COLORADO FOREST RESTORATION INSTITUTE
Colorado State University

2018 Mothership Plot Protocol:

Field Data Collection Protocol for Evaluating Forest Restoration and Fire Mitigation Management Effectiveness

Developed by Colorado Forest Restoration Institute

CFRI-1810

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, fuels and fire potential, and plant species abundance and diversity as a result of management actions in forests and shrublands of Colorado.

Sampling Design and Intensity Recommendations:

The most accurate and straightforward method for quantifying changes in vegetation structure, abundance, and diversity as a result of management actions is to measure at the same location before and after treatment. A more robust study design will include measurements in similar nearby habitats that do not experience management to serve as controls. Establishing control sites is often critical to determine longer term ecological change and effectiveness, but less essential for monitoring short term management outcomes. When conducting pre-post comparisons, permanently marked plot locations are highly desirable and 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, but not always, 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 of much less intensity than described here may be needed. However, if you want to determine management effectiveness and differences in fire hazard over a large area before and after treatment, much more intensive sampling is required. Exactly how many samples (plots) you need for a reliable answer depends on local site variability, which cannot be predicted remotely. This protocol is very thorough, but also very labor and time intensive and requires a skilled botanist. Typically CFRI recommends about 6 of these effectiveness plots per forest stand. However, for more accurate estimate of fuels and forest density, we often combine 6 of these intensive plots with 10+ additional less intensive rapid assessment plots ("CFRI Simple Plot", not described here) to add accuracy for fuels and forest density estimates in an efficient manner. Typically a crew of 3 trained individuals completes this sampling combination of 6 intensive effectiveness plots and 10+ additional rapid assessment plots within the managed area in 4-ish full days including travel time. Measuring untreated control sites typically doubles sampling effort if the same sampling intensity is used.

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 our 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.

This protocol is referred to as the **Mothership** because it combines elements of three protocols commonly used in Colorado:

1. USFS Common Stand Exam.
2. Colorado Front Range Collaborative Forest Landscape Restoration Initiative Understory Plant monitoring protocol.
3. CFRI Wildfire Risk Reduction Grant Program fuels inventory.

Data collected using the Mothership protocol is intended to be comparable with each of these three monitoring methods.

Plot Layout

1. Randomly locate the plot center within the sample area. Use GIS/GPS 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.
    a. If a randomly generated GPS point falls in an area that is not a suitable sample area (e.g. on a road, riparian, treatment boundary, etc.), use the random number table to choose a direction and distance to move the point to a suitable area. If a suitable area cannot be found, use another random point generated in a GIS.
2. From plot center, establish 8 transects in the cardinal (0°, 90°, 180°, 270°) and ordinal directions (45°, 135°, 225°, 315°) using a **declinated** compass (set north to positive 9 degrees for Colorado – 9 degrees to the east). You will use 4 X 100-ft tapes to establish these. To ease calculations, center the 40-ft mark of all 4 tapes over the plot center and extend the tape out to 80-ft. Clip tapes together with a binder clip to ensure they stay in place. Be sure the 0 foot mark is on the south end of the north-south transect (the reel should be on the north end of the transect). Colored tape will be marking the plot center and transect ends, as well as the understory plant and fuels measurement areas on each 100-ft tape. Note that this protocol can be implemented with 50-ft tapes, but care must be taken to ensure measurements happen at the correct locations. This protocol is written

under the assumption that 100-ft tapes are used, with the 40 foot marks centered over the plot center.

a. If 100-ft transect tapes are not marked with colored tape, add a small strip of colored tape around the transect tape at 2.8-ft, 9.5-ft, 34-ft, 40-ft (center), 46-ft, 70.5-ft, and 77.2-ft. Use a different color to mark the 15-ft and 62-ft locations on a designated north-south tape to denote 1m² sample frame locations.
b. Before proceeding, be sure that the edge of the plot is at least 100 feet from a treatment boundary.

