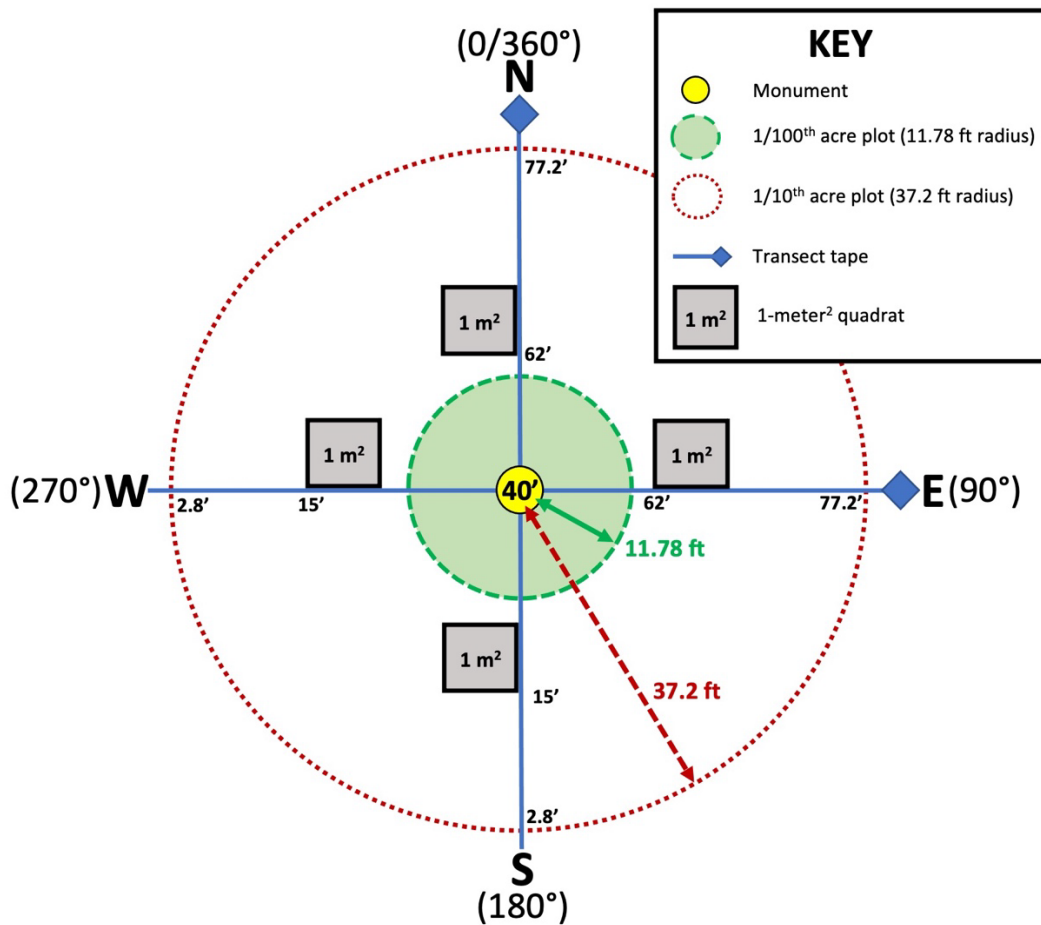


## COSWAP Forest Inventory Protocol:

*Field Data Collection to Assess Forest Restoration and Fire Mitigation Treatments*  
Developed by the Colorado Forest Restoration Institute

### Sampling Objective:

This protocol is designed by the Colorado Forest Restoration Institute (CFRI) to collect comprehensive data for changes in non-spatial forest structure and composition, and fuels and fire potential as a result of management actions in forests and woodlands of Colorado.



