# FIREMON Sampling Methods – Combined Documents

These documents were combined to provide a single resource for all of the most up-to-date FIREMON Sampling Method documents.

Combined: 9/19/2005

# Plot Description (PD)
## Sampling Method

EXECUTIVE SUMMARY

The Plot Description (PD) form is used to describe general characteristics of the FIREMON macroplot to provide ecological context for data analyses. The PD data characterize the topographical setting, geographic reference point, general plant composition and cover, ground cover, fuels, and soils information. This method provides the general ecological data that can be used to stratify or aggregate fire monitoring results. The PD method also has comment fields that allow for documentation of plot conditions and location using photos and notes. The key for the FIREMON database, made up of the Registration Key, Project ID, Plot Number and Date, is part of the PD form.

## INTRODUCTION

The Plot Description (PD) methods were designed to describe important ecological characteristics of the FIREMON macroplot. The macroplot is the area where the other FIREMON methods will be applied. All fields in the PD method pertain to the entire macroplot and should be estimated and recorded so that they describe the macroplot as a whole.

There are seven general categories of data in the PD method: 1) required, 2) plot information, 3) biophysical settings, 4) vegetation, 5) ground cover, 6) fire and 7) common/comment. Only the required fields must be completed. However, within each category, there are some groups of fields that belong together and must be completed as a group. These will be evident on the PD Plot Form and discussed in detail in these methods.

All fields in the required category must be completed regardless of the sampling methods employed. These fields uniquely identify the plot data within the FIREMON database.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

The PD sampling methods described here are the recommended procedures for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

Unlike most other FIREMON sampling procedures, the PD methods are mostly simple, straightforward, and sequential.  There are no nested or repeating fields, and most fields require only one piece of data.

If there is data that you would like to collect but cannot due to broken equipment or other unforeseen circumstances record each instance in the Comments field for the plot. For instance, if you cannot measure the slope because the clinometer was broken leave the Slope field empty and note in the Comments field, “No slope measurements were taken because the clinometer was broken”. This will explain empty fields to future users of the data. Do not enter 0 (zero) in a field that could not be assessed. Either leave the field blank or enter the code that denotes you were not able to assess the attribute.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Required PD Fields – Database key

These four fields constitute the key for your FIREMON database. If you are entering data these fields *must* be entered.

The FIREMON Analysis Tools program will allow summarization and comparison of plots only if they have the same Registration and Project Codes. This restriction is set because typically each monitoring project has unique objectives with the sample size and monitoring methods developed for specific reasons intimately related to each project. Comparisons made between projects with dissimilar methods may not be appropriate.

**Registration Code –** The Registration Code is a 4-character code determined by you or assigned to you. The Registration Code should be used to identify a large group of people such, as all the people at one district of a National Forest or a number of people working under one monitoring leader. You are required to use all four characters. Choose your Registration Code so that the letters and numbers are related to your business or organization. For example:

MFSL = Missoula Fire Sciences Lab
MTSW = Montana DNRC, Southwest Land Office
CHRC = Chippewa National Forest, Revegetation Crew
RMJD = Rocky Mountain Research Station, John Doe

**Project Code** – The Project Code is an 8-charcter code used to identify project work that is done within the group. You are not required to use all eight characters. Some examples of Project Codes are:

TCRESTOR = Tenderfoot Creek Restoration
BurntFk = Burnt Fork Project
SCF1 = Swan Creek Prescribed Fire, Monitoring Crew 1
BoxCkDem = Box Creek Demonstration Project

It will be easier to read the sorted results if you do not include digits in the left most position of the project code. For instance, if two of your projects are 22Lolo and 9Lolo, then when sorted 22Lolo will come before 9Lolo. The preferred option would be to name the projects Lolo09 and Lolo22, although Lolo9 and Lolo22 will sort in the proper order, also.

**Plot Number -** Identifier that corresponds to the site where sampling methods are applied. Integer value.

**Sampling Date –** Enter the date of sampling as an 8-digit number in the MM/DD/YYYY format where MM is the month number, DD is the day of the month and YYYY is the current year. For example, April 01, 2001 would be entered 04/01/2001.

**Organization Code Fields**

These four fields are provided so that users can sort and summarize data using agency location codes, for instance USFS Region, Forest and District. All for fields allow alphanumeric characters.

**Field 1: Organization Code 1** - 4-character field.

**Field 2: Organization Code 2** - 2-character field.

**Field 3: Organization Code 3** - 2-character field.

**Field 4: Organization Code 4** - 2-character field.

**Plot Information Fields**

**Field 5: Examiner Name -** The name of the FIREMON crew boss or lead examiner should be entered up to 8-characters. This is a non-standardized field so anything can be entered here, but we suggest the name follow the convention of first letter in first name followed by a dot followed by the entire last name. So, Smokey Bear would be s.bear and John Smith would be j.smith. We strongly suggest that there are no blanks in the text, for example, don't enter Smokey Bear as s. bear.

**Field 6: Units** – Enter "E" if you will be collecting data using English units or "M" if you using Metric units. These units are used for all measurements in the sampling. The only exception is the Error Units field associated with the GPS location. GPS error may be in English or Metric units regardless of what is entered in Field 6.

The macroplot is the area where you will be applying the FIREMON methods. The size of the macroplot ultimately dictates the representative area to be sampled (table PD-1). If vegetation is dense, large plot sizes usually take longer to sample because it is difficult to traverse the plot. However, some ecosystems have very large trees scattered over large areas so that large plot sizes are needed to obtain realistic estimates. There have been many studies to determine the optimum plot size for different ecosystems with mixed results. We offer the following table to help determine the plot size that matches the fire monitoring application. Plot size and shape selection should be determined by the FIREMON project leader prior to entering the field.

Table PD-1. Suggested FIREMON macroplot plot sizes.

| Average plant height (feet) | Plant Cover (%) | Suggested Plot Size (acres) | Plot Radius (feet) | Suggested Plot Size (sq. meters) | Plot Radius (meters) |
|---|---|---|---|---|---|
| X < 15 | < 50 | 0.10 | 37.2 | 400 | 11.3 |
| | >50 | 0.05 | 26.3 | 200 | 8.0 |
| 15 < X < 100 | < 50 | 0.10 | 37.2 | 400 | 11.3 |
| | >50 | 0.08 | 33.3 | 300 | 9.8 |
| X > 100 | < 50 | 0.40 | 74.5 | 1,000 | 17.8 |
| | >50 | 0.13 | 42.5 | 500 | 12.6 |

Usually, the 0.1-acre circular plot will be sufficient for most ecosystems and this size should be used if no other information is available. A general rule-of-thumb is that the plot should be big enough to capture at least 20 trees above 4 inch diameter at breast height (DBH) on average (i.e., across all plots in your project). It is important that the plot size stay constant across all plots in a sampling project. For example, if a FIREMON project contains shrublands, grasslands, and forests, don't change the plot size when you sample each one. Select the largest plot size (forests, in this example) and use it for all ecosystems. In general you should use circular PD macroplot if you are not using any of the vegetation sampling methods.

Two fields in the PD method are used to describe plot shape and size. If the plot shape is circular, then enter plot radius/length in Field 7 and enter 0 (zero) in Field 8. If a rectangular plot shape is required, the length of the macroplot is entered in Field 7 and the width is entered in Field 8. No other plot shapes are used in FIREMON.

*Plot size*

**Field 7: Plot Radius** (ft/m) – If the macroplot is circular enter the radius of the macroplot. Enter the length of the macroplot if it is rectangular.

**Field 8: Plot Width** (ft/m) **–** Enter the width of the plot if it is rectangular, or enter zero (0) or leave the field blank if the macroplot shape is circular.

*Sampling information*

FIREMON data can be collected on "Monitoring" plots or "Control" plots. Monitoring plots are located inside the treatment area so that you can compare the effects of different treatments on the sampled attributes. Control plots are placed outside the treatment area and used to check that any changes in the sampled attributes were actually due to the treatments and not some unrelated factor. This topic is discussed more in the **Integrated Sampling Strategy** document.

**Field 9: Plot Type** – Enter "M" if you are sampling a monitoring plot or "C" if you are sampling a control plot.

**Field 10: Sampling Event** – Monitoring requires that sampling be stratified by space and time. Since monitoring is a temporal sampling of repeated measures, it is essential that you record the reason for sampling to provide a context for analysis. The Sampling Event field is used to document why the plot is being measured at this particular time (as recorded by Date). The Sampling Event field will help you track changes at the plot level more easily than if you used only the sampling date. The codes are used for this field: 1) P is the pre-treatment measurement of the plot, 2) R is the post-treatment, re-measurement of the plot and 3) IV indicates an Inventory plot that is not permanently monumented and won't be resampled (table PD-2). The codes P and R and followed by a numeric value that indicates the sampling visit of the current sampling. For instance, if you sample a plot once before a prescribed fire the code would be P1, then when you sample after the fire the code will be R1 for the first sampling, R2 for the second sampling and so on. When you change event codes, from P to R, you should start the sequential sample number over at 1. The FIREMON database will accept data for up to three pre-treatment measurements. You will have to consult the FIREMON notebook when you are sampling a plot that has been sampled once or more, before, so that you use the appropriate sequential sample number. For simplicity we have only provided standardized codes for pre- and post-treatment measurements. This may be a problem if, for instance, you plan on three measurements: one pre-harvest, one post-harvest/per-burn and one post-burn. We suggest not using the R sampling event code until all the treatments are done. In the previous example the codes would be; P1 for the pre-harvest sample, P2 for the post-harvest/pre-burn sample and R1 for the post-burn sample. Be sure to note the sampling event numbering scheme in the Metadata table. You can make up your own codes if you chose, however the FIREMON Analysis Tools program will not recognize codes other than those listed in table PD-2 and won't be able to do any analysis for you. If you are doing inventory sampling (e.g. you will not be resampling the plots) code them IV.

Table PD-2. Sampling Event codes.

| Code | Event |
|---|---|
| P*n* | Pre-treatment measurement, sequential sample number. |
| R*n* | Post-treatment re-measurement of a plot, sequential sample number. |
| IV | Inventory plot, not a monitoring plot. |

*Linking Fields*

**Field 11: Fire ID -** Enter a Fire ID of up to 15 characters. The ID number or name that relates the fire that burned this plot to the same fire described in the Fire Behavior (FB) table. This field links this plot scale data with the fire scale data in the FB method. There may be many FIREMON plots referencing one fire. This field will be empty until after the burn has been completed.

**Field 12: Metadata ID** – Enter code of up to 15-characters that links the plot data to the MD table. The Metadata (MD) table is used to store information on the sampling intensity and methods used in the monitoring project. This field is highly recommended so that important information will be recorded for future reference.

*Georeferenced Plot Positions*

The next set of fields is important for relocating FIREMON sample plots, and for using FIREMON plot data in mapping and map validation of remote sensing projects. These fields fix the geographic location of the plot center.

Geographic coordinates are nearly always obtained from a Geographic Positioning System (GPS). GPS technology uses data from at least four orbiting satellites to triangulate your position in three dimensions (X, Y, Z or North, East, Elevation) to within 3 to 50 meters of accuracy. GPS receivers are available from many sources and there are a wide range of GPS models to choose from depending on various sampling criteria. GPS selection and training are not part of the FIREMON sampling methods however, there are number of resources that provide advice on purchasing the right GPS for your sampling needs. There are also a wide variety of public and private agencies that provide excellent training. We recommend that the georeferenced coordinates for FIREMON plots be taken from a GPS receiver and not from paper maps such as USGS quadrangle maps because of the high degree of error. Average the plot location over at least 200 readings to reduce the location error.

Many map projections are available to record FIREMON plot georeferenced coordinates. Users can use either latitude-longitude (lat-long) or the UTM (Universal Transverse Mercator) coordinate system. If you are using UTM coordinates record four pieces of data: northing, easting, zone and datum. Record easting and northing to there nearest whole meter. If you are using lat-long coordinates record latitude and longitude to the sixth decimal place using decimal degrees (this corresponds to about one meter of ground distance at 45 degrees latitude). The down side of lat-long coodinates is that it is difficult to visualize the measurements on the ground (e.g. how far is 0.05 degrees latitude. Be especially alert because units of degrees-min-seconds look very similar to decimal degrees. If using lat-long coordinates enter data in Fields 14, 15, 19, 20 and 21. If using UTM coordinates enter data in Fields 16 to 21

**Field 13: Coordinate System** – This field is automatically filled based on the data entered in Fields 14 to 21. The user does not see this field.

**Field 14: Latitude –** Enter the latitude, in decimal degrees to six decimal places.

**Field 15: Longitude -** Enter the longitude, in decimal degrees to six decimal places.

**Field 16: Northing -** Enter the UTM northing to the nearest whole meter.

**Field 17: Easting -** Enter the UTM easting to the nearest whole meter.

**Field 18: Zone -** Enter the UTM zone of the plot center.

**Field 19: Datum -** Enter the datum used in conjunction with the UTM coordinates.

**Field 20: Position Error -** Enter the position error value provided by the GPS unit. This should be entered regardless of whether you are using lat-long or UTM coordinates.

**Field 21: Error Units** (E/M) **-** Enter the units associated with the GPS error. May be different than the units listed in Field 6.

Fields 5 through 21 make up the information that is critical to have for every FIREMON macroplot, regardless of the sampling intensity or methods you will be using to collect data.

The following sections describe the measurement or estimation of various ecosystem characteristics that are important to fire effects monitoring. These sections are presented in the order of their priority for sampling.

### Biophysical Setting Fields

The biophysical setting describes the physical environment of the FIREMON plot relative to the organisms that grow there. Many site characteristics can be included in a description of biophysical setting, but only topography, geology, soils, and landform fields are implemented in FIREMON.

*Topography*

**Field 22: Elevation** (ft/m) – Enter the elevation above MSL (mean sea level) of the FIREMON plot in feet (meters) to the nearest 100 feet (30 m). Elevation can be estimated from three sources. Most GPS readings include an estimate of elevation and these estimates are usually fairly accurate. Elevation can also be estimated from an altimeter. There are many types of altimeters, but most are barometric, estimating elevation from atmospheric pressure. Altimeters are notoriously fickle and need calibration nearly every day. When there are frequent weather systems passing the area (e.g., cold and warm fronts), altimeters should be calibrated every four hours. Finally, elevation can be taken from USGS topographic maps.

**Field 23: Plot Aspect –** Enter the aspect of the FIREMON plot in degrees true north to the nearest five degreees. Aspect is the direction the plot is facing. For example, a slope that faces exactly west would have an aspect of 270 degrees true north. Be sure to record the aspect that best represents the macroplot as a whole and not just the point where you are standing. Also, be sure you check your compass reading with your knowledge of the area to be sure that the aspect indicated is really correct. Often, metal on sampling equipment, or iron rebar plot center, can influence the estimation of aspect. For information about using a compass see **How to Use a Compass - Sighting and Setting Declination.**

**Field 24: Slope –** Record the plot slope using the percent scale to the nearest five percent. The slope is measured as an average of the uphill and downhill slope from plot center. See **How To Measure Slope** for more information. Be sure the recorded slope reflects the slope of the entire plot and not just the line where you are standing. Always enter slope as a positive number.

**Field 25: Landform –** Enter up to a 4-charcter code that best describes the landform containing the FIREMON macroplot from table PD-3. See **Appendix C: NRIS Landform Codes** for a complete list.

Table PD-3. Landform codes.

| Code | Landform |
|---|---|
| GMF | Glaciated mountains-foothills |
| UMF | Unglaciated mountains-foothills |
| BRK | Breaklands-river breaks-badlands |
| PLA | Plains-rolling planes-plains w/breaks |
| VAL | Valleys-swales-draws |
| HIL | Hill-low ridges-benches |
| X | Did not assess |

**Field 26: Vertical Slope Shape –** Enter up to a 2-character code using the classes in table PD-4, that best describes the general contour of the terrain upslope and downslope from plot center. As you look up and down the slope estimate a shape class that best describes the horizontal contour of the land (figure PD-1).

