

2018 Simple Plot Protocol:

Field Data Collection Protocol for Evaluating Fire Mitigation Effectiveness

Developed by Colorado Forest Restoration Institute

CFRI-1809

Sampling Objective:

This fuels assessment protocol is designed to collect comprehensive data for ground, surface, herbaceous, shrub, and tree fuels to determine changes in fuel abundance and distribution resulting from management actions in forests and shrublands of Colorado. The following protocol was developed from a 2013 version designed to quantify fuel condition and fire hazard potential for analysis with the Fuels Characteristic Classification System, within the Fuel and Fire Tools analysis package, but this protocol ultimately is a general fuels sampling method and can be used for any objective where fuel loading is needed (cite original). CFRI staff refers to this protocol as the “simple plot protocol”, in comparison to the “mothership plot protocol” (not included here) that is a similar yet separate and more intensive protocol designed to better capture secondary ecological change resulting from forest management.

Sampling Design and Intensity Recommendations:

The most accurate method for quantifying changes in fuels resulting from management actions is to quantify fuels at the same location before and after treatment. When conducting pre-post fuel loading comparisons, permanently marked plot locations increase ease of finding plot locations and comparability of multiple measurements over time. Sample plots located randomly throughout an area of interest provide a robust study design and is generally recommended over a gridded plot system.

How many plots do you need? Appropriate sampling intensity will depend on monitoring objectives and level of confidence needed in results. If you are gathering information to determine standard fuel model for fire behavior modeling, only a few plots may be needed. However, if you want to determine differences in fire hazard over a large area before and after treatment, much more intensive sampling is required. Exactly how many plots you need to get a reliable answer depends on local site variability, which cannot be predicted remotely. However, when using our fuels assessment protocol in Colorado, typically a minimum of roughly 10 to 15 plots is adequate monitoring to evaluate differences pre- and post- treatment with relatively high confidence, although we often aim for 20 or more plots per site when possible. CFRI crews often sample an area using this protocol with a crew of 3 trained individuals, at a rate of 5-8 plots per day. On sites with sparse fuels or vegetation where sampling may take less time and an above average number of samples can be taken in the 2-3 days of sampling, it may still appropriate to sample for 2-3 days to increase sample sizes for a robust data set with high confidence.

Underlying Methods and Data

This protocol relies heavily on the experience of CFRI staff in conducting combined decades of forest and fire ecology monitoring and research. It is designed to use standard protocols

where appropriate so that data is comparable to large monitoring and research efforts in Colorado and throughout the Rocky Mountains. We rely heavily on the Fire Effects Monitoring and Inventory System protocols (FIREMON <https://www.frames.gov/partner-sites/firemon/firemon-home/>) to remain comparable with national datasets. Much of the sampling protocol was also modified by CFRI staff to facilitate use of the Fuel and Fire Tools modeling platform, which we find useful in evaluating treatment effectiveness and communicating changes in fire potential.

Plot Installation and Layout

1. Randomly locate the plot center within the desired sample area. Use GIS technology if available, or a random number table with numbers 0-359 can be used to choose a random direction and then a random distance to walk.
2. From the plot center, chose a random direction (0-359) for the plot transect orientation. *Revisit azimuth accuracy standard: +/-5°*
3. Stretch out a measuring tape 25ft in each direction along the randomly chosen direction to establish the transect, being careful to place the tape as close to the soil surface as possible. Before proceeding, be sure that the edge of the plot is at least 50ft from a treatment boundary.
4. Each of the three 1m² sampling frames are placed to the left of the 50ft transect as depicted below. The frames begin at 0ft, 25ft, and 47ft on the transect. To avoid trampling vegetation and woody fuels, walk on the right side of the transect as much as possible.

