

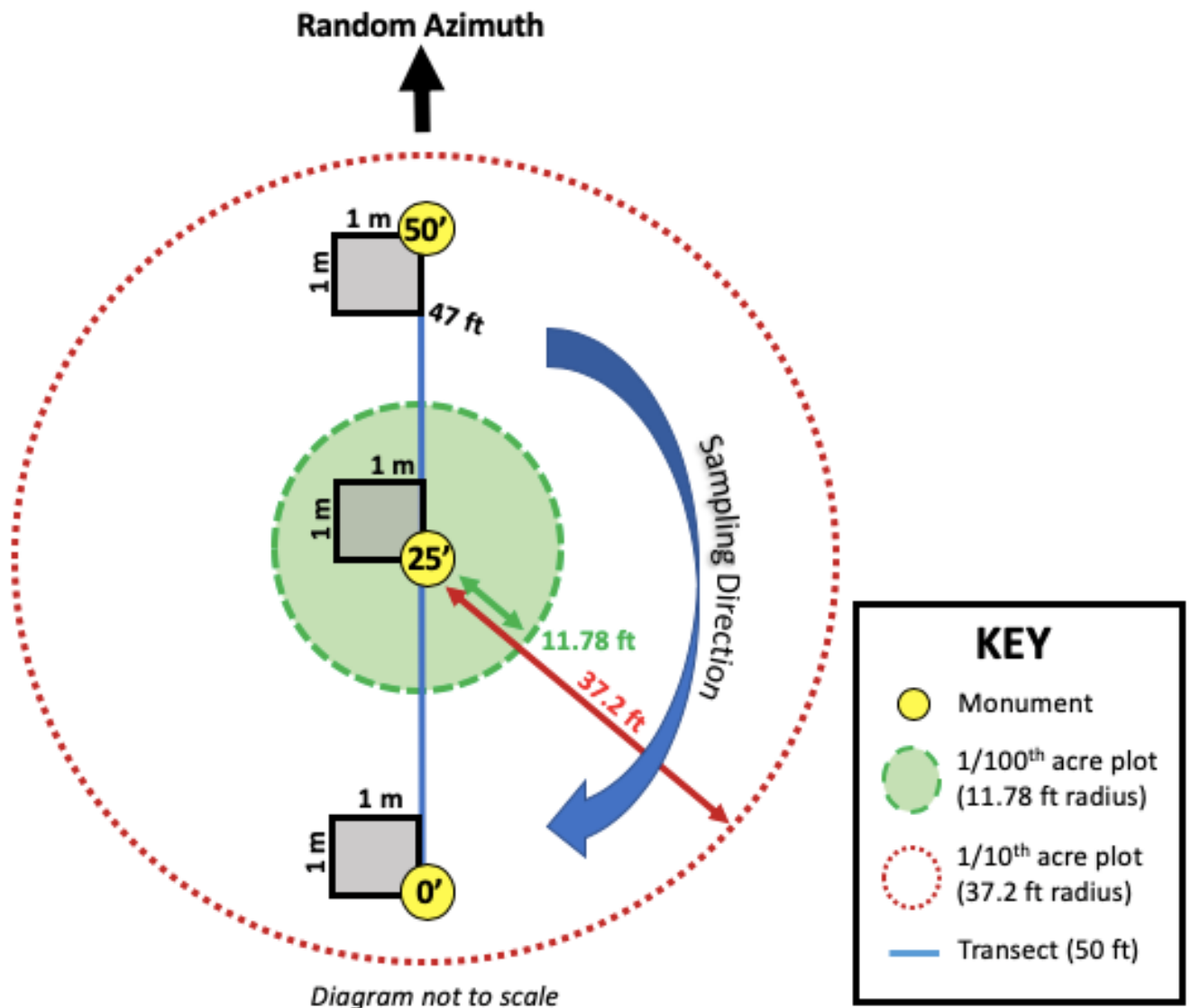
Simple Plot Protocol:

Field Data Collection Protocol for Evaluating Fire Mitigation Effectiveness

Developed by Colorado Forest Restoration Institute

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.



