cold checks similar to that described by the USFS Forest Inventory Analysis (FIA) program. The basic components of the FIA program are:

- Hot checks: Normally performed as part of the training procedure. Personal observation to ensure accurate carrying out of protocol by field technicians.
- Cold checks: An inspection done either as part of the training process, or as part of an ongoing QC program. Technicians are not present, and inspector does have access to field crew generated data at time of inspection.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## 4 SCHEDULE

### 4.1 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 will occur once per site.

Annual establishment and re-marking of permanent plots for visibility may occur each year of operations prior to seasonal field sampling.

Plot establishment must occur prior to scheduled taxa sampling.

### 4.2 Criteria for Determining Establishment Dates

Plot acceptance, delineation and marking should occur prior the start of first year of sampling. Annual plot establishment activities including re-marking of permanent plots should occur prior to seasonal field sampling.

### 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. Interruptions or delays in the process—either during a specific plot or all plots—do not impact NEON data products as long as plots are in place to facilitate the accurate and repeatable observations of Operational sampling.

Reasons to delay sampling have to do with the optimization of establishing a precise, accurate plot with good geographic record (GPS collection). Reasons to alter the timing of sampling include:

- Precipitation (rain or snow) that interferes with rangefinder
- 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.** Contingent decisions

Delay/Situation	Action	Outcome for Data Products
Precipitation or snow	Stop rangefinding 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	No impact on data products as long as plots are established prior to sampling

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

## 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 EHS Safety Policy and Program Manual (AD[01]). Additional safety issues associated with this field procedure are outlined below. The Field Operations Manager and the Lead Field Technician have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop their work in unsafe conditions.

There is no additional Personal Protective Equipment beyond that specified in the Operations Field Safety and Security Plan (AD[02]) and EHS Safety Policy and Program Manual (AD[01]) required to carry out the plot establishment procedures.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## 6 PERSONNEL AND EQUIPMENT

### 6.1 Equipment

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

**Table 3.** Equipment list – A crew of two technicians preparing for establishment of one plot

Item No.	R/S	Description	Purpose	Quantity	Special Handling
<b>Durable items</b>					
MX102549	R	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	N
MX100322	R	TruPulse 360R Laser Range Finder	Laying out the plot in proper dimension	1	N
	R	GPS Pathfinder Office Software NEON	Loading data to GPS that will locate plots and generate spatial locations of plot points	1	N
	S	Marker cutting equipment	Cutting secondary markers	1	N
<b>Consumable items</b>					
	S	Secondary markers (e.g. PVC pipe)	Raw material for secondary markers		
	S	Additional materials to label markers (e.g. spray paint)	Label flags, PVC and/or other secondary markers	1	N

R/S=Required/Suggested

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**Table 4.** Equipment list – A crew of two technicians performing field establishment of one plot

Item No.	R/S	Description	Purpose	Quantity	Special Handling
<b>Durable Items</b>					
MX102549	R	GPS receiver, decimeter accuracy (GEO XH 6000, 7000)	Locate plots and generate spatial locations of plot points	1	N
	R	Extra battery for GPS receiver	Extend field GPS collection time	1	N
MX105014	R	Range Pole Bracket	Secure range pole to GPS	1	N
MX105015	R	Range pole with bi-pod attachment	Hold antenna	1	N
MX105009	R	Antenna	Receive satellite information	1	N
MX105012	R	Antenna Cable	Connect antenna to GPS	1	N
MX100322	R	Laser Rangefinder, ½ foot accuracy	Lay out the plot in proper dimension	1	N
	R	Extra batteries for Laser Rangefinder	Extend field time of rangefinder		N
	R	Lens cleaning cloth	Cleaning rangefinder lens	1	N
	R	Reflective tape or bicycle reflector	Sight rangefinder	2	N
	R	Compass with mirror and declination adjustment	Sight angles for laying out the plot	2	N
	R	Measuring tapes ≥30 m	Measure distances for laying out the plot	2	N
	R	Chaining pins or other suitable anchor	Anchor measuring tapes	5	N



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

Item No.	R/S	Description	Purpose	Quantity	Special Handling
	R	Maps	Navigation to plot		N
	R	Log Sheets	Record information/notes	1	N
	R	Definitions of Land Use and Land Cover Classification	Field-based validation	1	N
	R	Remotely-sensed plot assessment data sheets (Morton Order Data Sheets)	Reference	1	N
	S	GPS receiver, recreational accuracy with fully charged batteries	Navigation	1	N
	R	GPS Pathfinder Office Software	Transfer and inspect spatial data	1	N
	S	Anchor	Plot delineation	1	N
	S	PVC pipe cutter	Cutting secondary markers	1	N
	R	Survey Monument Driving Pin	Install primary markers		N
	R	Survey Monument Driving Pin Adapter	Install primary markers		N
<b>Consumable Items</b>					
	R	Pin Flags, PVC posts or other temporary markers <sup>1</sup>	Used during plot delineation	Max 20 per plot	N
	R	Secondary Markers (e.g. PVC, Survey stakes) <sup>1</sup>	Marking plot corners		N
Multiple	R	Survey Monument Rod	Primary marker		N

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

Item No.	R/S	Description	Purpose	Quantity	Special Handling
MX107388	R	Survey Monument Cap	Primary marker		N
	S	Additional materials to label markers (e.g. spray paint)	Label flags, PVC and/or other secondary markers	2	N
	S	Pencils	Record information/notes	3	N
	S	Additional materials to label markers (e.g. spray paint)	Label flags, PVC and/or other secondary markers	1	N

R/S=Required/Suggested

<sup>1</sup> 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.

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

## 6.2 Training Requirements

All technicians must complete required safety training as defined in the NEON Training Plan (AD[04]). Additionally, technicians must complete protocol-specific training for safety and implementation of this protocol as required in the Field Operations Job Instruction Training Plan (AD[05]).

All field technicians 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.

## 6.3 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.

## 6.4 Estimated Time

The time required to implement a protocol will vary greatly 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.

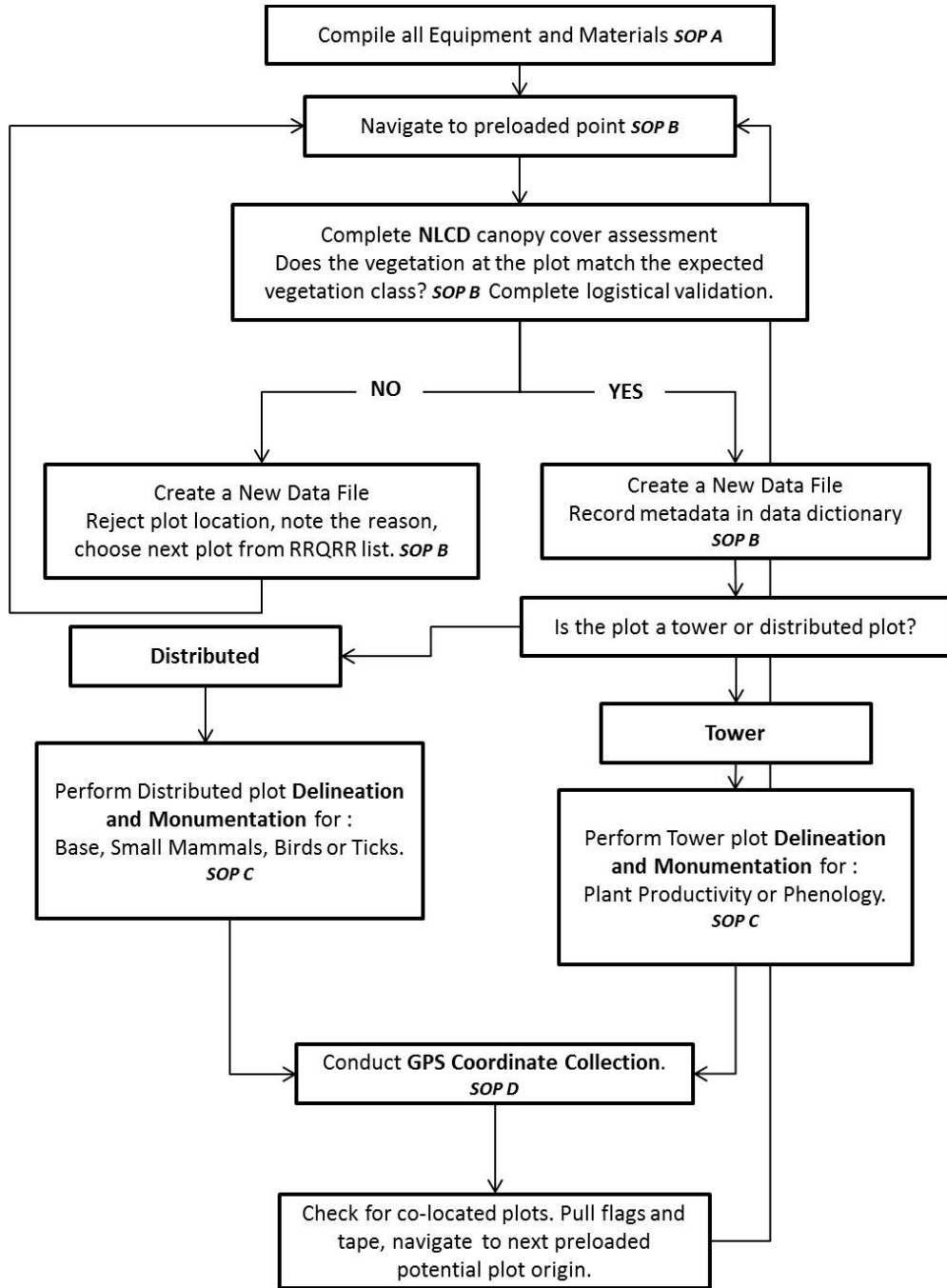
A two person team will require approximately four hours to establish one distributed base plot. Plot establishment includes metadata collection, plot delineation, marking, and spatial data collection.

**7 STANDARD OPERATING PROCEDURES FOR TOS PLOTS**



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

### 7.1 Workflow of Field Activities



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**SOP A Preparing for Establishment**

Follow A.1-A.6 to complete preparation for plot establishment.

**A.1 Resources**

During training you will be provided with a NEON network drive path. This drive will serve as a communication gateway between FSU and FOPS; it will also serve as a source of materials for data collection. The corresponding drive will include the following materials:

**Table 5.** Materials provided for use of FOPSs and FSU. These folders are located in the designated drive; the specific organization of these folders is not outlined in this table.

Folder	Content	Format	Purpose
GPS_Pathfinder_Files	Contains all GPS data files (plot locations, roads, boundary and others) used by FOPS for collection.	.imp	Data files to be used by FOPS staff to collect plot data.
Site_Information_&_Datashets	Maps	.pdf	Maps to be used by FOPS.
	Plot layout and site information	.kmz	Layers to be used in google earth by FOPS
	XX_XXXX_TOS_Plots_Datashet: Contains all Distributed plots, Morton Order, vegetation type, plot status and coordinates.	.xlsx	Datashet to be used by TOS and FOPS, must be regularly updated by FOPS.
	Contains site information and notes from previous remote and field (if applicable) validation	.docx	Background information about the site for FOPS
Established	XX_XXXX_Unique_Identifiers: Contains plot type, Morton Order and PlotID.	.xlsx	This datashet contains all PlotIDs used to label TOS plots. Datashet created by TOS and used by FOPS.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

Folder	Content	Format	Purpose
	XX_XXXX_Validation_Information:	.docx	Unique Identifiers should be provided by TOS after plots are established, to be used for plot marker labels.
Data_Dictionaries	Contains all data dictionaries. A Data dictionary is a digital form used to log metadata about each plot. Data Dictionaries are uploaded to the GPS receiver.	.ddf	To be used by FOPS to collect ALL plot establishment data.
Log Sheets	Contains log sheets used to maintain a record of markers and GPS data collection.		

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

## A.2 GPS Receiver Setup

The following are the general steps to follow in order to complete the GPS setup. To complete this section please follow the detailed steps for the relevant GPS model and software version in Appendix B.

1. Turn GPS receiver **on**.
2. **Initialize** GPS software (e.g. Terra Sync).
3. Once the GPS software is initiated, the first day of work at a site, make sure to **adjust the GPS time**, specifically the GPS unit Time Zone, Date and Time.
4. Complete **setup menu** specifics.



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.3 Global Navigation Satellite System (GNSS) Planning Online software

The GNSS Planning online software tool will help you understand satellite availability (number of satellites) before heading out to the field. If the site at hand has little satellite cover (fewer than six satellites at a time), it is important to find the windows of time with higher satellite availability. Use these windows of time to collect high-accuracy data. If the site has a constant flow of six or more satellites at a time, then the time of collection is less important. To find out satellite availability and to plan your field days -as needed-, use the following steps:

1. Visit <http://www.trimble.com/GNSSPlanningOnline/#/Settings>
2. Click on the **Setting** tab located in the upper left side of the window.
  - a. To assess the relative satellite availability across a site, add the latitude and longitude of the tower location (Appendix C).



To assess satellite availability of a particular plot location of concern, add the latitude and longitude of the specific plot. You can find the plot location in the datasheets provided by TOS. This may be useful if a technician knows of a potential satellite obstruction located close to a plot (e.g. boulder) previous to field work.

- b. Height : **0 m**
  - c. Cutoff: change it to **0°**—however, this field can be changed if obstructions are known at a particular plot. For this the latitude and longitude must be related to a particular plot.
  - d. Select the field **Day**
  - e. Select the starting time or **Visible Interval** and the time span in hours (generally a 6- or 12-hour span).
  - f. Select the appropriate **Time Zone**.
  - g. Click **Apply**.
3. To the left of the screen click on the **Satellite Library**
  - a. Click on the **GPS** and the **GLONASS** satellite libraries; unclick the rest of the satellite libraries.
4. To the left of the screen click on the **Number of Satellites**.

This histogram will display the number of satellites (GPS and GLONASS) available on the Y axis, and time on the x axis, including what the GPS would measure with any obstructions previously plugged in the **Settings** (if any). The higher the number of satellites available the better the accuracy will be. This graph will allow field workers to know when the best times to establish challenging plots may or may not be.

**In your notes**, record what times have the highest number of satellites (highest accuracy) and what times have the lowest number of satellites (lower accuracy) to collect GPS data. Avoid accruing data in the times when there are fewer than four satellites available; otherwise the data will contain low accuracy.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

#### A.4 Transfer data to GPS

##### 1. Connecting GPS unit to the computer

To complete this step, follow the directions in pages 30-33 in the Terra Sync “Getting Started Guide” (Trimble, 30-33). This guide is available in the NEON network drive folder described in SOP A.1.

##### 2. Types of files to transfer for a typical fieldwork campaign

The data files to transfer for a typical fieldwork campaign will be located in a shared folder (Table 5 in folder ‘GPS\_Pathfinder\_Files’). These files will be in .imp format (these are Trimble imported files that can be read by both Pathfinder Office and the GPS unit). There are three types of files that will be transferred from Pathfinder Office to the GPS unit:

- a. **Background files** include roads, lakes, streams, buildings, contours and others. These files are located in folder GPS\_Pathfinder\_Files, see Table 5.
- b. **Data files** Points converted from ArcGIS shape files. These are the points that will be followed and have been previously assessed for plot establishment. These files are located in folder GPS\_Pathfinder\_Files, see Table 5.
- c. **GPS Data dictionary** contains pre-defined attributes and metadata that can be associated with newly logged GPS data. The GPS data dictionary will be completed for every point collected. These files are located in folder Data\_Dictionaries, see Table 5.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.5 Loading and checking files in GPS with Pathfinder Office

1. **Open** Pathfinder Office software
2. **Create a project** for each site. Set up the Default folders in the shared folders provided (see Figure 2).

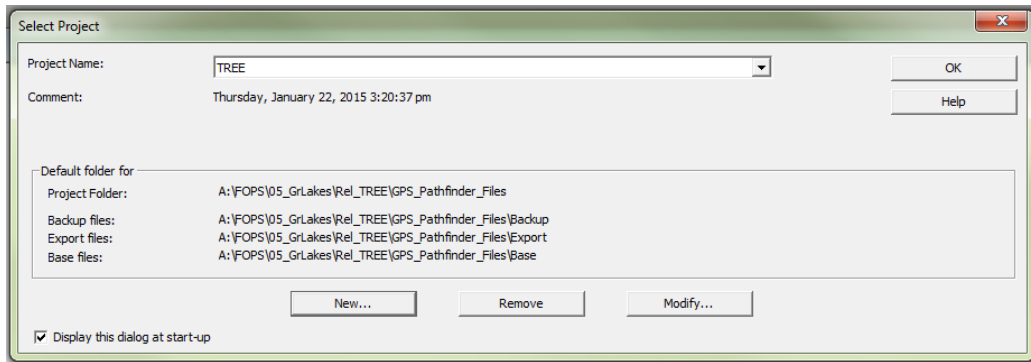


Figure 2. Pathfinder Office project

3. Go to Options and select **Coordinate System**
  - a. Select by: click on **Coordinate System and Zone** select the appropriate system, zone and datum (OC)
  - b. **Altitude Measured From:** select **Mean Sea Level (MSL)**
  - c. **Coordinate units: Meters**
  - d. **Altitude Units: Meters**
  - e. Click **OK**
4. In the main screen, select **File > Background...** and in the “Load Background Files” window, click “Add...” and select the file(s) desired as background images (e.g. boundary, roads, streams).
5. Check the box next to the desired image(s).
6. Click **OK** to load the background .tif files into the Map.
7. Click **View > Map** to visually check the images that will be loaded to the GPS.
8. To check datafiles open the imp, .ssf, or .cor file in pathfinder by selecting **File>Open** or dragging the file into the map
9. In the main screen select **Data>Feature Properties** and select **Data>Position Properties**
10. Click on the X’s in the map view (the individual points) to load the point information in the Feature Properties and Position Properties boxes.
  - a. For example, you can view the date, number of logs, estimated accuracy, and point feature name of a point in an .ssf or .cor file.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

#### A.6 Transfer data files, GPS data dictionary, and background image(s) to the GPS unit

1. On the GPS, connect the GPS to the computer with the supplied USB cable, and power on the unit. Tap on the Windows icon at the bottom left side of the GPS screen.
2. Find the TerraSync icon and tap twice with the stylus.
3. On the computer, use the Windows Mobile Device Center (Win7 or Vista) to connect the device to Windows. If this is the first time connecting the GPS to the computer the Windows Mobile Device Center may install automatically, if it doesn't, download it online from the windows software website.
4. Set the coordinate system in the Trimble TerraSync software to the corresponding coordinate system used for the site:
  - a. In the TerraSync software on the GPS, from the MDD tap **Setup** then click the "Coordinate System" box.
  - b. Match to the coordinate system of downloaded data, select: System = UTM, Zone = appropriate zone, and Datum then click **OK** (Appendix C).
  - c. From the MDD, return to the **Map** screen.
5. Once the GPS unit is connected to the computer, within Pathfinder Office, use the **Data Transfer** utility to transfer all the files (background, data dictionary and data files) to the Trimble:
  - a. Go to **Utilities > Data Transfer...** and in the window that comes up, click the **Send** tab and click **Add...** and select **Background** from the list. Select background files (e.g. boundary, roads, streams and others) and click **OK**.
  - b. Then click **Add** and select **Data Dictionary**, browse for the appropriate GPS data dictionary location in the shared drive, select all applicable data dictionaries and click **Open**.
  - c. Once more, click **Add** and select **Data File**, browse for the point files for all of the plot locations, and click **Open**.
  - d. After selecting all file types to transfer to the GPS click **Transfer All**.
6. In the TerraSync software on the GPS, select the transferred image(s) as the background:
  - a. Use MDD and tap on **Map**. From this pane go to the **Layers SDD** and click **Background Files...**
  - b. In the list of files, select which image file(s) you would like to use as background and click **OK**.
  - c. To temporarily turn off the background image (can be used to reduce software wait time while making measurements) go to the **Layers SDD** and un-check **Background**.
7. When transfer is complete, disconnect the unit and follow model instructions.
8. Make sure the GPS is fully charged before heading to the field.