**Field 27: Horizontal Slope Shape –** Enter up to a 2-character code using the classes in table PD-4, that best describes the general contour of the terrain upslope and downslope from plot center. This is an estimate of the general shape of the slope parallel to the contour of the slope.

As you look across the slope along the contour, estimate a shape classes that best describes the horizontal contour of the land (figure PD-1).

Table PD-4. Slope shapes.

| Code | Slope shape |
|---|---|
| LI | Linear or planar |
| CC | Depression or concave |
| PA | Patterned |
| CV | Rounded or convex |
| FL | Flat |
| BR | Broken |
| UN | Undulating |
| OO | Other shape |
| X | Did not assess |

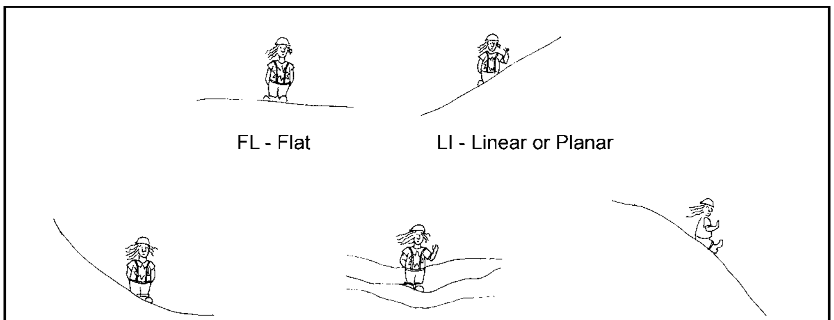


Figure PD-1. These illustrations depict the different types of vertical slope shapes. Horizontal slope shapes use the same classification but are determined by examining the across slope profile, rather than up and down the slope.

*Geology and Soils Fields*

**Field 28: Primary Surfical Geology –** This is the first of five fields used to describe geology and soils. Determine the geological rock type composing the parent material at the plot and enter the appropriate code from table PD-5 into the field. Generally, identification of surficial geology requires someone with specialized training and experience.

Table PD-5. Common primary surficial geology codes.

| Primary Code | Rock Type 1 |
|---|---|
| IGEX | Igneous Extrusive |
| IGIN | Igneous Intrusive |
| META | Metamorphic |
| SEDI | Sedimentary |
| UNDI | Undifferentiated |
| X | Did not assess |

**Field 29: Secondary Surficial Geology (Field 29-SGEOLOGY)** – Use this field only if you have coded a primary surficial geology type. Determine the secondary geological rock type

composing the parent material at the plot and enter the appropriate code from table PD-6 into the field. Generally, identification of surficial geology requires someone with specialized training and experience. Table PD-6 is an abridged list of common surficial types. A complete list is included in **Appendix B: NRIS Lithology Codes.**

Table PD-6. Common secondary surficial geology codes. Additional codes are listed in Appendix B.

| Secondary Code | Rock Type 2 |
|---|---|
| ANDE | Andesite |
| BASA | Basalt |
| LATI | Latite |
| RHYO | Rhyolite |
| SCOR | Scoria |
| TRAC | Trachyte |
| DIOR | Diorite |
| GABB | Gabbro |
| GRAN | Granite |
| QUMO | Quartz Monzonite |
| SYEN | Syenite |
| GNEI | Gneiss |
| PHYL | Phyllite |
| QUAR | Quartzite |
| SCHI | Schist |
| SLAT | Slate |
| ARGI | Argillite |
| CONG | Conglomerate |
| DOLO | Dolomite |
| LIME | Limestone |
| SANS | Sandstone |
| SHAL | Shale |
| SILS | Siltstone |
| TUFA | Tufa |
| MIEXME | Mixed Extrusive and Metamorphic |
| MIEXSE | Mixed Extrusive and Sedimentary |
| MIIG | Mixed Igneous (extrusive & intrusive) |
| MIIGME | Mixed Igneous and Metamorphic |
| MIIGSE | Mixed Igneous and Sedimentary |
| MIINME | Mixed Intrusive and Metamorphic |
| MIINSE | Mixed Intrusive and Sedimentary |
| MIMESE | Mixed Metamorphic and Sedimentary |
| X | Did not assess |

**Field 30: Soil Texture Class** – The description of soil on the FIREMON plot is limited to a general description because fire effects are not influenced by fine-scale soil characteristics. Generally, identification of soil texture requires someone with specialized training and experience. Many fire effects can be described by general soil characteristics and soil texture is one of those general characteristics. Enter the code that best describes the texture of the soil on

the FIREMON macroplot (table PD-7). These soil textures are described in many soils textbooks. If you are unsure of how to evaluate soil texture or have no confidence in your estimates, then use the X code or leave the field blank. We have only included the codes for soil texture required by FOFEM; if additional codes are desired you may design them on your own and note them in the MD table.

Table PD-7. Soil texture codes.

| Code | Description | Code | Description |
|---|---|---|---|
| C | Clay | S | Sand |
| CL | Clay loam | SC | Sandy clay |
| COS | Coarse sand | SCL | Sandy clay loam |
| COSL | Coarse sandy loam | SI | Silt |
| FS | Fine sand | SIC | Silty clay |
| FSL | Fine sandy loam | SICL | Silty clay loam |
| L | Loam | SIL | Silt loam |
| LCOS | Loamy coarse sand | SL | Sandy loam |
| LFS | Loamy fine sand | VFS | Very fine sand |
| LS | Loamy sand | VFSL | Very fine sandy loam |
| LVFS | Loamy very fine sand | X | Did not assess |

**Field 31: Erosion Type -** Erosion is an important second order fire effect that needs to be documented. We have based the Erosion Type on the classification used by the Natural Resources Conservation Service Soil Survey Handbook (table PD-8). See www.nrcs.usda.gov/technical/references/ for more information. If your macroplot is on a site that has moved in its entirety through landslip include that information in the comments field of the PD form then code Field 31 with the code the identifies the erosion conditions you are seeing on the surface. Be sure to record erosion on pre-burn plots in order to provide the reference conditions. The types of erosion are listed along with the codes in table PD-9. Enter the code that best describes the erosion occurring on the plot.

Table PD-8. Erosion type codes.

| Code | Erosion type |
|---|---|
| S | Stable, no erosion evident |
| R | Water erosion, rill |
| H | Water erosion, sheet |
| G | Water erosion, gully |
| T | Water erosion, tunnel |
| W | Wind erosion |
| O | Other type of erosion |
| X | Did not assess |

**Field 32: Erosion Severity** - The severity of the erosion event is extremely difficult to assess and is best estimated by those who have some experience with erosion processes. We have based the Erosion Severity on the classification used by the Natural Resources Conservation Service Soil Survey Handbook (table PD-9). The severity codes use the depth and extent of erosion to

quantify severity. Enter the code that best fits the severity of the erosion on the plot in this field. Severity codes do not apply to tunnel erosion. If you have tunnel erosion on your plot enter –1 in this field

Table PD-9. Erosion severity codes

| Code | Erosion severity |
|---|---|
| 0 | Stable, no erosion is evident. |
| 1 | Low erosion severity; small amounts of material are lost from the plot. On average less than 25 percent of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Throughout most of the area the thickness of the soil surface layer is within the normal range of variability of the un-eroded soil. |
| 2 | Moderate erosion severity; moderate amounts of material are lost from the plot. On average between 25 and 75 percent of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Erosion patterns may range from small, un-eroded areas to small areas of severely eroded sites. |
| 3 | High erosion severity; Large amounts of material are lost from the plot. On average 75 percent or more of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Material from deeper horizons in the soil profile is visible. |
| 4 | Very high erosion severity; Very large amounts of material are lost from the plot. All of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Erosion has removed material from deeper horizons of the soil profile throughout most of the area. |
| -1 | Unable to assess |

**Vegetation Fields**

These PD fields describe general aspects of the vegetation using percent canopy cover as the measurement unit. All vegetation fields require an estimate of percent canopy cover recorded by class (table PD-10). Canopy cover estimation methods are described in the **How To Estimate Cover**.

Table PD-10. Canopy cover codes. Use these codes to record vegetation cover in the fields the call for cover estimation.

| Code | Canopy cover |
|---|---|
| 0 | Zero percent canopy cover |
| 0.5 | >0-1 percent of canopy cover |
| 3 | >1-5 percent canopy cover |
| 10 | >5-15 percent canopy cover |
| 20 | >15-25 percent canopy cover |
| 30 | >25-35 percent canopy cover |
| 40 | >35-45 percent canopy cover |
| 50 | >45-55 percent canopy cover |
| 60 | >55-65 percent canopy cover |
| 70 | >65-75 percent canopy cover |
| 80 | >75-85 percent canopy cover |
| 90 | >85-95 percent canopy cover |
| 98 | >95-100 percent canopy cover |

Vegetation cover in these PD fields is stratified by lifeform and size class. This makes estimation of canopy cover difficult because all the cover of all plants within a lifeform requires quite a bit of experience to consistently assess lifeform and size class cover when lifeforms and classes are unevenly distributed in all three dimensions. If you are unable to make an estimation for any reason, leave the field blank and note the reason in the comments section (Field 81). Always enter the code 0 (zero) when there is no cover for that ground element.

Vegetation cover does not need to sum to 100 percent by lifeform because there will probably be overlapping cover across all lifeforms. However, the total cover for each lifeform must always be greater than any of the covers estimated for the size classes within that lifeform.

*Vegetation - Trees*

The following fields provide an estimate of tree cover by size class.

**Field 33: Total Tree Cover -** Enter the percent canopy cover of all trees using the canopy cover codes presented in table PD-10 above. This estimate includes cover of ALL tree species from the smallest of seedlings to the tallest of old growth stems. It includes all layers of canopy vertically projected to the ground.

**Field 34: Seedling Tree Cover** - Enter the percent canopy cover of all trees that are less than 4.5 feet (1.4 meters) tall using the codes in table PD-10. This cover estimate includes only the small seedlings.

**Field 35: Sapling Tree Cover -** Enter the percent canopy cover of all trees that are greater than 4.5 feet (1.4 meters) tall and less than 5.0 in (13 cm) DBH using the codes in table PD-10.

**Field 36: Pole Tree Cover -** Enter the percent canopy cover of all trees that are greater than 5 in (13 cm) DBH and less than 9 in (23 cm) DBH using FIREMON cover codes in table PD-10.

**Field 37: Medium Tree Cover -** Enter the percent canopy cover of all trees that are greater than 9 in (23 cm) DBH up to 21 in (53 cm) DBH using the codes in table PD-10.

**Field 38: Large Tree Cover -** Enter the percent canopy cover of all trees that are greater than 21 in (53 cm) DBH up to 33 in (83 cm) DBH using the FIREMON codes in table PD-10.

**Field 39: Very Large Tree Cover -** Enter the percent canopy cover of all trees that are greater than 33 in (83 cm) DBH using the codes in table PD-10.

*Vegetation - Shrubs*

The next set of fields allows the FIREMON sampler to estimate shrub cover in three height size classes.

**Field 40: Total Shrub Cover -** Enter the percent canopy cover of all shrubs on the plot into using the FIREMON canopy cover in table PD-10. This cover estimate includes vertically projected cover of all shrub species of all heights.

**Field 41: Low Shrub Cover -** Enter the percent canopy cover of all shrubs that are less than 3 feet (1 meter) tall on the plot using the codes in table PD-10.

**Field 42: Medium Shrub Cover -** Enter the percent canopy cover of all shrubs that are greater than 3 feet (1 meter) tall and less than 6.5 feet (2 meters) tall on the plot into using the codes in table PD-10.

**Field 43: Tall Shrub Cover -** Enter the percent canopy cover of all shrubs that are greater than 6.5 feet (2 meters) tall on the plot into using the codes in table PD-10.

*Vegetation - Herbaceous*

Cover of grasses, forbs, ferns, mosses and lichens are entered in the next set of vegetation fields. If you feel uncomfortable distinguishing between species within and across lifeforms, try to get some additional training from the ecologist, forester, or other resource specialists at your local offices. Phenological adjustments must be made for many herbaceous species because most cure during the dry season, making cover estimation very difficult. Follow the suggestions in **How To Estimate Cover** to get the correct cover estimates.

**Field 44: Graminoid Cover -** Enter the percent canopy cover of all graminoid species on the plot into using the codes in table PD-10. Graminoid cover includes all grasses, sedges and rushes in all stages of phenology. This cover is for all sizes and species of graminoids.

**Field 45: Forb Cover -** Enter the percent canopy cover of all forbs on the plot using the FIREMON cover codes in table PD-10.

**Field 46: Fern Cover -** Enter the percent canopy cover of all ferns on the plot using the FIREMON cover codes in table PD-10.

**Field 47: Moss and Lichen Cover -** Enter the percent canopy cover of all mosses and lichens on the plot using the codes in table PD-10. These mosses and lichens can be on the ground or suspended from plants in the air (i.e., arboreal).

*Vegetation - Composition*

The following fields document the dominant plant species in each of three layers or strata on the FIREMON plot. These fields are used to describe the existing vegetation community based on dominance in cover. These descriptions are especially useful in satellite classification for mapping vegetation, developing existing vegetation community classifications, and for stratifying FIREMON fire effects results.

In order for a species to be dominant it has to have at least 10 percent canopy cover in that stratum and the species must have higher cover than any other species in that stratum. In the PD method, two species per stratum are used to describe dominance. The first species (Species 1) is the most dominant in terms of canopy cover, and the second species (Species 2) is the second most dominant. Use the NRCS plant code or local species code to record the species.

There are three strata for stratifying dominant existing vegetation. The first stratum is called the Lower Stratum and is the cover of all plants less than 3 feet (1 m) tall. The Mid Stratum is for plants 3 to 10 feet (1 to 3 m) tall, while the Upper Stratum is for plants taller than 10 feet tall (3 m). Only species cover within the stratum is used to assess dominance. Many shade tolerant tree species can be dominant in all three strata.

If there are no species above 10 percent cover in a stratum, enter the code N indicating that there are no species that qualify for dominance. The same applies if there is no secondary species for dominance.

**Field 48: Upper Dominant Species 1 -** Enter the species code of the most dominant species in the upper level stratum of the FIREMON plot. This is the stratum that is greater than 10 feet (3 m) above ground level.

**Field 49: Upper Dominant Species 2 -** Enter the species code of the second most dominant species in the upper level stratum of the FIREMON plot. This is the stratum that is greater than 10 feet (3 m) above ground level.

**Field 50: Mid Dominant Species 1 -** Enter the species code of the most dominant species in the mid level stratum of the FIREMON plot. This is the stratum that is greater than 3 feet and less than 10 feet (1 to 3 m) above ground level.

**Field 51: Mid Dominant Species 2 -** Enter the species code of the second most dominant species in the mid level stratum of the FIREMON plot. This is the stratum that is greater than 3 feet and less than 10 feet (1 to 3 m) above ground level.

**Field 52: Lower Dominant Species 1 -** Enter the species code of the most dominant species in the lowest level stratum of the FIREMON plot. This is the stratum that is less than 3 feet (1 m) above ground level.

**Field 53: Lower Dominant Species 2 -** Enter the species code of the second most dominant species in the lowest level stratum of the FIREMON plot. This is the stratum that is less than 3 feet (1 m) above ground level.