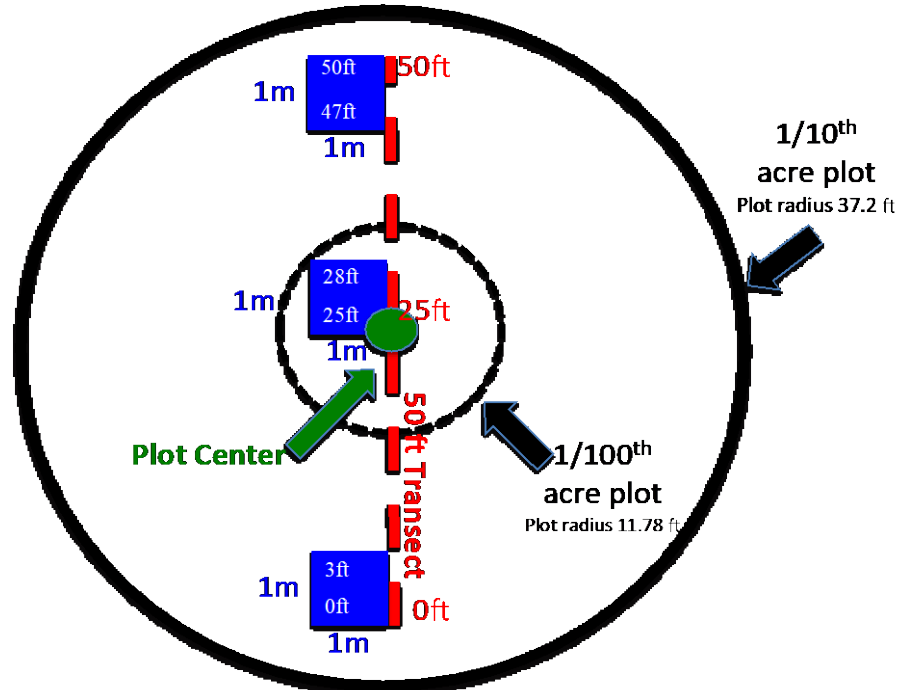


Figure 1: Diagram of the CFRI Rapid Fuels Assessment (simple plot). Diagram not to scale.

Center Sample Point

1. Location

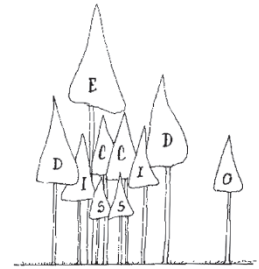
- a. Using a GPS unit, record the location (UTM) and elevation (ft) at the center point. Use the **NAD83 map datum**, or record the datum that was used. *Revisit UTM accuracy standards: +/-5m E & N*
- b. Using a **declinated (8.5°E)** compass, record the hillslope azimuth in degrees (0-359) within the 1/10th acre plot. This is NOT along the transect, but measures whether the sample location is on a north or south facing hillside. *Revisit hillslope azimuth accuracy standards: +/- 15°*
- c. Using a clinometer, record the slope of the hillside along the hillslope azimuth to the nearest percent within the 1/10 acre plot. Take slope measurements from plot center both downhill and uphill, and then record the average slope of the two measurements.
Revisit slope accuracy standards: +/- 5%
- d. Take note of any signs of past disturbances (e.g. fire, insect outbreaks, stumps from logging, animal signs/grazing, human disturbance, etc.) and record the start and end time of data collection for each plot.
- e. Install **two** monuments:
 1. Use a nail, yellow painted washer, and a silver “CFRI Long-term Monitoring Plot” tag. Inscribe plot name, date, and location (“0ft,” “25ft Center,” or “50ft”) on the tag with a pen. Install monuments at the start of the transect (0 ft) and plot center (25 ft).
 2. Wrap a small piece of pink flagging around each washer. If flagging is missing in post-treatment years, re-flag nails.