#### A.7 Configure the rangefinder

Refer to RD[19] for details.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## SOP B Plot Acceptance

### AT THE START OF THE FIELD DAY, REMEMBER TO:

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- Turn on the unit in an open area for at least 5 min before entering a closed canopy system.
- On a daily basis, verify that the GPS almanac has been updated within the last week or anytime the unit is moved to a new NEON site. To update the almanac it is necessary to have at least one satellite locked and it should take at most 15 minutes. To check when the almanac was last updated go to MDD>Status and SDD>Receiver, there should be a line for 'Almanac' with a corresponding date of last update.
- Once the GPS has been turned on, take care to always keep the antenna relatively flat, even when not collecting data. This will ensure that a minimum number of satellites are dropped.
- Do not stand in front of or otherwise block GPS unit. Make sure the barometric pressure holes on the under-side of the Trimble are not obstructed.
- While hiking or collecting data, make sure the sleep function is disabled, every time the unit goes into sleep mode satellites will be lost. To disable the sleep function:
  - o Press the green button for approximately 3 seconds. This button located below the screen,
  - o Click on **Power Settings**
  - o Uncheck the box below *On battery power*
  - o Click **OK**
- Always take an extra fully charged GPS battery.
- Create a Waypoint for the location of the vehicle:
  1. Click on MDD > **Navigation**
  2. On the SDD > **Waypoints**
  3. Click on **New** at the lower left side of the screen.
  4. Location **Default**
  5. Name waypoint at **File Name**
  6. Click **Done**
  7. Click on **Options** on the upper right, and then click on **New**.
  8. Name the waypoint (i.e. RMNP\_Car\_06162011)
  9. Click on **Create Form** on the upper right, and then click on GNSS. The coordinates should load.
  10. Click **Done**. Waypoint should be created.
  11. To close the created file, go to **Options** and click on **Close File**.
  12. Go back to MDD > **Navigation**. Make sure the SDD is on Waypoint and then Click **OK**. The waypoint should be created.
  13. When returning to the car, click on MDD > **Navigation** and SDD > **Waypoints**. Highlight the file of interest and click **Open** on the lower right side of the screen.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

14. Click on the box to active and tap for one second on the waypoint files. Click on **Set Nav Target**
15. Go back to SDD> **Navigate** and when moving it will point you to the navigation target.

Or:

1. Use a hiking GPS to set up a waypoint.

**Note: Make sure to write the coordinates in a field notebook!**

### B.1 Navigate to pre-loaded GPS point

Preloaded GPS points will be classified by plot type. Before leaving the car create a waypoint of the car location or starting location AND write down the coordinates and elevation of the car in a field notebook, this is a safety practice to ensure technicians have coordinates to navigate back to the vehicle.

1. **Open** the data file associated with the current site:
  - a. Go to **MDD > Data**, and then go to the **SDD > Existing File**. You should see a list of data files loaded onto the Trimble.
  - b. Select the data file associated with the current site, and click **Open**.
    - Make sure that the Antenna **Height** is at 1 m, and the **Type** refers to the GPS model Internal and keep setting on “measure to bottom of receiver”; then click **OK** on “confirm antenna height” pop-up.



When using the antenna ensure it is set to 2m.

- c. Go to **MDD > Map** to see the plots loaded on the map. Go back to **MDD > Data**
- d. Find the Plot **Morton Order** of the targeted plot. **Tap** and press (1-2 seconds) on the Morton Order number. A pop-up menu should appear. Select **Set Nav Target**. Note: the targeted plot should now have a flagged symbol.

Or

To set a plot as a navigation target from the **MDD > Map**, choose the **Select** tool (↗) from the left-most SDD, and hold the stylus on the plot until a box pops up that says “Delete” and “**Set Target.**” Choose “**Set Target.**”



To check the Morton order of a plot from the Map pane, tap on the select tool from the left-most SDD menu. Tapping a plot icon quickly with the stylus will bring up the name and coordinates of that particular plot.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

2. To zoom in, while in the MDD>Map, go to the leftmost SDD menu and select the **zoom-in** tool. Zoom in by dragging the stylus along a diagonal that encompasses the desired area.
3. Go to **MDD > Navigation** and make sure the left SDD says **Navigate**.



The Navigate window won't make any sense until you are moving, as there is no internal compass in the Trimble. Position needs to be calculated as changes in XY space are calculated by the GPS receiver.

- a. When close to the target position the location of the GPS is displayed as an "X" and the target as an "O". You will need to move around until you are as close as possible to the desired location ("O"). Make sure you are at least 3 meters from the desired location. If you are having trouble obtaining the desired location within 3 meters, attach the antenna following the instructions in SOP D.
- b. When you have arrived at a targeted point, go to **MDD > Map**, and select **Options > Clear Nav Targets**. Go to **MDD > Data** and click on **Done** and then on **Close** button to exit the points data file. A window will pop up asking: Close this file. Are you sure? Click on **Yes**.



If the unit goes into sleep mode, push the power button again to wake the unit and resume data collection. Make sure to wait until satellites are re-acquired. A warning will pop up; click **Dismiss**. If the GPS unit is not collecting satellites, go to **MDD > Setup** and click the **GPS** button again to reconnect the GPS receiver. Then return to the **Map** screen and resume data collection.

## B.2 Canopy cover assessment

Canopy cover assessment will be based on the National Land Cover Database (NLCD) classification descriptions (Appendix F). Use the NLCD classification to evaluate each plot. The NLCD is divided into two levels; make sure to use both the NLCD classification sheet and the datasheets provided by TOS with previous assessment of the plot to aid in the vegetation assessment (see SOP A).

1. Once within the plot, determine location of 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.
2. Then determine plot Level 1 classification (e.g. Forest, Shrubland). Located in NLCD classification description (Appendix F).

NLCD defines the dominant vegetation stratum by height (i.e. the tallest vegetation is "dominant"). NLCD assesses canopy with aerial views.

3. Within Level 1, now determine Level 2 classification.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D



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

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 Appendix F), acceptance or rejection should be 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.

4. Begin data collection with the Trimble.
  - a. If plot is accepted, place a temporary marker (anchor, flag, etc.) in the center of the plot, and continue with section SOP B.5. Otherwise reject plot (see SOP B.4).



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### B.3 Data File Naming Conventions

Files **must** be named according to the following convention:

Filename begins with the letter D, followed by the two digit number for the domain, followed by an underscore: e.g. **D01\_**

1. Add the four letter site ID followed by an underscore: e.g. D01\_**HARV\_**
2. Add the value denoting Morton Order plot number followed by an underscore: e.g. D01\_HARV\_1\_, D01\_HARV\_1234020\_
3. Add a module letter followed by an underscore: e.g. D01\_HARV\_1\_**T\_**. modules are:
  - “T” to indicate “**T**ower” plot type.
  - “H” to indicate “**P**Henology” plot type.
  - “R” to indicate “**D**ist**R**ibuted Base” plot type.
  - “K” to indicate “**T**ic**K**” plot type.
  - “M” to indicate “**M**ammal” grid.
  - “B” to indicate “**B**ird” grid.
  - “Q” to indicate “**M**os**Q**uito” point.
4. The letters “GPS” to indicate 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.**

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## B.4 Rejected sampling plots

In all cases where a plot is rejected, record the rationale in the corresponding pre-loaded Data Dictionary. 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 FSU at HQ to provide additional plot locations.

A selected plot may be rejected by the field crew if:

- Plot location is in a creek, is too wet (see Appendix D), or presents other geographical features that prevents sampling as specified in the TOS protocol.
- The distributed plot conditions do not match the NLCD vegetation classification. NLCD vegetation doesn't apply to Tower Type A and Type B plots as well as collocated Bird grids.
- Field conditions are deemed unsafe by the field crew.
- Logistical reasons as determined by Field Operations staff; make sure the reasoning is outlined in the comments field of the plot's metadata.
- Tick plots may be rejected if more than 50% the plot perimeter (i.e., 80m of the 160m 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

To record rejected plots follow these steps:

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. Go to **MDD > Data**, and then go to the **SDD** menu and select **New (T)**. -Use data naming conventions (see SOP B.3) -and **add** the corresponding **data dictionary**,
3. Click **Create**.
4. Keep the settings on **File type** (Rover) and **Location** (Default); Click on the **File Name** field, choose an appropriate name and data dictionary. e.g. D10\_RMNP\_1095\_R\_GPS.
5. Change antennae height to 1.000 m
6. Keep Type as GeoXH 6000 Internal and click **OK**, this will set the unit for hiking.
7. Answer all relevant questions in the GPS metadata feature (see section B.6, step 1 in this SOP for metadata fields). Once metadata is completed, **close** feature.
8. **Close** data file; a message will appear: No positions recorded. Do you want to store this feature now? Tap on **Yes**
9. **Close** data file; a message will appear: Close this file. Are you sure? Tap **Yes**.
10. And select next location following the Morton Order.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## B.5 Accepted sampling plots

### 1. 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 crew 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), and
- The plot centroid is shifted  $\leq 3$  meters (10% of the randomly generated RRQRR cell) from the point provided; for more details refer to shifts in the section below. Record compass direction, distance of shift, and rationale in the comments section of the data dictionary. Also make a note on the data sheet that a shift occurred.

Each plot will be saved under **one** data file during each visit. Once a file is created and named, this file will not be closed until all points within the plot are measured (i.e. centroids and all corner and cardinal points) . Alternatively, staff could collect centroids for all plots first and then during another instance delineate and collect the remaining points in a new file. In this instance the second .ssf file created will be labeled DXX\_Sitecode\_MOrder\_Module letter\_GPS\_V2.

## B.6 Shifting and offsetting point locations

*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 and direction to the marked offset from the desired point must be recorded in the comment section of the metadata.

### Centroid points

In the event that a plot centroid must be **shifted**, record the compass direction (azimuth from True North) and distance of the shift, and the rationale for the shift in the metadata; then 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.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## 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  $\leq 0.5$  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  $\leq 0.5$  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 FSU at HQ.

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.

### 1. Metadata collection

Metadata is collected with the GPS by creating a NEW file that will ultimately contain ALL metadata and any GPS coordinates collected after delineation. The expected workflow starts with metadata collection > plot delineation and marking> collect GPS data. Use the appropriate GPS data dictionary and plot ID labeling (Appendix D).

To collect metadata use the following instructions:

- a. 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**.
- b. 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)**.
- c. Keep the settings on **File type** (Rover) and **Location** (Default); Click on the **File Name** field and choose an appropriate name. Refer to the 'Data File Naming Guidelines' (SOP B.3) of this protocol for naming convention.
- d. In **Dictionary Name** choose the GPS data dictionary that is appropriate for the given site and task.
- e. Click **Create**.
- f. Change antennae height to **2.000 m**
- g. Select Type as **antenna model 2** and click **OK** (Do not set up the antenna at this point).
- h. **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:

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

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



All GPS data dictionaries will contain a set of features; you will need to go through all of them.

- i. Go back to the MDD>**Data** screen; once the new file is created open the **metadata feature**. The following includes all fields across GPS data dictionaries reflected in the **metadata** feature. All or a subset of these questions will be in the corresponding GPS data dictionary:
  - **Date:** Click on the drop down menu and choose the corresponding date.
  - **Operator Name:** click on the blank space below and the keyboard should appear, write down the initials of the two crew members.
  - **Morton Order:** on the list of plot find the corresponding plot Morton Order number and record it.
  - **NLCD Vegetation:** click on the drop down menu and select the vegetation subclass information that has been predetermined by NLCD and vetted by remote sensing validation specialists.
  - **Site Vegetation:** after a team analysis of the canopy percent cover, come up with the existing vegetation category and record it.
  - **Percent Cover:** NLCD Percent Cover: i.e. 55 deciduous forest 45 evergreen forests.
    - Make sure that the addition of the percentages add to 100%. Account for the highest strata only (i.e. if there is an evergreen, deciduous upper canopy and a shrub lower canopy, only account for the higher stratum for your percent cover—see section B.2).
  - **Plot Accepted:** if the NLCD vegetation is the same as your team’s assessment site vegetation then click on **YES** to accept the plot, otherwise select **NO**. When No is selected, several fields will recede from view, at this point click Done and close the feature.
  - **Tree Cover: assess cover based on bird’s eye view,** select from the drop down.
  - **Saplings and shrubs cover: assess cover based on bird’s eye view,** select from the drop down. For example, if the entire understory of a plot is shrubs but 50% of the plot is covered by tree cover than the sapling and shrubs cover will be 50%.
  - **Herbaceous cover: assess cover based on bird’s eye view,** select from the drop down.
  - **Slope:** standing at the centroid, select the steepest slope to any of the following point IDs: 49, 50, 51, 40, 42, 31, 32, 33. Use the rangefinder RD[19] to measure angle.
    - If the steepest slope point does not have a line of sight, choose the next location that has a line of sight and is the closest to the steepest slope in the

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- If there isn't a line of sight to any of the point IDs targeted, find a line of sight that brings you the closest to any of the previously mentioned point IDs; for example, a line of sight between the centroid and 5 meters towards point ID 32.
  - Slope Azimuth: this is the azimuth of the slope inclination previously made, use rangefinder, RD[19].
    - With TruPulse 360R Laser Rangefinder still at low end of slope and reflector at the high end, change measurement mode to **AZ**.
    - Measure azimuth (degrees)
      - If the slope is 0 the azimuth is not required.
  - **Comments:** add any pertinent comments, for example 'plot has several fallen tree trunks.' *If* there are potential obstructions that can affect GPS measurements make note of azimuth and description of obstruction object.
  - **Photos (camera icon):** When prompted use the Trimble to take a photo towards the plot centroid or for the phenology transect clockwise towards the next point on the transect. Be sure that photos are clear and portray the landscape only (i.e. no technicians or backpacks).
- j. Click **Done** to store data. Close the feature but **NOT** the file. A message should appear: "No positions recorded. Do you want to store this feature now?" click **Yes**. If the data file is accidentally closed follow instructions in **below**.

#### How to Access an Existing Closed Data File



1. Go to MDD>Data and SDD>Existing files
2. Look for the desired existing file
3. Click on the file
4. Click Open on the lower left of the screen

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## SOP C Plot Delineation and Marking

The following procedure contains instructions followed by a bracketed number [#] that refers to the pointID. Plot pointID numbering is available in Appendix D and delineation schematic in Appendix G. We recommend using the diagrams provided in appendices previously outlined while conducting plot delineation.

### BEFORE GETTING STARTED

- **Check compass and TruPulse 360R Laser Rangefinder declination.** Make sure the compass and TruPulse have their declination set appropriately for the geographic location. Declination changes through time so must be looked up annually for a given location.
  - Magnetic declination adjustment values are available at <http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp>
- **Calibrate TruPulse 360R Laser Rangefinder internal compass against compass.** Ensure that the internal compass of the Rangefinder has been properly calibrated by checking it against a standard mirror-site compass in more than one direction.
  - If the internal compass of the TruPulse is not accurate, follow the calibration steps listed in the ‘Configuring the rangefinder’ topic in RD[19].
  - When checking compass calibration, take care that no metal objects are within 18 inches of the compass or the Rangefinder– i.e. plot markers, watches, etc.
  - The magnetic environment around certain buildings will completely prevent accurate compass calibration in the Rangefinder.
- **General Rules**
  - **Measurements:** The goal is to create plots of constant area when viewed from the air. Use tape measure to delineate the plot unless site conditions make using the tape impractical (e.g. steep slope, dense understory). If using tape measure is not possible, use the rangefinder to delineate the plot. Use the rangefinder in slopes over 20%. When establishing a plot where the slope of the ground is greater than 20%, measuring a distance of 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 has to go around large trees or over/below brush, see obstruction methods in Appendix I When making delineation measurements, make sure the distance measured is exactly as desired (e.g. if 10.0 m).
    - Gullies and hills will, if large enough, require use of the rangefinder in order to meet this requirement.
  - **Verification:** when using the tape measure to delineate, use the Rangefinder to verify measurements. If the rangefinder is used to make measurements verify the distance by measuring from different angles/locations.
    - ***It is required that verification measurements are within ±1 degree for the azimuth and ±0.3 meters for the distance.*** For example, if the instrument is verifying a horizontal

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

distance measured previously with the tape of 10.0 m, the rangefinder values for verification should be between 9.7 and 10.3 meters to accept the verification.

• **Plot delineation reminders:**

- Always make sure the internal compass of the rangefinder is properly calibrated and declination is properly set before beginning.
- **Always keep metal objects (including flags, chaining pins, cell phones, watches, jewelry etc.) at least 2 feet away from the rangefinder when using the internal compass.**
- 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.

Bring the Log Sheets (Appendix A) and to fill them out once a plot has been delineated.