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 plot, use Collector, Avenza, GPS coordinates, or a random number table with numbers 0-359 to choose a random direction and distance. When establishing a 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 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 50 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, lay out the 50 ft tape in a randomly chosen azimuth (0-359°) using a **declinated compass** (set -8.5° east for the Front Range). *If establishing a plot*, use the random number table to choose an azimuth. Lay the tape as close to the soil surface as possible with the 25 ft mark at plot center and the azimuth going toward 50 ft. *If resampling*, align the plot with all 3 permanent plot markers (0 ft, 25 ft/center, and 50 ft). Plots established before 2019 may not have a monument at 50 ft. Make sure that the previously recorded azimuth is correct. and check that the *edge of the plot is at least 50 ft from a treatment boundary.* Place the 1 m² quadrat at 25 ft on the left side of the transect if facing the 50 ft mark. To avoid trampling vegetation and woody fuels, walk on the right side of the transect as much as possible.
 3. **Monument.** Install three permanent markers, or monuments, using a nail, yellow painted washer, and a silver “CFRI Long-term Monitoring Plot” tag. Inscribe plot name, date, and location (“0 ft,” “25 ft,” or “50 ft”) on the tag with a pen and write it on the washer with a permanent marker. Monuments should be located at 0 ft, 25 ft (plot center), and 50 ft. Wrap a piece of pink flagging around each washer. Re-flag nails on each revisit or once a year. Some older plots may not have all three monuments; if this is the case, install missing monuments and make note on the complete plot form.

PLOT SET-UP:

1. Basic Plot Info-

- a. **Aspect:** Using a **declinated (8.5°E)** compass, measure the hillslope aspect in degrees (0-359) within the 1/10th 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: $\pm 30^\circ$*
- b. **Slope:** Using a clinometer, record the slope of the hillside along the aspect (hillslope azimuth) to the nearest percent within the 1/10th 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: $\pm 5\%$*
- c. **Transect Azimuth:** Using a compass, record the transect azimuth or the compass direction of the transect when facing 50 ft. If revisiting, record the previously measured aspect unless it is outside of revisit standards. *Revisit transect azimuth standards: $\pm 5^\circ$*
- 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 Tech) assign a fire behavior fuel model to the plot using the Fuel Model Key¹, 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.).

2. Photos-

- a. Standing at the plot center, take 4 photos. Fill out a whiteboard with the plot name and date, hold whiteboard 10ft 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.*
 1. **Down:** Face 50 ft and hold the camera at eye level while standing about 5 ft back from plot center. Angle the tablet camera downward to include the entire 1 m² sampling frame and plot center in the photo; making sure that the transect is in the center of the photo.
 2. **Eye level:** Face 50 ft and hold the camera over plot center, looking along the transect at eye level.
 3. **Canopy:** Face 50 ft and hold the camera over plot center, looking along the transect towards the upper tree canopy.

4. *Opposite eye level:* Face 0 ft and hold the camera over plot center, looking along the transect at eye level.

PLOT MEASUREMENTS:

For all plot measurements, begin sampling on the right side of the transect when facing 50 ft and move clockwise through the plot (see plot diagram).

1/100th Acre Plot (11.78 ft radius)

Tree Seedlings and Saplings

1. **Tree Seedlings:** individuals within the 1/100th acre plot (11.78 ft radius) that are less than 4.5 ft tall. Add a note if Class 1 seedlings are recent germinants.

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

Class 1: 0 - 4 in

Class 3: 18.1 - 30.1 in

Class 2: 4.1 - 18 in

Class 4: 30.1 - 54 in

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

Species	Record species of each tree.
Status Class	L= Live trees with green needles. 1a <i>with needles</i> = Recently dead trees, top intact, needles/ foliage and fine branches present. <i>Record CBH for trees with needles.</i> 1b <i>without needles</i> = Recently dead trees, top intact, fine branches present. 2 = Snags with coarse branches, but fine branches and foliage have fallen off. 3 = Rotten snags. Very few if any branches remain. Usually short (<20 ft) due to decay status.
Diameter at Breast Height (DBH)	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>
Height	Ocular estimate up to 10 ft. Use rangefinder/ hypsometer for heights taller than 10 ft, making sure that the value returned seems reasonable.
Crown Base Height (CBH)	Lowest height of continuous needles/leaves for all live saplings and <i>class 1a snags.</i>

Notes	Record any information to help re-locate saplings in the future (split top, split base, dead top, etc.).
Tag Number	Only if tagging trees (primarily sites where 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. Saplings with a small DBH (roughly < 1 inch) should be tagged with wire and not a nail to avoid damaging the tree. Tree tags should be sequentially numbered in the order trees are measured.
RX Burn only: Bark Beetle Evidence	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.