*Potential Vegetation*

An important characteristic for describing biotic plant communities, especially in the western United States, is the potential vegetation type. Potential vegetation generally describes the capacity of a site or FIREMON plot to support unique vegetation species or lifeforms. Potential vegetation is evaluated by describing the vegetation that would eventually occupy a site in the absence of disturbance over a long time. For example, an alpine site can only support herbaceous communities because these sites are too cold for shrubs or trees, whereas a clearcut cedar-hemlock site has the potential to support coniferous forest ecosystems. Potential vegetation classifications are highly ecosystem specific and are locally developed for certain regions, so a standardized potential vegetation classification for the entire United States does not currently exist. In FIREMON, potential vegetation is evaluated to broad lifeforms to aid in the interpretation of FIREMON results.

**Field 54: Potential Vegetation Type ID -** Potential vegetation types are the foundation of many management decisions. Many forest plans and project designs stratify treatments by potential vegetation type to achieve better results. Unfortunately, there is no National standard list of potential vegetation types in the United States. Instead, we have provided a generic field is provided for the user to enter their own PVT code to stratify FIREMON results. This field is not standardized and any combination of alpha or numeric characters can be used. Do not use spaces in the text (e.g., enter ABLA/VASC). Be sure you document your codes in the FIREMON MD table. There are 16 characters available in this field.

**Field 55: Potential Lifeform -** Enter the potential lifeform code that best describes the community lifeform that would eventually inhabit the FIREMON plot in the absence of disturbance (table PD-11).

Table PD-11. Potential lifeform codes.

| Code | Potential lifeform |
|---|---|
| AQ | Aquatic -- Lake, pond, bog, river |
| NV | Non-vegetated -- Bare soil, rock, dunes, scree, talus |
| CF | Coniferous upland forest -- Pine, spruce, hemlock |
| CW | Coniferous wetland or riparian forest -- Spruce, larch |
| BF | Broadleaf upland forest -- Oak, beech, birch |
| BW | Broadleaf wetland or riparian forest – Tupelo, cypress |
| SA | Shrub dominated alpine – Willow |
| SU | Shrub dominated upland – Sagebrush, bitterbrush |
| SW | Shrub dominated wetland or riparian -- Willow |
| HA | Herbaceous dominated alpine -- Dryas |
| HU | Herbaceous dominated upland – grasslands, bunchgrass |
| HW | Herbaceous dominated wetland or riparian -- ferns |
| ML | Moss or lichen dominated upland or wetland |
| OT | Other potential vegetation lifeform |
| X | Did not assess |

**Ground Cover Fields**

This next set of PD fields describes the fuels complex on the FIREMON plot. The first group of fuels fields characterizes ground cover by various characteristics important for evaluating fire effects. The standard FIREMON percent cover class codes (PD-10) are used to quantify ground cover. Ground cover is critical for describing fuel continuity and cover, but it is also used for evaluation of erosion potential and for classification of satellite imagery.

A group of generalized fuel attributes are used to describe biomass characteristics for the entire FIREMON plot. The first fields describe surface fuel characteristics through standardized fuel models, while the last fields describe crown fuel characteristics important for fire modeling.

*Ground Cover*

Ground cover attempts to describe important attributes of the forest floor or soil surface. Ground cover is estimated into ten different categories, with each category important for calculating subsequent or potential fire effects. Ground cover is another difficult sampling element. Cover within a category is evaluated as the vertically projected cover of that category that occupies the ground. *Only elements that are in direct contact with the ground are considered in the estimation of ground cover*. Ecosystem components suspended above the ground, such as branches, leaves, and moss, are not considered in the estimation of ground cover.

Ground cover is described by a set of 10 fields where the sum *must add to 100 percent* (unlike the PD vegetation cover fields) plus or minus 10 percent. We suggest the following strategy for making these cover estimates. First, estimate ground cover for those categories with the least ground cover. These categories are the easiest to estimate with high accuracies. Be sure you scan the entire FIREMON plot to check for mineral soil, moss/lichen, and rock ground cover. Next, estimate the basal vegetation field to the cover codes 0.5, 3, or 10 (basal vegetation rarely exceeds 15 percent ground cover). Lastly, use the ground cover fields with the most cover (this is often only one or two fields, such as duff/litter) to make your estimate add to 100 percent. See **How to Estimate Cover** for more information. If you are unable to make an estimation for any reason, leave the field blank and note the reason in the comments section (Field 81). Always enter the code 0 (zero) when there is no cover for that ground element.

**Field 56: Bare Soil Ground Cover -** Estimate the percent ground cover of bare soil using the codes in table PD-10. Bare soil is considered to be all those mineral soil particles less than 1/16 inch (2 mm) in diameter. Bare soil does not include any organic matter. The bare soil can be charred or blackened by the fire.

**Field 57: Gravel Ground Cover -** Estimate the percent ground cover of gravel using the codes in table PD-10. Gravel is those mineral soil particles greater than 1/16 inch (2 mm) in diameter to 3 inches in diameter (80 mm). Again, gravel does not include any organic soil colloids. The gravel can be charred or blackened by the fire.

**Field 58: Rock Ground Cover -** Estimate the percent ground cover of rock using the codes in table PD-10. Rock ground cover is considered to be all those mineral soil particles greater than 3 inches (8 cm) in diameter, including boulders. Rocks can be blackened by the fire.

**Field 59: Litter and Duff Ground Cover -** Estimate the percent ground cover of all *uncharred* litter and duff on the soil surface using the codes in table PD-10. Litter and duff cover is mostly organic material, such as partially decomposed needles, bark, and leaves, deposited on the ground. Do not include any woody material into this ground cover category unless it is highly decomposed twigs or logs that appear to be part of the duff. Sometimes after a fire the litter and duff will be charred and the cover of this charred litter/duff is estimated into the Charred Ground Cover field and not here. Other ground cover elements that are included in this category include plant fruits, buds, seeds, animal scat and bones. If human litter appears on the FIREMON plot, pick it up and throw it away, and do not include it in the ground cover estimate.

**Field 60: Wood Ground Cover -** Estimate the percent ground cover of all *uncharred* woody material using the codes in table PD-10. Woody ground cover is only those wood particles that are recognizable as twigs, branches or logs. Do not include cover of suspended woody material, such dead branches connected on shrub or tree stems, into this field.

**Field 61: Moss and Lichen Cover -** Enter the percent canopy cover of all mosses and lichens on the plot using the codes in table PD-10. These mosses and lichens can be on the ground or suspended from plants in the air (i.e., arboreal). This is the same estimate as in Field 43. The duplication is because some people consider moss an lichens ground cover and some consider it vegetation.

**Field 62: Charred Ground Cover -** Estimate the percent ground cover of all *charred organic* material using the codes in table PD-10. Char is the blackened charcoal left from incomplete combustion of organic material. Char can occur on any piece of organic matter, such as duff, litter, logs, and twigs, and cover of all char is lumped into this category. Do not include ash into the charred ground cover. If it is difficult to distinguish char and black lichen, try to scrap the black area with your fingernail and then rub your nail on your plot sheet. Char will usually leave a mark.

**Field 63: Ash Ground Cover -** Estimate the percent ground cover of all ash material using the codes in table PD-10. Ash can sometimes look like mineral soil, but mineral surface feels sandy or gritty when touched, ash will often feel like a powder. Ash can occur in a variety of colors (red, gray, white), but light gray is often the primary shade.

**Field 64: Basal Vegetation Ground Cover -** Estimate the percent ground cover of basal vegetation using the codes in table PD-10. Basal vegetation is the area of the cross-section of the stem where it enters the ground surface expressed as a percent of plot cover. This category is extremely difficult to estimate, but fortunately, it has some repeatable characteristics. First, basal vegetation rarely exceeds 15 percent cover, so it will only get four valid FIREMON cover codes: 0, 0.5, 3, or 10. Next, it is highly ecosystem specific. Usually only forested ecosystems have high basal vegetation ground covers. This field is only used for vascular plant species. All non-vascular species are estimated in the Moss/Lichen Ground Cover field.

**Field 65: Water Ground Cover -** Estimate the percent ground cover of standing water using the codes in table PD-10. Water ground cover includes rainwater puddles, ponding, runoff, snow, ice, and hail. Do not include wet surfaces of other ground cover categories in this estimate. Although water is often only ephemeral, its cover must be recorded to account make cover estimates sum to 100.

*General Fuel Characteristics*

These fields are designed to describe general, plot-level fuel attributes for mapping and modeling fuel characteristics to predict fire behavior and effects. For instance, these fields could provide the information needed to run the FARSITE model. Estimation of fuel characteristics is highly subjective and very dependent on the experience of the FIREMON crew. If more objective, repeatable, and accurate fuel estimates are needed, then use the Fuel Load (FL) and the Tree Data (TD) methods to more accurately and objectively measure information on surface and crown fuels.

**Field 66: Surface Fire Behavior Fuel Model -** Choose the appropriate fire behavior fuel model from the Anderson 1983 publication, Aids for Determining Fuel Models for Estimating Fire Behavior, or a custom fire behavior fuel model

**Field 67: Fuel Photo Series ID -** Many areas in the United States have associated photo series guides. The guides use photos to describe typical fuel loadings by major cover types and geographical area. Each picture is linked to intensively sampled fuel loadings. These series are used to visually estimate fuel loadings by matching the picture with current conditions observed in the field. It is important to note that this method is highly subjective and notoriously inaccurate, but it is often the only means available for quantifying the fuelbed loadings. This PD field is used to record the photo series picture that best describes current fuel conditions. Simply match the picture in the photo series developed for your area with your stand conditions and enter a locally designed code for that picture. You can use the publication number combined with the picture number to uniquely identify the photo. For instance, if you are using the photo series for estimating natural fuels in the Lake States (Ottmar and Vihnanek 1999) you could combine the NFES publication number, 2579, and the plot number of the photo that best describes your fuels conditions. In this case you would enter NFES2579MP04 in Field 63. You can use up to 12-characters. Design this field to best suit your needs, but document your code conventions in the FIREMON MD table.

**Field 68: Stand Height** (ft/m) **–** Estimate the height of the highest stratum that contains at least 10 percent crown cover. This value is used to model crown fire spread. Estimate to the nearest 3 feet (1 m).

**Field 69: Canopy Fuel Base Height** (ft/m) **-** The lowest point above the ground at which there is a sufficient amount of canopy fuel to propagate a fire vertically into the canopy. Canopy fuel base height is a stand level measurement that provides an index for crown fire initiation and should account for dense dead vertical fuels (e.g., lichens, needle-drape, dense dead branches) that could provide a conduit for entrance of a surface fire into the crown. Estimate canopy base height to the nearest foot (0.3 m). A trick to estimating canopy base height for the entire FIREMON plot is to envision a plastic sheet on the ground with a hole for each tree. Then, mentally try to lift the plastic sheet to the first dense section of the crown (i.e., part of crown having burnable biomass that could catch fire). Do this for each tree, and then try to estimate the average height of the sheet.

**Field 70: Canopy Cover -** Estimate the percent canopy cover of the forest canopy above 6 feet (2 m) using the code in table PD-10. This value is used to estimate crown bulk density for crown fire spread modeling. Be sure the estimate cover as percent vertically projected canopy cover and includes cover for all species.

**The Fire Behavior and Effects Fields**

These FIREMON fields are used to identify the fire event, describe the fire behavior and the subsequent fire effects. Fire behavior is a physical description of the fire, whereas fire effects are assessed from observations of the ecosystem after the fire has burned the area. Fire behavior data will generally be collected at two scales: the plot scale and the fire scale. Plot scale data is collected on the FIREMON macroplot and is contained in just two fields on the PD field form: flame length and fire spread rate. There is also one field to enter the file name of a fire behavior photo. There will probably never be a fire where samplers are able to collect this data on every macroplot but the information can be useful in determining relationships between fire behavior and fire effects. Recording flame length and spread rate, as well as taking a fire behavior photo, on even a subset of the total plots will be to your advantage. You will be collecting only flame length and spread rate data during a fire event. Any other fields on the PD form that are important to your project will be completed before the fire. Fire scale data, things like fuel moistures, plume behavior and spotting observations are recorded in the FIREMON Fire Behavior (FB) table.

*Fire Behavior*

Enter the plot scale estimates of flame length and fire spread in the following two fields. This information will be collected during the fire event but using the data sheets from the most recent sampling before the fire. For example, if there were two preburn sampling visits, record data in Fields 71 and 72 on the forms (and then in the FIREMON database) where P2 was coded in the Sampling Event field. We recognize that this may lead to some confusion because you will be doing most of your sampling before the fire, then waiting until the weather allows you to burn at a later date. At that time you will have to relocate the field forms and fill in additional fields – Fire ID, Flame Length, Spread Rate and Fire Behavior Picture. Remember, you can also use the Date field to identify the most recent forms.

**Field 71: Flame Length** (ft/m) – Flame length is the length of the flames from the center of the combustion zone to the end of the continuous flame. It is more highly correlated with fire intensity than flame height. (figure PD-2). Estimate flame length as an average within the FIREMON macroplot boundaries to the nearest 0.5 feet (0.2 meter).

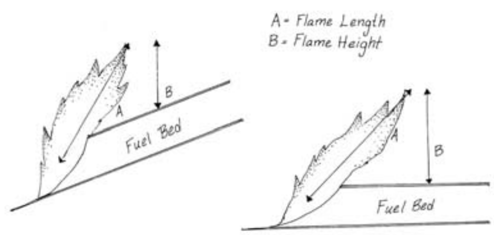


Figure PD-2. Illustration showing flame length vs. flame height measurement. Enter your flame length estimate (A) into Field 71.

**Field 72: Spread Rate** (ft/min or m/min) – Estimate the average speed of the fire as it crosses the macroplot in feet per minute to nearest 1 foot per minute (meters per minute to nearest 0.3 meter). Estimate spread rate by noting the number of minutes it takes for the flaming front to pass two points separated by a known distance.

**Field 73: Fire Behavior Picture -** Enter the picture code – up to 15 characters - for a picture that best shows fire behavior as the flaming front crosses the FIREMON plot. This code will link to a digital picture placed into the FIREMON database. The picture code can be something like R01P02 for Roll 1, picture number 2 for film cameras, or it could be a filename (e.g., file0001.jpg) for digital cameras. Scan slides or paper photographs into JPEG files for entry into the FIREMON database.

*Fire Effects*

Fire effects must be evaluated from the burned evidence left on the FIREMON plot after the fire has passed. The fire severity classification used in the PD method is based on the NPS Fire Monitoring Handbook. Fire severity on larger areas (30 X 30 m) can be obtained by completing the Composite Burn Index methods (see the **Landscape Assessment** methods).

**Field 74: Fire Severity Code –** Enter the number (0 to 5) corresponding to the fire severity observed on the FIREMON plot using the descriptions in table PD-12. This fire severity classification is based on that used in the NPS Fire Monitoring Handbook (www.fire.nps.gov/fmh/books.htm). Examine the substrate and the vegetation on your macroplot, then choose the Severity Code that best matches the conditions you are on the macroplot. Be sure the Fire Severity Code is determined only from observations made inside the macroplot.