## PLOT LAYOUT:

1. **Navigate to the plot.** If resampling an area, use the site map, GPS coordinates, and/or plot photos to navigate to the plot. If establishing a new plot, use Avenza map or GPS coordinates. When establishing a new plot, make sure that the GPS point falls in an area that is suitable (e.g. not on a road, riparian, treatment boundary, etc.) and characteristic of the surrounding area. If the plot needs to be moved, use the random number table/generator to choose a direction and distance to move the point to a suitable area. Before proceeding, be sure that the *edge of the plot is at least 100 feet from a treatment boundary.*

### *Helpful hints for relocating a plot:*

- *Use the metal detector.*
  - *Plug coordinates into the GPS – occasionally points on the map can be off.*
  - *Match the plot location using previous plot photos. Look for distinctive rocks, branches, snags, topography, etc.*
  - *Speak with RAs – occasionally we have multiple sources for plot coordinates.*
2. **Lay out the plot.** From plot center, establish 4 transects in the cardinal (0°, 90°, 180°, 270°) and directions using a **declinated** compass (set - 8.5° east for the Front Range) and two 100 ft tapes. Center the 40 ft mark of both tapes over the plot center and extend tapes to 78 ft. Clip tapes together with a binder clip at plot center to ensure they stay in place. Be sure the 0 ft mark is on the S and W ends of the transects (the reel should be on the N and E ends). Colored tape marks the plot center and transect ends.  
[Note that this protocol can be implemented with 50 ft tapes, but care must be taken to ensure measurements happen at the correct locations.]
  3. **Monument.** Install one permanent marker, or monument, using a nail, yellow painted washer, and a silver “CFRI Long-term Monitoring Plot” tag. Inscribe plot name and “PC” for plot center on the tag with a pen and write it on the washer with a permanent marker. Wrap a piece of pink flagging around each washer. Re-flag nails on each revisit or once per year.

## PLOT SET-UP:

### 1. **Basic Plot Information**

- a. *Plot Name:* Triple check that the plot name is correct! Look at the map and compare tablets. Errors in plot names cascade to all data and are very difficult to fix later.

- b. *Aspect*: Using a declinated (8.5°E) compass, measure the hillslope aspect in degrees (0-359) within the 1/10<sup>th</sup> acre plot. This is NOT along the transect, but where a ball would roll down the hill. If revisiting, record the previously measured aspect unless it is outside of revisit standards. *Revisit aspect accuracy standards: ±15°*
- c. *Slope*: Using a clinometer, record the slope of the hillside along the aspect to the nearest percent within the 1/10<sup>th</sup> acre plot. Take slope measurements from plot center both downhill and uphill and record the average slope of the two measurements. In general, new plots should not be installed when slope >40%. If revisiting, record the previously recorded slope unless it is outside of the revisit standards. *Revisit slope accuracy standards: ±5%*
- d. *Coordinates*: Record the location (UTM) and elevation (ft) using the built-in function on the Survey123 form. *Revisit UTM accuracy standards: ±5 m E & N*
- e. *Fuel Model*: (Crew Leader/Senior Technician) assign a fire behavior fuel model to the plot using the Fuel Model Key<sup>1</sup>, found in the clipboard.
- f. *Plot Notes*: Record any plot notes in the \*complete\* Survey123 form, including notes on plot location (near road, near treatment boundary), making specific notes of past disturbances (e.g. fire, insect outbreaks, stumps from logging, animal signs/ grazing, human disturbance, etc.). *Notes should only be recorded on the \*complete\* Survey123 form.*

## 2. Photos-

- a. Standing at the plot center, take 6 photos. Fill out a white board with the plot name and date. Hold whiteboard 10 ft from plot center. Take photos in the landscape orientation, frame photos so the white board is legible, and exclude gear and people in the shot. *For post-treatment plots, check pre-treatment photos to ensure the same view is captured.* The photo sequence is:
  1. *Ground, North*: Face the north transect and hold the tablet at eye level while standing about 5 ft back from plot center. Angle the tablet downward to include the entire 1 m<sup>2</sup> sampling frame and plot center in the photo; making sure that the transect is in the center of the photo.
  2. *Eye level, North*: Hold the tablet over plot center, looking along the north transect at eye level.
  3. *Canopy, North*: Hold the tablet over plot center, looking along the north transect towards the upper tree canopy.
  4. *Eye level, East*: Hold the tablet over plot center, looking along the East transect at eye level.
  5. *Eye level, South*: Hold the tablet over plot center, looking along the South transect at eye level.
  6. *Eye level, West*: Hold the camera over plot center, looking along the West transect at eye level.