2. Photos

- a. Photos will be used to describe fuel conditions and to help locate plots post treatment. Fill out a white board with the plot name and date. Standing at the plot center (25ft on transect), take 4 photos in the below order. Record camera ID, photo file numbers, and time of photos on the datasheet. Frame photos so the white board is legible when viewed on a computer screen (not camera viewfinder), and exclude gear and people in the shot. Photo sequence (Appendix A for full training steps):
 1. **Down:** Along the transect looking in the direction of 50ft holding the camera eye level pointed towards the ground (capturing 25-35ft on the transect and the 1 m² sampling frame). Take enough steps back from plot center to capture the plot center in the photo.
 2. **Eye Level:** Holding the camera over plot center, along the transect looking in the direction of 50ft at eye level.
 3. **Canopy:** Holding the camera over plot center, along the transect looking in the direction of 50ft towards the upper tree canopy.

4. **Opposite Eye Level:** Holding the camera over plot center, along the 50ft transect looking in the direction of 0ft at eye level.
3. **Tree Overstory**
 - a. Record the basal area prism or angle gauge size and units. Use BAF of 10 for first plot visits. *If the site has been previously sampled, use the same prism size used in previous visits.*
 - b. Standing at the plot center, use a basal area prism to record basal area of the variable radius plot for all live and dead trees taller than 4.5ft with a diameter at breast height (DBH) ≥ 5.0 in. Hold the prism at any convenient distance from the eye, directly over the plot center. If a tree is a 'hit' and included in the basal area count, mark that tree for further measurement by placing a pin flag at its base. *Record trees in clockwise order starting along the transect azimuth. If two trees are aligned in clockwise order, measure the furthest from plot center first.*
 - c. For each hit tree in the basal area count, record:
 1. Tree Species
 2. Status Class: For standing trees taller than DBH, record survivorship or decay class on a scale of 1-3.
 - i. L = live trees with green needles.
 - ii. 1a *with needles* = recently dead trees, top intact, needles/ foliage and fine branches present. *Record CBH for trees with needles.*
 - iii. 1b *without needles* = recently dead trees, top intact, fine branches present.
 - iv. 2 = snags with coarse branches and bark present, but fine branches and foliage have fallen off.
 - v. 3 = rotten snags, bark not present. Very few if any branches remain.
 3. DBH (nearest 0.1in)
Measure the distance from top of mineral soil to breast height with a measuring tape and mark the diameter measuring point on the tree bark with a timber crayon. Stand on upslope side of bole. If tree is leaning, lean with it to determine breast height and measure perpendicular to central axis.
 4. Tree Height (nearest 1ft)
Ocular estimate up to 10ft, and with a range finder when height is >10 ft.
 5. Crown Base Height (CBH, nearest 1ft)
Lowest height of continuous live vegetation for all live trees and class 1a snags. This measure estimates the lowest vegetation (needles, branches, etc.), not including the main stem (tree trunk) or where the lowest branch converges with the trunk.
 6. Crown Position: The position in the canopy determined by how much light is available to tree crown. 5 total sides, 4 lateral sides and the top.

- a. O—Open grown, the tree is not taller than other trees in the stand but still receives light from all directions.
- b. E—Emergent, the crown is over twice the height of the average canopy height of the stand. Rare in Colorado.
- c. D—Dominant, the crown receives light from at least three to four directions.
- d. C—Codominant, the crown receives light from at least one to two directions.
- e. I—Intermediate, the crown only receives light from the top.
- f. S—Suppressed, the crown is entirely shaded and underneath the stand canopy.



1m² Sample Frame

Use extreme care to avoid trampling fuels while orienting three 1m² sampling frames along the left side of the transect, facing 50ft, at 0-3ft, 25-28ft, and 47-50ft. Photoload Calibration Plot (PCP): At every other plot, add a fourth frame outside of the plot 3yd in a random direction from 0. Measure the following in each frame:

1. Groundcover

- a. Use the ocular estimate method to measure cover of ground cover classes to the nearest 1% within the 1 m² sample frame. Classes include litter/duff, moss/lichen, soil/gravel (<1 cm), rock (>1 cm), 1000hr fuel, woody basal (stumps or live tree trunks), and herbaceous vegetation basal (large dead plant material suppressing growing space; rarely found in Colorado). Each class should be measured independently and together sums to 100% (e.g. 80% litter/duff, 20% rock). Exclude live vegetation from ground cover estimates.

