

Title: TOS Standard Operating Procedure: TruPulse Rangefinder Use and Calibration		Date: MM/DD/2015
NEON Doc. #: NEON.DOC.001717	Author: E. Azuaje	Revision: B

TOS STANDARD OPERATING PROCEDURE: TRUPULSE RANGEFINDER USE AND CALIBRATION

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	02/06/2015	ECO-02567	Initial release
B	11/13/2015	ECO-03193	Revisions for 2015 baselining. Changes include: <ul style="list-style-type: none"> • Section A.4: The distance from ferrous objects to the unit is now consistent with the manual (18 inches) • Sections B.2 & B.3: Clarified procedure for measuring canopy diameter and heights. • Removed obsolete "Training Plan" from Applicable Documents table • Updated broken link to NOAA Declination Calculator

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1 DESCRIPTION

1.1 Purpose

The TruPulse 360R Rangefinder Standard Operating Procedure is intended as a supporting document for all protocols that require use of the laser rangefinder. This SOP provides step-by-step instruction for use of the TruPulse360R rangefinder. Protocols that reference this procedure include, but are not limited to, Plot Establishment RD[04], Measurement of Herbaceous Biomass RD[05], Measurement of Vegetation Structure RD[06], Litterfall and Fine Woody Debris RD[07], Bryophyte Productivity RD[08], and Coarse Downed Wood RD[09]. This SOP will require revision if equipment specifications change in the future. Protocols will specify tasks to be completed with a laser rangefinder while this document provides the steps specific to the model being used. Note that as of Rev A, this document is geared toward TOS applications, though AOS applications exist. AOS content may be added in a future revision.

1.2 Scope

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

1.3 Applies To

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

Doc #	Title
NEON.DOC.001025	TOS Protocol and Procedure: Plot Establishment
NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass
NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
NEON.DOC.001710	TOS Protocol and Procedure: Litterfall and Fine Woody Debris
NEON.DOC.001709	TOS Protocol and Procedure: Bryophyte Productivity
NEON.DOC.001711	TOS Protocol and Procedure: Coarse Downed Wood

1.4 Acknowledgments

All illustrations in SOP A came from:

TruPulse® 360°R User's Manual (2011). Laser Technology, Inc., Centennial, CO.

Step by step instructions throughout this SOP have been modified from the TruPulse 360R User's Manual, to accommodate specific needs for implementation of NEON TOS protocols.

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2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain higher-level information that is implemented in the current document. Examples include designs, plans, or standards.

AD[01]	NEON.DOC.004300	EHS Safety Policy and Program Manual
AD[02]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD[03]	NEON.DOC.050005	Field Operations Job Instruction Training 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.001025	TOS Protocol and Procedure: Plot Establishment
RD[05]	NEON.DOC.014037	TOS Protocol and Procedure: Measurement of Herbaceous Biomass
RD[06]	NEON.DOC.000987	TOS Protocol and Procedure: Measurement of Vegetation Structure
RD[07]	NEON.DOC.001710	TOS Protocol and Procedure: Litterfall and Fine Woody Debris
RD[08]	NEON.DOC.001709	TOS Protocol and Procedure: Bryophyte Productivity
RD[09]	NEON.DOC.001711	TOS Protocol and Procedure: Coarse Downed Wood

2.3 Acronyms

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

2.4 Definitions

N/A

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3 SAFETY

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

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

A laser rangefinder/hypsometer/compass instrument is used to map individual woody stems as points, and to measure various stem structural attributes. Safety considerations for this instrument include:

- Avoid staring directly at the laser beam for prolonged periods. The rangefinder is classified as eye-safe to Class 1 limits, which means that virtually no hazard is associated with directly viewing the laser output under normal conditions. As with any laser device, however, reasonable precautions should be taken in its operation. It is recommended that you avoid staring into the transmit aperture while firing the laser.
- Never attempt to view the sun through the scope. Looking at the sun through the scope may permanently damage the eyes.