Although plots are a variety of sizes all follow a combination of the following four delineation workflows. Tower base plots, distributed base plots, and tick plots must all be delineated. Phenology transects, bird girds, mammal grids, and mosquito sampling points all involve using pre-loaded points in the Trimble to place markers on the ground. This delineation process is outlined based on a two person crew:

- Person 1 holds the rangefinder and measures angles and distances and
- Person 2 holds the reflector.

Both crew members should have tapes, a handful of flags and of chaining pins.

1. **Establishing Cardinal Positions- 10m**

- a. Person 1, stand at the centroid with the TruPulse and tape anchored at centroid [41]
- b. Person 2, take a compass bearing North (360/0°) and walk unspooling tape to 10m [50]
- c. Person 2, turn toward centroid, hold up reflector (away from face) directly above tape at 10m for Person 1
  - 1) Person 1, shoot azimuth and distance to reflector, fine tune Person 2 to the targeted azimuth position (e.g. 180°), then verify measurement including the instrument error of ±1 degree.
  - 2) Person 2, place a flag at the 10m N point [50]

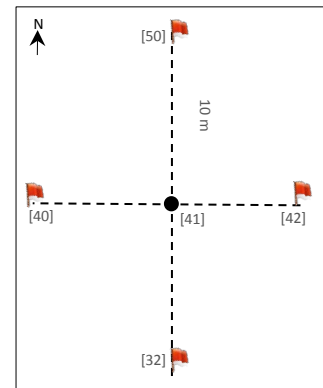


Figure 3. Plot Delineation step 1

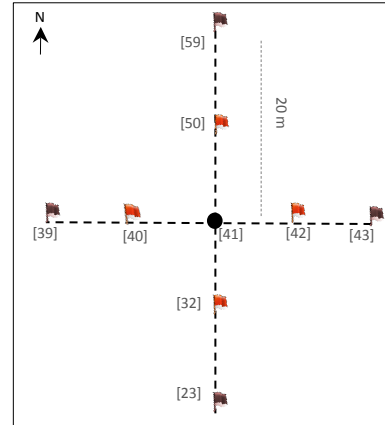


Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- d. Spool the tape to the centroid and complete repeat steps a-c for the remaining cardinal directions: South [32] 180°, East [42] 90°, West [40] 270°.

**2. Establishing Cardinal Positions- 20m**

- a. Person 1, stand at the centroid with the rangefinder and tape anchored at centroid.
- b. Person 2, take a compass bearing North (360/0°) and walk unspooling tape to 10 meters [50]
- c. Person 2, turn toward centroid, hold up reflector (away from face) directly above tape at 10m for Person 1
  - 1) Person 1, shoot azimuth and distance to reflector, fine tune Person 2 position
  - 2) Person 2 place a flag at the 10m N point [50],
- d. Continue 10m N to establish the 20m N point [59]



**Figure 4.** Plot Delineation step 2

- 1) Person 1, stand at point [50] with the TruPulse and tape still anchored at the centroid [41]
- 2) Person 2, take a compass bearing North (360/0°) and walk unspooling tape to 20m [59]
- 3) Person 2, turn toward point [50], hold up reflector (away from face) directly above tape at 20m for Person 1
- 4) Person 1, shoot azimuth and distance to reflector, fine tune Person 2 position
- 5) Person 2 place a flag at the 20m N point [59]
- e. Spool the tape to the centroid and complete repeat steps a-d for the remaining cardinal directions at both 10m and 20m : South [32] & [23] 180°, East [42] & [43] 90°, West [40] & [39] 270°.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### 3. Establishing 20m by 20m corners

- a. Establish North 20m x 20m plot corners (Appendix E and Appendix G)
  - 1) Person 1 and Person 2 each anchor a tape at East [42] and West [40] respectively with a chaining pin.
  - 2) From points [42] and [40], each person walks north (estimate visually) 10m
  - 3) Place chaining pins at the NE and NW corners [51] & [49], wrap tapes around pins
  - 4) Turn 90 degrees toward the center line [50] (meet in the middle)
  - 5) Anchor tape at 20m
  - 6) Adjust corners [51 & 49] so that both sides of the tape are taut and the pins are placed precisely at 10m
  - 7) Once the tape is properly placed, mark corners [51 & 49].

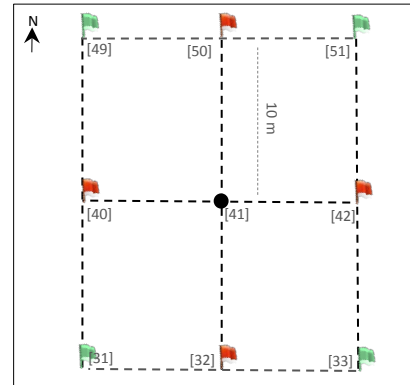


Figure 5. Plot Delineation Step 3

- b. **Verify north layout of 20m x 20m plot**
  - 1) Person 1 stand at NW corner [49], Person 2 move to center [41]
    - a) Person 1 measure horizontal distance between the NW plot corner and the centroid. Diagonal should measure  $14.14 \pm 0.3$  meters.
- c. Repeat at NE corner [51]
- d. Spool tapes
- e. **Establish south 20m x 20m plot corners** (Appendix G)
  - 1) Facing south from points [42] and [40], follow step 1 above to establish SE [33] and SW [31] corners.
- f. **Verify south layout of 20m x 20m plot**
  - 1) To verify southern layout, follow step 2 above to verify SE [33] and SW [31] corners.

### 4. Establishing 40m by 40m corners

(Appendix E and Appendix G). The remainder of the plot may be completed relying on the tapes, only using the TruPulse to verify diagonal distance.

- a. Anchor 2 tapes to NW corner [49]
- b. Walk one tape 10m North [58], verify with the Range Finder shoot azimuth ( $360^\circ$ ) and 10m distance.
- c. Place chaining pin on tape at the 10m.
- d. Walk the other tape from NW corner [49] to the West [48] 10m, verify with the Rangefinder shoot azimuth ( $270^\circ$ ) and 10m distance.
- e. Place chaining pin on tape at the 10m.

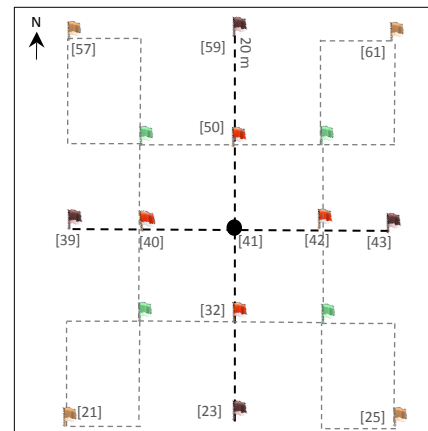


Figure 6. Plot Delineation Step 4

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- f. Wrap both tapes around 90 degrees, walk toward Northwest most corner [57]
- g. Clamp both tapes at 20m intersecting the tapes at Northwest corner [57]
- h. To verify layout, stand at corner [57] and shoot the Rangefinder HD back from corner [49]; the distance should = 14.14m
- i. Adjust if needed
- j. Flag point
- k. Repeat steps to establish remaining points:
  - 1) [51], [60] & [52] → [61]
  - 2) [33], [34] & [24] → [25]
  - 3) [31], [30] & [22] → [21]

### C.1 Tower Plots

Tower plot dimensions depend on vegetation type and will be listed on the site datasheet.

#### 20m by 20m Tower Plot

1. Follow: Establishing Cardinal Positions- 10m (Step 1)
2. Follow: Establishing 20m by 20m corners (Step 3)
3. Leave markers and collect GPS points at [41], [49], [51], [31], [33]. See SOP B.5 for guidance on offsetting markers.
4. Use the GPS to take photos facing toward center from points [49], [51], [31], [33].
5. Fill out log sheet (Appendix A)

#### 20m by 20m Tower Plot with 40m corners for Soil Sampling

1. Follow: Establishing Cardinal Positions- 10m (Step 1)
2. Follow: Establishing 20m by 20m corners (Step 3)
3. Follow: Establishing 40m by 40m corners (Step 4)
4. Leave markers and collect GPS points at [41], [49], [51], [31], [33], [57], [61], [21], [25]. See SOP B.5 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 (Appendix A)

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### 40m by 40m Tower Plots

1. Follow: Establishing Cardinal Positions- 20m (Step 2)
2. Follow: Establishing 20m by 20m corners (Step 3)
  - Suggestion: Flags may be left at all 20x20m corners within 40m tower plots (where sites permit), until tower plots with plant diversity sampling are accepted.
3. Follow: Establishing 40m by 40m corners (Step 4)
4. Leave markers and collect GPS points at [41], [57], [59], [61], [43], [25], [23], [21], [29]. See SOP B.5 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 (Appendix A)

### 40m by 40m Tower Plots with 20m corners for Plant Diversity Sampling

1. Follow: Establishing Cardinal Positions- 20m (Step 2)
2. Follow: Establishing 20m by 20m corners (Step 3)
3. Follow: Establishing 40m by 40m 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.5 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 (Appendix A)

## C.2 Tower Phenology Transect

Located within the tower airshed (RD[09]). See workflow sheet at Appendix D.

1. **Primary Phenology Transect:** 8 points every 100 meters around square transect.
  - a. **Navigate to preloaded points** with GPS receiver.
  - b. **Place primary markers at the SW and NE points, the remaining points require secondary markers.**
  - c. **Collect GPS points** (refer to SOP B.5)
  - d. **Marker type and labeling** instructions located in Appendix D. See SOP B.6 for guidance on offsetting markers.
  - e. Fill out log sheet (Appendix A)
2. **Secondary Phenology Transect:** line contains three points. Not applicable for all sites (refer to tower data sheet in FOPS folder).
  - a. **Navigate to preloaded points.** Place primary marker at SW corner, remaining points require secondary markers.
  - b. **Collect GPS points** (refer to SOP B.5)
  - c. If possible, place temporary flags as needed along transect to visually guide phenology sampling efforts. For more details, refer to RD[09].

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- d. **Marker type and labeling** instructions located in Appendix D. See SOP B.6 for guidance on offsetting markers.
- e. Fill out log sheet (Appendix A)

### C.3 Distributed Plots

#### Distributed Base Plot

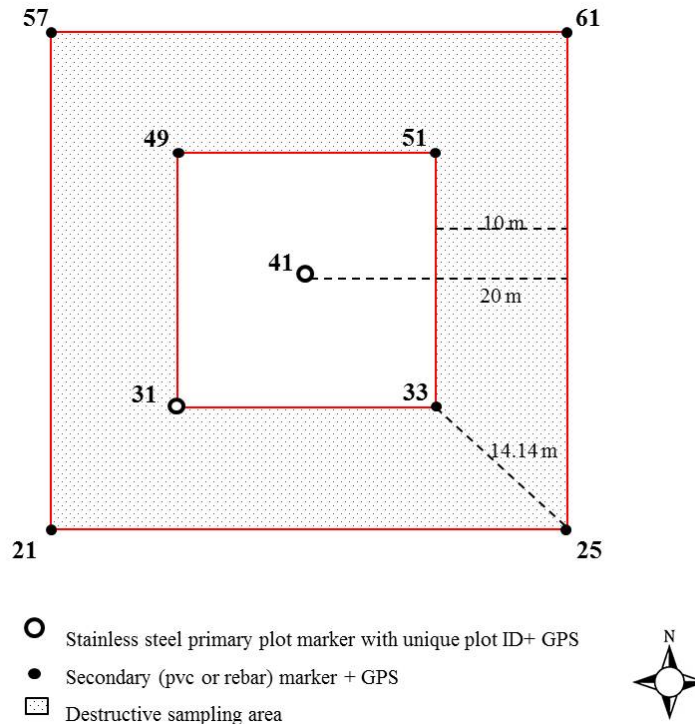
1. Follow: Establishing Cardinal Positions- 20m (Step 2)
2. Follow: Establishing 20m by 20m corners (Step 3)
3. Follow Establishing 40m by 40m corners (Step 4)
4. Leave markers and collect GPS points at [41], [49], [51], [33], [31], [61], [25], [21], [57]. See SOP B.6 for guidance on offsetting markers.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

#### Distributed Tick Plots

**Once at the plot verify that at least 50% of the plot perimeter** (i.e., 80m of the 160m 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].

1. Follow: Establishing Cardinal Positions- 20m (Step 2)
2. Follow: Establishing 20m by 20m corners (Step 3)
3. Follow: Establishing 40m by 40m corners (Step 4)
4. Leave markers and collect GPS points at [41], [57], [61], [25], [21]. See SOP B.6 for guidance on offsetting markers.
5. Fill out log sheet (Appendix A)

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D



**Figure 7.** Plot layout and marker positions for 40 m by 40m Distributed Base Plots

### Distributed Mammal Grid

See workflow in Appendix D.

1. **Locate the desired plot centroid** with GPS receiver, using pre-loaded waypoints and/or data files.
2. **Mark the plot centroid.** See SOP B.6 for guidance on offsetting markers.
3. **Locate the plot corner** with the GPS receiver, using pre-loaded waypoints and/or data files. See SOP B.6 for guidance on offsetting markers.
4. **Mark plot corner**
5. **Repeat steps 3-4 for remaining corners.**
6. **Set up grid before sampling** as outlined in Small Mammal protocol.
7. Fill out log sheet (Appendix A)

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### Distributed Bird Grid

See workflow in Appendix D.

1. **Locate the desired plot centroid** with GPS receiver, using pre-loaded waypoints and/or data files.
2. **Mark the plot origin**, if the latter is not yet available use a temporary marker. See SOP B.6 for guidance on offsetting markers.
3. **Collect GPS point**
4. **Bird Grid preloaded points will be provided for use when sampling.**
5. **Marker type and labeling** instructions located in
6. Fill out log sheet (Appendix A)

### Distributed Mosquito Sampling Point

See Workflow in Appendix D.

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 5m from a road and a maximum distance of 45 m.
  - b. **Shift the point** within 10m 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 40m by 40m 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 by 40 m plot is road, exclude this 30% and assess the plot based on the remaining 70%.
  - d. **Fill out** the data dictionary
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 (Appendix A)

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**SOP D Collect GPS coordinates**

After delineating a plot, GPS coordinate collection follows. To collect highly accurate coordinate set up surveyor style standing GPS system (Figure 8):

1. Monopole set up:
  - a. Set up monopole directly on top of the point to be measured
  - b. Add bipod legs to ensure stability.
2. Connect the antenna and GPS:
  - a. Connect cable to the antenna.
  - b. Screw antenna to the top of the monopole.
  - c. Connect the other end of the antenna cable to the GPS unit; connector is located in the upper right side of the unit.
  - d. Open the monopole clamp and attach it to the monopole.
  - e. Open the GPS clamp and attach it to the GPS unit.
  - f. Attach the GPS clamp to the quick release mount in the monopole clamp.
  - g. Make sure the system remains stable.



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



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**Table 6.** Points to be logged by FOPS (also see workflow for each plot type in Appendix D).

Plot_Type	Sub_Type	Module	Provided by FSU	GPS points collected by FOPS for Post Processing	Total Points
Distributed	Base	Base	Centroid	Centroid, 4 corners of 20m plot, 4 DSA corners (40m)	9
Distributed	Collocated	Mammal	Centroid, corners	Centroid	1
Distributed	Collocated	Bird	Centroid, 9 pt grid (includes centroid)	Centroid	1
Distributed	Collocated	Mosquitoes	Centroid	Centroid	1
Distributed	Collocated	Ticks	Centroid, 4 Corners	Centroid and 4 Corners	5
Tower	Type A	Tower-40m by 40m	Centroid	Centroid, 4 outer corners, 4 cardinal points	9
Tower	Type A	Tower- 40m by 40m with plant diversity	Centroid	Centroid, 4 outer corners, 4 inner corners, 4 cardinal points	13
Tower	Type A	Tower-20m by 20m	Centroid	Centroid, 4 corners	5
Tower	Type A	Tower- 20m by 20m with DSA corners	Centroid	Centroid, 4 inner corners, 4 outer corners	9
Tower	Type B	Phenology 1H	8 pts on transect	8 points along transect	8
Tower	Type B	Phenology 2H	3 pts	3 pts	3

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### 3. Acquire GPS location

#### a. Begin the collection of the first point within the plot:

- 1) Open the first feature of the current file (generally centroid point or other origin point is the first)

To ensure High-Accuracy Logging

Make sure your values are:

- Position Dilution of Precision (PDOP) is  $\leq 6$ .
- The signal to Noise Ratio (SNR) should be  $\geq 4$ .
- Number of satellites used  $\geq 4$ .

These measurements are located on the bottom right of the **MDD > skyplot** in the TerraSync software on the Trimble unit.

- 2) Allow the GPS to log positions (note the logging symbol in the upper right side of the screen). Depending on the canopy cover choose the appropriate action:

- **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 Box 1) and collect the 120 logs regardless of accuracy. Once you are back at the domain office please contact NEON spatial ecologists at HQ and provide the list of plots with this issue.
- **Semi-open and closed canopy:** record GPS data for at least 300 logs using the accuracy-based logging feature.
  - 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. Once you are back at the domain office please contact NEON spatial ecologists at HQ and provide the list of plots with this issue.



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 HQ (when available).

- For all canopy conditions:
  - 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

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

scroll to **Status** in the upper left drop down and the scroll to **Receiver** in the lower left drop down menu.

- 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.



This feature is already enabled if you completed the GPS Setup in Appendix B.

4. Tap **Done** to store data. Close the feature but **NOT** the data file.
5. The following screen should return to the display all features that a required to be completed for the plot at work. If the data file is accidentally closed follow instructions in Box 6.
  - a. There are several scenarios that could follow. Select the appropriate one:
    - If you are at the center point, once this first point is collected and the feature is closed move the monopole to next feature.

*Or*


    - If a picture follows the work flow, you can take the picture while the GPS is attached to the monopole. Make sure pictures are always taken facing the center of the plot. To take a picture open the photo feature, **tap** on the **photo icon** to the right of the blank box. To take the picture **tap** on the physical **camera button** located towards the bottom center of the GPS underneath the screen. Once a photo is taken tap **OK/Done**.