## PLOT MEASUREMENTS:

*For all plot measurements, begin sampling on the north transect and move clockwise through the plot.*

### Tree Overstory

1. **Fixed radius plot:** 1/10<sup>th</sup> acre plot (37.2 ft radius).
2. **Flag trees in plot:** Tree overstory includes: all live and dead trees  $\geq 4.5$  ft tall, with a diameter at breast height (DBH)  $\geq 5.0$  in, and the center of the tree is within 37.2 feet of plot center. Flag all trees meeting these requirements using alternate pin flag colors (color choice does not matter), starting to the east side of the north transect and working clockwise. Since trees are not always tagged, **it is essential that trees are recorded in order** to understand changes in tree overstory. If one tree is in front of another but both are in the plot, measure the furthest from plot center first. Use extra 100 ft transect tape to check whether the center of the bole of a boundary tree is within the plot.
3. *When conducting **post-treatment measurements***, check for any new or missing trees prior to beginning measurements and make note of any changes in tree order in the notes for each tree.
4. **Measurements for each tree:**

<b>Species</b>	Record species of each tree.
<b>Status Class</b>	<p>L= Live trees with green needles.</p> <p>1a <i>with needles</i> = Recently dead trees, top intact, needles/ foliage and fine branches present. <i>Record CBH for trees with needles.</i></p> <p>1b <i>without needles</i> = Recently dead trees, top intact, fine branches present.</p> <p>2 = Snags with coarse branches, but fine branches and foliage have fallen off.</p> <p>3 = Rotten snags. Very few if any branches remain. Usually short (&lt;20 ft) due to decay status.</p>
<b>Diameter at Breast Height (DBH)</b>	<p>Measure the distance from the top of mineral soil to breast height (54 inches) with a measuring tape on the uphill side of the tree. <b>Mark this measuring location with timber crayon.</b> If a tree is leaning, arrange the tape so that it goes along the length of the tree and measure DBH perpendicular to the central axis. <i>Measure to the nearest 0.1 inch.</i></p>
<b>Height</b>	<p>Ocular estimate up to 10 ft. Use rangefinder/ hypsometer for heights taller than 10 ft, making sure that the value returned seems reasonable. <i>Measure to the nearest foot.</i></p>

<b>Crown Base Height (CBH)</b>	Lowest height of continuous needles/leaves for all live trees and <i>class 1a snags</i> . Measure to the nearest foot.
<b>RX Burn only: Tag Number</b>	Only at sites where treatment involves prescribed burning. Tag trees at breast height (4.5') facing plot center. Angle the head of an aluminum nail downwards and leave about 1" of nail exposed so that tree growth does not close over the tag. Tree tags should be sequentially numbered in the order trees are measured.
<b>RX Burn only: Bark Beetle Evidence</b>	Only at sites where treatment involves prescribed burning. Look for small holes, frass (looks like sawdust), and pitch tubes (blobs of sap). Mark "Yes" if there is evidence of bark beetle attack in the lowest 6' of the tree stem.

**Special cases:**

- *Multiple qualifying stems:* If a single tree has multiple stems that divide below DBH (4.5 ft or 54 inches) – very common in juniper and pinyon pine – consider each qualifying stem (DBH < 5 in) as its own tree (take all measurements and tag if tagging trees).

**Tree Seedlings and Saplings**

1. **Tree Seedlings:** live trees within the 1/100<sup>th</sup> acre plot (11.78 ft radius) that are less than 4.5 ft tall.

Record the species and number of individuals in each height class:

Class 0: Germinants

Class 1: 0 - 4 in

Class 2: 4.1 - 18 in

Class 3: 18.1 - 30.1 in

Class 4: 30.1 - 54 in

2. **Tree Saplings:** live trees within the 1/100<sup>th</sup> acre plot (11.78 ft radius) that are 4.5 ft or taller with DBH < 5 in. For each individual record:

<b>Species</b>	Record species of each tree.
<b>Status Class</b>	<p>L= Live trees with green needles.</p> <p>1a <i>with needles</i> = Recently dead trees, top intact, needles/ foliage and fine branches present. <i>Record CBH for trees with needles.</i></p> <p>1b <i>without needles</i> = Recently dead trees, top intact, fine branches present.</p> <p>2 = Snags with coarse branches, but fine branches and foliage have fallen off.</p> <p>3 = Rotten snags. Very few if any branches remain. Usually short (&lt;20 ft) due to decay status.</p>