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4 PERSONNEL AND EQUIPMENT

4.1 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 1. Equipment list – Using the TruPulse laser rangefinder

Item No.	R/S	Description	Purpose	Conditions Used	Quantity	Special Handling
Durable items						
	R	Reflector	Used to make measurements with the TruPulse 360R	All	1	N
MX100322	R	TruPulse 360R Laser Range Finder		All	1	N
	R	Non-magnetic tripod with non-magnetic ¼" x 20 ball mount	Hold TruPulse directly over plot marker, eliminate magnetic interference with TruPulse compass.	When TruPulse is used	1	N
	S	Mirror-site compass, declination adjusted	Verify compass calibration	All	1	N
Consumable items						
	R	Batteries	Used to power the TruePulse 360R	All	6	N

R/S=Required/Suggested

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4.2 Training Requirements

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

All technicians using the TruPulse 360R laser rangefinder to implement NEON field protocols will be trained on proper use of this equipment prior to conducting field work.

4.3 Specialized Skills

No specialized skills are required to implement this Standard Operating Procedure.

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5 CONTINGENCIES AND NOTES

The range finder may not provide accurate measurements when used in rainy or snowy conditions. This is due to the laser scatter around highly reflective surfaces such as water and snow.



Similar to a traditional compass, the TruPulse 360R is sensitive to magnetic interference from nearby metallic objects. The magnetic environment around certain buildings may completely prevent accurate compass calibration in the TruPulse. When checking compass calibration, take care that no metal objects are within 18 inches of the compass or the TruPulse—e.g., plot markers, watches, etc.

The following are examples of metallic objects that may affect the compass performance. Such objects should be kept at least 50 cm (20 in) away from the TruPulse during operation.

- Batteries
- Nails
- Data collectors or computers
- Pin flags w/ metal stakes
- Portable electronics
- Steel-rimmed eyeglasses
- Metal jewelry near hands or face
- Eyeglass spring-hinges
- Non-aluminum tripods

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6 STANDARD OPERATING PROCEDURES

SOP A Configure the TruPulse 360R Laser Rangefinder

Use this procedure to configure the TruePulse 360R Laser Rangefinder before starting a field campaign.

A.1 Selecting the correct Target Mode

Prior to collecting data with the TruPulse 360R, select the correct laser Target Mode for the current field conditions. The TruPulse has 5 Target Modes which allow for accurate measurement under variable field conditions. Set the Target Mode as follows:

1. Power on the unit by pressing the “Power/Fire” button.
2. To set the Target Mode:
 - a. Press ▲ (away from ocular) for 4 seconds. The active Target Mode appears in the viewfinder. Press ▲ or ▼ to cycle through available Target Modes (Table 2).
 - b. Press “Power/Fire” to make the chosen Target Mode active.

Table 2. Laser Target Modes for the TruPulse 360R

Target Mode	Definition	When to Use
Std	Standard, single-shot	Clear shot to unobstructed target
Con	Continuous; pressing and holding “Power /Fire” will continuously acquire targets for up to 10 s	Useful for scanning trees in order to find the highest point
CLO	Closest; pressing and holding “Power /Fire” will acquire multiple targets, the viewfinder displays the closest target	Narrow targets in the foreground
FAR	Farthest; identical to CLO, but the viewfinder displays the farthest target	Target partially obscured by brush Finding highest point of a tree
Flt	Filter; the sensor sensitivity is reduced to only detect laser pulses returned from a reflective surface; ‘F’ appears in the viewfinder	Measuring targets through thick brush In very heavy brush, the optional foliage filter is highly recommended but it is not required for the unit to function.

3. The Target Mode can be adjusted as needed in order to acquire the best data possible.



In general protocols utilizing this rangefinder should be performed with the TruPulse 360R in “Filter” mode to ensure that the right distances are measured.