Table PD-12. Use these fire severity class to determine the fire severity across the FIREMON macroplot.

| FIRE SEVERITY CODE | Substrate | Forest Vegetation | Shrubland Vegetation | Grassland Vegetation |
|---|---|---|---|---|
| **Unburned (5)** | Not burned | Not burned | Not burned | Not burned |
| **Scorched (4)** | Litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | Foliage scorched and attached to supporting twigs. | Foliage scorched and attached to supporting twigs. | Foliage scorched |
| **Lightly Burned (3)** | Litter charred to partially consumed; upper duff layer may be charred but the duff is not altered over the entire depth; surface appears black; where litter is sparse charring may extend slightly into soil surface but soil is not visibly altered; woody debris partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned. | Foliage and smaller twigs partially to completely consumed; branched mostly intact. | Foliage and smaller twigs partially to completely consumed; branched mostly intact; typically, less than 60 percent of the shrub canopy is consumed. | Grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable. |
| **Moderately Burned (2)** | Litter mostly to entirely consumed, leaving coarse, light colored ash (ash soon disappears, leaving mineral soil); duff deeply charred, but not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned out stump holes are evident. | Foliage twigs and small stems consumed; some branches still present. | Foliage twigs and small stems consumed; some branches smaller branches (0.25-0.50 in.) still present; typically, 40 to 80 percent of the shrub canopy is consumed. | Unburned grass stubble usually less than two inches tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning. |
| **Heavily burned (1)** | Litter and duff completely consumed, leaving fine white ash (ash disappears leaving mineral soil); mineral soil charred and/or visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. | All plant part consumed, leaving some or no major stems or trunks; any left are deeply charred. | All plant parts consumed leaving only stubs greater than 0.5 in. in diameter. | No unburned grasses above the root crown; for other species, all plant parts consumed. |
| **Not Applicable (0)** | Only inorganic material on site before burn. | None present at time of burn. | None present at time of burn. | None present at time of burn |

**Common Fields**

Photographs, conventional or digital, are a useful means to document the FIREMON plot a number of ways. They provide a unique opportunity to visually assess fire effects and document plot location in a database format. Previously established FIREMON plots can be found by orienting the landmarks in photos to visual cues in the field. Photos can be compared to determine important changes after a fire. Lastly, photos provide excellent communication tools for describing fire effects to the public and forest professionals.

Document the FIREMON macroplot location using two photographs taken facing north and east. For the north-facing photo move about 10 feet south of the FIREMON macroplot center then take the photo facing north being sure that the plot center stake or rebar will be visible in the picture (figure PD-3). Then, move west of the plot center about 10 feet and take a photo facing east, again, being sure that the plot center stake or rebar will be visible in the picture. For these pictures be sure that the camera is focused on the environment surrounding the plot, not the distance or foreground and that the camera is set for the correct exposure and aperture for existing light conditions. A flash might be needed in low-light conditions.

Figure PD-3. Take your plot photos so that they show the plot center and the general plot conditions.

Enter an identifier in Field 75 for the north-facing photo and Field 76 in the east-facing field. Photos taken with conventional film can be identified by assigning a code that integrates the roll number or name (e.g., John Smith Roll 1) and the picture number (i.e., number on camera). For example, John Smith Roll 1 and picture 8 might be assigned JSR01P08 on the PD Plot Form. You must label the roll so that you will be able to find the correct photos after the film has been developed. One way is to take a picture of a card with the roll information on it, as your first photo. Or, you can write the roll information on the film canister before you load it into the camera. The first method is the most foolproof. For digital cameras, enter the file name of the digital picture. Film photos will need to be scanned once they are developed and stored on your computer in digital format. The file names in Fields 75 and 76 will be linked to the plot photos when you enter your data into the FIREMON database.

**Field 75: North Digital Photo -** Enter a code of up to 15-characters that uniquely describes the location of the photo taken in the direction of due north. This field in the PD database will be linked actual digital photo when you enter data into the FIREMON database.

**Field 76: East Digital Photo** – Enter code of up to 15-characters that uniquely describes the location of the photo taken in the direction of due east. This field in the PD database will be linked actual digital photo when you enter data into the FIREMON database.

There are many methods for documenting the before and after plot conditions using a series of photos. Rather than describe these procedures in FIREMON, we recommend you use the methods of Hall (2002) for photo point documentation. Hall (2002) has published a guide for establishing and analyzing photo points over time and it is very useful for fire monitoring. You can download Hall's publication at: www.fs.fed.us/pnw/pubs/gtr526/. We have provided fields for two photo points per FIREMON plot. We strongly recommend a comprehensive photo-documentation of the plot conditions. These two additional photo fields will provide you with the opportunity to record important changes on the FIREMON plot.

Enter an identifier in Fields 77 and 78 for the first and second photo points, respectively. The file names in these fields will be linked to the plot photos when you enter your data into the FIREMON database.

**Field 77: Photo Point 1 -** Enter a code of up to 15-characters that uniquely describes the first photo taken at a point in or near this FIREMON plot. This field in the PD database will be linked actual digital photo when you enter data into the FIREMON database.

**Field 78: Photo Point 2 -** Enter a code of up to 15-characters that uniquely describes the first photo taken at a point in or near this FIREMON plot. This field in the PD database will be linked actual digital photo when you enter data into the FIREMON database.

## Comments Fields

It is impossible for any standardized sampling methodology to estimate all ecosystem characteristics that are important to fire effects monitoring. There may be attributes that are locally important but of limited value in a nationwide fire effects sampling system like FIREMON. A sampling method design that accounts for all ecological variables across the North America would be so large and complex it would be difficult to use and apply. We have tried to reduce complexity in FIREMON, but as a result, we probably missed some variables that describe important ecological conditions for your region. The Comments Fields allows locally important observations to be included into standardized and non-standardized fields.

### *Local Codes*

We included some unstandardized fields so that plot level ecological data that does not fit in any standardized field, can be recorded for later use. For example, you will notice that there is no PD field for structural stage, which is an important vegetation attribute for many land management applications. We omitted structural stage because there are many unstandardized classifications of structural stage across the country that are only applicable for local conditions and for a limited number of management objectives. However, some FIREMON users may have developed structural stage classes that they want to use and the Local Code and Comments fields allow them a place to store and document that information.

**Field 79: Local 1 -** Enter a user designed code that is up to 10 characters in length, and uniquely describes some condition on the FIREMON plot. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Comments field.

**Field 80: Local 2 -** Enter a user designed code that is up to 10 characters in length, and uniquely describes some condition on the FIREMON plot. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Comments field.

*Comments*

The Comments field is provided so that the field crew can record any information associated with the macroplot that cannot be recorded elsewhere on the PD form. For example, you can record ecological conditions on the plot, directions for plot location, sampling conditions that might affect data quality and/or other attributes important for management objectives.

It is important that field samplers accurately describe ecological characteristics on the FIREMON plot so that these can be integrated into the monitoring analysis. Important ecological attributes include: wildlife utilization (browsing, grazing), human use (clearcutting, logging, mining), fire characteristics (abnormalities, burn coverage), topographic characteristics (seeps, swales) and/or disturbance (insects, disease, etc).

The notetaker should provide detailed notes for relocating the plot for future remeasurements including succinct, short directions such as “proceed 140 degrees azimuth from junction of roads 432 and 543 exactly 200 meters to a blazed 100 cm spruce”. Try to write the directions as though you will be the one relocating these important plots.

It is important that observations of any factor that might affect the quality and integrity of the collected data be recorded. A sampling condition that is often recorded is the weather – “cold, rainy, windy day”, for instance - but many other factors can be entered, such as, “high stand density which precluded accurate measurement of diameter and canopy cover”.

Comments should directly address the purpose of FIREMON sampling. For example, a sampling objective might be an evaluation of coarse woody debris, so a useful comment might be “many large logs consumed by fire; most were rotten”.

**Field 81: Comments**– Enter up to a 256-character comment. Try to use shorthand and abbreviations to reduce space as long as the comments are still understandable. You might try to organize comments in a standard order with appropriate punctuation. For example, you might describe weather first and only use colons to separate the next major category of comments.

## Precision Standards

Use these standards for the PD method.

Table PD-13. Precision guidelines for TD sampling.

| Component | Standard |
|---|---|
| Latitude | ±0.000001 degree |
| Longitude | ±0.000001 degree |
| Northing | ±1 meter |
| Easting | ±1 meter |
| Elevation | ±100 ft/30 m |
| Aspect | ±5 degrees |
| Slope | ±5 percent |
| All cover estimates | ±1 class |
| Stand Height | ±3 ft/1 m |
| Canopy Fuel Base Height | ±1 ft/0.3 m |
| Flame Length | ±0.5 ft/0.2 m |
| Spread rate | ±1 ft/min. or 0.3 m/min. |
| Severity Class | ±1 class |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the PD sampling method can be modified to collect more detailed information or streamlined to collect only the most important tree characteristics. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Alternative PD Sampling Design

The recommended PD sampling design follows the Alternative FIREMON Sampling Strategy where the optimal number of fields are sampled to achieve a strong, but limited field sample. We suggest that besides the **Required** PD field set, you complete all fields in the **Biophysical Setting** field set, the **Vegetation** field set, and the **Comments** field set. This leaves the Fuels and Fire field sets empty. However, completion of both of these field sets would require less than 5 minutes, per plot, even under the worst conditions. So, it probably would be prudent to complete all PD fields, even if you are working under the Alternative FIREMON Sampling Strategy.

### Simple PD Sampling Design

The streamlined PD sampling design follows the Simple FIREMON sampling strategy where only the minimal set of fields are measured. For the PD method, the minimal set of fields are simply those in the **Required** field set. No other fields need be completed. However, completion of the **Comments** and the two plot pictures would add great detail to the simple structure.

### Detailed PD Sampling Design

The comprehensive PD sampling design follows the Detailed FIREMON sampling strategy and is quite easy to implement. Simply complete all fields in the PD Plot Form and leave none blank.

### User-specific PD Sampling Design

There are three ways to create user-designed fields for describing local ecological conditions. The two local fields in the Comments field set each allow up to a 10-character code in the database. This means the user can design a complex code to describe some important ecological characteristic critical to fire management. For example, the presence of weeds may be a significant management concern, so these fields might describe the cover and species, respectively, of the dominant weed.

Creative approaches can be used to enter local data if more than two fields are needed. Using the weed example, the cover and weed species can be integrated in one field by making the first six characters the local species code and the next two characters the FIREMON cover code. A third attribute, say plant height, could be added as a 2-character code in the 9-10 character slot.

The 256-character comments field also can contain mixes of locally designed fields. Some people create search engines within a database query that look for certain combinations of special characters and numbers to link to a locally created standard field. For example, the term

$SRF could be entered in the comments field to indicate the dominant fire regime (Stand-Replacement Fire).

**Sampling Hints and Techniques**

Field sampling can become quite complicated, especially when visiting complex ecosystems with many canopy strata and high biodiversity. It can be easy for the field crew to become overwhelmed by all the heterogeneity on the landscape. It is important that the field crew concentrate their evaluation of the PD fields to those ecosystem characteristics inside the FIREMON macroplot.

# Plot Description (PD) Form

Plot Key

RegistrationID: _ _ _ _
ProjectID: _ _ _ _ _ _ _ _ _ _
PlotID: _ _ _
Date: _ _/_ _/_ _ _ _

PD Page _ _ of _ _

| | | | |
|---|---|---|---|
| Organization Codes | Field 1 | Organization Code 1 | |
| | Field 2 | Organization Code 2 | |
| | Field 3 | Organization Code 3 | |
| | Field 4 | Organization Code 4 | |
| Field Information | Field 5 | Examiner | |
| | Field 6 | Units | |
| | Field 7 | Plot Radius or Length (ft/m) | |
| | Field 8 | Plot Width (ft/m) | |
| Sampling Info | Field 9 | Plot Type (M/C) | |
| | Field 10 | Sampling Event (Pn/Rn/IV) | |
| Linking Data | Field 11 | Fire ID | |
| | Field 12 | Metadata ID | |
| Georeferenced Position | Field 13 | Coordinate System (UTM/Lat-Long) | |
| | Field 14 | Latitude | |
| | Field 15 | Longitude | |
| | Field 16 | Northing | |
| | Field 17 | Easting | |
| | Field 18 | Zone | |
| | Field 19 | Datum | |
| | Field 20 | Position Error | |
| | Field 21 | Error Units | |

| | | | |
|---|---|---|---|
| Biophysical Settings | Field 22 | Elevation | |
| | Field 23 | Aspect | |
| | Field 24 | Slope% | |
| | Field 25 | Landform | |
| | Field 26 | Vertical Slope Shape | |
| | Field 27 | Horizontal Slope Shape | |
| Geology and Soils | Field 28 | Primary Surficial Geology | |
| | Field 29 | Secondary Surficial Geology | |
| | Field 30 | Soil Texture | |
| | Field 31 | Erosion Type | |
| | Field 32 | Erosion Severity | |
| Tree Cover | Field 33 | Total Tree Cover | |
| | Field 34 | Seedling Tree Cover | |
| | Field 35 | Sapling Tree Cover | |
| | Field 36 | Pole Tree Cover | |
| | Field 37 | Medium Tree Cover | |
| | Field 38 | Large Tree Cover | |
| | Field 39 | Very Large Tree Cover | |
| Shrub Cover | Field 40 | Total Shrub Cover | |
| | Field 41 | Low Shrub Cover | |
| | Field 42 | Medium Shrub Cover | |
| | Field 43 | Tall Shrub Cover | |
| Herbaceous Cover | Field 44 | Graminoid Cover | |
| | Field 45 | Forb Cover | |
| | Field 46 | Fern Cover | |
| | Field 47 | Moss & Lichen Cover | |

| | | | |
|---|---|---|---|
| Composition | Field 48 | Upper Dominant Species 1 | |
| | Field 49 | Upper Dominant Species 2 | |
| | Field 50 | Mid Dominant Species 1 | |
| | Field 51 | Mid Dominant Species 2 | |
| | Field 52 | Lower Dominant Species 1 | |
| | Field 53 | Lower Dominant Species 2 | |
| Potential Veg. | Field 54 | Potential Veg. Type ID | |
| | Field 55 | Potential Lifeform | |
| Ground Cover | Field 56 | Bare Soil Cover | |
| | Field 57 | Gravel Ground Cover | |
| | Field 58 | Rock Ground Cover | |
| | Field 59 | Litter & Duff Ground Cover | |
| | Field 60 | Wood Ground Cover | |
| | Field 61 | Moss & Lichen Cover | |
| | Field 62 | Charred Ground Cover | |
| | Field 63 | Ash Ground Cover | |
| | Field 64 | Basal Vegetation Ground Cover | |
| | Field 65 | Water Ground Cover | |
| General Fuel Characteristics | Field 66 | Surface Fuel Model | |
| | Field 67 | Fuel Photo Series ID | |
| | Field 68 | Stand Height (ft/m) | |
| | Field 69 | Canopy Fuel Base Ht (ft/m) | |
| | Field 70 | Canopy Cover | |

| | | | |
|---|---|---|---|
| Fire Behavior | Field 71 | Flame Length (ft/m) | |
| | Field 72 | Spread Rate (ft,m/min) | |
| | Field 73 | Fire Behavior Picture | |
| F/E | Field 74 | Fire Severity Code | |
| Photo Documentation | Field 75 | North Digital Photo | |
| | Field 76 | East Digital Photo | |
| | Field 77 | Photo Point 1 | |
| | Field 78 | Photo Point 2 | |
| Comments | Field 79 | Local Code 2 | |
| | Field 80 | Local Code 1 | |
| | Field 81 | Comments | |

# FIREMON
# PLOT DESCRIPTION (PD) FIELD DESCRIPTIONS

**Required PD Fields – Database key**

**Registration Code**. The Registration Code is a 4-character code determined by you or assigned to you. All four characters must be used.

**Project Code**. The Project Code is an 8-charcter code used to identify project work that is done within the group. You are not required to use all eight characters.

**Plot Number**. Identifier that corresponds to the site where sampling methods are applied. Integer value.

**Sampling Date**. 8-digit number in the MM/DD/YYYY format where MM is the month number, DD is the day of the month and YYYY is the current year.

**Organization Codes**

Field 1: **Organization Code 1**. 4-character field used to identify part of the agency location code.

Field 2: **Organization Code 2**. 2-character field used to identify part of the agency location code.