2. Depth of Litter, Duff, and Small Woody Fuels

- a. Measure depth of litter and duff (nearest 0.25in) at each corner of each sample frame.
 - a. **Litter** is the loose layer made up of needles, dead grasses detached from the plants, recently fallen leaves, twigs not visible from above, and so forth, where the individual pieces are still identifiable and little altered by decomposition.
Duff is the layer below the litter layer and above the mineral soil. It is made up of litter material that has decomposed to the point that the individual pieces are no longer identifiable (RMRS-GTR-164-CD). Pine cones are considered litter or duff, not woody fuel.
- b. Measure four depths of 1hr/10hr/100hr, deciduous woody fuels below breast height, lumped as one category, where they occur in the sample frame. Depth must be >0 if a photoload >0 of small woody fuels is recorded in the frame. If no

woody fuels occur in the plot, note 0 in for the depth. If woody fuels occur, but fewer than four estimates can be made, record "NA" in all fields following positive depth values.

3. Herbaceous Vegetation Cover and Height

- a. Using the ocular estimate method, measure canopy cover of all non-woody vegetation to the nearest 1% (graminoids and forbs). As a rough guide, a closed fist equals ~ 1% cover. For cover <1%, classify cover as either 0.1% or 0.5% as appropriate.
 1. Total Herbaceous Cover: all non-woody vegetation rooted in the sample frame.
 2. Estimate average total maximum height of all herbaceous vegetation at the highest point of each plant, as it stands, rooted within the frame (nearest 1in).
 3. Record canopy cover for the 3 most common herbaceous species rooted in each frame. Identify plants to the species level using the USDA PLANTS database 4 letter code, or the full Latin nomenclature if code is unknown. The goal is to identify dominant plants in the plot. If you can't identify to species, record as unknown graminoid or unknown forb. Note succulent plants (e.g. cactus, sedum, etc.) that are less reactive in a fire than grasses or other forbs.

4. Photoload Estimates

- a. Use the Photoload technique (RMRS-GTR-190, 2007) to estimate fuel loading for 1hr, 10hr, 100hr, and herbaceous fuels in tons/acre within the frame. Photos in Appendix B are intended as guides and not absolute choices. Estimate as close to the picture as possible or chose an intermediate loading between pictures if appropriate. Herbaceous fuel heights should be maximized by straightening the vegetation. A go-no-go fuels gauge can be used to help classify fuels in the sample frame.
 - i. 1 hr fuels (0 to 0.24 inch)
 - ii. 10 hr fuels (0.25 to 0.99 inch)
 - iii. 100 hr fuels (1.00 to 2.99 inches)

5. Biomass Collection

Record one frame at every plot where herbaceous biomass is collected from. Collect woody biomass in every PCP frame, and record this is completed. All biomass is to be returned to the lab, oven dried to constant mass, and weighed to attain dry weight of herbaceous material (loading in tons/acre). Do not collect litter or duff (e.g. no needles or cones).

- a. Herbaceous: Clip all herbaceous material at the soil surface (current year's growth and senesced/ dead material that is still attached to plants) for each plant *rooted* within the frame.
- b. Woody: Collect 1hr, 10hr, and 100hr fuels, within the sample frame, and respectively place into individual bags.

- c. Label each of the four biomass bags with 1) plot code, 2) date, 3) fuel type (herb, 1hr, 10hr, or 100hr), 4) sample frame location (0ft, 25ft, 47ft, or PCP), and 5) photoload estimator initials.

50 foot Transect

1. Shrubs

- a. Record cover of any live shrubs along the 50ft transect.
 1. Using the line intercept method, record the amount of line covered by each shrub by species (nearest 1in). Record only the top shrub layer.
 2. For shrubs with sparse leaves, clump the shrub and record the continuous cover of shrub if any part of the live shrub intersects the tape. If a gap of more than 6in exists between shrubs, or within the canopy of a large single shrub, record that gap as a break and separate shrubs on the datasheet.
- b. For each clump of shrubs, record the average shrub height, to the nearest 1in), at the highest point of each plant within each clump (or several times as appropriate for large clumps). A yard stick is handy to estimate heights.