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A.2 Selecting the correct measurement units

Units for measuring distance may be reported by the laser rangefinder as yards, meters, or feet. The TruPulse 360R will save unit settings so that each time the rangefinder is turned on, it will return to the same unit setting that was last used. It is a good idea to check these settings at the beginning of a field day so that work must not be repeated if the TruPulse is set incorrectly and after changing the batteries.

To change unit settings:

1. Power on the unit by pressing the “Power/Fire” button.
2. Press and hold ▼ for 4 s to enter “System Setup Mode”. **UnitS** will appear in the Main Display.
3. Press “Power/Fire” to select the **UnitS** option.
4. Press either ▲ or ▼ to change the distance units, displayed beneath **UnitS**, to read **METERS**
5. Press “Power/fire” to enter Inclination units mode
6. Press either ▲ or ▼ to change the inclination units, displayed beneath **UnitS**, to read **PERCENT**
7. Press “Power/fire” to confirm and return to the “Measurement Mode” screen.

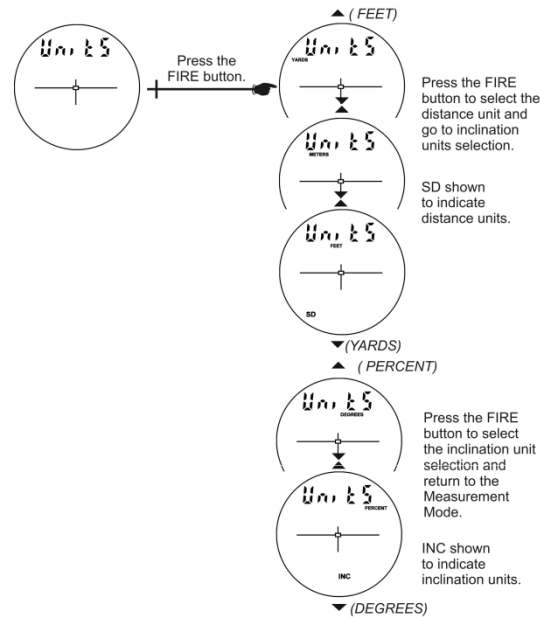


Figure 1. The TruPulse viewfinder, showing units

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A.3 Setting the declination of the TruPulse internal compass

Declination changes with time and space, so it must be looked up annually for a given location. Positive declination values are East, negative values are West. Obtain the current declination values for your location from <http://www.ngdc.noaa.gov/geomag-web/> and be sure to note the positive or negative sign before heading into the field. Also check declination if the battery dies or is replaced.

The following procedure can be used to check and set the declination (if necessary) on the TruPulse:

1. Press the “Power/Fire” button to turn on the unit. The viewfinder will display the main “Measurement Mode” screen.
2. Press and hold ▼ for 4 s to enter “System Setup Mode”. **UnitS** will appear in the Main Display.
3. Press ▼ until **H_Ang** is displayed in the viewfinder, then press “Power/Fire”.
4. **dECLn** will be displayed in the viewfinder, press “Power/Fire”.
5. **no** and **dECLn** will blink. Press ▼ until **YES** and **dECLn** blink, then press “Power/Fire” again. The current declination is shown in the viewfinder (Figure 2).
6. If this is the correct value, press and hold ▲ to return to the main “Measurement Mode” screen.

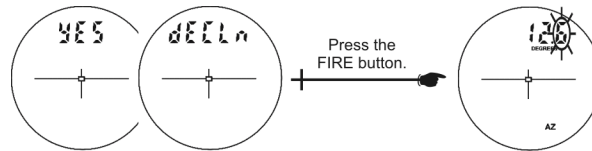


Figure 2. The TruPulse viewfinder, showing a user-entered declination value.