Field 3: **Organization Code 3**. 2-character field used to identify part of the agency location code.

Field 4: **Organization Code 4**. 2-character field used to identify part of the agency location code.

**Plot Information Fields**

Field 5: **Examiner Name**. 8-character field used to identify the crew boss or lead examiner.

Field 6: **Units**. (E/M). Units of measure use on the plot – English or Metric.

Field 7: **Plot Radius**. (ft/m). Radius of the macroplot. If the macroplot is rectangular, plot length.

Field 8: **Plot Width**. (ft/m). Width of the plot if it is rectangular. Enter 0 (zero) or blank if the plot is circular.

*Sampling information*

Field 9: **Plot Type**. (M/C). Plot type - Monitoring or Control.

Field 10: **Sampling Event**. (P*n*/R*n*/IV). Treatment relative sampling identification. Valid codes are in table PD-2 of the sampling method.

*Linking Fields*

Field 11: **Fire ID**. Fire ID of up to 15 characters. The ID number or name that relates the fire that burned this plot to the same fire described in the Fire Behavior (FB) table.

Field 12: **Metadata ID**. Metadata ID of up to 15-characters that links the plot data to the MD table.

*Georeferenced Plot Positions*

Field 13: **Coordinate System**. Identifies whether lat-long or UTM coordinates were used. This field is automatically filled based on the data entered in Fields 14 to 21. The user does not see this field.

Field 14: **Latitude**. Latitude. Precision: ±0.000001 decimal degree.

Field 15: **Longitude**. Longitude. Precision: ±0.000001 decimal degree.

Field 16: **Northing**. UTM northing. Precision: ±1 m.

Field 17: **Easting**. UTM easting. Precision: ±1 m.

Field 18: **Datum**. Datum used in conjunction with the UTM coordinates.

Field 19: **Position Error**. Position error value provided by the GPS unit.

Field 20: **Error Units** (E/M). Enter the units associated with the GPS error. May be different than the units listed in Field 6.

Field 21: **Zone**. UTM zone of the plot center.

**Biophysical Setting Fields**
*Topography*

Field 22: **Elevation** (ft/m). Plot elevation. Precision: ±100 ft/30 m.

Field 23: **Plot Aspect** (degrees). Aspect measured in degrees true north. Precision: ±5 degrees.

Field 24: **Slope**. (percent). Average plot slope. Precision: ±5 percent.

Field 25: **Landform**. 4-letter landform code. Valid codes are in table PD-3 of the sampling method.

Field 26: **Vertical Slope Shape**. 2-letter slope shape code. Valid codes are in table PD-4 of the sampling method.

Field 27: **Horizontal Slope Shape**. 2-letter slope shape code. Valid codes are in table PD-4 of the sampling method.

*Geology and Soils Fields*

Field 28: **Primary Surfical Geology**. 4-letter code describing the geological rock type composing the parent material. Valid codes are in table PD-5 of the sampling method.

Field 29: **Secondary Surficial Geology**. 4-letter code describing the secondary geological rock type composing the parent material. Use this field only if you have coded a primary surficial geology type. Valid codes are in table PD-6 of the sampling method. Table PD-6 is an abridged list of common surficial types. A complete list is included in the Lithology Appendix.

Field 30: **Soil Texture Class**. Up to 4-letter code that describes the soil texture. Valid codes are in table PD-7 of the sampling method.

Field 31: **Erosion Type**. 1-letter code describing the erosion on the plot. Valid codes are in table PD-8 of the sampling method.

Field 32: **Erosion Severity**. 1-number code describing the severity of the soils erosion. Valid codes are in table PD-9 of the sampling method.

**Vegetation Fields**
*Vegetation – Trees*

Field 33: **Total Tree Cover**. Vertically projected canopy cover of all the trees on the macroplot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 34: **Seedling Tree Cover**. Vertically projected canopy cover of all trees that are less than 4.5 feet (1.4 meters) tall. Valid codes are in table PD-10 of the sampling method. Precision: 1 class.

Field 35: **Sapling Tree Cover**. Vertically projected canopy cover of all trees that are greater than 4.5 feet (1.4 meters) tall and less than 5.0 in (13 cm) DBH. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 36: **Pole Tree Cover**. Vertically projected canopy cover of all trees that are greater than 5 in (13 cm) DBH and less than 9 in (23 cm) DBH. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 37: **Medium Tree Cover**. Vertically projected canopy cover of all trees that are greater than 9 in (23 cm) DBH up to 21 in (53 cm) DBH. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 38: **Large Tree Cover**. Vertically projected canopy cover of all trees that are greater than 21 in (53 cm) DBH up to 33 in (83 cm) DBH. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 39: **Very Large Tree Cover**. Vertically projected canopy cover of all trees that are greater than 33 in (83 cm) DBH. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

*Vegetation - Shrubs*

Field 40: **Total Shrub Cover**. Vertically projected canopy cover of all shrubs on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 41: **Low Shrub Cover**. Vertically projected canopy cover of all shrubs that are less than 3 feet (1 meter) tall. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 42: **Medium Shrub Cover**. Vertically projected canopy cover of all shrubs that are greater than 3 feet (1 meter) tall and less than 6.5 feet (2 meters) tall. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 43: **Tall Shrub Cover**. Vertically projected canopy cover of all shrubs that are greater than 6.5 feet (2 meters) tall. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

*Vegetation – Herbaceous*

Field 44: **Gramminoid Cover**. Vertically projected canopy cover of all graminoid species on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 45: **Forb Cover**. Vertically projected canopy cover of all forbs on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 46: **Fern Cover**. Vertically projected canopy cover of all ferns on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 47: **Moss and Lichen Cover**. Vertically projected canopy cover of all mosses and lichens on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

*Vegetation – Composition*

Field 48: **Upper Dominant Species 1**. Either the NRCS plants species code or the local code of the most dominant species in the upper level stratum (greater than 10 feet (3 m) above ground level). Plant code is either the NRCS plant code or locally defined code.

Field 49: **Upper Dominant Species 2**. Either the NRCS plants species code or the local code of the second most dominant species in the upper level stratum (greater than 10 feet (3 m) above ground level). Code is either the NRCS plant code or locally defined code.

Field 50: **Mid Dominant Species 1**. Either the NRCS plants species code or the local code of the most dominant species in the mid level stratum (greater than 3 feet and less than 10 feet (1 to 3 m) above ground level). Code is either the NRCS plant code or locally defined code.

Field 51: **Mid Dominant Species 1**. Either the NRCS plants species code or the local code of the second most dominant species in the mid level stratum (greater than 3 feet and less than 10 feet (1 to 3 m) above ground level). Code is either the NRCS plant code or locally defined code.

Field 52: **Lower Dominant Species**. Either the NRCS plants species code or the local code of the most dominant species in the lowest level stratum (less than 3 feet (1 m) above ground level).

Field 53: **Lower Dominant Species**. Either the NRCS plants species code or the local code of the second most dominant species in the lowest level stratum (less than 3 feet (1 m) above ground level).

*Potential Vegetation*

Field 54: **Potential Vegetation Type ID**. 10-character, unstandardized code used to identify locally determined potential vegetation type.

Field 55: **Potential Lifeform**. 2-letter potential lifeform code. Valid codes are in table PD-11 of the sampling method.

**Ground Cover Fields**
*Ground Cover*

Field 56: **Bare Soil Ground Cover**. Percent ground cover of bare soil. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 57: **Gravel Ground Cover**. Percent ground cover of rock. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 58: **Rock Ground Cover**. Percent ground cover of rock. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 59: **Litter and Duff Ground Cover**. Percent ground cover of all uncharred litter and duff on the soil surface. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 60: **Wood Ground Cover**. Percent ground cover of all uncharred woody material. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 61: **Moss and Lichen Cover**. Percent canopy cover of all mosses and lichens on the plot. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 62: **Charred Ground Cover**. Percent ground cover of all *charred organic* material. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 63: **Ash Ground Cover**. Percent ground cover of all ash material. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 64: **Basal Vegetation Ground Cover**. Percent ground cover of basal vegetation using the codes. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

Field 65: **Water Ground Cover**. Percent ground cover of standing water. Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

*General Fuel Characteristics*

Field 66: **Surface Fire Behavior Fuel Model**. Fire behavior fuel model from the Anderson 1983 publication, Aids for Determining Fuel Models for Estimating Fire Behavior. Or, custom fire behavior fuel model.

Field 67: **Fuel Photo Series ID**. 12-character, unstandardized field to enter a photo guide publication number and photo number that is similar to fuel characteristics seen on the plot.

Field 68: **Stand Height**. (ft/m). Height of the highest stratum that contains at least 10 percent vertically projected canopy cover. Precision: ±3 ft/1 m.

Field 69: **Canopy Fuel Base Height**. (ft/m). Lowest point above the ground at which there is a sufficient amount of canopy fuel to propagate a fire vertically into the canopy. Precision: ±1 ft/0.3 m.

Field 70: **Canopy Cover**. Percent canopy cover of the forest canopy above 6 feet (2 meters). Valid codes are in table PD-10 of the sampling method. Precision: ±1 class.

**The Fire Behavior and Effects Fields**
*Fire Behavior*

Field 71: **Flame Length**. (ft/m). Length of the flames from the center of the combustion zone to the end of the continuous flame. Precision:±0.5 ft/ 0.2 m.

Field 72: **Spread Rate**. (ft/min. or m/min.). Average speed of the fire across the macroplot. Precision: ±1 ft/min. or 0.3 m/min.

Field 73: **Fire Behavior Picture**. Up to a 15-character filename used to identify the location of a digital photo showing the fire behavior on the plot.

*Fire Effects*

Field 74: **Fire Severity Code**. 1-number code describing the fire severity on the plot. Range for 1 (heavily burned) to 5 (unburned). Valid codes are in table PD-11 of the sampling method. Precision: ±1 class.

**Common Fields**

Field 75: **North Digital Photo**. Up to a 15-character filename used to identify the location of a digital photo showing general plot conditions facing north.

Field 76: **East Digital Photo**. Up to a 15-character filename used to identify the location of a digital photo showing general plot conditions facing east.

Field 77: **Photo Point 1**. Up to a 15-character filename used to identify the location of a digital photo for general use.

Field 78: **Photo Point 2**. Up to a 15-character filename used to identify the location of a digital photo for general use.

**Comments Fields**
*Local Codes*

Field 79: **Local 1**. User designed code that is up to 10 characters in length.

Field 80: **Local 2**. User designed code that is up to 10 characters in length.

*Comments*

Field 81: **Comments**. 256-character, unstandardized comment field.

**FIREMON**
**PLOT DESCRIPTION (PD) EQUIPMENT LIST**

Camera with film and flash
Clear plastic ruler (2)
Clinometer (2)
Clipboard
Cloth tape (2)
Compass (2)
Flagging
Geographic Positioning System or GPS receiver
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Logger’s tape (2 plus steel tape refills)
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Previous measurement plot sheets
Field notebook
PD Plot Forms and cheatsheet

**Sampling Event Codes**

| Code | Event |
| --- | --- |
| P*n* | Preburn measurement, sequential sample number. |
| R*n* | Postburn remeasurement of a plot, sequential sample number. |
| C*n* | Control plot measurement, sequential sample number. |
| IV | Inventory plot, not a monitoring plot. |

**Common Landforms**

| Code | Landform |
| --- | --- |
| GMF | Glaciated mountains-foothills |
| UMF | Unglaciated mountains-foothills |
| BRK | Breaklands-river breaks-badlands |
| PLA | Plains-rolling planes-plains w/breaks |
| VAL | Valleys-swales-draws |
| HIL | Hill-low ridges-benches |
| X | Did not assess |

**Vertical and Horizontal Slope Shape.**

| Code | Slope shape |
| --- | --- |
| LI | Linear or planar |
| CC | Depression or concave |
| PA | Patterned |
| CV | Rounded or convex |
| FL | Flat |
| BR | Broken |
| UN | Undulating |
| OO | Other shape |
| X | Did not assess |

**Primary Geologic Codes**

| Primary code | Rock type 1 |
| --- | --- |
| IGEX | Igneous Extrusive |
| IGIN | Igneous Intrusive |
| META | Metamorphic |
| SEDI | Sedimentary |
| UNDI | Undifferentiated |
| X | Did not assess |

**Secondary Geologic Codes**

| Secondary code | Rock type 2 |
|---|---|
| ANDE | Andesite |
| BASA | Basalt |
| LATI | Latite |
| RHYO | Rhyolite |
| SCOR | Scoria |
| TRAC | Trachyte |
| DIOR | Diorite |
| GABB | Gabbro |
| GRAN | Granite |
| QUMO | Quartz Monzonite |
| SYEN | Syenite |
| GNEI | Gneiss |
| PHYL | Phyllite |
| QUAR | Quartzite |
| SCHI | Schist |
| SLAT | Slate |
| ARGI | Argillite |
| CONG | Conglomerate |
| DOLO | Dolomite |
| LIME | Limestone |
| SANS | Sandstone |
| SHAL | Shale |
| SILS | Siltstone |
| TUFA | Tufa |
| MIEXME | Mixed Extrusive and Metamorphic |
| MIEXSE | Mixed Extrusive and Sedimentary |
| MIIG | Mixed Igneous (extrusive & intrusive) |
| MIIGME | Mixed Igneous and Metamorphic |
| MIIGSE | Mixed Igneous and Sedimentary |
| MIINME | Mixed Intrusive and Metamorphic |
| MIINSE | Mixed Intrusive and Sedimentary |
| MIMESE | Mixed Metamorphic and Sedimentary |
| X | Did not assess |

**Soil Types**

| Code | Description | Code | Description |
|---|---|---|---|
| C | Clay | S | Sand |
| CL | Clay loam | SC | Sandy clay |
| COS | Coarse sand | SCL | Sandy clay loam |
| COSL | Coarse sandy loam | SI | Silt |
| FS | Fine sand | SIC | Silty clay |
| FSL | Fine sandy loam | SICL | Silty clay loam |
| L | Loam | SIL | Silt loam |
| LCOS | Loamy coarse sand | SL | Sandy loam |
| LFS | Loamy fine sand | VFS | Very fine sand |
| LS | Loamy sand | VFSL | Very fine sandy loam |
| LVFS | Loamy very fine sand | X | Did not assess |

**Erosion Type Types**

| Code | Erosion type |
|---|---|
| S | Stable, no erosion evident |
| R | Water erosion, rill |
| H | Water erosion, sheet |
| G | Water erosion, gully |
| T | Water erosion, tunnel |
| W | Wind erosion |
| O | Other type of erosion |
| X | Did not assess |

**Erosion Severity Codes**

| Code | Erosion severity |
|---|---|
| 0 | Stable, no erosion is evident. |
| 1 | Low erosion severity; small amounts of material are lost from the plot. On average less than 25 percent of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Throughout most of the area the thickness of the soil surface layer is within the normal range of variability of the uneroded soil. |
| 2 | Moderate erosion severity; moderate amounts of material are lost from the plot. On average between 25 and 75 percent of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Erosion patterns may range from small, uneroded areas to small areas of severely eroded sites. |
| 3 | High erosion severity; Large amounts of material are lost from the plot. On average 75 percent or more of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Material from deeper horizons in the soil profile is visible. |
| 4 | Very high erosion severity; Very large amounts of material are lost from the plot. All of the upper 8 in. (20 cm) of soil surface have been lost across the macroplot. Erosion has removed material from deeper horizons of the soil profile throughout most of the area. |
| -1 | Unable to assess |