*Or*

    - 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.
      - *Optional:* To quickly verify that all required points have been collected, before closing the file:
        - Use the MDD to view the Map.
        - Zoom to the area where your plot is located.
        - Visually confirm that all features have been collected (each logged feature will be displayed as an “X” on the map)
        - Photo icons will only be displayed if logs were taken while the photo feature is open, which will not always be the case

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**Box 1. Disable 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.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## SOP E Data Entry and Verification

As a best practice, field data collected on paper datasheets should be digitally transcribed and transferred to the shared folder for post-processing by FSU 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:

- Transfer data from GPS handheld to computer (see section SOP E.1).
- Update all fields in the FOPS drive for:
  - XX\_X\_TOS\_Plots\_Datasheet (e.g. 05\_C\_TOS\_Plots\_Datasheet). The naming convention and format of this document are subject to change.
- If it is the first day of collection under a closed or open canopy forest, through e-mail, notify HQ that there is data available for post processing.

### E.1 Transferring data from GPS handheld to PC

1. **Open** Pathfinder Office software
2. **Open** the previously created project (see 0.4).
3. Pathfinder does **not** save previously set coordinate systems, make sure to update the coordinate system when transferring and verifying data, see SOP A.4 for details.
4. Connect the Trimble to the computer with the USB cable, and power on the unit.
5. The Windows Mobile Device Center (Win7 or Vista) should pop-up displaying a connection of the device to Windows. Select “Connect without setting up my device.”
6. Within Pathfinder Office, use the **Data Transfer** utility to transfer the .ssf file to the Trimble:
  - a. Go to **Utilities > Data Transfer...** and in the window that opens, click the “**Receive**” tab and then click **Add...** and select **Data File** from the list and click **Open**.
  - b. After selecting all data files relevant to all the new plots recorded, click **Transfer All**.
7. The .ssf files will be transferred automatically. Make sure all files are transferred to the shared folder. Head Quarter scientist will post process the data files.



If certain points don’t meet the accuracy threshold of 30 cm or less, the corresponding points will have to be re-measured.

8. Once data have been transferred, disconnect GPS from the computer.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## E.2 Data Verification

Once the data is transferred complete the following quality checks:

1. Make sure that the **data file is correctly named**, see SOP B.3. To view filenames go to the folder where files were downloaded.

If the filename is incorrect, make sure that the name is changed in the GPS unit before transferring the data to the computer. This ensures that the original, backup, and photo files all follow the same naming convention.

- a. Turn on the GPS unit
- b. Open the Terra Sync Software
- c. Once in Terra Sync, tap on the MDD (Main Drop Down) menu located to the upper left side of the screen and select **Data**.
- d. Tap on the SDD (Sub Drop Down) menu located beneath the MDD and select **Manager**.
- e. Below the SDD there should be a box with the list of existing data files, select the file to be renamed.
- f. Once the file is selected, tap on the options menu located parallel to the SDD in the upper right side of the screen and select the **Rename** option.
- g. The screen will display the file in question highlighted
- h. Edit the datafile name
- i. Once the rename is complete, tap outside of the filename highlighted area and this should establish the new name of the file.
- j. Once the datafile name is modified, transfer the file to the computer through the Pathfinder transfer tool (see SOP E.1 for instructions)
- k. Make sure that the incorrectly named files are deleted from the shared folder.
2. Make sure the **spatial location of the point ID is accurate**, for example: point ID 41 should be in the center of the plot. To do this spatial check open the .ssf file in pathfinder office. To view the spatial location go to the main pane of Pathfinder and click on **View** > click on **Map**. To view the pointID in the file go to the main pane and click on **Data** > then click on **Feature Properties**.

If the point ID is incorrect make sure an e-mail is sent to the FSU at HQ with both the incorrect pointID and the intended pointID.



3. . Send your FSU point person an e-mail to notify them about the added data ready for post processing.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### E.3 Post-hoc mission analysis: Working for higher accuracy in challenging locations

Once the collected GPS data are sent to HQ, they will be post processed and assessed to determine if points meet the accuracy standards. Field technicians will recollect any data that require re-measurement. If re-measurement is required the mission planning can be a useful tool to make sure that measurements will be collected at the best time of the day. Please complete the following steps for mission planning when re-measurement occurs:

1. Go to <http://www.trimble.com/GNSSPlanningOnline/#/Settings>
2. To begin, click on the **Setting** link located in the upper left side of the window:
  - a. Add the latitude and longitude of one of the plots within the site to visit. Look in Appendix C for the latitude and longitude.
  - b. If the challenging areas are located close to obstructions like mountains, cliffs, or valleys use the **Obstructions** tool to define the open sky area available (Figure 9). Make sure the azimuth where the obstruction occurs is acquired. For example if there are mountains within sight located at 95° azimuth and 20° elevation:
    - 1) Start by clicking on the **blue circumference** on the area around 95° where the obstruction occurs. The blue circumference (represents a clear sky view) will allow the modification of the view. Modifying the blue circumference to align with the actual sky view available at a particular location of measurement will allow for a better assessment of satellite availability.

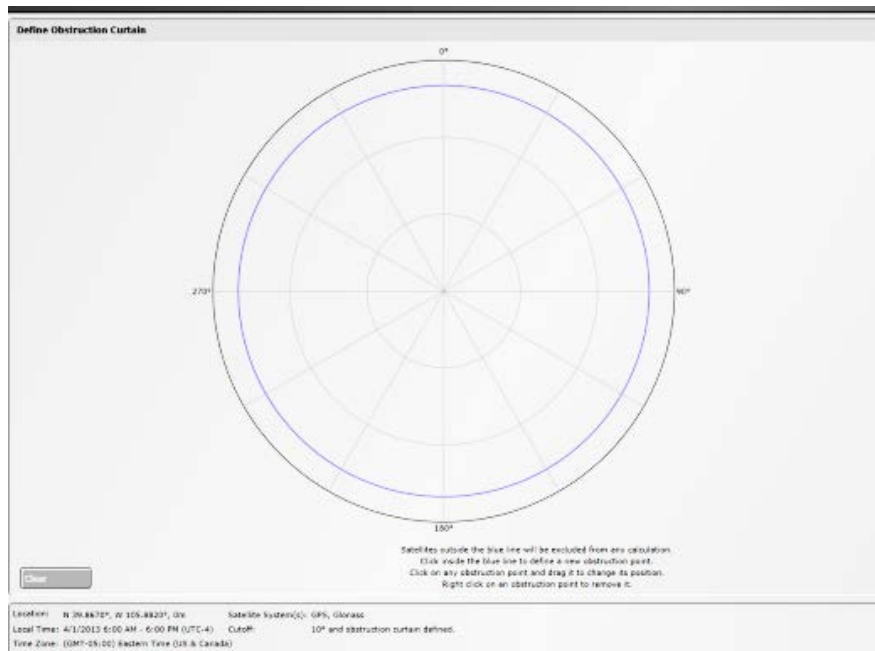


Figure 9. The Obstructions tool within the Trimble Mission Planning web-based software

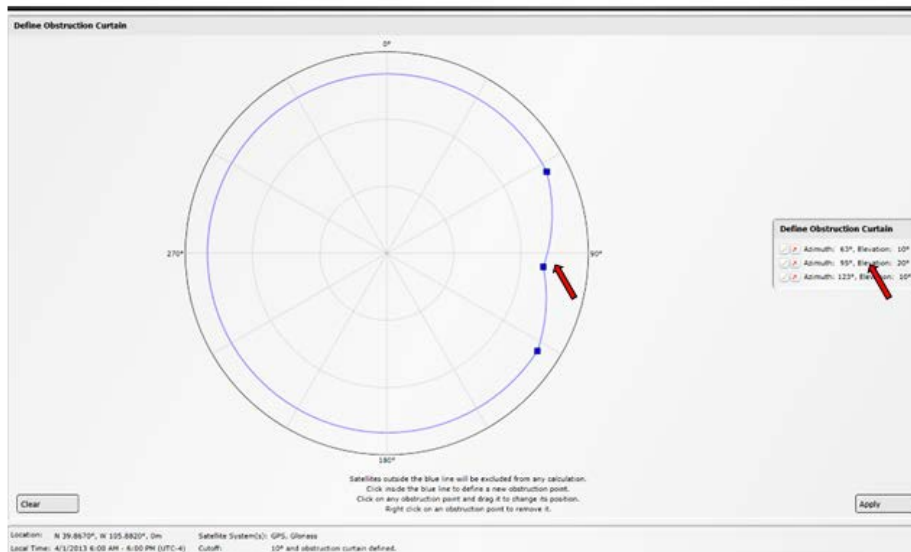
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

2) After clicking on the line, several nodes should appear. There are two ways to apply the azimuth and elevation to the central node:

- To the right center of the screen there should be three items representing the three nodes, with specs on the azimuth and elevation. Click on the pencil icon in the second item (should represent the central node) and type the azimuth and elevation, press **Enter**, the obstruction curtain should be recorded.

Or

- **Drag the center node to 95°**. Once the node is in the right place, use the same center node and **drag it inward**, to a window should appear to the right and the second item should reflect the azimuth and elevation of the moving target. Make sure that the node ends up at 95° azimuth and 20° elevation. Don't worry about the outer nodes unless the width of the obstruction is significantly different than the one shown on the circumference (Figure 10).



**Figure 10.** Adding an obstruction observed in the field within the Trimble Mission Planning software.

3) Once the desirable obstruction curtain is created click **Apply** and an updated satellite histogram should be created.

- Select the field **Day**
  - Select the starting time or **Visible Interval** and the time span in hours (generally a 6 or 12 hour span).
  - Select the appropriate **Time Zone**.
  - Click **Apply**
3. Click on the **Satellite Library**
- Click on the **GPS** and the **GLONASS** satellite libraries; unclick the rest of the satellite libraries.



<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

4. Click on the **Number of Satellites**

This histogram will display the number of satellites (GPS and GLONASS) available on the day and times previously set up in the settings window. The higher the number of satellites available, the better the accuracy will be. This graph will allow field workers to know when the best times to establish challenging plots may or may not be.



If there is a time in the day where satellite availability is poor, take this time to hike or do activities other than collecting coordinates.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## SOP F Re-measuring GPS locations

If a point does not meet the required accuracy the first time around, the following steps will be used either separately or in combination during subsequent re-measurements. In most cases FOPs will be asked to attempt re-measurement up to 4 times.

1. Wait until leaf off canopy
  - 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 amount logs. In some cases this could be as many as 800 to 1000 logs per high-accuracy point.
3. Utilize mission planning
  - Even one or two additional satellites can make a huge different in reaching 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.

- In open canopy make a new file, click create, confirm the antenna height, and choose point generic.
- 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.
  - Two minutes of carrier time might take longer than two minutes to acquire
- Once you reach two minutes, hike to the point that will be re-measured without closing the file you just created.
- At the point log the appropriate number of logs and pause the logging.
- Without clicking “done” or closing the file return to the open canopy area and wait until two minutes of carrier time is obtained.
- Close the file.

<i>Title:</i> TOS Protocol and Procedure: Plot Establishment		<i>Date:</i> 02/23/2015
<i>NEON Doc. #:</i> NEON.DOC.001025	<i>Author:</i> E. Azuaje	<i>Revision:</i> D

**SOP G    Sample Shipment**

This protocol generates no samples for shipment.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## 8 REFERENCES

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Luo, Y. Q., K. Ogle, C. Tucker, S. F. Fei, C. Gao, S. LaDeau, J. S. Clark, and D. S. Schimel. 2011. Ecological forecasting and data assimilation in a data-rich era. *Ecological Applications* **21**:1429-1442.

Schimel, D., M. Keller, S. Berukoff, R. Kao, H. Loescher, H. Powell, T. Kampe, D. Moore, W. Gram, D. Barnett, R. Gallery, C. Gibson, K. Goodman, C. Meier, S. Parker, L. Pitelka, Y. Springer, K. Thibault, and R. Utz. 2011. 2011 science strategy: Enabling continental-scale ecological forecasting.

Thompson, S. K. 2012. *Sampling*. Wiley, New Jersey.

Vitousek, P. M. 1997. Human domination of Earth's ecosystems (vol 277, pg 494, 1997). *Science* **278**: 21-21.

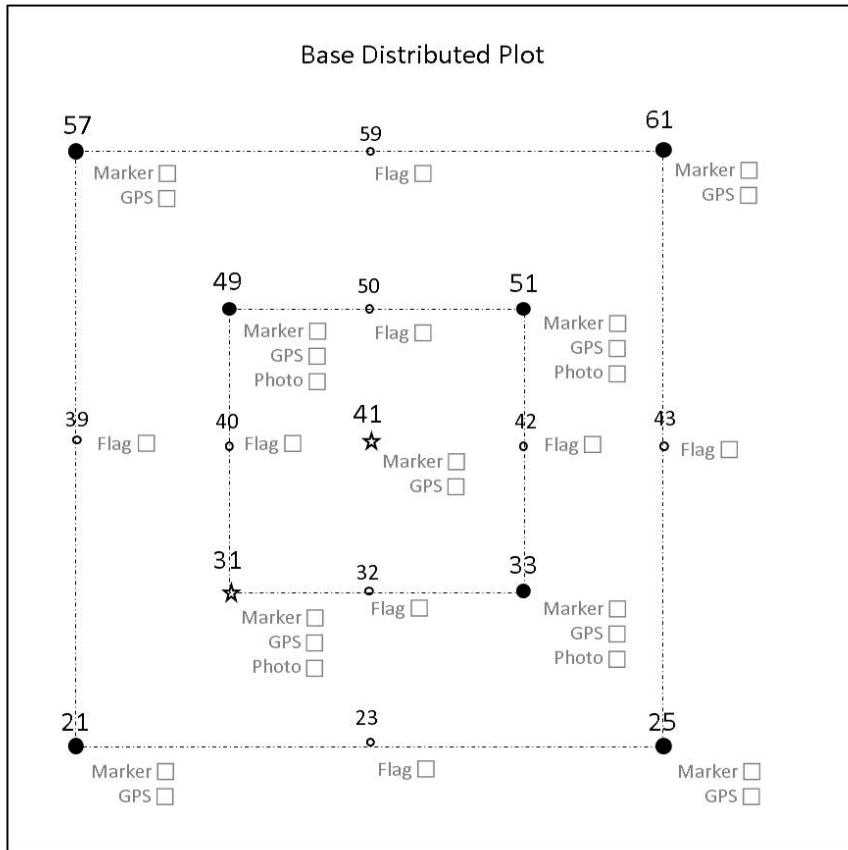
TerraSync Software Getting Started Guide. Trimble Version 3. Revision A, 30:33.

## APPENDIX A LOG SHEETS

### A.1 Distributed Base Plot Log Sheet

Base distributed plot  
 Domain \_\_\_\_\_ Site \_\_\_\_\_  
 Morton Order \_\_\_\_\_ Plot ID \_\_\_\_\_

Date accepted \_\_\_\_\_  
 Trimble GPS used \_\_\_\_\_  
 Tech names \_\_\_\_\_  
 Plot nickname \_\_\_\_\_  
**Please mark box when each step is completed.**



Note: Pin flags (or equivalent) not required by protocol, but helpful.

Comments or mission planning notes:

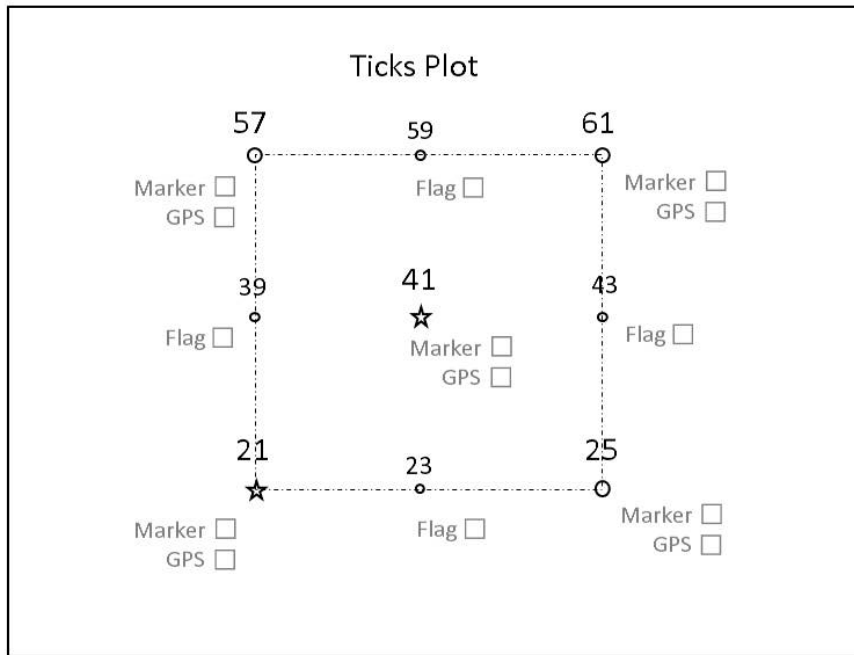
Key	61 <b>Example:</b>
★ Primary Marker	Marker <input checked="" type="checkbox"/>
● Secondary Marker	GPS <input checked="" type="checkbox"/>
○ Flag	Photo <input checked="" type="checkbox"/>

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## A.2 Tick Plot Log Sheet

Distributed plot  
 Domain \_\_\_\_\_ Site \_\_\_\_\_  
 Morton Order \_\_\_\_\_ Plot ID \_\_\_\_\_

Date accepted \_\_\_\_\_  
 Trimble GPS used \_\_\_\_\_  
 Tech names \_\_\_\_\_  
 Plot nickname \_\_\_\_\_  
**Please mark box when each step is completed.**



Note: Pin flags (or equivalent) not required by protocol, but helpful.  
 Comments or mission planning notes:

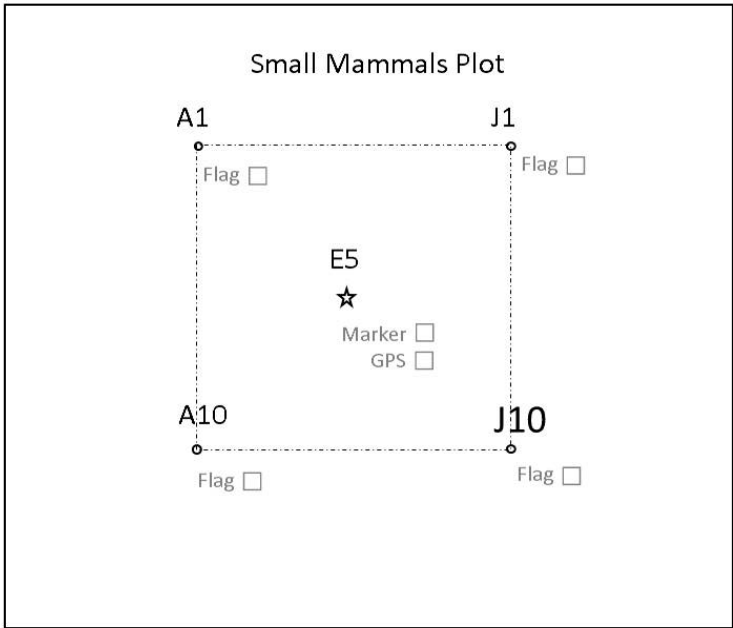
Key	
★ Primary Marker	
○ Secondary Marker	
◦ Flag	
41 <b>Example</b>	
★	
Marker <input checked="" type="checkbox"/>	
GPS <input checked="" type="checkbox"/>	

