



Field Data Collection Protocol for Evaluating Fire Mitigation Effectiveness

2017 Simple Plot Protocol
Developed by Colorado Forest Restoration Institute
CFRI-1709

Sampling Objective:

This fuels assessment protocol is designed to collect comprehensive data for ground, surface, herbaceous, shrub, and tree fuels in order to determine changes in fuel abundance and distribution as a result of management actions in forests and shrublands of Colorado. The following protocol was designed to provide suitable data for analysis with the Fuels Characteristic Classification System (within the Fuel and Fire Tools analysis package) in order to quantify fuel condition and fire hazard potential, but this protocol ultimately is a general fuels sampling method and can be used for any objective where fuel loading is needed. CFRI staff unofficially 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 ecological change resulting from forest management.

Sampling Design and Intensity Recommendations:

The most accurate and straightforward method for quantifying changes in fuels as a result of 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 greatly increase ease of finding plot locations and comparability of multiple measurements over time. Sample plots located randomly throughout the area of interest provides 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 for 2-3 full days no matter

how many plots are measured. Typically we will complete around 10-15 plots in that time. 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 is still appropriate to sample for 2-3 days to increase sample sizes and account for likely higher variability/lack of data.

Underlying Methods and Data

Where did we come up with all this stuff? 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 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.
3. Stretch out a measuring tape 25 ft 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 50 ft from a treatment boundary.
4. Each of the three 1 m² sampling frames are placed to the left of the 50 foot transect as depicted below. The frames begin at 0 ft, 25 ft, and 47 ft on the transect. To avoid trampling vegetation and woody fuels, walk on the right side of the transect as much as possible.