3. Each of the three 1m² Sample frames are placed to the left (west) of the north-south transect as depicted in Figure 1. The frames should be located adjacent to the 15 – 18 foot mark on the tape (25 feet south of the center), at the plot center (40 – 43 foot marks), and adjacent to the 62 – 65 foot marks (22 feet north or center, refer to Figure 1). To avoid trampling vegetation and woody fuels, walk on the right side of the transect as much as possible.

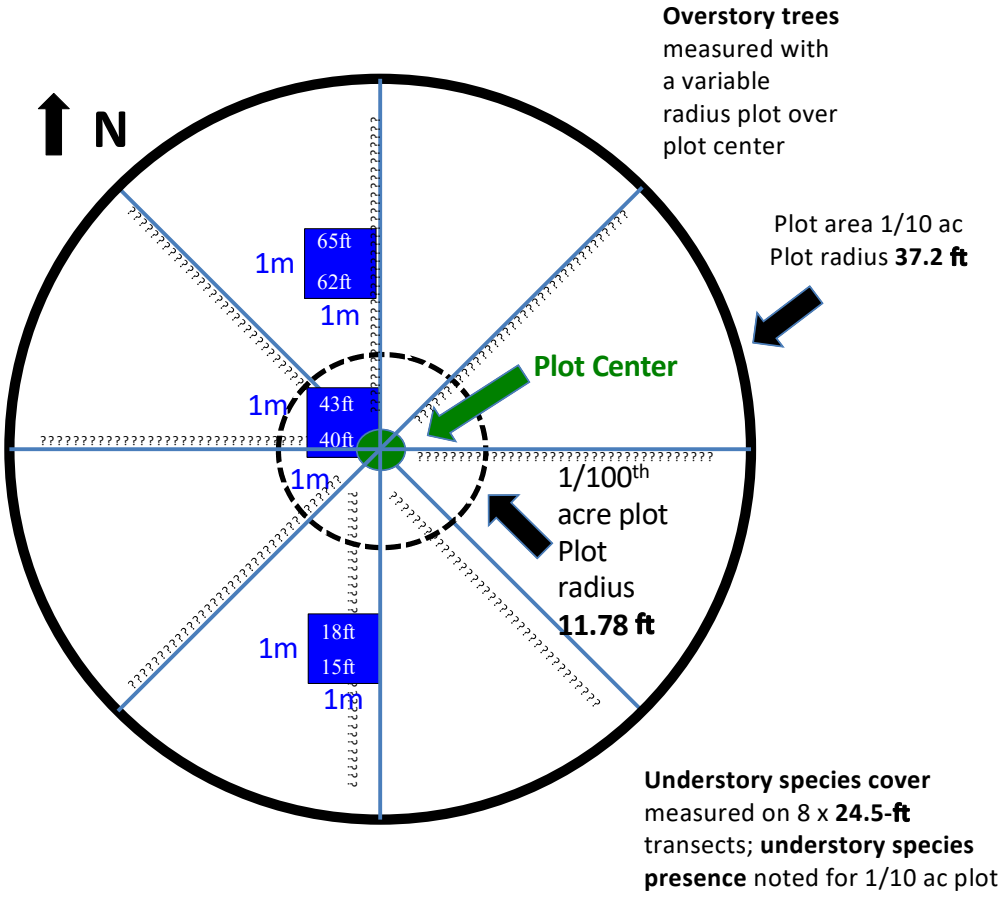


Figure 1. Diagram of the CFRI Forest Restoration and Fire Mitigation Effectiveness Assessment sample plot

Plot Center

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 **three** monuments:
        1. Use a nail, yellow painted washer, and a silver "CFRI Long-term Monitoring Plot" tag. Inscribe plot name, date, and location ("N," "Center," or "E") on the tag with a pen. Install monuments at plot center, and at 37.2-ft along both the North and East transects.
        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. Standing at the plot center, take 6 photos. 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 when viewed on a computer screen (not camera viewfinder), and minimizing visible people in the photo. Photos will be used to describe fuel conditions, plant growth, and to help locate plots post treatment. The photo sequence is:
        1. Ground, North: Along the north transect, holding the camera eye level pointed towards the ground and capturing 0-10ft on the transect, including the 1m^2 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. Eye, North: Holding the camera over plot center, along the north transect at eye level.
        3. Canopy, North: Holding the camera over plot center, along the north transect looking towards the upper tree canopy.