2. Tree Cover

- a. Use a densitometer scope to record cover of any live tree taller than 4.5ft (breast height) at every foot along the 50ft transect. Stand directly over each point along the tape, look straight up through the densitometer scope, and record when a species (foliage or trunk) is encountered. Each transect will have 50 potential hits.

3. Tree Group Size Transect

Measure the distances covered by closed-canopy forest areas ("tree clumps") versus openings along a transect.

- a. Record the start and end points of "openings" and "canopy clumps" directly overhead the length of the transect, starting at 0ft and ending at 50ft. Include as canopy clumps, any canopy overhead the transect produced by trees >1in DBH. Use the densitometer scope to identify the location along the transect at which transitions between canopy and openings occur. Each start point should begin at the prior end point (i.e. 0-5ft, 5-12ft, 12-50ft)
- b. Along with the start and end points for each length of canopy clump, record the number of trees that contribute to the formation of that clump. For example, the tree canopy intersecting the transect may be an individual tree, or it may be part of a small or large clump of trees extending beyond the transect. Record the number of trees forming each canopy clump as classes (0 if open, Class 1= 1 tree, Class 2= 2-4 trees, Class 3= 5-9 trees, Class 4 = 10-15 trees, or Class 5= 16+ trees). If canopies of trees are interlocking, or less than 5ft apart, count them as part of the same canopy clump. Remember to record intervals of the transect classified as open (size class 0).

1/100th Acre Plot (11.78 ft radius)

1. Tree Saplings and Seedlings

If a fixed radius plot was not used to sample seedlings and saplings during the initial visit, repeat the initial method used (i.e. variable radius plot or 1m² frame), in addition to the 1/100th acre plot estimate, and note the respective sampling method on separate datasheets.

- a. **Tree Saplings** taller than 4.5 ft, but <5 in DBH within the 1/100th acre subplot:
 1. Tree Species
 2. DBH (nearest 0.1in)
Stand on the upslope side of the bole. If tree is leaning, lean with it to determine breast height and measure perpendicular to central axis.
 3. Tree Height (nearest 1ft)
Ocular estimate up to 10ft, and with a range finder when height is >10ft.
 4. Crown Base Height (CBH, nearest 1ft)
Lowest height of continuous live vegetation for all live trees and class 1a snags.
 5. Decay class: L, 1a, 1b, 2, or 3 (See “3. Tree Overstory” for class descriptions)

- b. Note: Typically large shrubs, such as Gambel Oak, are not counted as trees and their abundance is only measured on the 50ft shrub transect. Where Gambel Oak takes on more of a large single stem tree growth form in southwestern Colorado or further south, it may be appropriate to measure this and other tall shrubs as a tree.

- c. **Tree Seedlings** (less than 4.5 ft tall within the 1/100th acre subplot):
 1. Record the species and number of individuals in each height class.

1. Class 1: 0 - 4in	3. Class 3: 18.1 - 30in
2. Class 2: 4.1 - 18in	4. Class 4: 30.1 - 54in

1/10th Acre Plot (37.2 ft radius)

1. **1000 hr fuels** (larger than 3 in diameter)
 - a. Measure the end diameters, the length, and species of every log larger than 3 inches diameter within the 1/10 acre plot (nearest 0.1in).
 1. If diameter drops below 3in on the log, stop measuring at that point.
 2. When a log travels outside of the 1/10th acre plot boundary, stop measuring the log at the plot boundary.
 3. If the center point of the log is below the duff, stop measuring at that point.
 - b. Record if the log is rotten or sound. Consider pieces rotten when the piece at the intersection is obviously punky, can be easily kicked apart, or buckles under weight.