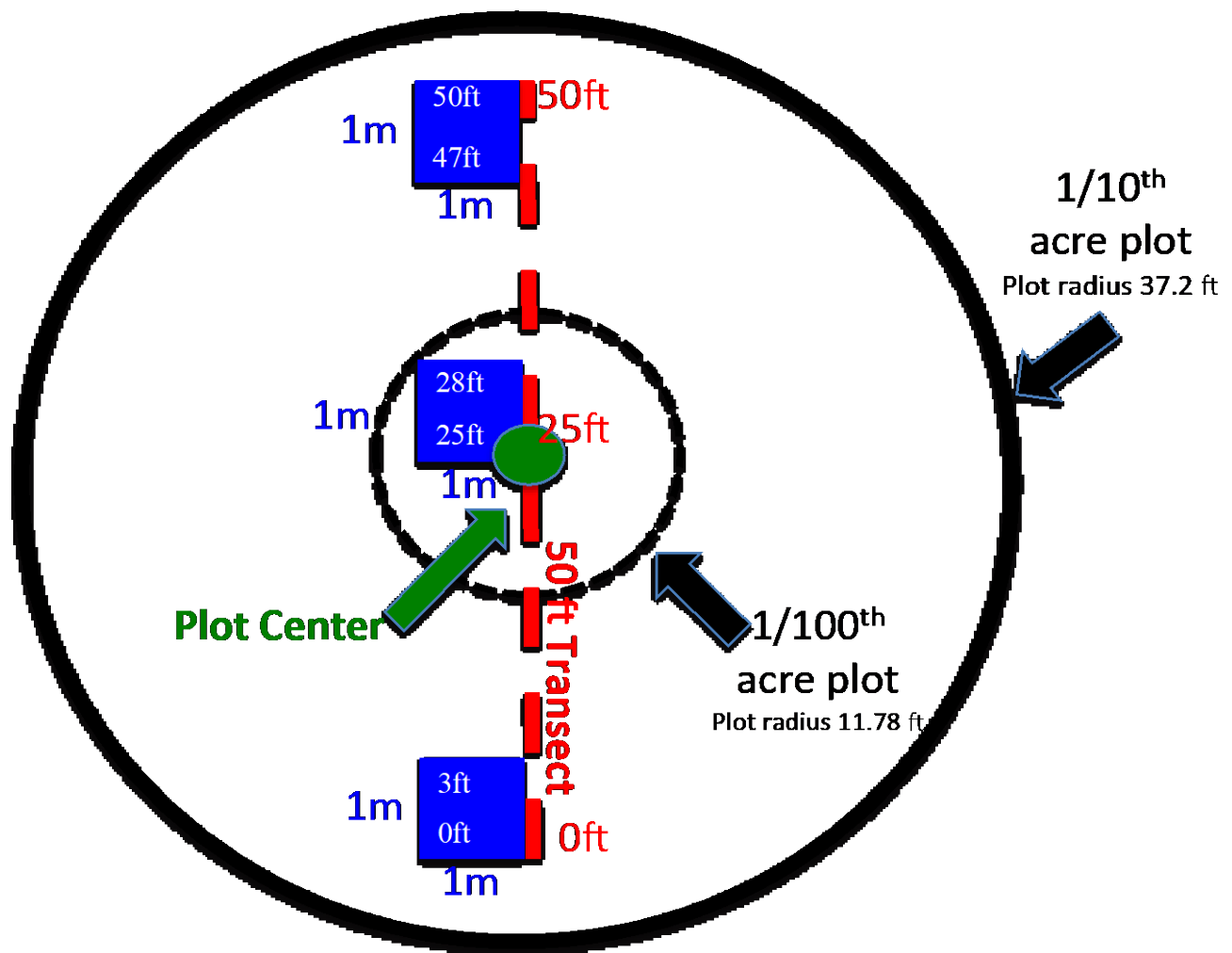


Figure 1. Diagram of the CFRI Rapid Fuels Assessment (simple plot). Diagram not to scale.

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.
 1. To locate plots post-treatment, leave two monuments (Use a nail and washer, painted yellow, and a silver “CFRI Long-term Monitoring Plot” tag (mark “0ft Start” or “25ft Center”, Plot Name, and the date on the silver tag with a pen)). Install the two monuments at the start of the transect (0 ft) and plot center (25 ft).
 2. Wrap a small piece of pink flagging around the top of each nail. If flagging is missing in post-treatment years, re-flag nails.
- b. Using a **declinated** (~ 8.5°E) compass, record the hill-slope 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.

- 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.
- 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.

2. Photos

- a. Standing at the plot center (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, treatment status (pre or post), and date. Photos should be framed such that the white board is visible/legible when viewed on a computer screen (not camera viewfinder), and minimizing visible people in the shot. Photos will be used to describe fuel conditions and to help locate plots post treatment. Suggested photo sequence:
 1. Along the transect looking in the direction of 50 ft holding the camera eye level pointed towards the ground (capturing 25-35 ft on the transect and the 1 m² sampling frame). Rather than stand at the plot center, the photographer should take enough steps back in order to capture the plot center in the photo.
 2. Holding the camera over plot center, along the transect looking in the direction of 50 ft at eye level.
 3. Holding the camera over plot center, along the transect looking in the direction of 50 ft towards the upper tree canopy.
 4. Holding the camera over plot center, along the 50 ft transect looking in the direction of 0 ft at eye level.

3. Tree Overstory

- a. Record the basal area prism or angle gauge size and units. Choose a basal area factor prism based on expected tree numbers after harvest in order to capture 6-10 trees *post treatment*. If the site has been previously sampled, use the same prism size that was used in previous visits regardless of current tree density.
- b. Standing at the plot center, use a basal area prism or angle gauge to record the basal area of the variable radius plot for all live and dead trees taller than 4.5 ft with a diameter at breast height (DBH) ≥ 5.0 inches. Hold the basal area prism at any convenient distance from the eye, directly over the plot center. The prism should be held vertically (rounded edge on top) and at a right angle to the line of sight (number indicating the basal area factor on the left side). 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. *Tip: Alternate the color of pin flags – makes it easier to remember tree order when measuring heights. Record trees in sequence starting at the 50 ft mark on the transect moving in a clockwise direction.*
- c. For each hit tree included in the basal area count, record:
 1. Tree species.
 2. Status: Live or dead
 3. Diameter at breast height (to nearest 0.1 in).
 4. Tree height (to the nearest ft).
 5. Lowest height of continuous live vegetation (e.g. crown base height or CBH) for all live trees and class 1a snags (to the nearest ft). This measure should be the lowest vegetation (needles, branches, etc.) not including the main stem (tree trunk), and not where the lowest branch converges with the trunk.
- d. For standing dead trees taller than DBH (snags) that are included in basal area count, also record decay class on a scale of 1-3.

1. Decay class 1a *with needles* = recently dead trees, top intact, needles/foilage and fine branches present. NOTE: Record CBH for trees with needles.
2. Decay class 1b *without needles*= recently dead trees, top intact, fine branches present.
3. Decay class 2 = snags have coarse branches and bark present, but fine branches and foliage have fallen off.
4. Decay class 3= snags are rotten, bark not present. Very few if any branches remain.