7. If the displayed value is incorrect for your current location:
 - a. Press either ▲ or ▼ to change the tenths value, press “Power/fire”.
 - b. Press either ▲ or ▼ to change first integer value, press “Power/fire”.
 - c. Press either ▲ or ▼ to change second integer value, press “Power/fire”.
 - d. The value just entered will blink. Press “Power/fire” to confirm and return to the “Measurement Mode” screen.

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A.4 Calibrating the TruPulse internal compass

The internal compass of the TruPulse is susceptible to error. When beginning work, the TruPulse should be checked against an actual compass or a previously established plot line. ALWAYS CHECK AND RECALIBRATE THE COMPASS AFTER CHANGING THE BATTERIES! It is not uncommon for the compass calibration to be inaccurate when the low battery indicator is displayed in the viewfinder. You should replace the batteries when this indicator appears.

To calibrate the TruPulse’s internal compass, use the following procedure:

1. Before calibrating the internal compass, take the TruPulse outside (away from local electromagnetic interference) and at least 18 inches (approx 50 cm) away from all ferrous metal objects (i.e., anything made from iron or steel, including watches, eyeglass rims, etc.).
2. Press the “Power/Fire” button to turn on the unit. The viewfinder will display the main “Measurement Mode” screen.
3. Press and hold ▼ for 4 s to enter “System Setup Mode”. **Units** will appear in the Main Display.
4. Press ▼ until **H_Ang** is displayed in the viewfinder, then press “Power/Fire”.
5. **dECLn** is displayed. Press ▼ to display the **HACAL** option, then press “Power/Fire” again (Figure 3).
6. **No** and **HACAL** will alternately blink. Press ▲ or ▼ to display **YES** and **HACAL**, then press “Power/Fire” to begin calibration.

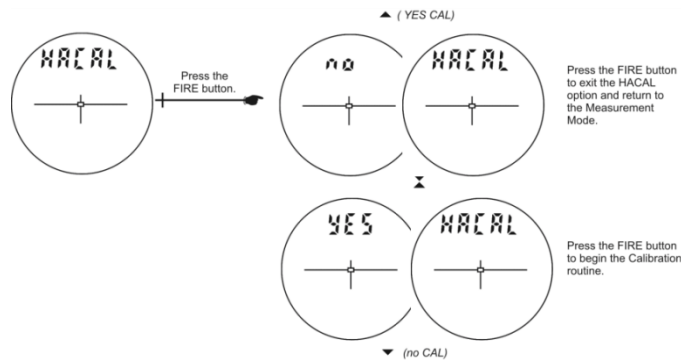


Figure 3. The TruPulse viewfinder during the compass calibration procedure.

- Calibration can be aborted by pressing “Power/Fire” when **no** and **CAL** are alternately displayed.
7. **C1_Fd** will be displayed in the viewfinder.
 8. Place the TruPulse facing magnetic North (within 15 deg of N) on a relatively flat surface, or hold it while maintaining it flat (within 15 deg of level). To calibrate the compass, follow the sequence outlined in **Figure 4** below. The TruPulse provides confirmation after each step in **Figure 4** is completed by displaying the following:

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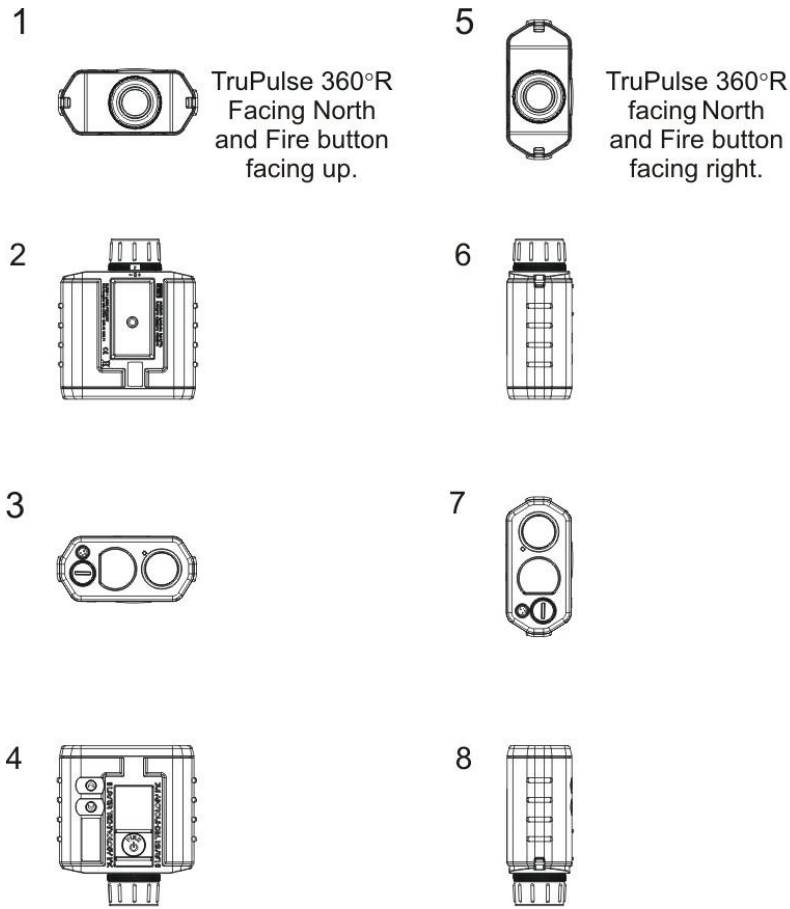


Figure 4. The TruPulse compass calibration routine.

- a. At each step, wait approximately 1 second before pressing “Power/fire”, then wait another second before moving to the next position. It is important that the unit is held steady when you press “Power/fire”.
 - b. To abort and return to previous calibration at any point hold ▲ or ▼ for 4 sec.
9. After all 8 positions have been run through, look through the eyepiece. Either a **PASS** or **FAIL** message appears in the viewfinder.
 - **PASS:** Press the “Power/Fire” Button to return to the measurement mode.
 - **FAiL1:** Excessive motion during calibration. Unit was not held steady.
 - **FAiL2:** Magnetic saturation error. Local magnetic field too strong.
 - **FAiL3:** Mathematical fit error.
 - **FAiL4:** Calibration convergence error.
 - **FAiL6:** Orientations were wrong during the calibrations.
 10. If **FAiL** appears, press the “Power/Fire” button. **No** and **CAL** will alternately blink allowing you to do a new calibration. If the calibration fails, the unit reverts to the previous calibration.

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A.5 Calibrating the tilt sensor of the TruPulse 360R Laser Rangefinder

In the rare case that the TruPulse suffers severe drop shock, the following procedure can be used to calibrate the tilt sensor (vertical angle):

1. Press the “Power/Fire” button to turn on the unit. The viewfinder will display the main “Measurement Mode” screen.
2. Press and hold ▼ for 4 s to enter “System Setup Mode”. **Units** will appear in the Main Display.
3. Press ▼ until **inC** is displayed in the viewfinder, then press “Power/Fire” (Figure 5).
4. **no** and **CAL** will blink. Press ▼ until **yes** and **CAL** blink, then press “Power/Fire” again.
 - Calibration can be aborted by pressing “Power/Fire” when **no** and **CAL** are alternately displayed.

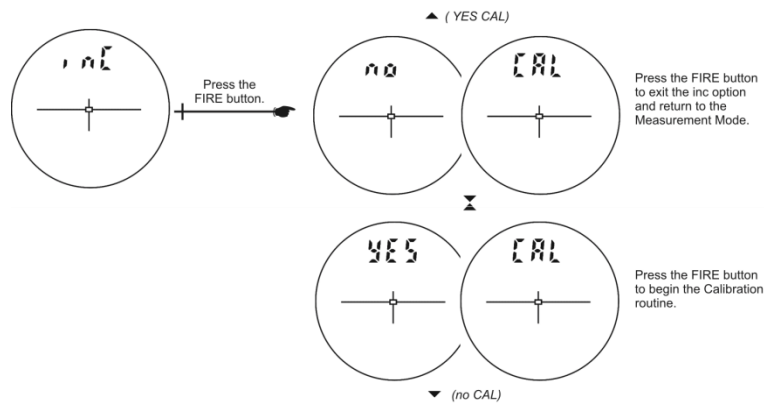


Figure 5. The TruPulse viewfinder when initiating the tilt-sensor calibration routine.