Tip: occasionally 1000hr fuel is very abundant and can take very long to measure. If 1000hr fuel volume is homogenously distributed across the plot, consider measuring half, or even a quarter of the plot and recording total area measured on the datasheet. Always start from the transect azimuth towards 50ft and work clockwise around the plot. If half a plot is measured the loading will be multiplied by 2, a quarter

plot multiplied by 4. If only measuring a portion of the plot due to abundant 1000 hr fuel, ALWAYS circle "Full," "Half," or Quarter" indicating the portion of the plot measured.

2. Log Decks or Burn Piles

Managers often pile large woody fuels for later burning or removal. Because logs are often inaccessible for measuring, the pile should be measured as a single volumetric unit.

- a. Record length, width, and height of pile to nearest inch
- b. Record dominant species represented in pile
- c. Note if the feature is a burn pile or log deck
- d. If no piles are present, enter 'NONE' in species name.

Simple Plot Gear List

Plot Center Baggie

- 1 - Prism (10 BAF)
- 1 - Prism (20 BAF)
- 1 - Calipers 6"
- 1 - Clinometer
- 1 to 2 - Compass
- 1 - Timber Crayon
- 1 - 11.78ft fixed plot rope

Canopy Baggie

- 2 - Click counters
- 1 - GRS Densitometer

Fuels Baggie

- 2 - Duff/litter ruler
- 2 - Fuel gauge

Gear bag (small, green)- Zipper Pocket

- Batteries: AAA (4), AA (4), 9V(1), 123A (2)
- 1 - Camera (Ricoh WG or Canon powershot)
- 1 - GPS (Garmin eTrex-20)
- >2 each - Pencils, Pens, Sharpie, Dry erase markers
- 1 - Flagging tape (pink)
- Small (10), Medium (10), and Large (3) brown paper biomass bags
- Monuments: 40 tags and 40 washers / bag

Gear bag (small, green)- Main Compartment

- 1 - 100' reel tape (10th inch)
- 1 - Diameter tape (small 10'/8')
- 1 - Measuring tape
- 1 - Folding saw

- 1 - Hammer
- 1 - Rangefinder
- 1 - White board
- 2 - Shears in Sheaths
- 1 - Trowel
- 2 - Logger's tape (Eng)
- 2 - Clipboard/Tatum: filled with below forms
 - Data sheets and unknown plant sheets (regular and rite in the rain)
 - 1 - Protocol
 - 1 - The photoload sampling technique - herbaceous fuels x1
 - 1 - The photoload sampling technique -1hr, 10hr, and 100hr fuels (pages 15-17)
 - 1 - Random number table (0-359)
 - 1 / person - Species lists
 - Maps of the site (quads and plot maps)

Refill each day from vehicle

- 2 / plot - Monuments (large nails, whiskers, washers, plot tags, etc.)
- 2 of each size / plot - Paper bags for fuels (medium and large)
- Appropriate forms

Tube bag (orange)

- 1 - Sample frame (1 x 1 m)
- 1 - Tree caliper (18")
- 4 - Chaining pins
- 15 to 20 - Pin flag bundle 2 different colors
- 2 - Yard stick for plant heights and tree seedling height class markings

Vehicle Bag - Gear bag (large, yellow)

- Extra paper bags (medium and large)
- 1 - Complete First aid kit, bug spray, sunscreen
- 4 - Cruising Vests
- Jumper cable
- 1 - Tow strap
- Colorado atlas (navigating to study area)
- Duct tape

Vehicle Form Box

- Data sheets
- Protocols
- Herb and Woody Photoload Templates
- Random number lists

- 2-pager reports
- Plant field guide (Ackerfield, Wingate Illustrated keys to grasses of Colorado, etc.)

Vehicle Loose

- 1 - Metal detector
- Plant press
- 4 - Hard Hats
- 1 - Small shovel
- Water cooler(s)

Electronics Box

- 2 - Tablets
- 1 - Walkie-Talkie (Motorola)
- 1 - Walkie-Talkie micro USB charger
- 1 - Camera cable
- 1 - Tablet USB Charger
- 1 - Portable charging device
- 2 - Tablet stylus
- 1 - Flora of Colorado

Plot Photo Protocol for ALL CFRI Research and Monitoring Plots

Post Treatment Protocol: Take photos from the same perspective and frame as pre-treatment as best you can. Rather than follow the below instructions, repeat photography is important to *repeat* what was done in the past, so replicate previous photos as best you can.