1m² Sample Frame

In each of the three 1 m² sampling frames located at 0-3 ft, 25-28 ft, and 47-50 ft along the left side of the transect, measure the following:

1. Groundcover

- a. Using the ocular estimate method, measure ground cover at the soil surface to the nearest 1% within the 1 m² sample frame. This includes litter/duff, moss/lichen, soil/gravel (<1 cm), rock (>1 cm), and 1000 hr fuel. If stumps or live tree trunks occur in the frame, record them separately as woody basal. If large dead plant material suppresses growing space, record as herbaceous vegetation basal (rarely found in Colorado). Each category should be measured separately and total ground cover 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. At the 4 corners of each sample frame along the transect, measure the depth of litter and duff to the nearest 0.25 inch. Within the sample frame, also measure the depth of 1hr/10hr/100hr fuels lumped as one category. If you record a photoload >0 of small woody fuels in the plot, the depth must be >0.

Since woody fuels tend to have small cover, measuring depth of woody fuels at the 4 corners of the sample frame often results in no depth measurements and an average depth of 0 inches. To avoid this, often it is best to measure the depth of these small woody fuels *where they occur* in the sample frame and not at the 4 corners.

- b. Following the FIREMON protocol (RMRS-GTR-164-CD) "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. The "duff" layer lies 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. Pine cones are considered litter or duff, not woody fuel.

3. Herbaceous Vegetation Cover and Height

- a. Using the ocular estimate method, measure vegetation canopy cover to the nearest 1% within the 1 m² sample frame of all non-woody vegetation (graminoids – grasses and grass like plants, and forbs). As a rough guide, a closed fist equals ~ 1% cover.
 1. Record Total Herbaceous Cover of all non-woody vegetation that is rooted in the 1 m² sample frame.
 2. Estimate average total maximum height of all herbaceous vegetation at the highest point of each plant that is rooted within the 1m² frame to the nearest inch.
 3. Record cover for the 3 most common herbaceous species rooted in each 1 m² sample frame. Identify plants to the species level using the USDA PLANTS database 4 letter code or the full Latin nomenclature if unsure of code. The goal is to identify dominant plants in the plot (roughly the 3 most abundant species). If you can't

identify to species, record as unknown graminoid or unknown forb. It is important to note succulent plants (e.g. cactus, yucca, etc.) that are less reactive in a fire than grasses or other forbs.

4. Herbaceous Biomass

- a. 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. Place in paper bag with plot, date, "HERB", and the sample frame location (0 ft, 25 ft, or 47 ft).
- c. All herbaceous material should then be returned to the lab, oven dried to constant mass, and weighed to attain dry weight of herbaceous material (loading in tons/acre).
 - i. Clipping herbaceous biomass can be time intensive. For a rapid assessment, we recommend collecting biomass at only one sample frame (e.g. 25 ft), or at an additional sample frame outside of the plot (e.g. 3 large steps in a random direction from 0 ft away from the transect). **Herbaceous biomass should be collected at EVERY plot, unlike woody fuels, which is collected every other plot or when appropriate.**

5. Woody Fuels

"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

- a. Using the Photoload technique, estimate fuel loading for 1 hr, 10 hr, and 100 hr fuels in tons/acre within the frame. The photos on pages 15-17 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. A go-no-go fuels gauge can be used to help classify fuels in the sample frame.
 - ii. 1 hr fuels (0 to 0.24 inch)
 - iii. 10 hr fuels (0.25 to 0.99 inch)
 - iv. 100 hr fuels (1.00 to 2.99 inches)
- b. Double sampling is recommended, but not required, in order to increase the accuracy of fuels measurements. This involves performing the photoload estimates then collecting all woody material in the 1m² sample frame in paper bag with plot, date, initials of photoload estimator, "1hr, 10hr, or 100hr", and the Sample Frame location (0ft, 25ft, or 47ft). When performing double sampling, use one separate paper bag per fuel size class (e.g. 3 bags per plot for 1hr, 10hr, and 100hr). Collect only woody material, not litter or duff (e.g. no needles or cones).
- c. All woody material should then be returned to the lab, oven dried to constant mass, weighed to attain dry weight (loading in tons/acre).
 - i. Double sampling woody fuels can be time intensive and is not required. Generally a double sample rate of 20% is adequate. **We recommend collecting biomass in one sample frame outside of the plot (e.g. 3 large steps in a random direction from 0 ft away from the transect) approximately every other plot.**

50 foot Transect

1. Shrubs

- a. Record cover of any shrubs along the 50 ft transect.
 1. Using the line intercept method, record the amount of line covered by each shrub by species to the nearest inch. 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 6 inches

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 inch 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. Using the densitometer scope, at every foot along the 50 ft transect record cover of any live tree taller than 4.5 ft (DHB). 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

The goal here is to measure the distances covered by closed-canopy forest areas ("tree clumps") versus openings along a transect.