**Cover Classes**

| Code | Canopy cover |
|---|---|
| 0 | Zero percent canopy cover |
| 0.5 | >0-1 percent of canopy cover |
| 3 | >1-5 percent canopy cover |
| 10 | >5-15 percent canopy cover |
| 20 | >15-25 percent canopy cover |
| 30 | >25-35 percent canopy cover |
| 40 | >35-45 percent canopy cover |
| 50 | >45-55 percent canopy cover |
| 60 | >55-65 percent canopy cover |
| 70 | >65-75 percent canopy cover |
| 80 | >75-85 percent canopy cover |
| 90 | >85-95 percent canopy cover |
| 98 | >95-100 percent canopy cover |

**Potential Lifeform Codes**

| Code | Potential lifeform |
|---|---|
| AQ | Aquatic -- Lake, pond, bog, river |
| NV | Non-vegetated -- Bare soil, rock, dunes, scree, talus |
| CF | Coniferous upland forest -- Pine, spruce, hemlock |
| CW | Coniferous wetland or riparian forest -- Spruce, larch |
| BF | Broadleaf upland forest -- Oak, beech, birch |
| BW | Broadleaf wetland or riparian forest – Tupelo, cypress |
| SA | Shrub dominated alpine – Willow |
| SU | Shrub dominated upland – Sagebrush, bitterbrush |
| SW | Shrub dominated wetland or riparian -- Willow |
| HA | Herbaceous dominated alpine -- Dryas |
| HU | Herbaceous dominated upland – grasslands, bunchgrass |
| HW | Herbaceous dominated wetland or riparian -- ferns |
| ML | Moss or lichen dominated upland or wetland |
| OT | Other potential vegetation lifeform |
| X | Did not assess |

**Plot Level Fire Severity Codes**

| FIRE SEVERITY CODE | Substrate | Forest Vegetation | Shrubland Vegetation | Grassland Vegetation |
|---|---|---|---|---|
| **Unburned (5)** | Not burned | Not burned | Not burned | Not burned |
| **Scorched (4)** | Litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | Foliage scorched and attached to supporting twigs. | Foliage scorched and attached to supporting twigs. | Foliage scorched |
| **Lightly Burned (3)** | Litter charred to partially consumed; upper duff layer may be charred but the duff is not altered over the entire depth; surface appears black; where litter is sparse charring may extend slightly into soil surface but soil is not visibly altered; woody debris partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned. | Foliage and smaller twigs partially to completely consumed; branched mostly intact. | Foliage and smaller twigs partially to completely consumed; branched mostly intact; typically, less than 60 percent of the shrub canopy is consumed. | Grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable. |
| **Moderately Burned (2)** | Litter mostly to entirely consumed, leaving coarse, light colored ash (ash soon disappears, leaving mineral soil); duff deeply charred, but not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned out stump holes are evident. | Foliage twigs and small stems consumed; some branches still present. | Foliage twigs and small stems consumed; some branches smaller branches (0.25-0.50 in.) still present; typically, 40 to 80 percent of the shrub canopy is consumed. | Unburned grass stubble usually less than two inches tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning. |
| **Heavily burned (1)** | Litter and duff completely consumed, leaving fine white ash (ash disappears leaving mineral soil); mineral soil charred and/or visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. | All plant part consumed, leaving some or no major stems or trunks; any left are deeply charred. | All plant parts consumed leaving only stubs greater than 0.5 in. in diameter. | No unburned grasses above the root crown; for other species, all plant parts consumed. |
| **Not Applicable (0)** | Only inorganic material on site before burn. | None present at time of burn. | None present at time of burn. | None present at time of burn |

**Precision**

| Component | Standard |
|---|---|
| Latitude | ±0.000001 degree |
| Longitude | ±0.000001 degree |
| Northing | ±1 meter |
| Easting | ±1 meter |
| Elevation | ±100 ft/30 m |
| Aspect | ±5 degrees |
| Slope | ±5 percent |
| All cover estimates | ±1 class |
| Stand Height | ±3 ft/1 m |
| Canopy Fuel Base Height | ±1 ft/0.3 m |
| Flame Length | ±0.5 ft/0.2 m |
| Spread rate | ±1 ft/min. or 0.3 m/min. |
| Severity Class | ±1 class |

# Tree Data (TD)
## Sampling Method

EXECUTIVE SUMMARY

The Tree Data (TD) methods are used to sample individual live and dead trees on a fixed-area plot to estimate tree density, size, and age class distributions before and after fire in order to assess tree survival and mortality rates. This method can also be used to sample individual shrubs if they are over 4.5 feet tall. When trees are larger than the user specified breakpoint diameter; diameter at breast height, height, age, growth rate, crown length, insect/disease/abiotic damage, crown scorch height and bole char height, are recorded. Trees less than breakpoint diameter and taller than 4.5 feet are tallied by species-diameter-status class. Trees less than 4.5 feet tall are tallied by species-height-status class and sampled on a subplot within the macroplot. Snag measurements are made on a snag plot that is usually larger than the macroplot. Snag characteristics include species, height, decay class and cause of mortality.

## INTRODUCTION

The Tree Data (TD) methods were designed to measure important characteristics about individual trees so that tree populations can be quantitatively described by various dimensional and structural classes before and after fires. This method uses a fixed area plot sampling approach to sample all trees that are within the boundaries of a circular plot (called a macroplot) and that are above a user-specified diameter at breast height (called the breakpoint diameter) are sampled. All trees or shrubs below the breakpoint diameter are recorded by species-height-status class or species-diameter-status class, depending on tree height. The TD method is appropriate for both inventory and monitoring.

The TD sampling methods were developed using fixed-area sampling procedures that have been establish and accepted by forestry professionals. Field sampling and the data collected are similar to that in ECODATA.

The fixed area plot used to describe tree characteristics in the TD methods is different than the standard timber inventory techniques that use plot-less point sampling implemented with the prism. We use the fixed area technique for many reasons. First, the plotless method was designed to quantify stand characteristics using many point samples across a large area (e.g., stand). This means that the sampling strategy is more concerned with conditions across the stand than within the plot. Second, plot-less sampling was designed for inventorying large, merchantable trees and is not especially useful for describing tree populations - especially within a plot - because the sampling distribution for the plot-less methods under-samples small and medium diameter trees. These small trees are the ones many fire managers are interested in monitoring, for instance in a restoration project. Similarly, canopy fuels are not adequately sampled using plot-less techniques because there is insufficient number of trees in all age classes to obtain realistic vertical fuel loadings and distributions. Finally, there are many ecosystem characteristics recorded at each FIREMON macroplot and the origin and factors that control these characteristics are highly interrelated. For example, shrub cover is often inversely related to tree cover on productive sites. Plot-less sampling does not adequately allow the sampling of tree characteristics that influence other ecosystem characteristics, at the plot level, such as loading and regeneration. The expansion of trees per area estimates from fixed-area plots is much less variable than density estimation made using plot-less methods The contrast between point and fixed area plot sampling is really a matter of scale. Point or prism sampling is an efficient means to get stand-level estimations but it is inadequate for describing tree characteristics within a plot.

Many characteristics are recorded for each tree. First, the species and health status is recorded for each tree. Then, structural characteristics of diameter breast height (DBH), height, live crown percent, and crown position are measured to describe physical dimensions of the trees. Age and growth rate describe life stage and productivity. Insect and disease evidence is recorded in the damage codes. A general description of dead trees is recorded in snag codes. Fire severity is assessed by estimates of down hill bole char height and percent of crown scorched. There is one column to build user-defined codes for each tree, if needed. Each tree above the breakpoint diameter gets a tree tag that permanently identifies it for further measurements.

Besides being used to inventory general tree characteristics on the macroplot, the TD method can be used to determine tree survival or fire-caused tree mortality after a burn and used describe the pre- and post-burn tree population characteristics by species, size, and age classes. Values in many TD fields can be used to compute a host of ecological characteristics of the tree. For example, the tree's DBH, height, and live crown percent can be used to compute stand bulk density for modeling crown fire potential.

There are many ways to streamline the TD procedure. First, the number of measured trees can be lowered by raising the breakpoint diameter. A large breakpoint diameter will exclude the individual measurement of the many small trees on the macroplot. Next, age estimates of individual trees can be simplified by taking age in broad diameter and species classes. Last, the FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific TD Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

The sampling procedure is described in the order of the fields that need to be completed on the TD Data form. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling intensity classes can be used to modify the recommended procedure to match resources, funding, and time constraints.

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

### Preliminary Sampling Design

There is a set of general criteria recorded on the TD Data form that are the basis of the user-specified design of the TD sampling method. Each general TD field must be designed so that the sampling captures the information needed to successfully satisfy the management objective within time, money and personnel constraints. These general fields must be decided before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project.

See **How To Customize Plant Species Codes** if you are not planning on using the NRCS Plant species codes.

*Plot size selection*

There be as many as three nested fixed plots in the FIREMON TD methods. First, the macroplot is the primary sampling plot and it is the plot where all live tree population characteristics are taken. Next is the snag plot, which may be larger than the macroplot and it is used to record a representative sample of snags. Often, the incidence of snags on the landscape is so low that the macroplot area is not large enough to describe snag populations. The snag macroplot is allows more snags to be sampled. Last is the subplot where all seedlings are counted. This is smaller than the macroplot and is provided to streamline the counting of densely packed seedlings. All of the plots are concentrically located around the macroplot center.

*Macroplot area*

The size of the macroplot ultimately dictates the number of trees that will be measured, so large plot sizes usually take longer to finish because of the large number of trees on the plot. However, some ecosystems have widely spaced trees scattered over large areas so that large plot sizes are needed to obtain statistically significant estimates. There have been many studies to determine the optimum plot size for different ecosystems with mixed results. We offer the following table to help determine the plot size that matches the fire monitoring application. Unless the project objectives dictate otherwise, use the median tree diameter and median tree height - for trees greater than breakpoint diameter - to determine the size of your macroplot (table TD-1). Enter the macroplot size for the TD method in Field 1 of the TD Data Form

Table TD-1. Use the median tree diameter and median tree height to determine the size of the sampling macroplot.

| **Median Tree Diameter - trees greater than breakpoint** | **Median Tree Height** | **Suggested Plot Radius** | **Suggested Plot Size** |
|---|---|---|---|
| < 20 in. (<50 cm) | < 100 ft (<30 m) | 37.24 ft (11.28 m) | 0.1 ac (0.04 ha) |
| 20 to 40 in. (<100 cm) | 100 to 130 ft (<40 m) | 52.66 ft (12.61 m) | 0.2 ac (0.05 ha) |
| > 40 in. (<200 cm) | > 130 ft (<50 m) | 74.47 ft (17.84 m) | 0.4 ac (0.1 ha) |

In general, the 0.1 ac (0.04 ha) circular plot will be sufficient for most forest ecosystems and should be used if no other information is available. A general rule-of-thumb is the plot should be big enough to capture at least 20 trees above breakpoint diameter (see definition in next section) on the average across all plots in your project. Though it is not absolutely necessary, extra measures should be taken so that plot sizes are the same for all plots in a project.

*Subplot area*

All seedlings - trees less than 4.5 feet (1.37 meters) tall - are measured on a subplot nested within the macroplot (figure TD-1). Use seedling density to determine the subplot size (table TD-2) unless the project objectives dictate otherwise.

Table TD-2. Use seedling density to determine the subplot radius.

| **Seedling density** | **Subplot radius** | **Area** |
|---|---|---|
| Typical | 11.77 ft (3.57 m) | 0.01 ac (0.004 ha) |
| <2 seedlings per species | 18.62 ft (5.64 m) | 0.025 ac (0.01 ha) |
| >100 seedlings per species | 5.89 ft (1.78 m) | 0.0025 ac (0.001 ha) |

Again, make an effort to keep the subplot radius constant across all plots in the FIREMON project. Subplot sampling is discussed in later sections of this document. The area of the subplot is entered in Field 2 on the TD Data Form.

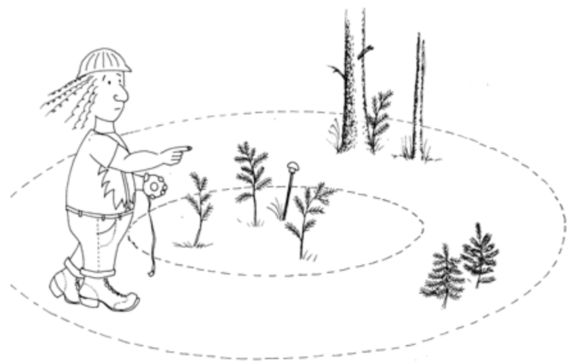

Figure TD-1. The subplot is nested inside the macroplot. The recommended circular plot shape is shown but rectangular plots may also be used.

*Snag plot area*

Snags are dead trees greater than breakpoint diameter. Snags can be measured within the macroplot, but often their numbers are so low that a larger plot is needed to detect changes in snag populations. A suitable snag plot size is difficult to determine because snags are non-uniformly distributed across the landscape. A good rule of thumb for sizing the snag plot is to double the macroplot diameter, which will increase the snag plot area by a factor of four. Enter the snag plot area in Field 3 of the TD form even if it is the same size as the macroplot. If snags are important to the project objectives you should chose a plot radius that will provide you with at least 20 snags, meaning the plot could be quite large.

*Breakpoint diameter*

Choose a breakpoint diameter that allows at least 20 trees to be measured on each FIREMON macroplot. (figure TD-2). The same breakpoint diameter should be used for all of the macroplots in the study.

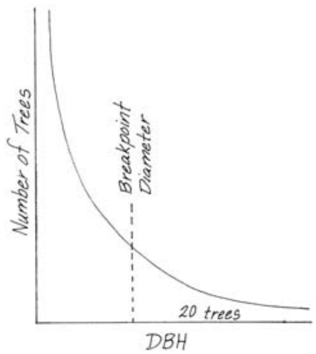


Figure TD-2. Choose a breakpoint diameter that leaves at least 20 trees in the tail of the distribution. The diameter distribution can be derived from a pilot study or estimated from previous experience.

The breakpoint diameter is the tree diameter at breast height (DBH) above which all trees are tagged and measured individually and below which trees are tallied to species-DBH classes. Selection of the breakpoint diameter must account for fire monitoring objectives as well as sampling limitations and efficiency. For example, a large breakpoint diameter (>8 in.) will exclude many small trees from individual measurements and reduce the sampling time. As long as the project objectives are very broad (e.g. 70 to 80 percent mortality of saplings) then a tally of trees below breakpoint will be sufficient. However, if the objectives are specific (determine the effect of crown scorch and char height on fire caused mortality of trees 2 in. and greater DBH) then a lower breakpoint diameter, and the associated increase in sampling effort, will be necessary. Individual measurement of small trees might be unrealistic if there are high sapling densities (>1,000 trees) on the macroplot. Selection of an appropriate breakpoint diameter requires some field experience and knowledge of the resources available to complete the fire monitoring project. In FIREMON we suggest using a 4-inch (10 cm) breakpoint diameter if no other information is available. The breakpoint diameter is entered in Field 4 of the TD Data Form.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

## Preliminary Sampling Tasks

Before setting out for your field sampling layout a practice macroplot and subplot in an area with easy access. Even if there are just a few trees on your practice plot, getting familiar with the plot layout and the data that will be collected before heading out will make the first day or two of field sampling less frustrating. It will also let you see if there are any pieces of equipment that will need to be ordered.

When you are ready to go into the field, consult the TD Equipment list and gather the necessary materials. Since you will probably be spending most of your day hiking from plot to plot it is important that supplies and equipment are placed in a comfortable daypack or backpack. Also, be sure that you pack spares of each piece of equipment so that an entire day of sampling is not lost if something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All TD Data Forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

If the sampling project is to remeasure previously installed FIREMON plots, then it is highly recommended that plot sheets from the first measurement be copied and brought to the field for reference. These data can be extremely valuable for help in identifying sample trees that have lost their tree tags or have fallen over and can provide an excellent reference for verifying data measurements.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future re-measurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook. For example, snow on the plot might be described in the notebook, which would be very helpful in plot re-measurement.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Locations and/or directions to the plots you will be sampling should be readily in order to reduce travel times. If the FIREMON plots were randomly located within the sampling unit it is critical that the crew is provided plot coordinates before going into the field. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. It is easy to mis-record latitude and longitude coordinates and marked maps can help identify any erroneous plot positions.