4. Eye, East: Holding the camera over plot center, along the East transect at eye level.
5. Eye, South: Holding the camera over plot center, along the South transect at eye level.
6. Eye, West: Holding the camera over plot center, along the West transect at eye level.

3. Tree Overstory

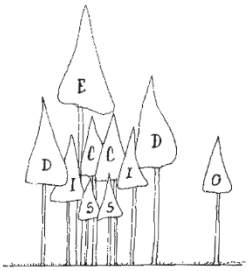
a. Record the basal area prism or angle gauge size and units. Use BAF of 10 for first plot visits. *If the site has been previously sampled, use the same prism size used in previous visits.*

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) ≥ 5.0in. 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 >10ft.

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 totally above the canopy 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.



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

c. Note: Typically large shrubs, such as Gambel Oak, are not counted as trees and their abundance is measured using the line-point intercept method on the transects. Where Gambel Oak takes on more of a large single stem tree growth form, especially in southwestern Colorado, it may be appropriate to measure tall shrubs as a tree.

1m² Sample Frame

In each of the three 1m² sampling frames located at 15-18ft, 40-43ft, and 62-65ft along the north-south transect, measure the following:

1. **Photoload Estimates**

"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, and herbaceous fuels in tons/acre within the 1m² sample 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 frame.
   1. 1 hr fuels (0 to 0.24 inch diameter)
   2. 10 hr fuels (0.25 to 0.99 inch diameter)
   3. 100 hr fuels (1.00 to 2.99 inches diameter)
   4. Herbaceous: All biomass connected to a live plant that is not laying on the ground.

2. **Biomass Collection**

Double sampling is recommended, but not required, in order to increase the accuracy of fuels measurements by calibrating actual vs estimated values. This involves performing the photoload estimates then collecting all woody and herbaceous material in the 1m² sample frame.

Collecting biomass can be time intensive. Generally a double sample rate of 20% is adequate. We recommend woody fuels be collected every other plot, in a PCP quad outside the plot, while herbaceous biomass should be collected at EVERY plot. **PCP Plot: Collect 1hr, 10hr, 100hr, and herb biomass in one sample frame outside of the plot (e.g. 3 large steps in a random direction from the 0ft of the North transect away from the plots center) approximately every other plot.**

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.
d. Collected material should then be returned to the lab, oven dried to constant mass, and weighed to attain dry weight of material (loading in tons/acre).

37.2 ft Transects

Along each of the 8 transects in cardinal and ordinal directions from the plot center:

1. **Understory Vegetation**
   a. Using the line-point intercept method, record any plant present at 25 evenly spaced points (every 1-foot) on all 8 transects. Begin counting at 6-ft from the center and collect data along a 24-ft section of each transect (e.g. understory data should be recorded along the **46 – 70**, and **10 – 34** foot marks along each transect tape).
      i. A buffer near plot center reduces trampling and autocorrelation of counts, and buffering the transect ends ensures vegetation estimates are within the plot area.
   b. Identify plants to the species level using the USDA PLANTS database 4 letter code or the full Latin nomenclature if unsure of code. If unable to identify a plant, give the plant an unknown number and name. Show the plant to everyone on the crew to ensure that consistent unknown names are used. Collect a specimen from outside the plot for later identification in the lab, and place in a paper bag labeled with the appropriate unknown name.
   c. If more than one species is visible at a sampling point record them all (i.e. kinnickinnick, mountain mahogany, Douglas-fir). Record the top most vegetation as the top hit, and then other species of shorter stature as bottom hits. This allows calculation of total percent cover as well as relative species cover.
      i. Each transect can have no more than 25 top vegetation counts, i.e. 1 top hit at every point measured. Multiple bottom hits may be recorded at each point.

ii. Include ANY live vegetation when they are encountered below 4.5 ft, e.g. large shrubs, tree branches, and live tree trunks, etc.