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.3 Small Mammal Log Sheet

Distributed plot  
 Domain \_\_\_\_\_ Site \_\_\_\_\_  
 Morton Order \_\_\_\_\_ Plot ID \_\_\_\_\_

Date accepted \_\_\_\_\_  
 Trimble GPS used \_\_\_\_\_  
 Tech names \_\_\_\_\_  
 Plot nickname \_\_\_\_\_  
**Please mark box when each step is completed.**



Have pin flags (A1 through J10) been installed?   
 Comments or mission planning notes:

Key

- ★ Primary Marker
- Flag

**E5 Example**

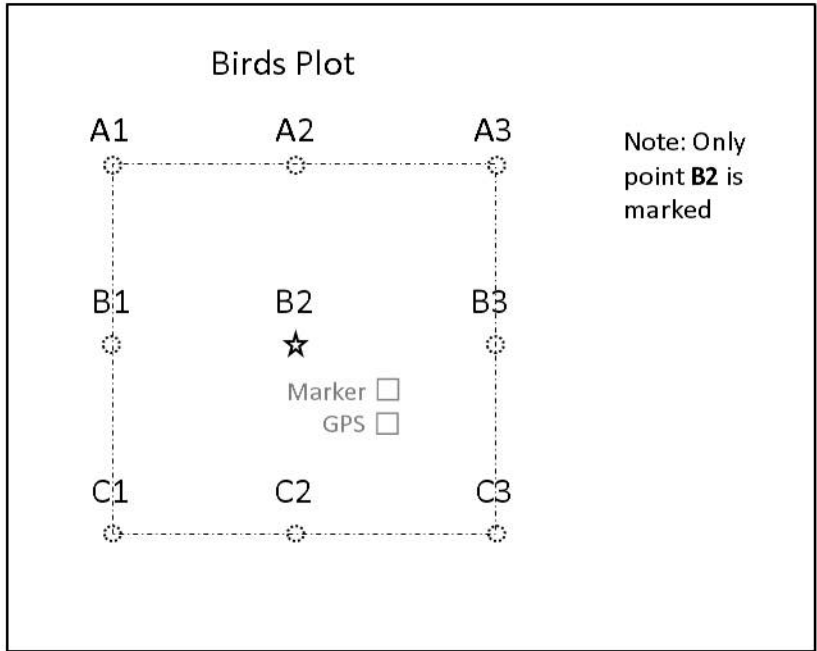
- ★
- Marker
- GPS

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.4 Bird Log Sheet

Distributed plot  
 Domain \_\_\_\_\_ Site \_\_\_\_\_  
 Morton Order \_\_\_\_\_ Plot ID \_\_\_\_\_

Date accepted \_\_\_\_\_  
 Trimble GPS used \_\_\_\_\_  
 Tech names \_\_\_\_\_  
 Plot nickname \_\_\_\_\_  
**Please mark box when each step is completed.**



Comments or mission planning notes:

**B2 Example**

★

Marker    
 GPS

**Key**

★ Primary Marker  
 ○ No Marker



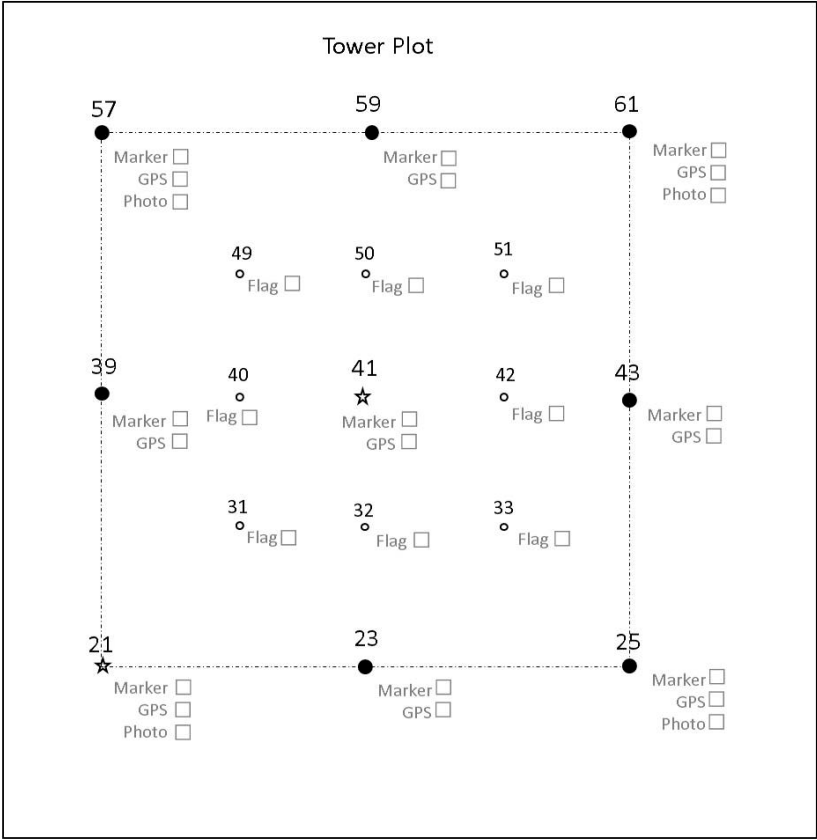


Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.6 Tower Plot

Tower plot  
 Domain \_\_\_\_\_ Site \_\_\_\_\_  
 Morton Order \_\_\_\_\_ Plot ID \_\_\_\_\_

Date accepted \_\_\_\_\_  
 Trimble GPS used \_\_\_\_\_  
 Tech names \_\_\_\_\_  
 Plot nickname \_\_\_\_\_  
**Please mark box when each step is completed.**



Note: Pin flags (or equivalent) not required by protocol, but helpful.

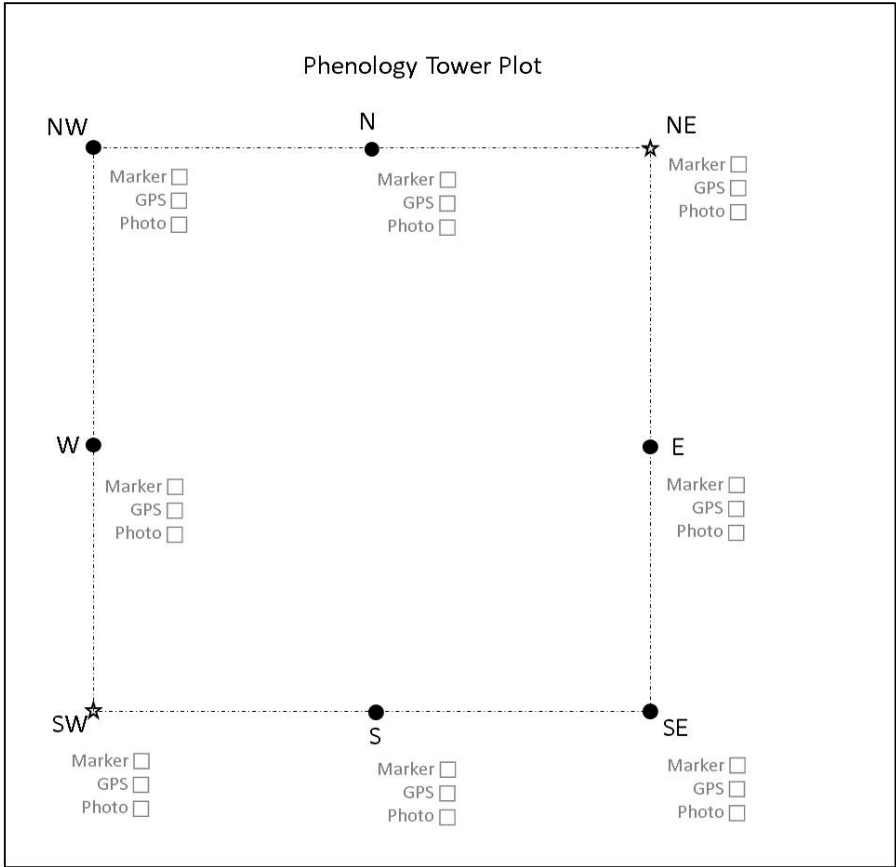
Comments or mission planning notes:

Key	
☆	Primary Marker
●	Secondary Marker
○	Flag

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.7 Phenology Tower Plot Log Sheet

Phenology Tower Plot and Transect Domain _____ Site _____ Morton Order _____ Plot ID _____	Date accepted _____ Trimble GPS used _____ Tech names _____ Plot nickname _____ <b>Please mark box when each step is completed.</b>
--	---



Mark box when flags laid out every 10 meters   
 For phenocam transect, circle points used.  
 Comments or mission planning notes:

**Example:**

NE  
★  
Marker   
GPS   
Photo

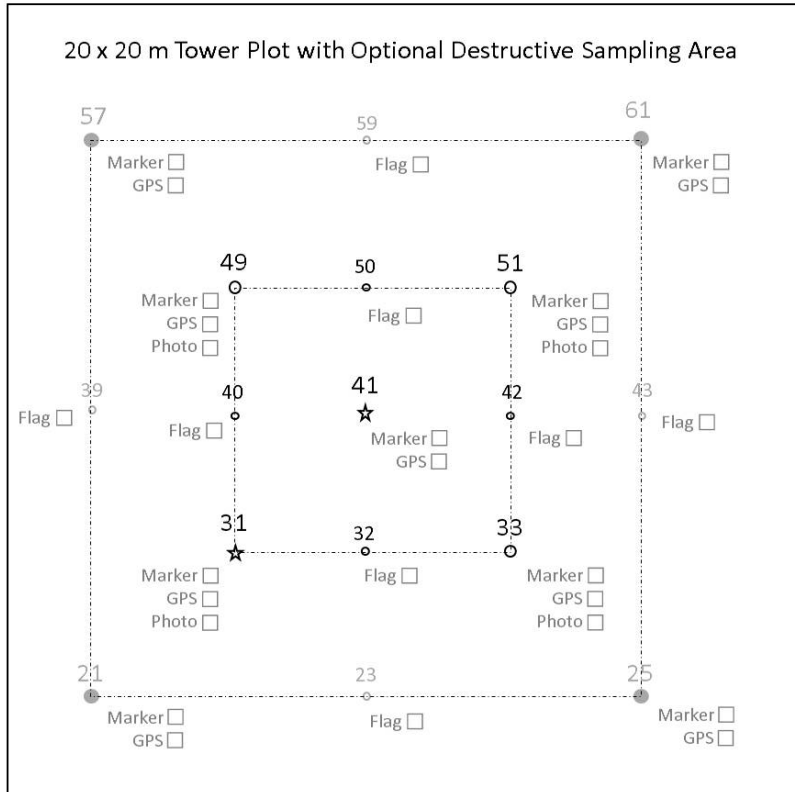
**Key**

★ Primary Marker  
● Secondary Marker

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.8 20 x 20 m Tower Plot with Destructive Sampling Area Log Sheet

Tower plot Domain _____ Site _____ Morton Order _____ Plot ID _____	Date accepted _____ Trimble GPS used _____ Tech names _____ Plot nickname _____ <b>Please mark box when each step is completed.</b>
---	---



Note: Pin flags (or equivalent) not required by protocol, but helpful.

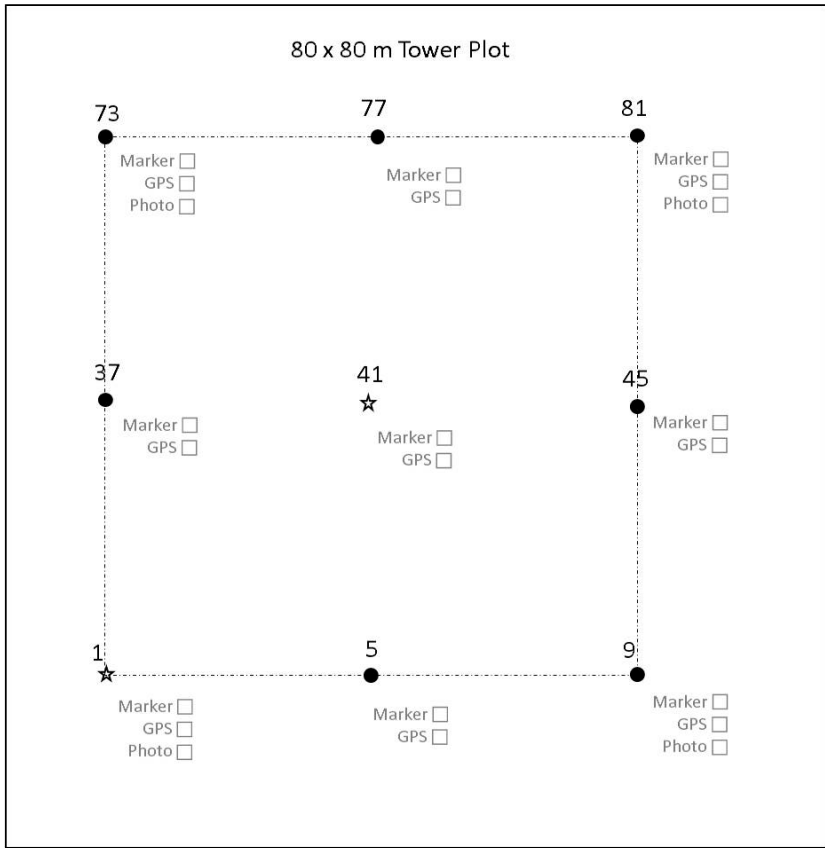
Comments or mission planning notes:

<b>Key</b> ★ Primary Marker ○ Secondary Marker ◦ Flag	<b>51 Example:</b> Marker <input checked="" type="checkbox"/> GPS <input checked="" type="checkbox"/> Photo <input checked="" type="checkbox"/>
--	--

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### A.9 80 x80 m Tower Plot

Tower plot Domain _____ Site _____ Morton Order _____ Plot ID _____	Date accepted _____ Trimble GPS used _____ Tech names _____ Plot nickname _____ <b>Please mark box when each step is completed.</b>
---	---



Comments or mission planning notes:  
 ALL DATA POINTS ARE GUESSES- this isn't in the protocol yet.

<b>Key</b> ☆ Primary Marker ● Secondary Marker	<b>81 Example:</b> ● Marker <input checked="" type="checkbox"/> GPS <input checked="" type="checkbox"/> Photo <input checked="" type="checkbox"/>
--	--

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## A.10 Mission Planning and Assignment Sheet

### Mission Planning/Assignment Sheet Plot Establishment and Maintenance

Domain/Site \_\_\_\_\_ / \_\_\_\_\_ Crew \_\_\_\_\_  
GPS Used \_\_\_\_\_ Date \_\_\_\_\_

Plot Information			Task Information		
Mort. Order/PlotID	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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	<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	NLCD Class	<input type="checkbox"/> Plot Acceptance <input type="checkbox"/> Establish/Repair Grid <input type="checkbox"/> Install Perm. Markers <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		


Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## APPENDIX B GPS RECEIVER SETUP

### B.1 GeoXH 6000 & Terra Sync version 5.11



Figure 11. GPS receiver Geo XH 6000


1. Turn GPS receiver **on** by pushing the green power button below the screen. Once the unit is on, in the screen, look for the Windows start icon (  ) in the lower-left side of the screen (Figure 11).
2. Initialize the Terra Sync software located in the Start menu of the High Resolution GPS unit.
3. Adjusting GPS Time

On the first day of work at a site, make sure that the GPS unit Time Zone, Date and Time are appropriate to the location where the measurements will be collected. See instructions below:


- Click on the time stamp at the top right of the screen. A pop up bar will appear underneath.
  - Click on the clock icon
  - Adjust the time **Zone, Date, and Time**
  - Click on the box for **Sync to current time zone**
  - Click **OK**
4. Setup Menu

#### Logging Settings

In the upper-left corner at the MDD menu select **Setup**, tap on **Logging Settings**:

- a. In **Accuracy Settings** tap on the wrench (  ) icon and make sure the Accuracy Values For Display/Logging settings are:
  - 1) Horizontal
  - 2) Postprocessed
  - 3) Postprocessing Base Distance:

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- Obtain this information in Appendix C, Table 7.
- 4) Base Data: select **GPS+GLONASS**
- 5) Use Accuracy-based Logging: select **Yes**
- 6) Apply Accuracy-based Logging To: **Point Features and Vertices**
- 7) Required Accuracy: **50cm**
- 8) Tap **Done** located in the lower left area of the screen
- b. Point/Vertex Auto-pause Count: tap on **None**
- c. Antenna Height, tap on the wrench () and modify the following to:
  - 1) Antenna Height: **1m**
  - 2) Confirm: **Per File**
  - 3) Type: select the appropriate antenna, when setting up the unit for hiking, select the **internal antenna**.
  - 4) Part Number:
  - 5) Measure Height to: bottom of receiver
  - 6) Tap **Done**
- d. Allow Position Update: tap on **Confirm**
- e. Confirm End Feature: select **No**
- f. Filename Prefix:
  - 1) Refer to SOP B.3 (Data File Naming Conventions) to determine the what the first nine characters of the filenames for the site where you will be working, which will take the form of **D##\_SITE\_** . Since the first part of the filename will not change, this may be set this as your prefix to save time in the field.
    - a) For example, Domain 02 working at SCBI would use the prefix **D02\_SCBI\_** .
  - 2) Optional: Placeholder text can be used to indicate the required file name format (see SOP B.3). Items beyond the four-letter site code can then be replaced with plot-specific text in the field.
    - a) For example: **D02\_SCBI\_Morton#\_Module\_GPS\_V#** .
- g. Waypoint Filename Prefix: **W**
- h. Between Feature Logging:
  - 1) Style: Time
  - 2) Interval: **off**
- i. Tap **Done** at the bottom left side of the screen.