- a. Walking along the entire length (50 ft) of the transect from 0 to 50 ft, record the start and end points of "openings" and "canopy clumps" that are directly overhead the transect. Include as canopy clumps any canopy overhead the transect produced by trees > 1 in DBH. Use the densitometer scope to identify the location along the transect at which transitions between canopy and openings occur.
- 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 5 ft 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

Often variable radius plots measured with a prism or angle gauge are not very effective at capturing smaller trees (saplings), or trees with multi-stem branching patterns (e.g. Juniper). However, fuel reduction treatments frequently are aimed specifically at removing these small trees to reduce ladder fuels and crown fire potential. We recommend a fixed radius plot to capture this tree layer.

- a. **Tree Saplings** taller than 4.5 ft, but <5 in DBH within the 1/100th acre subplot:
 1. Tree species.
 2. Live or dead.
 3. Diameter at breast height by size class.
 1. Class 1: 0.1-2.4 in.
 2. Class 2: 2.5-4.9 in.
 4. Tree height (to the nearest ft).
 5. Lowest height of continuous live vegetation (e.g. crown base height or CBH) for all live trees and class 1a snags (to the nearest ft).
 6. Decay class (1a, 1b, 2, or 3) if dead.
- b. If the number of sapling trees is excessive, an ocular estimate of tree height and CBH for all sapling trees by species and diameter class is typically quicker and sufficient for most monitoring objectives rather than measuring the height of every single sapling tree.
- c. 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.

d. **Tree Seedlings** (less than 4.5 ft tall within the 1/100th acre subplot):

If fire mitigation and estimating short term changes in fire potential using the Fuel and Fire Tools platform is the main focus of the monitoring, we recommend searching for tree seedlings only in the three 1 m² sample frames. However, if forest regeneration and longer term development is of interest, searching a larger area (1/100th acre) for tree seedlings is recommended.

1. Record the species and number of individuals in each height class.

1. Height Classes: 1 = 0"-4"; 2 = 4.1"-18"; 3 = 18.1"-30"; 4 = 30.1"-54".

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 to the nearest 1/10 inch.
 1. If diameter drops below 3 inches 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 or can be easily kicked apart.
- c. *Tip: occasionally 1000hr fuel is very abundant and can take very long to measure. Consider measuring half, or even a quarter of the plot if this is the case and recording total area measured on the datasheet. Always start from the end of the transect at 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. Our general rule of thumb is to measure maximum of approximately 30 logs in a plot, unless 1000hr fuels are a main focus of the monitoring. 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.*

Gear List

- 100 foot tape x1
- 1m² sampling frame x1
- Basal area prism or angle gauge x1
- 18 inch Calipers (for Fuels) x1-2
- 6 inch Calipers (for saplings, optional) x1
- Camera and Batteries/charger x1
- Chaining pins x3
- Clicker counter x1
- Clinometer x1
- Clipboard/Tatum x1-2
- Compass x1-2
- Cruising Vest x1 as necessary
- Data sheets and unknown plant sheets (regular and rite in the rain)
- Densitometer (for tree cover) x1
- Diameter tape x1 per person
- Duct tape
- First aid kit, bug spray, sunscreen
- Go no go fuels gauge (for woody fuel class size measurement, optional) x1-2
- GPS and Batteries x1
- Grass clippers/shears x1-2
- Hammer x1
- Hard Hats x1 for each person as appropriate
- Hypsometer and Batteries (to estimate tree height, optional) x1-2
- Loggers tape with diameter/length dual measurements x1 per person
- Maps of the site (quads and plot maps)
- Monuments (large nails, whiskers, washers, plot tags, etc.) x2 per plot
- Paper bags (medium and large sizes for plant biomass, fuels double sampling, and unknown plant collections)
- Pencils, Pens, Sharpie (at least 10 each crew)
- Photo load guides for 1hr, 10hr, and 100hr fuels (pages 15-17) x1
- "The Photoload Sampling Technique: Estimating Surface Fuel Loadings From Downward Looking Photographs of Synthetic Fuelbeds." By 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
- Photoload for herbaceous fuels x1
- Pin flags x15-20 flags of 2 different colors
- Pink Flagging x1 roll per person
- Plant field guides (Ackerfield, Wingate Illustrated keys to grasses of Colorado, etc.)
- Plant press x1
- Protocol x1
- Random number table (0-359) x1
- Road atlas (navigating to study area) x1
- Rope (measured out to 11.78ft for sapling and tree regeneration subplots) x1
- Ruler for litter/duff depths x1 per person
- Small shovel x1
- Species lists x1 per person
- Walkie-talkie and batteries/charger
- Water cooler
- White Board (for photos) and dry erase markers x1
- Yard stick for plant heights and tree seedling height class markings x1



Densitometer