5. **C1_Fd** will be displayed in the viewfinder.
6. Place the TruPulse on a relatively flat surface (within 15deg of level), and follow the sequence outlined in **Figure 6** below.

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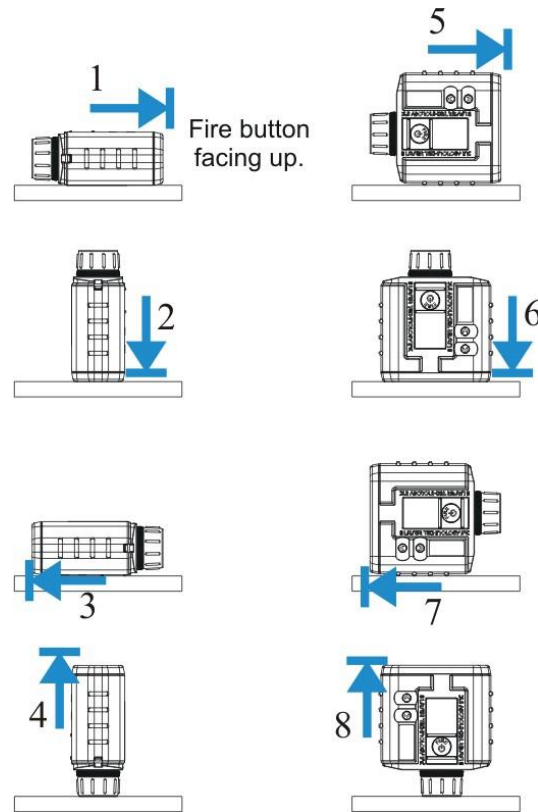


Figure 6. The TruPulse tilt-sensor calibration routine.

- a. At each step wait approximately 1 second before pressing “Power/fire”, then wait another second before moving to the next position. It is important that the unit is held steady when you press “Power/fire”.
 - b. To abort and return to previous calibration at any point hold ▲ or ▼ for 4 sec.
7. After all 8 positions have been run through, look through the eyepiece. Either a **PASS** or **FAIL** message appears in the viewfinder.
 - **PASS:** Press the “Power/Fire” Button to return to the measurement mode.
 - **FAiL1:** Excessive motion during calibration. Unit was not held steady.
 - **FAiL2:** Magnetic saturation error. Local magnetic field too strong.
 - **FAiL3:** Mathematical fit error.
 - **FAiL4:** Calibration convergence error.
 - **FAiL6:** Orientations were wrong during the calibrations.
 8. If **FAiL** appears, press the “Power/Fire” button. **No** and **CAL** will alternately blink allowing you to do a new calibration. If the calibration fails, the unit reverts to the previous calibration.

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SOP B Routine Tasks with the TruPulse 360R Laser Rangefinder

This SOP covers steps for completing the typical tasks necessary for protocol implementation.