A field crew of three people is probably the most efficient for implementation of the TD sampling method. For safety reasons there should never be a one-person crew. A crew of two people will require excessive and walking and trampling on the plot. Any more than three people will probably result in some people waiting for critical tasks to be done and unnecessary physical damage to the plot. For simplicity, we will refer to the people in the three-person crew as the crew boss, a note taker, and a technician. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The note taker is responsible for recording the data on plot forms or onto the laptop. The technician will perform most individual tree measurements while the note taker estimates tree heights. Of course, the crew boss can be the note taker, and probably should be for most situations. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency. Sampling tasks should be modified as the field crew gains experience and tasks should also be shared to limit monotony.

## Sampling Tasks

*Define macroplot boundary*

The first task to be completed is to define the boundary of the TD sampling plot. The TD macroplot should be established so that the sampling plots for tall of the methods overlap as much as possible. See **How To Establish Plots with Multiple Methods**.

If you are sampling using only the TD methods, it is not so important that flags are placed exactly at the fixed distance; rather, it is more important that the trees inside the macroplot are clearly identified for sampling. This means that borderline trees (questionable trees on the boundaries of the plot) be flagged so that the tree sampler knows if the tree is inside or outside the macroplot. This is done by tying the flag on a branch on the outside of the tree (away from plot center) if the tree is inside the macroplot, or tying the flag on a branch that faces toward plot center if the tree is outside the boundaries. Avoid tying flagging to tree boles as it can lead to some confusion about whether trees are "in" or "out". If you must flag around a bole, point the knot toward plot center if the tree is "out" or point the knot away from plot center if the tree is "in". See **How To Define the Boundaries of a Macroplot** for more information. With either method you will need to adjust for slope as you go around the plot (see **How to Adjust for Slope**).

The snag and subplot boundaries probably don't need the extensive marking and flagging as required for the macroplot. For the snag plot, we suggest fixing a cloth or fiberglass tape to the macroplot center and proceeding out to the distance of the Snag Plot Radius. We suggest a cloth or fiberglass tape because your diameter tape will probably not be long enough. Leave the tape pulled out and start traversing the snag plot to search for snags. You will be able to determine whether most of the snags you find are "in" or "out" just by looking however, you will have to use the tape to measure snags that are on the border. If you have a second cloth or fiberglass tape this task will go quicker. You probably won't need to flag the seedling subplot because it is so small. Seedling sampling is described in detail below.

*Define initial sample position*

Once the macroplot has been defined and all perimeter flags have been hung, flag the tree inside the macroplot, furthest from plot center and greater than breakpoint diameter, that is closest to due north (360 degrees azimuth) from plot center. Mark it near the base so that flagging won't be confused with the plot boundary marking. This tree will be the first tree measured and will also indicate when the sampling has been completed. If tree density is high then you may want to flag the closest tree to the left of your "first" tree as the "last" tree (you will be sampling clockwise around the plot). Tie a flag at the base of the tree(s) so that it will not be confused with plot boundary trees. You may even want to use another flag color, or you may want to use tree chalk instead of a flag (figure TD-3).

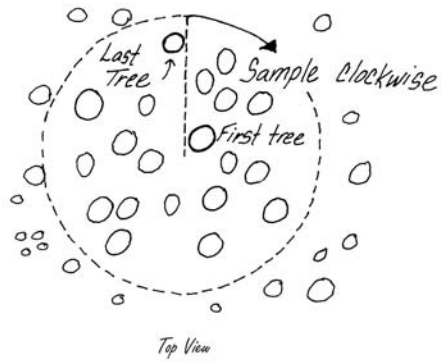


Figure TD-3. Sample trees clockwise around the plot starting with the first tree located clockwise from an azimuth of 360 degrees true north.

*Sampling seedlings*

In FIREMON we call trees less than 4.5 feet (1.37 meters) tall seedlings. Seedlings are sampled using a small subplot within the larger macroplot. This is done because seedlings are more numerous than larger trees so they can be sampled on a smaller area and still allow a representative sample. Trying to sample seedlings on the entire macroplot would be inefficient and time-consuming. Subplot sampling is done before individual tree measurements because repeated walking around the macroplot center by field crews may trample some seedlings and bias the tree sample.

To start your seedling counts attach the zero end of a logger's tape at plot center and walk away headed due north until you are at the distance (corrected for slope) you selected for you subplot radius from table TD-2. Once at the required distance, hold the tape just above the seedlings, then sweep clockwise around the plot, tallying seedlings by species into their respective status and height classes as you go. Use the following status classes:

**H** –**Healthy** tree with very little biotic or abiotic damage.
**U** – **Unhealthy** tree with some biotic or abiotic damage, and this damage will reduce growth. However, it appears the tree will not immediately die from the damage.
**S** – **Sick** tree with extensive biotic or abiotic damage and this damage will ultimately cause death within the next 5 to 10 years.
**D** – **Dead** tree or snag with no living tissue visible.

The height classes in table TD-3 are suggested but you can use any classes you choose. The Analysis Tools program assumes that the height class value recorded is the midpoint of the class. Make sure you note any size class changes in the Metadata table. Estimating height using a stick marked with the height classes will make counting quicker and easier.

Table TD-3. Size classes for seedlings.

| Midpoint Height Class (ft) | | Midpoint Height Class (m) | |
|---|---|---|---|
| Class | Height Range | Class | Height Range |
| 0.2 | >0.0 – 0.5 | 0.1 | >0.0 – 0.2 |
| 1 | >0.5 – 1.5 | 0.3 | >0.2 – 0.5 |
| 2 | >1.5 – 2.5 | 0.6 | >0.5 – 0.8 |
| 3 | >2.5 – 3.5 | 0.9 | >0.8 – 1.0 |
| 4 | >3.5 – 4.5 | 1.2 | >1.0 – 1.4 |

We recommend that you sample seedlings using two crew members, with one person tallying all of the seedlings on inner part of the plot and the other person counting all the seedlings on the outer part. Also, this way, when the tape encounters a tree as it is swept clockwise the sampler closest to the plot center can keep track of which seedlings have been counted so that the sampler holding the tape can move around the obstructing tree and return the tape to the proper point before the tally is resumed. Be sure to carefully search the subplot for all seedlings, no matter how small. Use the dot tally method for seedlings (figure TD-4) and when you have finished enter the counts in Seedlings table of the TD Data Form by mid-point class (Fields 31 to 34).

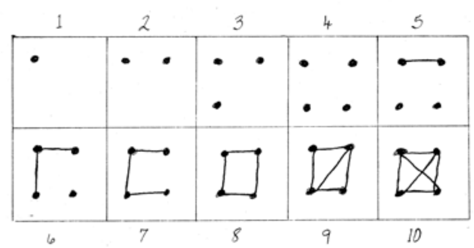


Figure TD-4. Use the dot tally method to make counts quickly with little chance of error.

Sampling seedlings by height class allows a compromise between sampling efficiency and the detail required for describing fire effects.

If a tree is broken below 4.5 feet (1.37 m) but you believe that the tree would be taller than 4.5 feet if unbroken you should still sample it as a seedling.

*Saplings and mature trees*

In FIREMON we divide trees taller than breast height (4.5 ft) into two groups: saplings and mature trees. Both groups are measured on the macroplot. Saplings are trees taller than 4.5 feet (1.37 m) but smaller than the breakpoint diameter and mature trees are greater than breakpoint diameter. Trees above the breakpoint diameter are tagged, measured and recorded in Table 1 of the TD Data Form. Trees below the breakpoint diameter, but taller than 4.5 feet (1.37 m), are measured and tallied in Table 2 of the TD Data Form. It is most efficient if both sampling tasks are done at the same time as the sampling proceeds around the macroplot because, especially in dense stands, it will be difficult determining which trees have been measured.

As with seedlings, sample saplings and mature trees in a clockwise direction starting with your "first" tree. The best way to do a repeatable sample is to measure trees in the order that a second hand would hit them as it moved around the plot (figure TD-5). Sometimes this method means that you travel back and forth between the middle and outer portions of the plot and this may seem inefficient but the benefit is that you will be able to relocate trees easier at a later date if something happens to the trees or the tree tags. For example, if tagged trees are blown down by heavy winds or knocked down by other falling trees you will be able to account for their mortality by locating them, in order, around the plot.

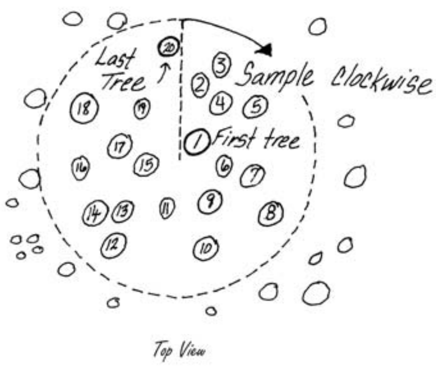


Figure TD-5. Sample trees by measuring the tree you flagged due north of the plot center, first, then move in a clockwise direction. It is easiest to sample all trees above DBH at the same time.

Once a tree is identified for measurement, the sampler must decide if it is above or below the breakpoint diameter. Usually you will be able to do this visually but use a ruler or diameter tape if the tree is borderline. We have found that it is usually less time consuming to initially estimate DBH using a clear plastic ruler rather than with a diameter tape (see **How To Measure Diameter with a Ruler**). However, if the ruler estimate is within 1 inch (2 cm) of breakpoint diameter, we recommend using a diameter tape because the diameter measurement will be more reliable.

*Measuring DBH*

The diameter of a tree or shrub is conventionally measured at exactly 4.5 feet (1.37 meters) above the ground surface, measured on the uphill side of the tree if it is on a slope. Wrap a diameter tape around the bole or stem of the plant, without twists or bends, and without dead or live branches caught between the tape and the stem (figure HT-6). Pull the tape tight and record the diameter. If you are only determining the diameter class then the measurement only needs to identify the class that the tree is in. If you are measuring the diameter of a mature tree then measure to the nearest 0.10 inch (0.5 cm). Large diameter trees are difficult to measure while standing at one point, so you have to hook the zero end of the tape to the plant bole (bark) and then walk around the tree, being sure to keep the tape exactly perpendicular to the tree stem and all foreign objects from under the tape. See **How To Measure DBH** for more information.

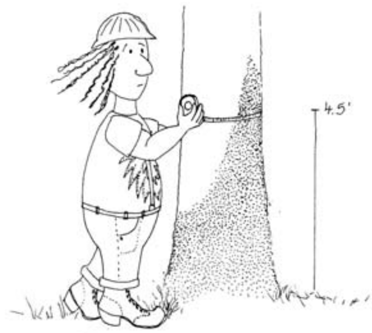


Figure TD-6. DBH Measurement. The diameter tape should carefully be pulled tight around the tree without twists or bends.

Forked trees should be noted in the damage codes discussed in later sections. Forked trees often occur in tall shrublands or woodlands (e.g. pinyon juniper) where trees are clumped due to bird caches or morphological characteristics. Many tree-based sampling techniques suggest that diameter be measured at the base rather than at breast height, but we feel this may bias an estimate of tree mortality by not counting survival of individual stems. Moreover, basal diameters may not adequately portray canopy fuels for fire modeling.

Trees are "live" if they have any green foliage on them regardless of the angle at which they are leaning. If a tree has been tipped or is deformed by snow make all the measurements but use the damage codes described below to record the nature of the damage.

*Sampling saplings*

Saplings are recorded in species-diameter-status class groups rather than as individuals. As mentioned above we suggest using a 4-inch (10-cm) breakpoint diameter. Tally trees by the diameter classes in Table TD-4. The Analysis Tools program assumes that the diameter class value you record is the midpoint of the class. Make sure you note any size class changes in the Metadata table.

Table TD-4. Diameter classes for saplings.

| Midpoint Diameter Class (in.) | | Midpoint Diameter Class (cm) | |
|---|---|---|---|
| Class | Diameter Range | Class | Diameter Range |
| 0.5 | >0 - 1 | 1.2 | >0 - 2.5 |
| 1.5 | >1 - 2 | 3.8 | >2.5 - 5 |
| 2.5 | >2 - 3 | 6.2 | >5 - 7.5 |
| 3.5 | >3 - 4 | 8.8 | >7.5 - 10 |

Note that no age or growth characteristics are recorded for trees below breakpoint diameter. The only fire severity attribute assessed from these data is tree mortality by species-diameter class.

Once a tree is determined to be below the breakpoint diameter the sampler must 1) estimate diameter to the appropriate diameter class, 2) determine the species of the tree, 3) identify the tree status, and 4) estimate height to nearest 1 foot (0.3 meter). Tree diameter is most easily estimated using a clear plastic ruler (see **How To Measure Diameter with a Ruler)**. A diameter tape can be used but it is often cumbersome when diameters are less than 4 inches (10 cm). Once the diameter class, species, status, counts and average heights have been determined, record them in Fields 24 to 28, respectively. Optionally, average live crown percent can be recorded in Field 29 using the classes in table TD-5. Record the class based on the percent of the tree that has live foliage growing from it, from the top of the live foliage to the ground.

Height and live crown percent are challenging to estimate because their values must represent all trees within the species-diameter-status class combination. The best way to do this is to look at the first tree, assign it to a species-diameter-status class, visually estimate height to the nearest 1 foot (0.5 meter), estimate live crown percent class and record the estimates in the Saplings table of the TD Data Form. As more trees in the same species-diameter-status class are found, the note taker must adjust the average height and average crown ratio of the class. Methods for measuring height and live crown percent are discussed in detail in Measuring Structural Characteristics in the next section.

*Sampling mature trees*

Mature trees are those with a diameter at breast height that is greater than or equal to the breakpoint diameter.

Tagging the trees -- If you are doing a monitoring project you should tag all of the mature trees on your macroplot so that they can be identified in the future. (If you are simply doing an inventory they do not need to be tagged). There are two methods for tagging the sample trees depending on whether you are using steel or aluminum tags. The tag number is recorded in Field 5 on the TD Plot Form.

We suggest using steel casket tags because they will not melt during the heat of the fire. Nail the casket tags to the tree using high-grade nails that also won’t melt during fires. Each tag should be tightly nailed to the tree bole with just enough pressure to prevent it from moving, but not so tight that the tag is driven into the bark. If the tag is allowed to move or twirl in the wind, the movement might wear through the nail and the tag could fall off. Nail the tags at breast height with the tag facing toward plot center. This is done so that each tree can be identified while standing in one place and will make relocating the plot center easier. It will also reduce macroplot travel, which can cause compaction and seedling trampling. If the trees are going to be cut, nail the tag less than one foot from the ground, facing plot center. This will leave the tags available for post treatment sampling and will keep them out of the sawyer’s way if the trees are cut with a chainsaw.

Unfortunately, casket tags are expensive and the steel tags and nails can damage saws so they should not be used if the trees you are tagging will eventually be harvested. As an alternative to steel tags, nail aluminum tags at DBH on the downhill side of all the mature trees using aluminum nails. Putting tags on the downhill side of the trees will help keep them out of the hottest part of the flame and help keep the tags and nails from melting. Pound the nails in at a downward angle, until the tags are tight but not driven into the bark. Typically, some of the tags will be melted by the fire but by using tree characteristics (species and DBH, primarily) and the clockwise sampling scheme you should be able to relocate all the mature trees. Occasionally, the head of the nail will melt off and the wind will blow the tag off the angled nail, so you may be able to find the tag lying at the base of the tree.