2. **Forest Floor Substrate**
   a. At each of the 25 points per transect record forest floor substrate as well. Each transect should have exactly 25 substrate counts, i.e. 1 substrate for every point measured.
   b. Substrate categories: litter/duff, soil/gravel (<0.5 in), rock (>0.5 inch), Coarse fuels (1000hr, rotten or sound), moss/lichen, woody basal, and herbaceous vegetation basal.
      i. If stumps or live tree trunks occur in the frame, record them separately as woody basal.
      ii. If large dead plant material suppresses growing space, record as herbaceous vegetation basal (rarely found in Colorado).
      iii. When estimating ground cover, exclude live vegetation from estimates.
3. **What about logs suspended off the forest floor?**
   a. If 1000hr coarse fuels are encountered suspended higher than ~1 inch above the ground, record that substrate as a species with the notation "1KINAIR" and then record a separate substrate category on the forest floor. For example, if a log is suspended above the ground with *Muhlenbergia montana* growing under it, and pine needles are under the grass, you would record 1KINAIR, MUMO for the grass, and then litter/duff as the substrate. Be judicious and only use the "in air" category if you can see potential growing space for plants under the suspended substrate. This measure will be used to estimate woody debris abundance, compare different slash disposal techniques, and estimate potential vegetation growing space.
4. **Fine Woody Fuels**
   a. Record fine woody fuels (wood in the 1hr, 10hr, or 100hr size classes) when they are encountered at each point along the transect. If fine fuels are encountered on the forest floor, record the fuel and then the substrate under the fuel. Note that larger 1000hr fuels are included as a substrate, but fine fuels are not.
5. **Heights for Vegetation and Fine Woody Fuels**
   a. At the end of each transect estimate the average maximum height of herbaceous and shrub vegetation in inches to the nearest 1 inch. Average the 1hr/10hr/100hr wood that was tallied to the nearest 0.25 inch. This is recorded at the bottom of the datasheet for each transect. This is not the height above the ground where the sampling point touches the vegetation, but the average maximum height of the plants that are tallied.

i. Measure heights *where they occur* and do not average in zero values within each transect. If you record a cover of any herbaceous, shrub, or 1hr/10hr/100hr on a transect, the height must be >0. Therefore, only height values >0 should be calculated into averages. A yard stick is handy to estimate heights.

6. **Litter and Duff Depths**
   a. At regularly spaced intervals along N, E, S, and W transects, measure litter and duff depths to the nearest 0.25 in. Measurement are at 10 ft, 20 ft, and 30 ft in each direction from plot center (e.g. 10 ft, 20 ft, 30 ft, 50 ft, 60 ft, and 70 ft on each transect tape.
      i. 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.
7. **Tree Cover**
   a. Use a densitometer scope to record cover of any live or dead tree taller than 4.5ft (breast height) at every foot along the 75ft North-South transect. Begin counting at the start of the South transect (3ft mark on the tape), and count every 1-ft until you reach 37-ft from plot center on the North transect (77ft mark on the tape) for a total of 75 measurements (37 counts each side of the plot center, plus one count over the plot center). 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.
      i. If multiple live tree species are encountered at one point, record the tree species lowest in height at that point. If a dead tree is encountered, record species as DEAD.

8. **Tree Group Size Transect**

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

   a. Walking along the length (75 ft) of the North-South transect, record the start and end points of "openings" and "canopy clumps" directly overhead the length of the transect, starting at 3ft and ending at 77ft. Include as canopy clumps, any canopy overhead the transect produced by live 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, 12-75ft).

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).