<b>Diameter at Breast Height (DBH)</b>	Measure the distance from the top of mineral soil to breast height (54 inches) with a measuring tape on the uphill side of the tree. Mark this measuring location with timber crayon. If a tree is leaning, arrange the tape so that it goes along the length of the tree and measure DBH perpendicular to the central axis. <i>Measure to the nearest 0.1 inch.</i>
<b>Height</b>	Ocular estimate up to 10 ft. Use rangefinder/ hypsometer for heights taller than 10 ft, making sure that the value returned seems reasonable. <i>Measure to the nearest foot.</i>
<b>Crown Base Height (CBH)</b>	Lowest height of continuous needles/leaves for all live saplings and <i>class 1a snags</i> . <i>Measure to the nearest foot.</i>
<b>Tag Number</b>	Only if tagging trees (only when treatment involves prescribed burning). Angle the head of an aluminum nail downwards and leave about 1" of nail exposed so that tree growth does not close over the tag. <b>Saplings with a small DBH (roughly &lt; 1 inch) should be tagged with wire</b> and not a nail to avoid damaging the tree. Tree tags should be sequentially numbered in the order trees are measured.

### Woody surface fuels

Four 1 m<sup>2</sup> sampling quadrats are located at 15 and 62 ft on the north-south transect and the east-west transect with the sample frame positioned on the left (west) side of north-south transect and on the upper (north) side of the east-west when looking north. If the quadrat contains masticated fuels (combined litter/duff/woodchips), select "Forest Floor" and refer to the masticated fuels protocol addendum; otherwise, select "Photoload."

- 1. Quadrat Photo:** Standing on the opposite side of the transect tape, take a downward-looking photo of the quadrat, include the whiteboard to the side of the quadrat with plot code, date, and quadrat location (e.g. "40 ft").
- 2. Photoload Estimates:** Using the Photoload<sup>2</sup> estimating technique, estimate fuel loading for 1 hr, 10 hr, and 100 hr fuels in tons/acre within the 1 m<sup>2</sup> sample frame. Estimate as close to the picture as possible or chose an intermediate loading between pictures if appropriate. A go-no-go fuel gauge should be used to help classify fuels in the frame. Fuel sizes are as follows:

1 hr: 0 to 0.24 inch diameter  
 10 hr: 0.25 to 0.99 inch diameter  
 100 hr: 1.00 to 2.99 inches diameter

- 3. Biomass Collection:** If treatment included mastication and at least one quadrat

falls on a masticated fuelbed, collect biomass in a 30 cm PCP frame. See Sampling Masticated Fuels Addendum for collection methods.

**4. 1000 Hour Fuels ( $\geq 3$  inches diameter):**

- a. *Plot size:* Mini ( $1/100^{\text{th}}$  acre; 11.78 ft radius), Whole ( $1/10^{\text{th}}$  acre; 37.2 ft radius), Half (half of  $1/10^{\text{th}}$  acre plot with 37.2 ft radius), or Quarter (quarter of  $1/10^{\text{th}}$  acre plot with 37.2 ft radius). Newly established plots should be Mini plots unless otherwise directed. If remeasuring a plot, use Mini only if it was used pre-treatment. Check the Site Information Packet or Plot Information Packet to see what plot size was used previously. If 1000 hr fuel volume is homogeneously distributed across the large  $1/10^{\text{th}}$  acre plot, consider using a Half or Quarter plot – and note in beginning of Survey123 form.
- b. *Measure and record* the following, starting from the transect azimuth towards 50 ft and working clockwise:
  - i. *Type:* conifer or hardwood
  - ii. *Rotten or sound.* Consider pieces rotten when it is obviously punky, can be easily kicked apart, or buckles under weight.
  - iii. *Diameter* at each end to nearest 0.1 inch. If diameter drops below 3 in on the log, stop measuring at that point.
  - iv. *Length* to the nearest 0.1 foot.
  - v. *Stumps:* Measure all stumps with a DBH  $\geq 3$  in. Diameter 1 is diameter of the base, diameter 2 is diameter at tallest point, and length is the height of the stump. Make sure to select “Stump” on the Survey123 form.

**Notes:**

- When a log travels outside of the plot boundary, stop measuring the log at the plot boundary.
- If the center point of the log is below the litter/duff layer, stop measuring at that point.

**5. Jackpots or Burn Piles:**

Managers often pile large woody fuels for later burning or removal. Because logs are often inaccessible for measuring, piles that fall within the 1000 hr fuel plot should be measured as a single volumetric unit.