Variable Radius Plot

1. Tree Overstory

- a. **Prism size:** Record the basal area prism (BAF) size. *The same BAF should be used throughout the entire site. If the site has been previously sampled, use the same prism size used in previous visits.*
- b. **Flag trees in plot:** While holding the prism over plot center, note all trees that are in the variable radius plot. Tree overstory includes all live and dead trees 4.5 ft or taller with a diameter at breast height (DBH) ≥ 5.0 in. Flag all trees meeting these requirements using alternate pin flag colors, 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 two trees are in the same location, measure the furthest from plot center first.
- c. *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 or corrections in DBH/height/CBH in the notes for each tree.*
- d. **Measurements for each tree:**

Species	Record species of each tree.
Status Class	L= Live trees with green needles. 1a <i>with needles</i> = Recently dead trees, top intact, needles/foilage and fine branches present. <i>Record CBH for trees with needles.</i> 1b <i>without needles</i> = Recently dead trees, top intact, fine branches present. 2 = Snags with coarse branches, but fine branches and foliage have

	fallen off. 3 = Rotten snags. Very few if any branches remain. Usually short (<20 ft) due to decay status.
Diameter at Breast Height (DBH)	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>
Height	Ocular estimate up to 10 ft. Use rangefinder/ hypsometer for heights taller than 10 ft, making sure that the value returned seems reasonable.
Crown Base Height (CBH)	Lowest height of continuous needles/leaves for all live trees and <i>class 1a snags</i> .
Notes	Record any information to help re-locate trees in the future (split top, split base, dead top, etc.), or if trees were measured out of order. Record if the tree was determined to be in with limiting distance.
Tag Number	Only if tagging trees (primarily sites where 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. Tree tags should be sequentially numbered in the order trees are measured.

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 species – consider each qualifying stem (DBH ≥ 5 in) as its own tree (take all measurements and tag if tagging trees). º
- *Borderline tree:* If it is unclear with the prism if the tree is in or not, use the borderline tree equation below to calculate and measure if a tree is in. The distance measured from plot center to the center of the tree should be shorter or the same as the calculated distance. Add a note if this method is used on a tree.

Borderline tree limiting distance calculations:

10 BAF prism: DBH x 2.75

20 BAF prism: DBH x 1.94

1 m² Quadrats

1 m² quadrats are located at 0, 25, and 47 ft with the sample frame positioned on the left side of the transect when looking from plot center towards 50 ft. If the quadrat contains masticated fuels (combined litter/duff/woodchips), select “Forest Floor” and refer to the masticated fuels protocol addendum; otherwise, the default is “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. “0 ft”).
2. **Ground Cover Estimates:** Visually estimate percent cover of ground cover substrates to the nearest 1% within the 1 m² quadrat. Make use of the 10 cm markings on the quadrat frame and use helpful hints below to assist in estimates.
 - **Litter/Duff:** non-woody; includes pine needles, bark, and pinecones
 - **Bare Soil/Gravel:** mineral particles that are < 0.5 inches
 - **Rock:** mineral particles > 0.5 inches
 - **1000-Hour Fuels:** Woody fuels with a diameter > 3 inches and NOT suspended from the ground
 - **Moss/Lichen:** any moss or lichen that is growing on the ground; moss or lichen growing on a rock is counted as rock
 - **Woody Basal:** Large, rooted woody vegetation that is larger than a branch; primarily tree trunks, stumps, and roots
 - **Herbaceous Vegetation Basal:** dead bunchgrasses; dead plant material that suppresses growing space for other plants; rarely encountered

Helpful hints for estimating percent cover:

- A hand or fist is roughly 1% cover (check your hand size using the quadrat).
 - For areas with large cover, it can be easier to think about visually lumping all cover into one corner and then using quadrat markings to estimate cover.
 - For areas with medium to large cover, it can be helpful to work through options to arrive at an estimate: is it more or less than 50%? More or less than 66%? More or less than 75%? etc.
3. **Litter and Duff Depths:** In each quadrat corner, measure litter and duff depths to the nearest 0.25 inch.