1/10th 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). If the log is from a conifer, but species cannot be determined, record "conifer."
      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 77ft 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.

3. **Understory Vegetation Presence**
   - **a.** Systematically search for and record any additional plant species present in the 0.1-acre plot that were not recorded on the 8 transects surveyed for percent cover.
   - **b.** Identify plants to the species level. If unable to identify a plant, give the plant an unknown number and name. Show the plant to everyone on the crew to ensure that consistent unknown names are used. Collect a specimen from outside the plot for later identification in the lab.
   - **c.** If any exotic species of concern are found during this search, estimate their cover in the 0.1-acre plot as rare (>0 – 1%), common (2 – 10%), abundant (11 – 50%), or very abundant (51% +).

Field Gear Bag

- Plot Center
  - 1 – 10 BAF Basal area prism or angle gauge
  - 1 – 20 BAF Basal area prism or angle gauge
  - 2 – Binder Clips
  - 1 – 11.78ft fixed plot rope
  - 1 – Clinometer
  - 2 – Compass
  - 1 – Diameter tape
  - 1 – Measuring tape
- Canopy Cover
  - 2 – Clicker counter
  - 1 – Densitometer
- Quadrats
  - 2 – Go no go fuels gauge
  - 2 – Litter/Duff ruler
- Main Compartment
  - 4 – 100ft tape
  - 1 – Hand saw for woody biomass
  - 1 – Hammer
  - 2 – Logger's tape with diameter/length dual measurements
  - 1 – Trowel
  - 1 – White Board
  - 1 – Metal caliper in case
  - 1 – Pair of gloves
  - Paper bags: 10 small, 10 medium, 3 large
- Zipper Pocket
  - Batteries: AAA (4), AA (4), 9V(1), 123A (2)
  - >10 - Pencils, Pens, Sharpie, Dry erase markers
  - 1 – Pink flagging roll
  - 12 - Plot tags and Washers
  - 1 – Garmin e-trex
  - 1 – Camera
- Side Compartments
  - 1 - Hypsometer
  - 2 – Grass clippers/shears in sheath
- 2 – Clipboard/Tatum: filled with below forms
  - Data sheets
  - Unknown plant sheets (Rite in Rain)
  - 1 – Protocol
  - 1 – Photoload for herbaceous fuels

  - 1 – Photo load guides for 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*
  - 3 / plot – Painted Nails, Washers, Stamped Tags
  - 2 of each size / plot – Paper bags for fuels
  - Forms

Shoulder Sheath

- 1 – 1m^2 sampling frame
- 1 – 18in Calipers
- 10 – Chaining pins
- 15 to 20 – Pin flags of 2 different colors (10 of each color)
- 1 – Yard stick w/ seedling class marks

Each Vehicle

- Form Box
  - Data sheets
  - Protocols
  - Photoload Templates
  - Random number lists
  - Example Reports
  - Tax Exempt Form
  - Crew and Emergency Contact List

- Plot Gear
  - Paper Bags (Small, Med, Large)
  - Monuments
    - Box of Nails
    - Box of Washers
    - Box of Stamped Tags
  - 1 – Metal detector
  - 1 – Plant press
  - 4 – Cruising Vests
  - 4 – Hard Hats

- Safety/Navigation Supplies
  - 1 – Duct tape
  - 1 – Complete First aid kit, bug spray, sunscreen
  - 1 – Jumper cables
  - 1 – Road atlas (navigating to study area)
  - 1 – Shovel

- 1 – Tow rope

- Electronics Box
  - 2 – KOBO Tablets
  - 1 – VGS Tablet
  - 2 – Walkie-Talkie (Motorola)
  - 1 – Walkie-Talkie micro USB charger
  - 1 – Camera cable
  - 2 – Micro USB Cables
  - 1 – Portable charging device
  - 2 – Tablet stylus
  - 1 – Flora of Colorado

- Camping Supplies
  - Water cooler(s)
  - Food cooler
  - Cookery