### GNSS Settings

- Tap on GNSS Settings:
  - a. GNSS Receiver Port: **COM3**
  - b. Check on the box for **Use Smart Settings**
  - c. NMEA Output: **OFF**
  - d. Tap **Done** located in the lower left area of the screen



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### Real-time Settings

Tap on Real-time Settings:

- a. Choice 1: tap on **Use Uncorrected GNSS**
- b. Tap **Done**

### Coordinate System

Tap on Coordinate System:

Select the coordinate system used for all shapefiles and imagery uploaded to the unit for a specific site.

- a) System: obtain this information in Appendix C
- b) Zone: obtain this information in Appendix C
- c) Datum: obtain this information in Appendix C
- d) Altitude Reference: **Mean Sea Level (MSL)**
- e) Altitude Units: **Meters**
- f) Display USNG: **OFF**
- g) Coordinate Units: **Meters**
- h) Coordinate order: **East/North**
- i) Click **Done** located in the lower left area of the screen

### Units

Tap on **Units**:

- a. Distance Units: **Meters**
- b. Area Units: **Square Meters**
- c. Velocity Units: **Kilometers per hour**
- d. Angle Units: **Degrees**
- e. Lat/Long Format: **DD.ddd°**
- f. Offset Format: **Horizontal/Vertical**
- g. North Reference: **Magnetic Declination**
- h. Magnetic Declination: Make sure that the declination is set on **auto**.
  - Declination changes with time and space; as long as the GPS is in auto, it will update it automatically. Positive declination values are East, negative values are West. To verify the correct auto declination is set, obtain the current declination values for your location from <http://www.ngdc.noaa.gov/geomag-web/#declination> .

### External Sensors

5. Tap on **External Sensors**: uncheck all sensor check boxes. This concludes GPS settings. Unit can be shut down or brought to standby mode.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## APPENDIX C SITE-SPECIFIC INFORMATION

**Table 7.** Base stations and Geographic Coordinate System properties

Domain	Site	Site Code	Distance to Base Station (km)	Latitude (N)	Longitude (E)	Coordinate System	UTM (N)	Datum
D01	Harvard Forest	HARV	<80	42.5369	-72.17266	World Geodetic System (WGS) 1984	18	WGS 1984
D01	Bartlett Experimental Forest	BART	<80	44.06388	-71.28731	World Geodetic System (WGS) 1984	19	WGS 1984
D01	Sawmill Brook Conservation Area -Burlington, MA	SAWB	<80	42.52395	-71.18293	World Geodetic System (WGS) 1984	19	WGS 1984
D02	Smithsonian Conservation Biology Institute	SCBI	<80	38.89292	-78.1395	World Geodetic System (WGS) 1984	17	WGS 1984
D02	Smithsonian Environmental Research Center	SERC	<80	38.89008	-76.56001	World Geodetic System (WGS) 1984	18	WGS 1984
D02	Blandy Experimental Farm	BLAN	<80	39.06026	-78.07164	World Geodetic System (WGS) 1984	17	WGS 1984
D03	Ordway-Swisher Biological Station	OSBS	<80	29.68927	-81.99343	World Geodetic System (WGS) 1984	17	WGS 1984
D03	Disney Wilderness Preserve	DSNY	<80	28.12504	-81.4362	World Geodetic System (WGS) 1984	17	WGS 1984
D03	Jones Ecological Research Center	JERC	<80	31.19484	-84.46861	World Geodetic System (WGS) 1984	16	WGS 1984
D04	Guanica Forest	GUAN	<80	17.96955	-66.8687	World Geodetic System (WGS) 1984	19	WGS 1984
D04	Lajas Experimental Station	LAJA	<80	18.02125	-67.0769	World Geodetic System (WGS) 1984	19	WGS 1984
D04	Mameyes	MAME	<80	18.02201	-66.61371	World Geodetic System (WGS) 1984	19	WGS 1984
D05	UNDERC	UNDE	<80	46.23388	-89.53725	World Geodetic System (WGS) 1984	16	WGS 1984
D05	Steigerwaldt Land Services	STEI	<200	45.50969	-89.58498	World Geodetic System (WGS) 1984	16	WGS 1984

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

D05	Treehaven	TREE	<200	45.49457	-89.58505	World Geodetic System (WGS) 1984	16	WGS 1984
D06	Konza Prairie Biological Station	KONZ	<80	39.10077	-96.56309	World Geodetic System (WGS) 1984	14	WGS 1984
D06	The University of Kansas Field Station	UKFS	<80	39.04043	-95.19215	World Geodetic System (WGS) 1984	15	WGS 1984
D06	Konza Prairie Biological Station	KONA	<80	39.10077	-96.56309	World Geodetic System (WGS) 1984	14	WGS 1984
D07	Oak Ridge	ORNL	<80	35.96412	-84.2826	World Geodetic System (WGS) 1984	16	WGS 1984
D07	Mountain Lake Biological Station	MLBS	<80	37.37828	-80.52484	World Geodetic System (WGS) 1984	17	WGS 1984
D07	Great Smoky Mountains National Park, Twin Creeks	GRSM	<80	35.68896	-83.50195	World Geodetic System (WGS) 1984	17	WGS 1984
D08	Talladega National Forest	TALL	<80	32.95046	-87.39327	World Geodetic System (WGS) 1984	16	WGS 1984
D08	Dead Lake	DELA	<80	32.54172	-87.80389	World Geodetic System (WGS) 1984	16	WGS 1984
D08	Choctaw National Wildlife Refuge, Lenoir Landing	LENO	<80	31.84773	-88.17045	World Geodetic System (WGS) 1984	16	WGS 1984
D09	Woodworth	WOOD	<200	47.12802	-99.24133	World Geodetic System (WGS) 1984	14	WGS 1984
D09	Dakota Coteau Field School	DCFS	<200	47.16144	-99.10653	World Geodetic System (WGS) 1984	14	WGS 1984
D09	Northern Great Plains Research Laboratory	NOGP	<80	46.76972	-100.91535	World Geodetic System (WGS) 1984	14	WGS 1984
D10	Central Plains Experimental Range	CPER	<80	40.81554	-104.74543	World Geodetic System (WGS) 1984	13	WGS 1984

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

D10	North Sterling, CO	STER	<80	40.461903	-103.029266	World Geodetic System (WGS) 1984	13	WGS 1984
D10	Rocky Mountain National Park, CASTNET	RMNP	<80	40.27591	-105.54592	World Geodetic System (WGS) 1984	13	WGS 1984
D11	LBJ National Grassland	CLBJ	<80	33.40123	-97.57	World Geodetic System (WGS) 1984	14	WGS 1984
D11	Klemme Range Research Station	OAES	<80	35.41059	-99.05879	World Geodetic System (WGS) 1984	14	WGS 1984
D11	Wichita Mountains Wildlife Reserve	WICH	<80	34.74512	-98.71515	World Geodetic System (WGS) 1984	14	WGS 1984
D12	Yellowstone Northern Range (Frog Rock)	YELL	<80	44.95348	-110.53914	World Geodetic System (WGS) 1984	12	WGS 1984
D12	Bozeman, MT	BOZE	<80	45.65703	-111.04628	World Geodetic System (WGS) 1984	12	WGS 1984
D12	Paradise Valley, MT	PARA	<80	45.392911	-110.7163	World Geodetic System (WGS) 1984	12	WGS 1984
D13	Niwot Ridge Mountain Research Station	NIWO	<80	40.05425	-105.58237	World Geodetic System (WGS) 1984	13	WGS 1984
D13	Moab	MOAB	<80	38.24833	-109.38827	World Geodetic System (WGS) 1984	12	WGS 1984
D13	Fraser Experimental Forest	FRAS	<80	39.89267	-105.89171	World Geodetic System (WGS) 1984	13	WGS 1984
D14	Santa Rita Experimental Range	SRER	<80	31.91068	-110.83549	World Geodetic System (WGS) 1984	12	WGS 1984
D14	Jornada LTER	JORN	<80	32.59068	-106.84254	World Geodetic System (WGS) 1984	13	WGS 1984
D15	Onaqui-Ault	ONAQ	<80	40.17759	-112.45244	World Geodetic System (WGS) 1984	12	WGS 1984
D15	Red Butte Canyon Research Natural Area	RBUT	<80	40.78205	-111.80394	World Geodetic System (WGS) 1984	12	WGS 1984

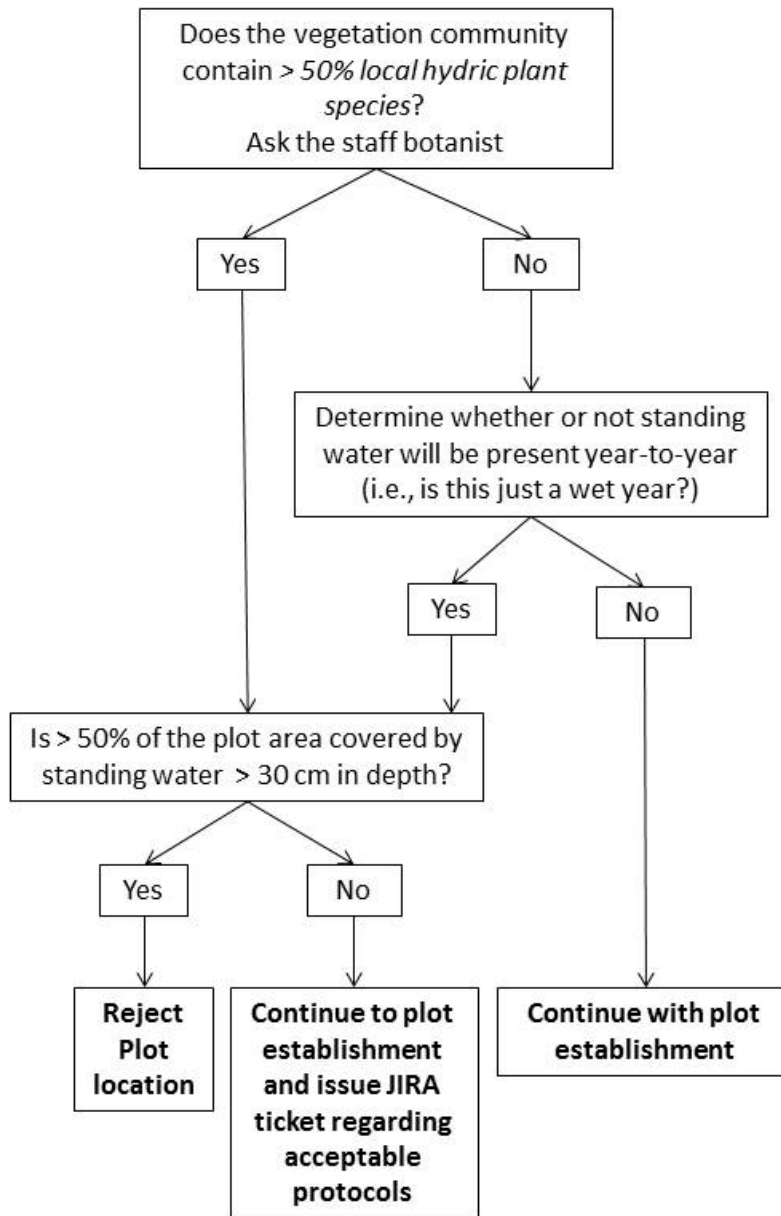
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NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

D16	Wind River Experimental Forest	WREF	<80	45.820488	-121.951912	World Geodetic System (WGS) 1984	10	WGS 1984
D16	Thayer	THAY	<80	45.71438	-122.34024	World Geodetic System (WGS) 1984	10	WGS 1984
D16	Abby Road	ABBY	<80	45.76243	-122.33033	World Geodetic System (WGS) 1984	10	WGS 1984
D17	San Joaquin	SJER	<80	37.10878	-119.73228	World Geodetic System (WGS) 1984	11	WGS 1984
D17	Soaproot Saddle	SOAP	<80	37.03337	-119.26219	World Geodetic System (WGS) 1984	11	WGS 1984
D17	Lower Teakettle	TEAK	<80	37.00583	-119.00602	World Geodetic System (WGS) 1984	11	WGS 1984
D18	Toolik Lake	TOOL	<80	68.66109	-149.37047	World Geodetic System (WGS) 1984	6	WGS 1984
D18	Barrow Environmental Observatory	BARO	<80	71.28241	-156.61936	World Geodetic System (WGS) 1984	4	WGS 1984
D19	Caribou Creek - Poker Flats Watershed	BONA	<80	65.15401	-147.50258	World Geodetic System (WGS) 1984	6	WGS 1984
D19	Delta Junction	DEJU	<80	63.88112	-145.75136	World Geodetic System (WGS) 1984	6	WGS 1984
D19	Poker Flat	POKE	<80	65.11298	-147.42274	World Geodetic System (WGS) 1984	6	WGS 1984
D19	Healy	HEAL	<80	63.87569	-149.21334	World Geodetic System (WGS) 1984	6	WGS 1984
D20	Olaa Forest Reserve	OLAA	<80	19.554785	-155.264178	World Geodetic System (WGS) 1984	5	WGS 1984
D20	Puu Waa Waa Forest Site	PUFO	<80	19.73759	-155.85907	World Geodetic System (WGS) 1984	5	WGS 1984
D20	Puu Waa Waa Grassland Site	PUGR	<80	19.74065	-155.87494	World Geodetic System (WGS) 1984	5	WGS 1984

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

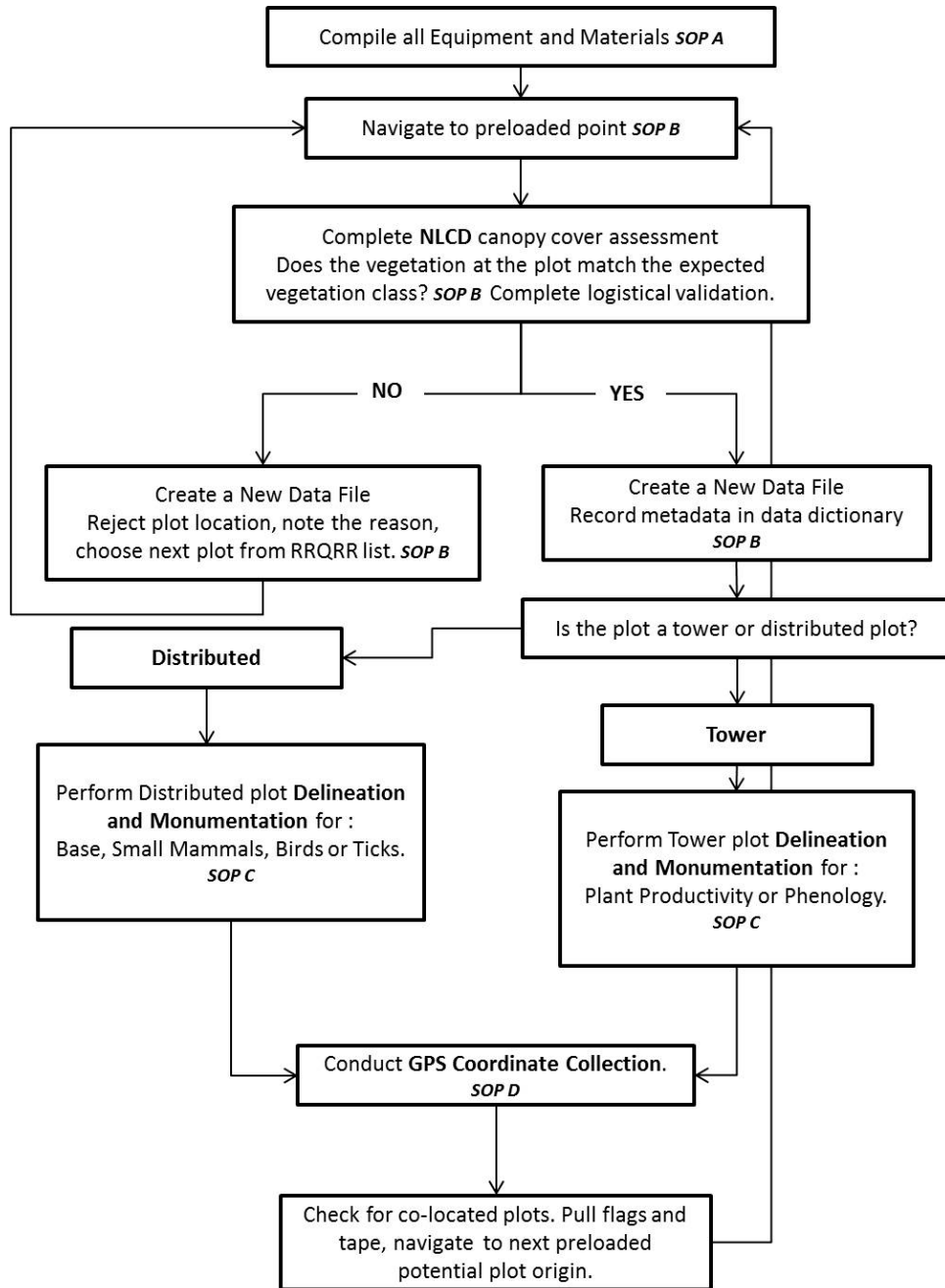
**APPENDIX D CRITERIA FOR PLOT ESTABLISHMENT IN WET LOCATIONS**

At a potential plot locations with present water, follow workflow below...