Distinguishing between litter and duff:

- **Litter:** Loose layer made up of needles, pinecones, dead grasses detached from the plants, recently fallen leaves, twigs not visible from above where the individual pieces are still identifiable, and little altered by decomposition.

- **Duff:** 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. [Per FIREMON protocol (RMRS-GTR-164-CD)]
4. **Photoload Estimates:** Using the Photoload estimating technique, estimate fuel loading for 1 hr, 10 hr, and 100 hr fuels in tons/acre within the 1 m² 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
5. **Herbaceous Vegetation Cover and Height:** Lump all herbaceous plants (graminoids and forbs; non-woody) within the 1 m² sample frame to estimate the following-
- a. *Total herbaceous cover:* Using the ocular estimating method, measure canopy cover of all herbaceous cover 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.
 - b. *Average maximum height:* Measure and average the height of the tallest herbaceous plants. Measure the highest point of each plant as it stands, rooted within the frame. Measure to the nearest 1 inch.
6. **3 Most Common Herbaceous Species:** Note the 3 most abundant herbaceous species (highest percent cover) that are rooted within the 1 m² sample frame. For each species:
- a. *Record the species name* using the USDA PLANTS database 4-letter code (found on the species list). If the species is unknown, record it as an unknown plant based on its growth form using one of the following codes:
 - 2GRAM = Unknown grass or grass-like graminoid (i.e. sedge or rush)
 - 2FORB = Unknown forb
 - b. *Record percent cover of each species.* If cover is less than 1%, measurements of 0.5% or 0.1% may be used. After recording percent cover of all three species, check that total herbaceous cover still seems reasonable.
7. **Biomass Collection:** If treatment included mastication and at least one quadrat falls on a masticated fuel bed, collect biomass in a 30 cm PCP frame. See Sampling Masticated Fuels Addendum for collection methods.

50 ft Transect

1. **Shrub Transect:** Record cover of live shrubs along the 50ft transect. Starting at 0 ft, walk the transect and note any shrubs that intersect or hang over the transect.
 - a. *Record the location* (to the nearest 0.1 ft) where their cover begins and ends along the transect. If multiple layers of shrubs are present, record only the top shrub layer. For shrubs with sparse leaves, record the continuous cover of shrub if any part of the live shrub intersects the tape. If there is a gap larger than 0.5 ft, record a new shrub group. Dead shrubs or dead stems connected to live shrubs are ignored and not recorded.
 - b. *Record average maximum shrub height* for each clump of shrubs, to the nearest 1 inch. Average maximum height is the average height of the tallest portions of the shrub.

For the following measurements, measure along the transect, beginning at 0 ft, measuring every foot and finishing at the 50 ft mark. Note that the following two measurements (tree cover and tree group transect) are typically measured in tandem.

2. **Tree Cover:** Use a densitometer scope to record cover of any live or dead tree 4.5 ft (breast height) or taller at each foot. Begin recording at 0 ft and record cover every foot until the 49 ft mark for a total of 50 measurement “hits.” Stand directly over each point along the tape, making sure that the scope is level and look to see what species (if any) is present in the crosshairs of the scope. If a tree is observed, use a clicker counter to make note of the observation. After looking up at 50 separate points, look to the clicker counters for your species totals and record in Survey123 form.

Notes:

- All dead trees are lumped recorded as their own species (“DEAD”).
 - If a dead branch on a live tree is encountered, it is recorded as the live tree species.
 - If multiple species are encountered at one point, record the species first encountered (species closest to the ground).
3. **Tree Group Transect:** Use the densitometer scope beginning at 0 ft and ending at 50 ft on the transect to measure the distance covered by closed tree canopy and openings. While standing directly over each point along the tape with a level densitometer, observe if the crosshairs of the scope meet canopy cover (*live tree cover with DBH ≥ 1 inch*) or canopy opening (open sky). If closed canopy is encountered, note the size class of that canopy clump. Canopy clumps are determined by the

number of interlocking **live trees (DBH ≥ 1 inch)** or trees with canopies **within 5 ft**.
Canopy classes are as follows:

Open: 0 trees	Class 3: 5 – 9 trees
Class 1: 1 tree	Class 4: 10 – 15 trees
Class 2: 2 – 4 trees	Class 5: 15+ trees

Openings of > 5 ft must be observed along the transect to transition from one cover type to another (i.e. 3 ft: canopy, 4 ft: canopy, 5 ft: open, 6 ft: canopy = canopy from 3-6 ft). Each start point should begin at the same location as the previous end point and canopy classes should be assigned for the entire length of the transect (i.e. 0-3 ft = Open, 3-5 ft = Class 1, 5-14 ft = Open, 14-50 ft = Class 5).