Pre-Treatment Photo Protocol: Standing at the plot center (typically 25 ft on transect), take 4 photos. Record camera ID and photo file numbers on the datasheet. Fill out a white board with the plot name and date (dd/mm/yyyy). Photos should be framed such that the white board is visible/legible when viewed on a computer screen and not necessarily on the camera viewfinder. Minimize visible people and gear in the photo. Photos will be used to describe forest conditions and to help locate plots post treatment.

- Always take the photos in landscape camera position.

General Photo Taking Tips:

- If you make a mistake with plot photos, DELETE the photo on the camera immediately. Extra plot photos unnecessarily complicates data management, there should always be exactly 4 photos for every plot, no more or no less.

- Take extra photos of the site! When not taking plot photos, take photos of people working, forestry equipment, visitors, scenic views, cool trees or interesting parts of the forest.

Anything that will help tell the story of our monitoring process or the forest conditions and management activities. Write “site photos taken near plot #3” or something similar on the datasheet.

Photo 1: Down

Along the transect looking in the direction of 50 ft holding the camera *eye level* pointed towards the ground. Capture 25-35 ft on the transect in the photo and the 1 m² sampling frame. Place the whiteboard at exactly 35 ft (10 ft from plot center). Rather than stand at the plot center, the photographer should take enough steps back in order to capture the plot center and whiteboard in the photo from eye level. This photo is designed to be at eye level looking downward in order to describe forest floor conditions (surface fuels, substrate, tree regeneration, understory plant community, etc.).

Be sure to move all gear out of the photo!!

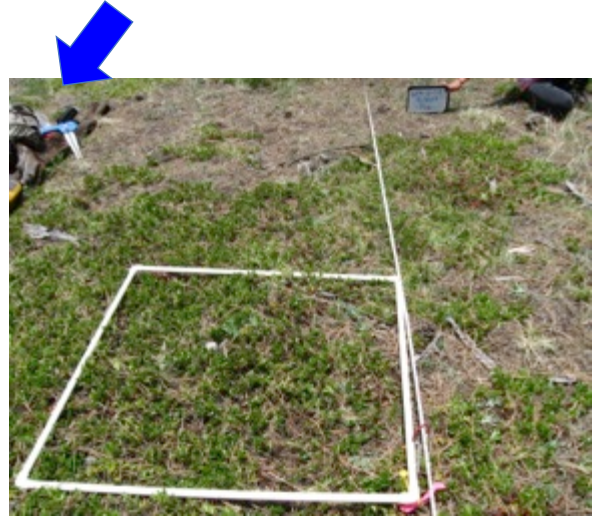


Photo 2: Eye Level

Step back up to plot center and hold the camera directly over the 25ft mark. Holding the camera over plot center, take a photo along the transect looking in the direction of 50 ft at eye level. The person holding the whiteboard should still be standing roughly at 35ft (10 ft from Plot Center), off to the side with only the whiteboard visible in the photo.



Photo 3: Canopy

Holding the camera over plot center, along the transect looking in the direction of 50 ft towards the upper tree canopy. The person holding the sign should still be at roughly 35ft (10 feet from plot center) holding the sign as high as they can reach. Sometimes they need to take a step or two towards the transect in order to get the sign in the photo. The sign should always be in the very bottom corner of the photo.



Photo 4: Opposite Eye Level

Holding the camera directly over plot center, take a photo along the 50 ft transect looking in the direction of 0 ft at eye level. The person holding the whiteboard should still be standing roughly 10 ft from plot center (15 ft on transect), off to the side with only the whiteboard visible in the photo. Occasionally it is desirable to have people in the photos for use in presentations and to give context. Plan to take about every other plot with this photo position having a person in the photo. Smile and look like you enjoy working in the forest!