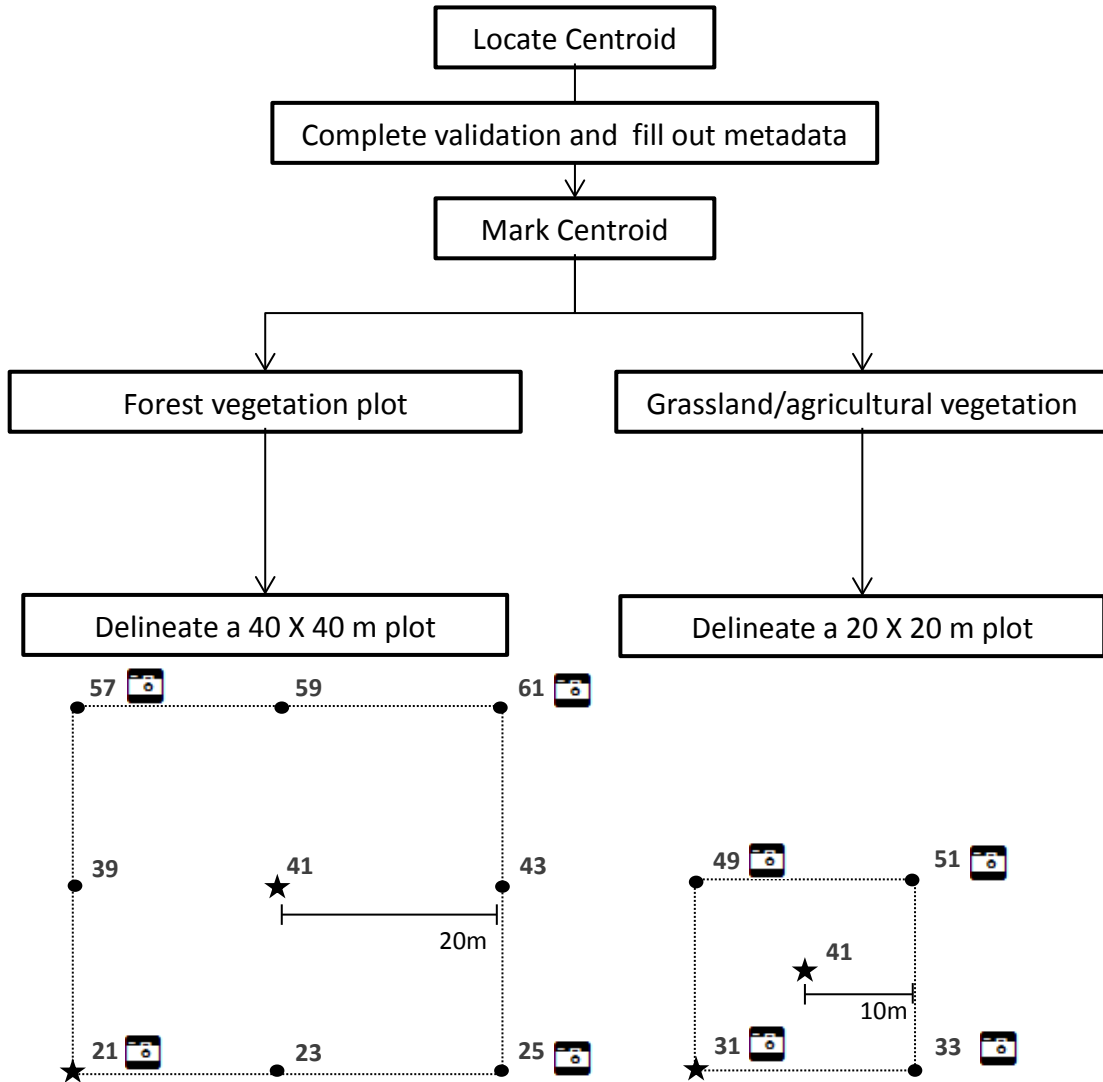
## APPENDIX E PLOT ESTABLISHMENT WORKFLOWS

### E.1 Overall field steps

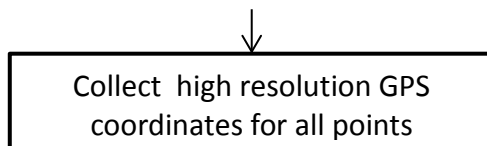


E.2 Tower, Plant Productivity Workflow

Type: Tower 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 plot centroid





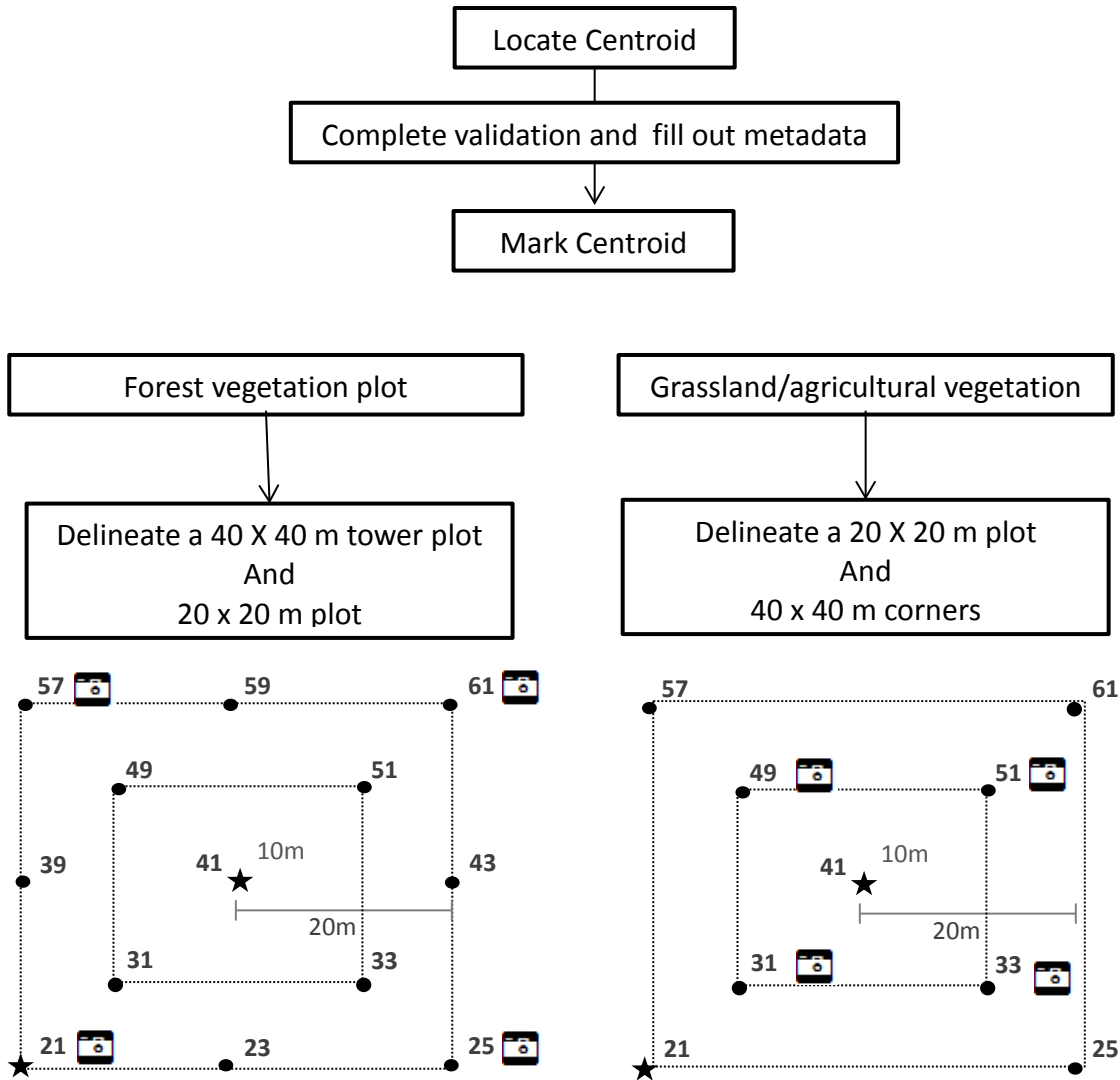
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**E.3 Tower, Subset that includes Biogeochemistry and Plant Productivity**

**Type: Tower**

**Subtype: Base Plot**

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



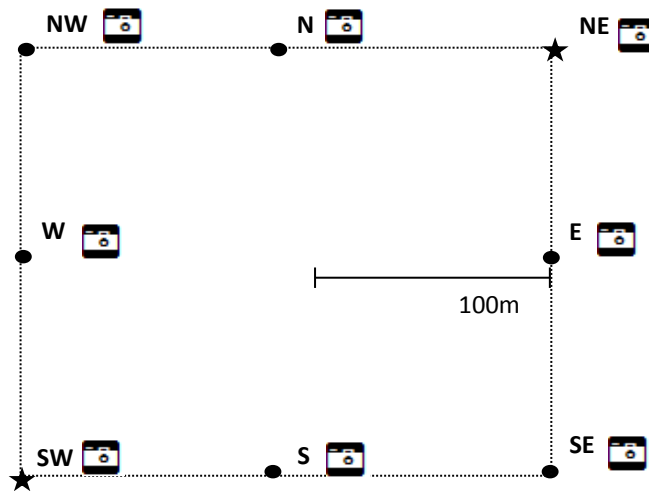
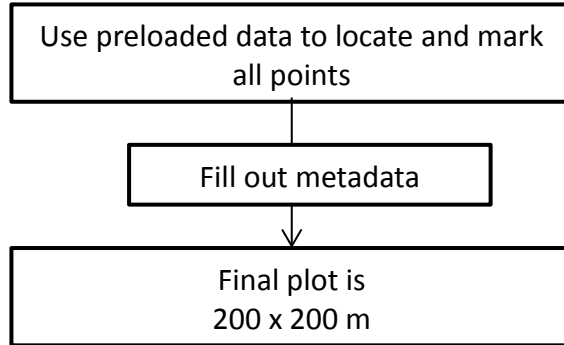
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (e.g. 41)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)
- 📷 Photos taken towards plot centroid


↓  
Collect high resolution GPS coordinates for all points

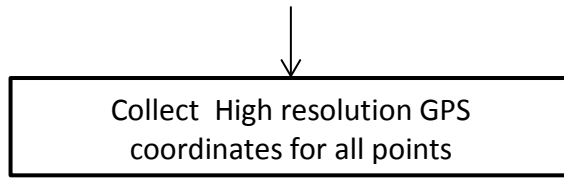
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

E.4 Tower, Primary Phenology workflow

Type: Tower  
Subtype: Phenology Plot



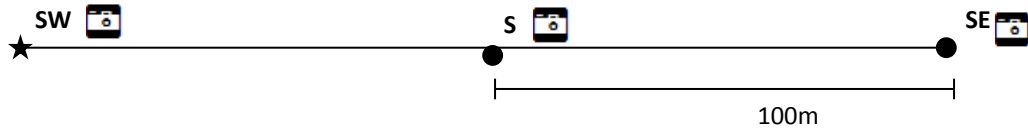
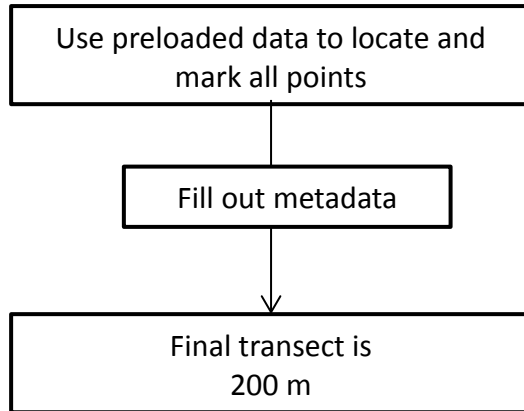
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (SW, NE)
- *Secondary Marker* label all markers with corresponding PointID cardinal directions, see above (e.g. NW)
-  Take photos towards next point on transect in a clockwise direction



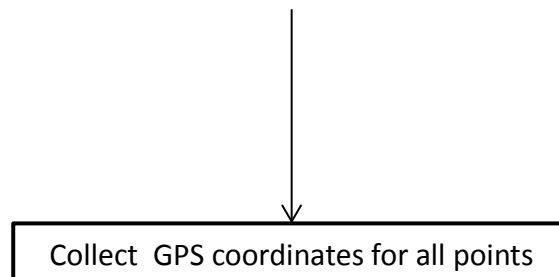
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

E.5 Tower, Secondary Phenology Workflow

Type: Tower  
 Subtype: Phenology Plot  
 Secondary Plot if applicable



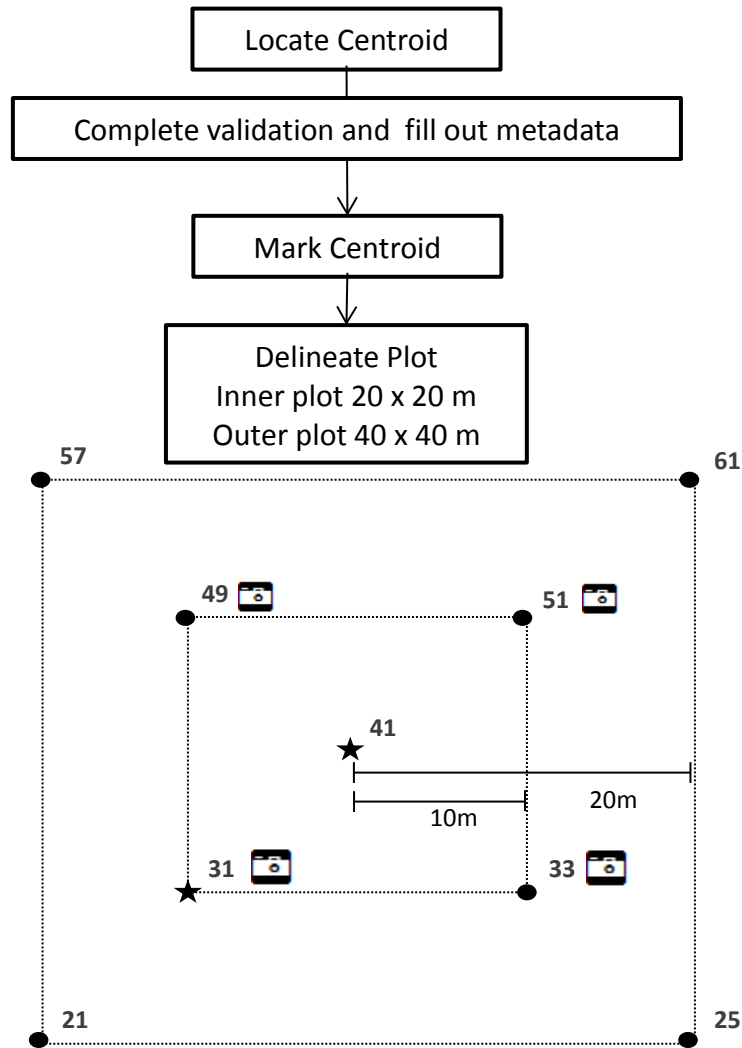
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (SW)
- *Secondary Marker* label all markers with corresponding PointID cardinal directions, see above (e.g. S)
- 📷 Take photos towards next point on transect in clockwise fashion. SW photo taken towards S point.




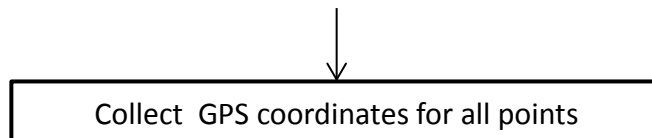
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

E.6 Distributed, Distributed Base Workflow

Type: Distributed  
Subtype: Base Plot



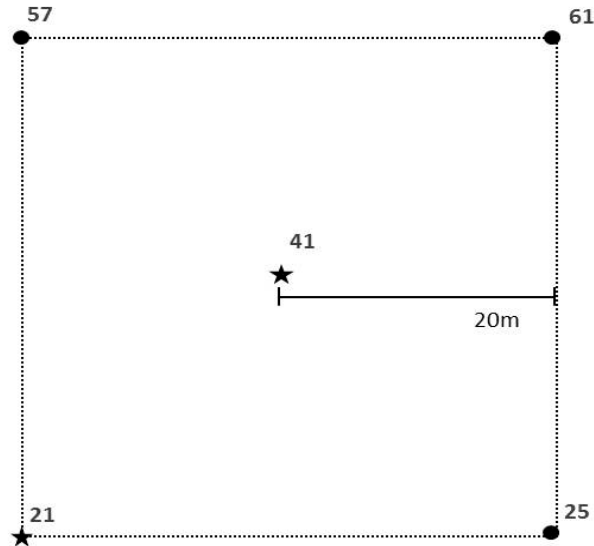
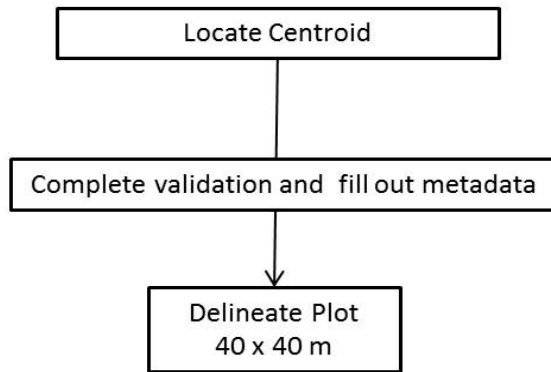
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (e.g. 41)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)
-  Photos taken towards the centroid



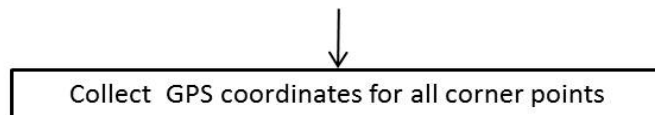
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## E.7 Distributed, Ticks Workflow

### Type: Distributed Ticks



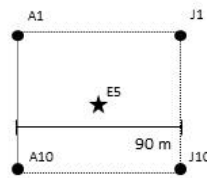
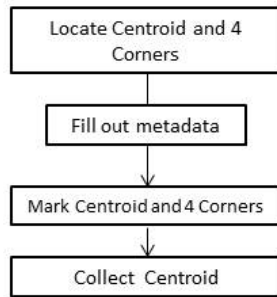
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (41, 21)
- *Secondary Marker* label all markers with corresponding PointID numbers, see above (e.g. 57)



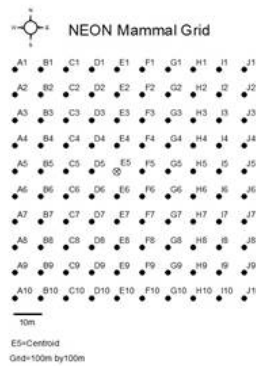
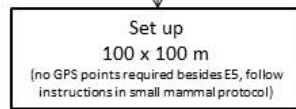
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## E.8 Distributed, Small Mammals Workflow

Type: Distributed  
Subtype: Mammal Grid



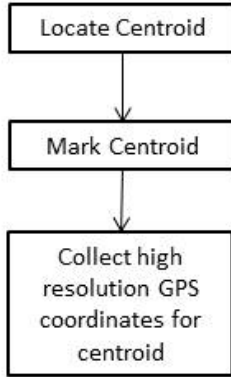
- ★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (E5)
- *Secondary Marker* label PointID (e.g. A1)