1/10th Acre Plot (37.2 ft radius) OR 1/100th Acre Plot (11.78 ft radius)

1. 1000 Hour Fuels (≥ 3 inches diameter):

- a. *Plot size:* Plot sizes are: Mini (1/100th acre; 11.78 ft radius), Whole (1/10th acre; 37.2 ft radius), Half (half of 1/10th acre plot with 37.2 ft radius), or Quarter (quarter of 1/10th 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. If 1000 hr fuel volume is homogenously distributed across the large 1/10th 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 ≥ 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 duff, stop measuring at that point.

2. 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.

Simple Plot Gear List

Main Compartment – Gear Bag:

- 1 – 100 ft tape
- 1 – 10 BAF prism
- 1 – Hammer
- 1-2 – Clinometer
- 1 – Densitometer
- 2 – Clicker counter
- 1 – Sapling calipers (mini)
- 1 – Fuel gauge
- 1 – Clipboard
- 1 – Whiteboard
- 1 – Hypsometer/ Rangefinder
- 1 – Ziploc with timber crayon, Litter/Duff ruler, pens/pencils, dry erase marker
- 1 – Tape measure
- Work gloves
- Flagging tape
- *For masticated sites:* 1 hand saw
- *For masticated sites:* small (10), med (10), and large (3) brown paper biomass bags
- *For prescribed fire sites:* Numbered tree tags and aluminum nails
- Batteries: AAA (4), AA (4), 9V(1), 123A (2)
- *[AAA for walkie talkies, AA for GPS, 123A for hypsometer/rangefinder, 9V metal detect]*
- 12 – Plot tags, large aluminum nails, and washers (3 each per plot)
- 1 – Garmin e-trex GPS device

Individual Gear (for each person in each pod):

- 1 – Compass
- 1 – Logger’s tape

Clipboard:

- Datasheets
- Protocol
- Photoload
- Fuel Model key & photos
- Random number table
- Species list
- Maps of the site
- Plot list

Shoulder Sheath:

- 1 - 18-inch Calipers
- 1 - 1 m² Quadrat
- 4 - Chaining pins
- 30+ - Pin flags of 3 different colors
- Yard sticks w/ seedling class marks

Vehicle:

- Food cooler
- Water jug
- Metal detector
- Plant press
- Plant ID books
- Monument box (nails, washers, tags)

Vehicle Form Box:

- Datasheets
- Protocols
- Photoload
- Fuel Model key & photos
- Random number table
- Kat/Katarina's business cards
- Unknown plant sheets
- Species lists

Vehicle Folder:

- Enterprise rental agreement
- Emergency contact sheet
- Vehicle maintenance protocol
- Vehicle tracking log
- CO counties map
- Workers' compensation protocol
- Vehicle parking permission sign

Vehicle Bag:

- Brown paper bags
- Duct tape
- CO atlas
- Jumper cable
- Tow strap
- First Aid Kit

- PPE (masks, hand sanitizer, gloves, disinfecting wipes & spray, Ziploc bags, trash bags)

Electronics Box:

- Samsung tablets & charger
- Portable charger
- Extra batteries
- Walkie talkie & charger
- Binder clips

Camp Box:

- Stove
- Propane
- Lighter(s)
- Toilet paper
- Trowel
- Trash bags
- Paper towels
- Biodegradable camp soap
- Pan(s)
- Tarp

Refill each day from vehicle:

- 3 per plot - Painted nails, washers, stamped tags
- 2 of each size / plot - Paper bags for fuels
- Forms
- PPE

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, take 4 photos. Fill out a white board with the *plot name* and *date*. 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 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: 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.