- a. Record length, width, and height of pile to nearest 0.1 ft.
  - a. if only part of the pile is within the 1000 hr fuel plot, record the total pile measurements as well as the percentage of the pile that falls within the plot area in Notes.
- b. Note if the feature is a burn pile (most material  $<3''$  diameter) or jackpot (most material  $>3''$  diameter).
- c. If no piles are present, enter ‘NONE’ in species name.

**Citations:**

<sup>1</sup> Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

<sup>2</sup>"The Photoload Sampling Technique: Estimating Surface Fuel Loadings From Downward Looking Photographs of Synthetic Fuelbeds." Robert E. Keane and Laura Dickinson. USFS General Technical Report RMRS-GTR-190, pages 15-17. April, 2007. [http://www.fs.fed.us/rm/pubs/rmrs\\_gtr190.pdf](http://www.fs.fed.us/rm/pubs/rmrs_gtr190.pdf)



## Gear List

### Main Compartment - Gear Bag:

- 2 - 100 ft transect tapes
- 1- Camera
- 1 - Clinometer
- 1 - Compass
- 2 - Clicker counter
- 1 - Sapling calipers (mini)
- 2 - Fuel gauge
- 2 - Loggers tapes
- 1 - Diameter tape
- 1 - Hypsometer/ Rangefinder
- 1 - Hammer
- 1 - Clipboard
- 1 - Whiteboard
- 1 - Ziploc with pens/pencils and dry erase markers
- 1- Ziploc with timber crayon and Litter/Duff rulers
- 1 - Tape measure
- 1- Trowel
- 1- First Aid Kit
- 1- Bear spray
- 1 - Flagging tape (pink)
- 12 - Plot tags, large steel nails, and washers (3 each per plot)
- 1 - Garmin e-trex GPS device
- Batteries: AAA (4), AA (4), 9V(1), 123A (2) [*AAA for walkie talkies, AA for GPS, 123A for hypsometer/rangefinder, 9V for metal detector*] in ziploc baggie
- Several - paper/plastic bags (for unknown plants)
- *For masticated sites:* 1 hand saw, work gloves, small (5), med (5), and large (5) brown paper biomass bags
- *For prescribed fire sites:* Numbered tree tags and aluminum nails

### Clipboard:

- Datasheets
- Protocol
- Photoload
- Fuel Model key & photos
- Random number table
- Species list
- Unknown plant sheets
- Plant guide sheets
- Plot map
- Plot list

**Shoulder Sheath:**

- 1 - 18-inch Calipers
- 1 - 1 m<sup>2</sup> Quadrat
- 10 - Chaining pins
- 30+ - Pin flags of 3 different colors
- 1 - Yard stick w/ seedling class marks

**Plot Photo Protocol**

**Post Treatment Protocol:** Take photos from the same perspective and frame as pre-treatment. Rather than follow the instructions below, 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 (40 ft on transects), take 6 photos. If using a paper datasheet, record camera ID and photo file numbers on the datasheet. Fill out a white board with the *plot name* and *date*. Photos should be framed such that the white board is visible/legible whenever possible. Minimize visible people and gear in the photo, especially in the North and South transect photos. Photos will be used to describe forest conditions and to help locate plots post treatment.  
- Always take the photos in *landscape camera position*.

**Photo 1: North Down**

Along the transect looking North, hold the camera at *eye level* pointed towards the ground. Capture 25-35 ft on the transect in the photo and the 1 m<sup>2</sup> 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: North Eye Level:**

Step back to plot center and hold the camera directly over the 40ft mark. Holding the camera over plot center, take a photo along the transect looking North at eye level. The person holding the whiteboard should still be standing at 35ft (10 ft from Plot Center), off to the side with only the whiteboard visible in the photo.



**Photo 3: North Canopy**

Holding the camera over plot center, along the transect looking North 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.



**Photos 4-6: E-S-W Eye Level**

Holding the camera directly over plot center, take a photo along the East, South, and West transects at eye level. The person holding the whiteboard should still be standing roughly 10 ft from plot center in each cardinal direction, off to the side with only the whiteboard visible in the photo.



Suggested Citation: Colorado Forest Restoration Institute (2023). 2023 COSWAP Forest Inventory Protocol. CFRI-2317.