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

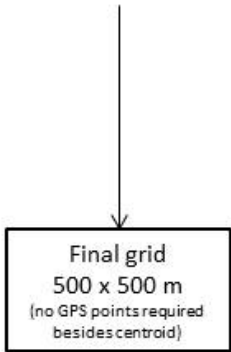
**E.9 Distributed, Bird Grid Workflow**

Type: Distributed  
 Subtype: Breeding Birds



B2 ★

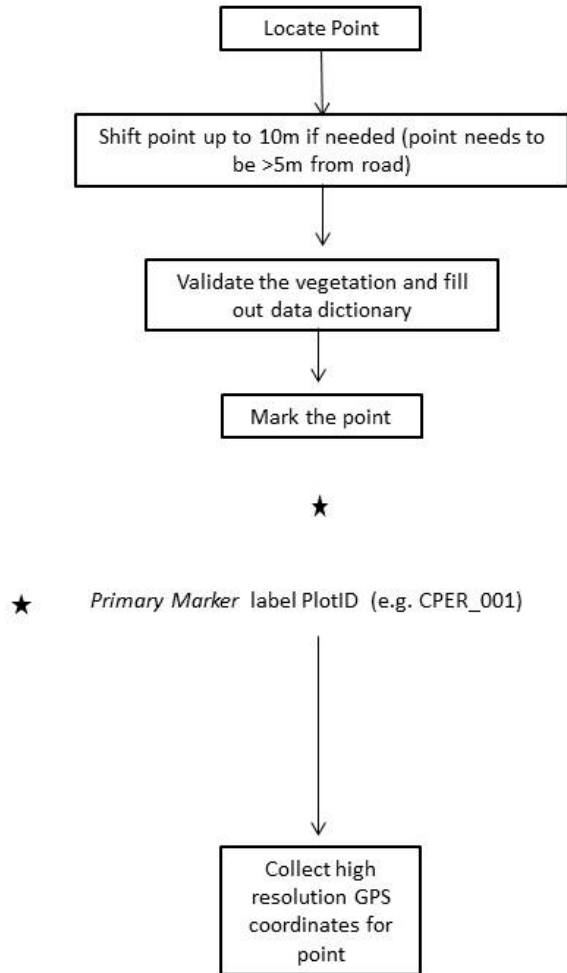
★ *Primary Marker* label PlotID (e.g. CPER\_001) and PointID (B2)



Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**E.10 Distributed, Mosquito Workflow**

Type: Distributed  
Module: Mosquitoes





Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**APPENDIX F NLCD VEGETATION CLASSIFICATION DESCRIPTION**

Class/Value	Classification Description
<b>Water</b>	<i>areas of open water or permanent ice/snow cover.</i>
11	<b>Open Water</b> - areas of open water, generally with less than 25% cover of vegetation or soil.
12	<b>Perennial Ice/Snow</b> - areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
<b>Developed</b>	<i>areas characterized by a high percentage (30% or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc.).</i>
21	<b>Developed, Open Space</b> - 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	<b>Developed, Low Intensity</b> - 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	<b>Developed, Medium Intensity</b> – 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	<b>Developed High Intensity</b> -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.
<b>Barren</b>	<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	<b>Barren Land (Rock/Sand/Clay)</b> - 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.
<b>Forest</b>	<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	<b>Deciduous Forest</b> - 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	<b>Evergreen Forest</b> - 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	<b>Mixed Forest</b> - 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.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

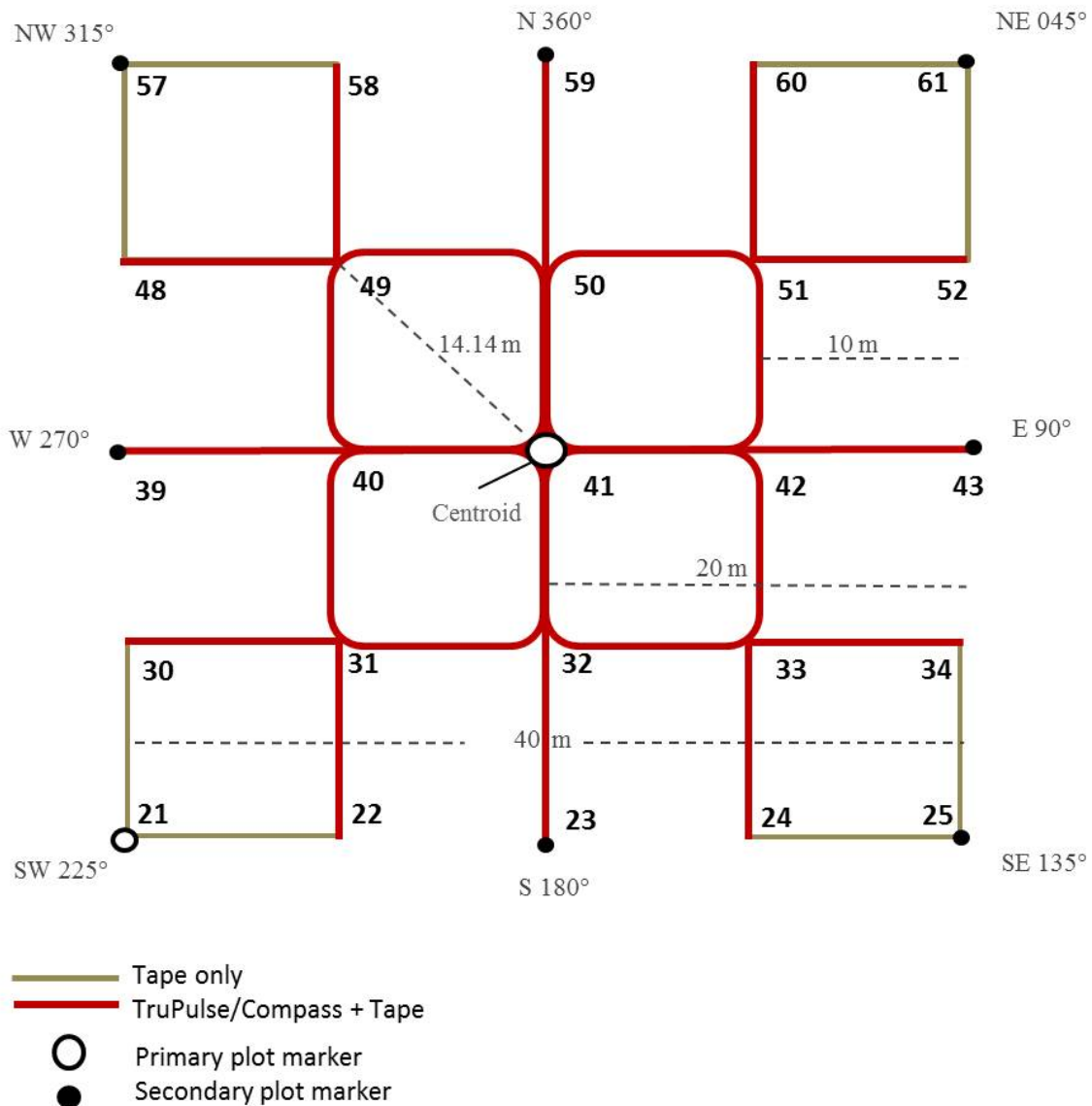
Class/Value	Classification Description
<b>Shrubland</b>	<i>areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 5 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included..</i>
51	<b>Dwarf Scrub</b> - 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	<b>Shrub/Scrub</b> - 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.
<b>Herbaceous</b>	<i>areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75% to 100% of the cover.</i>
71	<b>Grassland/Herbaceous</b> - 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	<b>Sedge/Herbaceous</b> - 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	<b>Lichens</b> - Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	<b>Moss</b> - Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
<b>Planted/Cultivated</b>	<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	<b>Pasture/Hay</b> – 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	<b>Cultivated Crops</b> – 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.
<b>Wetlands</b>	<i>areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al., (1979).</i>
90	<b>Woody Wetlands</b> - 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	<b>Emergent Herbaceous Wetlands</b> - 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.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

### APPENDIX G PLOT DELINEATION LAYOUT

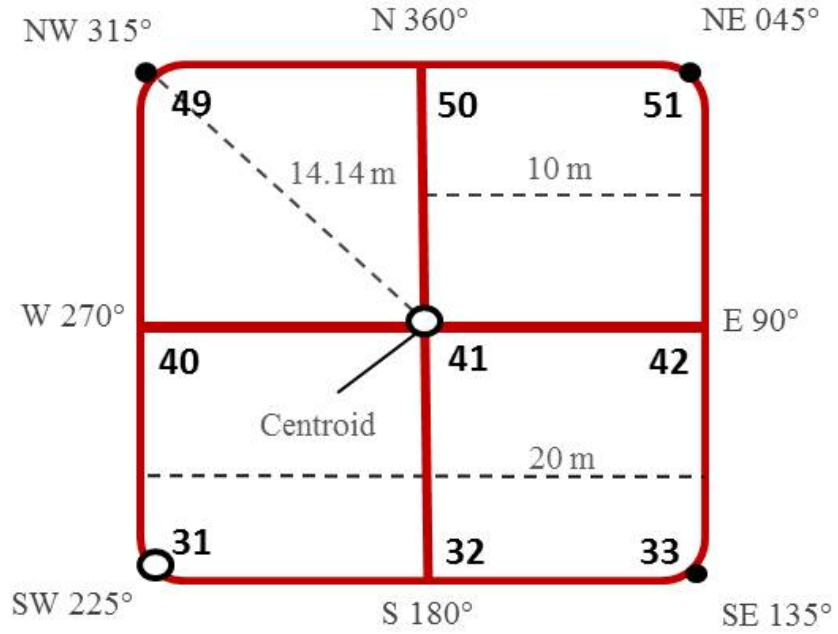
Use the following schematics in the field to keep track of your progress, place diagram in page protector, and mark off points with a dry erase as you locate them. Rounded corners indicate where tape is wrapped.




#### G.1 Tower Plot – 40x40 meters



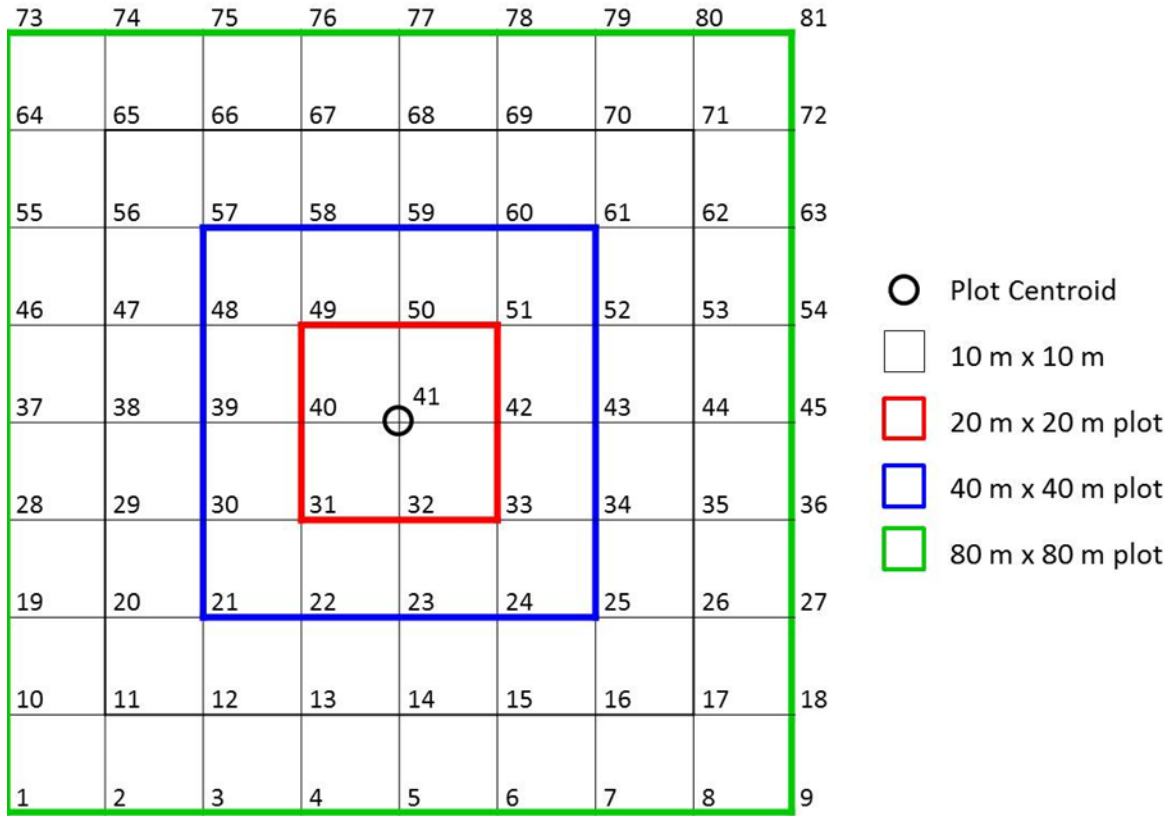
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

**G.2 Tower Plot – 20x20 meters**



-  TruPulse/Compass + Tape
-  Primary plot marker
-  Secondary plot marker

**APPENDIX H SCHEMATIC OF COMPLETE GRID USED TO LABEL PLOT POINTS**



**Figure 12.** Schematic of the point ID grid used in plot establishment.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## APPENDIX I TROUBLESHOOTING

### I.1 GPS

- The unit **shuts down** on its own:
  - Click on the **Power** button once to check if it is on standby mode. If it were on standby it should turn on once
  - Restart the unit by pressing on the Power button and check the battery, if the battery is low,
  - Replace the battery with a fully charged extra battery
  
- TerraSync map display is incorrect:
  - Tap with the stylus on MDD>Setup, then tap on coordinate system and make sure the coordinate system, zone, and datum are correct.
  - If the map doesn't display correctly check the .imp file coordinate system by locating the .txt file located in the shared folder where the .imp file is locate on the computer.
  - Click on the .txt files in the corresponding folder and find the one that displays the .imp file in use and check the output data coordinate system, zone and datum. If the coordinate system is incorrect, the file will have to be imported again into Pathfinder with the corrected coordinate system.
  
- Accidentally clicked on the camera button:
  - Click **OK** to the bottom right of the screen.
  - Click on the **'X'** symbol to the bottom right of the screen, the next screen should be the TerraSync working screen

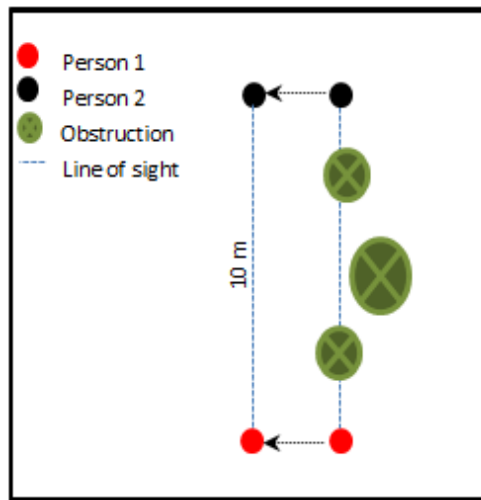
Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

## I.2 Plot Establishment Obstructions

- Large trees, rocks or over/below brush

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 TruPulse 360R in HD mode to accurately measure 10m of horizontal distance along the slope. Depending on the degree of slope, this 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 TruPulse 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 (Figure 13). Once a clear reading is acquired move back to the original point and place marker.



**Figure 13.** Alternative strategy when obstructions are in line of sight during plot delineation.

- If low/high stature obstructions are encountered between Person 1 & person 2 when using the tape, pull the tape up/down on both ends and measure above/below the obstruction; make sure to use the rangefinder to verify results.

Title: TOS Protocol and Procedure: Plot Establishment		Date: 02/23/2015
NEON Doc. #: NEON.DOC.001025	Author: E. Azuaje	Revision: D

- 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 (. 4). For example, if there is a line of obstruction for verification of point 49 from point 41 when delineating a 20 by 20 meter plot, there are several hypotenuse options (. 4a) select the one that is clear of obstructions and use it to verify point 49 (. 4b). 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 (. b) the hypotenuse “c” would be:

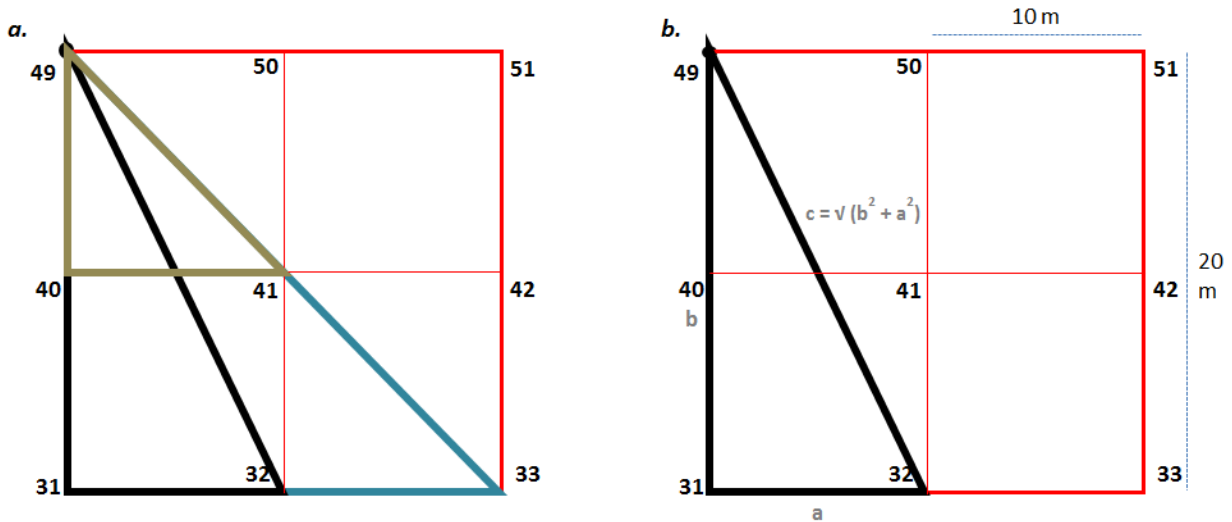
$$c^2 = b^2 + a^2$$

$$c = \sqrt{20^2 + 10^2}$$

$$c = \sqrt{500}$$

$$c = 22.36 \text{ meters}$$

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 14.** Hypotenuse option to verify plot delineation measurements; a. options available to verify delineation of point 49. b. hypotenuse measurement formula.