B.1 Distance

Distance is typically measured as the distance from the TruPulse to the point of interest. For TOS sampling this routine is used to:

- verify placement of plot corners laid out using tapes during plot delineation
- measure plot sides in heavy brush or along slopes
- locate clip strip grid cells for herbaceous clip harvest, litter trap placement and bryophyte productivity
- determine distance relative position mapping of woody stems or individuals selected for phenology monitoring

To measure distance:

1. Press “Power/Fire” to turn on the TruPulse.
 2. Set the unit to Target Mode = Filter (Flt). Press either the ▲ or ▼ button until HD (i.e. Horizontal Distance) appears in the viewfinder.
 3. Person 1: Hold the reflective surface centered at the base of the stem so that it is visible to Person 2.
 4. Person 2: Look through the TruPulse viewfinder, aim the crosshairs at the reflective surface held by Person 1, and press and hold “Power/Fire” until the distance is displayed in the viewfinder; record this distance.
- Verify that the units displayed = **METERS** and that the reading contains one decimal digit (e.g. 3.0), if the reading does not contain one decimal digit the measurement is bad (e.g. 3).
 - If YARDS or FEET are displayed, the units will need to be reset. See section A.2 for details.
 - Once a distance is displayed in the viewfinder, scrolling through measurement modes to **AZ** will display the azimuth of the object to which distance was measured. This feature also works for inclination.

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B.2 Distance between two points

For TOS sampling, this routine is used to:

- Measure canopy diameter

Canopy diameter measurements are reported to the nearest 0.1 meter. **canopyDiameterMax** = the diameter at the greatest canopy extent. **canopyDiameter90** = the diameter approximately perpendicular to canopyDiameterMax.

1. For individuals with height > approximately 2 m: Use the TruPulse 360R in **HD** (Horizontal Distance) mode.
2. Person 1 and Person 2 should position themselves below the edges of the canopy corresponding to either **canopyDiameterMax** or **canopyDiameter90**.
3. Person 1 should hold a reflective surface, and Person 2 should measure the horizontal distance to Person 1 using the TruPulse; to make this measurement, the unit must be in **HD** mode. Record this distance to the nearest 0.1 meter.

B.3 Height

For TOS sampling, this routine is used to:

- Measure height of woody stems
- Measure height of break point on broken boles

Two measurements are necessary to calculate height. In RD[06], the two vertical distances that must be measured with the unit are referred to as **VD1** and **VD2** (see Figure 7).

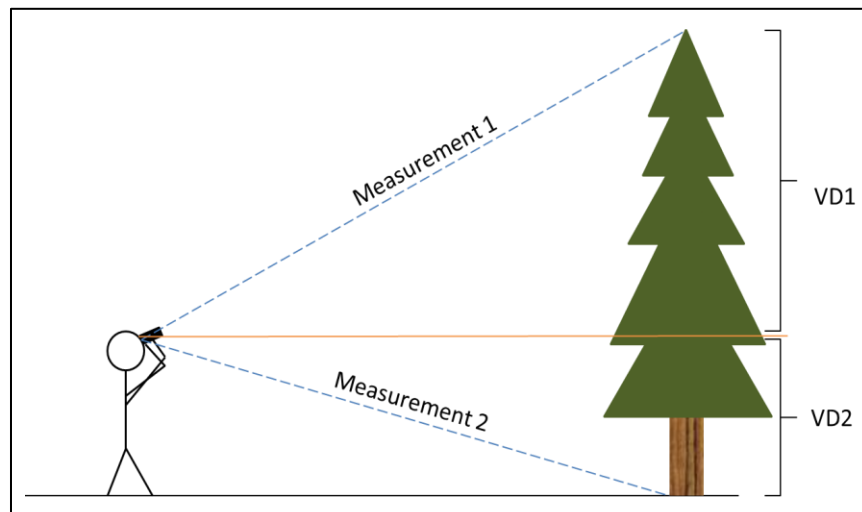


Figure 7. Two shot routine to measure height.

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First measure the vertical distance from the TruPulse to the top of the canopy (this is VD1; this number is typically positive). Next, use the TruPulse to measure the vertical distance from the TruPulse to the base of the stem (this is VD2; this number should be negative, since the base of the stem is typically below the height of the observer’s eyes).

$$\text{Height} = \text{VD1} - \text{VD2}$$

It is critical to ascertain that the observed **VD** values are associated with the stem of interest, and not any interfering or background vegetation. In cases where the desired **VD** cannot be measured in Continuous mode (e.g. foliage or branches obstruct the target), set the TruPulse with Target Mode = Farthest (FAR), so that the unit reports **VD** from the furthest laser return from the observer. If the observer is positioned carefully, the furthest return should correspond either to the base of the stem (i.e. the ground) or the highest canopy point.



To measure VD1 and VD2:

1. Select a location from which the likely canopy peak(s) and the base of the stem are visible. Both VD1 and VD2 must be measured from the same location.
2. Press “Power/Fire” to power on the TruPulse.
3. Set the Target Mode to either Continuous (Con) or Farthest (FAR); use your best judgement as to which mode is most appropriate for the stem of interest.
 - If the view of the point of interest is unobstructed, set the TruPulse Target Mode = Continuous (Con)
 - If the branches or other objects are between the observer and the point of interest, set the TruPulse Target Mode = Farthest (Far)
4. Press ▲ for 4 s, then press ▲ or ▼ until either “Con” or “FAR” is displayed, and press “Power/Fire” to select.
5. Press ▲ or ▼ until **VD** (Vertical Distance) is displayed in the viewfinder.
6. Look through the viewfinder and aim the cross-hairs at what appears to be the highest point of the canopy. If the TruPulse is in Continuous mode, “Power/Fire” may be pressed for up to 10 s, and “Laser” will display in the viewfinder and the VD value in the upper-right will update in real-time as the cross-hairs are aimed at targets. When “Laser” disappears, the unit will display the most recent VD in the upper-right.
 - If it is necessary to move around while locating the highest canopy point, make sure that the base of the stem is still visible from the new location.
 - If it is unclear which point in the canopy is the highest, press “Power/Fire” and use the TruPulse to explore potential peaks until the highest point is found. Once the highest point is located, record this value as **VD1**.
7. Look through the viewfinder and aim the cross-hairs at the base of the stem. Press and hold “Power/Fire” for at least 1 s. The **VD** value in the upper-right of the viewfinder should blink when “Power/Fire” is released. Record this value as **VD2**.

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B.4 Azimuth

This is the angle relative to True North from a given point to an object of interest

1. Press “Power/Fire” to turn on the TruPulse.
2. Press either the ▲ or ▼ button until **AZ** (i.e. azimuth from True North) appears in the viewfinder.
3. The angle in degrees is displayed; record this angle.

The angle should be preceded by a “d” indicating that declination has been set for the TruPulse at your current location (as described in A.3).

B.5 Slope

The unit is useful for any slope measurement. The slope of a plot will be measured with the rangefinder as part of Plot Establishment, RD[04], and also when assessing the appropriateness of using a tape measure to measure horizontal distance for any TOS protocol. If the plot slope is > 20 % (or >11.3 degrees), the TruPulse laser rangefinder used in **HD** mode is more accurate than a tape measure. *Note: the laser is not used when measuring slope so a Target Mode is not selected.*

To measure slope:

1. Press “Power/Fire” to turn on the TruPulse.
2. Press either the ▲ or ▼ button until **INC** (i.e. inclination measurement mode) appears in the viewfinder.
3. Press “Power/Fire” to display the slope
 - Verify that the units displayed = **PERCENT**.
 - If DEGREES is displayed, the units will need to be reset. See section A.2 for details.



Press the ▲ and ▼ buttons simultaneously for 4 seconds to power down the rangefinder. This helps preserve battery life.

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7 REFERENCES

TruPulse® 360°R User’s Manual (2011). Laser Technology, Inc., Centennial, CO.

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APPENDIX A QUICK REFERENCES

N/A

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APPENDIX B REMINDERS

- Make sure declination is set for the location
- Calibrate TruPulse before use at a new plot or after changing batteries
- Select a Target Mode appropriate for the plot conditions