Although it is not recommended, sometimes it may be necessary to remove some branches with a hatchet or bow saw so that the tag can be firmly attached to the tree. If needed, remove just the problem branches. Removing too many branches may influence the tree's health and/or modify the fuelbed around the tree.

Measuring General Attributes -- Record the general characteristics of the tree (species and health) in the next set of fields. These characteristics allow the stratification of results and provide some input values needed to compute crown biomass and potential tree mortality.

Enter the species of the tagged tree in Field 6 and the tree status in Field 7 of the TD Data Form. Tree status describes the general health of the tree. Use the following tree status codes:

**H** –**Healthy** tree with very little biotic or abiotic damage.
**U** – **Unhealthy** tree with some biotic or abiotic damage, and this damage will reduce growth. However, it appears the tree will not immediately die from the damage.
**S** – **Sick** tree with extensive biotic or abiotic damage and this damage will ultimately cause death within the next 5 to 10 years.
**D** – **Dead** tree or snag with no living tissue visible.

Tree status is purely a qualitative measure of tree health but it does provide an adequate characteristic for stratification of pre-burn tree health and for determining post-burn survival. Remember that trees marked as dead (code D) indicate the tree was sampled on the snag plot.

Measuring Structural Characteristics -- Five important structural characteristics are measured for each mature tree: DBH, height, live crown percent, crown fuel base height and crown class. These structural characteristics are used to assess a number of fire-related properties such as canopy bulk density, vertical fuel ladders, height to the base of the canopy, and potential fire-caused mortality. These characteristics can also be used to compute the input parameters needed by the fire growth model FARSITE (Finney 1998) and FOFEM (Reinhardt and others 1998).

Tree DBH is measured using a diameter or logger's tape. Be sure to measure DBH on the uphill side of the tree with the diameter tape perpendicular to the tree stem and directly against the bark. Measure DBH to nearest 0.1 inch (0.2 cm) and record in Field 8 on TD Data Form. (See **How To Measure DBH**).

Measure tree height from the ground level to the top of the bole or highest living foliage, whichever is higher, to the nearest 1 foot (0.5 meter) and enter the height in Field 9 of TD Data

Form. Tree height is commonly measured with a clinometer, but it can be measured with laser technology or other surveying techniques (i.e. transit) if that equipment is available and the crew has had adequate training in using that technology (see **How to Measure Plant Heigh**t).

Live crown ratio (LCR) is the percent of the tree bole that is supporting live crown based on the distance from the ground level to the top of the live foliage – not to the top of the bole. The LCR assessment is used as an indication of tree vigor and crown material for tree growth (e.g. in the Forest Vegetation Simulator). The illustrations in figure TD-7 show four trees with different crown characteristics. Tree A has a crown that, hopefully, will be the most common crown form you will see. Tree B is missing live foliage from the upper part of the crown (the area may be filled with dead branches and needles) and tree C is missing foliage along one side of the stem. Estimate LCR by visually redistributing the live tree crown evenly around the tree so the branches are spaced at about the same branch density as seen along the bole and form the typical conical crown. In the instance of recent abiotic or biotic damage use the Damage and Severity Codes described below to improve the crown fuel estimates. Record LCR in Field 10 on TD Data Form using the classes in table TD-5.

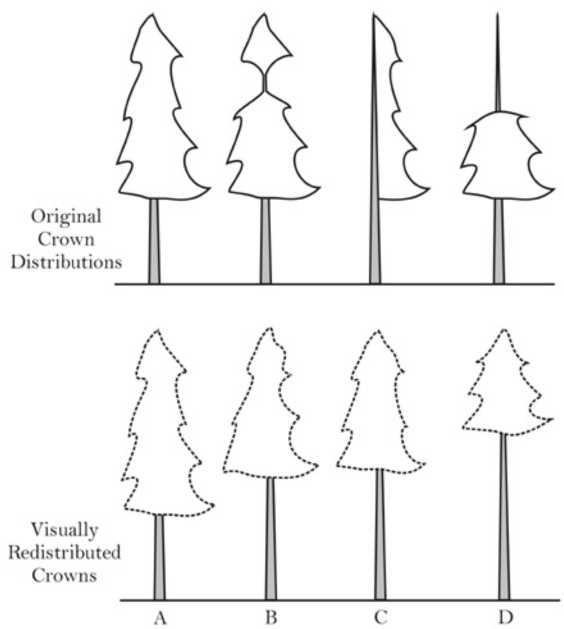


Figure TD-7. To estimate LCP visually rearrange the tree branches so that they are distributed evenly around the tree bole then estimate the percent length of the total tree stem that those branches would occupy. In this illustration the LCP class of trees A, B, C, and D are 70, 50, 50 and 30, respectively.

Table TD-5. Use these classes to record live crown percent and crown scorch.

| Code | Live crown percent |
|---|---|
| 0 | Zero percent |
| 0.5 | >0-1 percent |
| 3 | >1-5 percent |
| 10 | >5-15 percent |
| 20 | >15-25 percent |
| 30 | >25-35 percent |
| 40 | >35-45 percent |
| 50 | >45-55 percent |
| 60 | >55-65 percent |
| 70 | >65-75 percent |
| 80 | >75-85 percent |
| 90 | >85-95 percent |
| 98 | >95-100 percent |

Sometimes, you'll see a lone live branch at the bottom of the crown that doesn't appear as part of the crown, and in these cases you can ignore the branch's contribution to LCP.

Crown Fuel Base Height (CFBH) is important for assessing the risk of crown fire. In Field 11 record either the height of the dead material that is sufficient to carry a fire from the lower to the upper part of the tree crown or, if the dead fuel is insufficient, the height of the lowest live foliage. The dead material may include dead branches associated with mistletoe infection, lichens, dead needles, etc. This is probably the most subjective field of the TD assessment. We suggest that this information should not be collected unless there is a knowledgeable crew member available that can consistently estimate CFBH. He or she should also record in the Metadata table the characteristics used for their assessment so that it can be made the same way in future sampling.

Optionally, users can record height to live crown (i.e. ignore the dead component) to limit some subjectivity. Height to live crown is defined as the height of the lowest branch whorl that has branching in two quadrants – excluding epicormic branches and whorls not part of the main crown - measured from the ground line on the uphill side of the tree. If you decide to estimate height to live crown instead of CFBH be sure to note that in the Metadata information.

Crown classes (Field 12) represent the position in the canopy of the crown of the tree in question and describe how much light is available to the crown of that tree (figure TD-8).

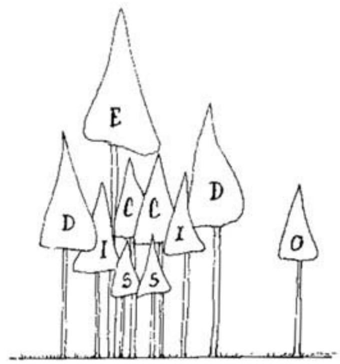


Figure TD-8. Use this illustration of crown classes to help you describe the crown class of the tree you are measuring

There are six categories describing crown class:

**O – Open grown,** the tree is not taller than other trees in the stand but still receives light from all directions.
**E – Emergent**, the crown is totally above the canopy of the stand
**D – Dominant**, the crown receives light from at least three to four directions
**C – Codominant**, the crown receives light from at least one to two directions
**I – Intermediate**, the crown only receives light from the top
**S – Suppressed**, the crown is entirely shaded and underneath the stand canopy

Crown class may be used for data report stratification, but it is also an important variable in the computation of tree biomass and leaf area.

Measuring Tree Age Characteristics -- Age characteristics allow better interpretation of the fire monitoring data by identifying important age and growth classes and using them for results stratification. In addition, growth data allows direct comparison of the change in growth rate as a result of the fire.

Tree age is estimated by extracting a core from the tree at stump height (i.e., about 1 foot above ground-line) on the downhill side of the tree using an increment borer. Rings on the increment core can be counted in the field or counted later in the office.

Coring trees to determine tree age is a time-consuming procedure that often requires over 50 percent of the sampling time. There are many reasons for this. First, there is a lot of time and effort involved in coring the tree, especially large trees, and often you will need to take more than one core per tree in order to get a usable core because of rot or because you missed the pith. Next, it is difficult to get comfortable when drilling at stump height because the sampler is stooped over in an unpleasant position. Certainly, you do not want to have to core every mature tree on your FIREMON macroplot, so the question is how many samples are enough? We suggest that one tree per species per 4 inch (10 cm) diameter class be cored if you are sampling at the Level III - Detailed intensity. The FIREMON project manager can increase the diameter class width to 8 inches or 12 inches (20 cm or 30 cm) to further limit coring time on the plot. Enter the tree age in Field 13 of the TD Data Form for each of the trees that were cored.

Growth rate should be determined for those trees that are cored for age however the growth rate core should be taken at DBH because the age core, taken at stump height, is not a good indicator of growth rate. Remove a core that is deep enough to allow you to measure the last 10 years growth. Growth rate is the distance between the cambium and tenth growth ring in from the cambium, measured to the nearest 0.01 in. (0.1 mm) (figure TD-9).

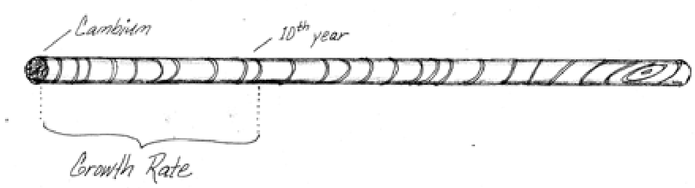


Figure TD-9. Tree growth rate is determined by measuring the last 10 years growth.

If changes in growth rates are a critical part of the monitoring effort (check sampling objectives), then more trees need to be cored for growth rate. If growth rate is an important facet of the fire monitoring project, we suggest that all tagged trees be cored to determine the 10-year growth increment. Enter the growth rate in Field 14 on the TD Data Form.

Measuring Damage and Severity -- This information may not be essential for determining the effects of prescribed and wildland fires, however, it can be useful for describing, interpreting, and stratifying monitoring results. We recommend that these fields be completed for most fire monitoring applications.

Biotic/Abiotic Damage and associated Severity Codes are entered in Fields 17 to 20 in Table 1 of the TD Data Form. These codes describe and then quantify the degree of damage by biotic (e.g. insect, disease, browsing) and abiotic (e.g. wind, snow, fire) agents for the mature trees. Additionally, you will be able to use the Abiotic codes for snags. The extensive list of damage and severity codes is presented in the **Damage and Severity Code Appendix.** These codes are the same ones that are used in the USDA Forest Service Common Stand Exam Guide. For your FIREMON project we suggest that you go through the appendix, select of codes that are important to your location and project objectives, and take a printed list with you in the field. If your project requires you to collect Damage and Severity Codes, as a minimum you should use the ones presented in table TD-6. You can add your own codes if needed but be sure to document them in the FIREMON Metadata table. When trees exhibit multiple forms of damage record the damage with the greatest severity first, then the damage with the second greatest severity.

Table TD-6. Record tree and snag damage using these codes or select a code from the set listed in the **Appendix A: NRIS Damage Categories, Agents, Severity Ratings, and Tree Parts Damage and Severity Code Appendix**.

| Damage Code | Description | Severity Code |
|---|---|---|
| 00000 | No Damage | No Damage |
| 10000 | General Insects | 101 – Minor – Bottlebrush or shortened leaders or <20% of branches affected, 0 to 2 forks on stem or <50% of the bole with larval galleries<br>102 – Severe – 3 or more forks on bole, or 20% or more branches affected or terminal leader dead or 50% or more ion the bole with visible larval galleries. |
| 19000 | General Diseases | 191 – Minor – Short-term tree vigor probably not affected<br>192 – Severe – Tree vigor negatively impacted in the short-term |
| 25000 | Foliage Diseases | 251 – Minor – <20% of the foliage affected or <20% of crown in brooms.<br>252 – Severe - >20% of the foliage affected or >20% of the crown in brooms. |
| 50000 | Abiotic Damage | 501 – Minor – <20% of the crown affected, bole damage is <50% circumference.<br>502 – Severe - >20% of the crown affected bole damage is >50% circumference. |
| 90000 | Unknown | 900 – 0-9% affected<br>901 – 10-19% affected<br>902 – 20-29% affected<br>903 – 30-39% affected<br>904 – 40-49% affected<br>905 – 50-59% affected<br>906 – 60-69% affected<br>907 – 70-79% affected<br>908 – 80-89% affected<br>909 – 90-99% affected |

We recognize that it would take a great deal of field experience to identify each of the damaging agents present in a tree. There are classes at local colleges or USDA Forest Service offices to learn insect and disease identification. However, if the FIREMON crew does not have experience in the identification of biotic and abiotic damage sources, then do not fill out these fields.

Measuring Fire Severity -- There are two fire severity measurements that are specific to the TD sampling method and apply to the mature trees. The first severity measurement is bole char height, which is the height of continuous char measured above the ground, the on the downhill side of the tree, or on flat ground the height of the lowest point of continuous char (figure TD-10). It is often used to quantify potential tree mortality and some mortality prediction equations use bole char height as an independent variable. Measure char height with the logger's tape or cloth tape, holding the tape on the downhill side of the tree and measure to the top of charred part of the bole keeping the tape exactly vertical to the tree. Be sure to measure vertical height. Do not measure along the tree bole, which might be tempting if the tree is leaning. Record bole char height to the nearest 0.1 foot (0.3 m) in Field 21 of the TD Data Form.

Figure TD-10. Measure char height on the downhill side of the tree.

Percent of crown scorched (PCS) is another fire severity measurement that directly relates to tree mortality. It is extremely difficult to estimate because the sampler often does not know if some of the charred branches were alive prior to the fire. However, estimates of PCS to the nearest 10 percent class are usually adequate for use in mortality equations so the bias introduced by dead branches should not cause major problems.

Estimate PCS by trying to rebuild the tree crown in your head, and then estimate the amount of live crown volume that was damaged or consumed by the fire. The foliage could have been entirely consumed, or scorched black or brown with needles/leaves still attached to the branches. Enter percent crown scorched in Field 22 of the TD Data Form using the classes in table TD-5.

*Sampling snags*

There are two fields on the TD field form that are specific to snags: snag decay class and primary mortality agent. Snags progress through a series of stages after the tree dies, from standing with red, dead needles still attached to a well decayed stump. As the snag passes through these stages they function differently in the ecosystem, thus it is important to record snag decay class so the ecosystem characteristics can be quantified. Enter the appropriate snag decay class code from table TD-7 into Field 15 of the TD Field Form.

Table TD-7. Determine snag decay class using these descriptive characteristics.

| Snag Code | Limbs | Top of Bole | Bark | Sapwood | Other |
|---|---|---|---|---|---|
| 1 | All present | Pointed | 100% remains | Intact | Height intact |
| 2 | Few, limbs | May be broken | Some loss, variable | Some Decay | Some loss in height |
| 3 | Limb stubs only | Usually broken | Start of sloughing | Some sloughing | Broken top |
| 4 | Few or no limb stubs | Always broken some rot | 50% or more loss of bark | Sloughing Evident | Loss in height always |
| 5 | No limbs or limb stubs | Broken and usually rotten | 20% bark remaining | Sapwood gone | Decreasing height with rot |

Snag characteristics, for example wildlife preference and snag persistence, can be greatly influenced by the mortality agent so it is important to try and identify what killed the tree. This can be difficult for snags that have been standing for a few years as it is generally accepted that after five years you cannot determine the cause of mortality with any certainty. Also, typically there is more than one mortality agent. In FIREMON we suggest recording the primary cause of mortality. For instance, a fire may injure a tree enough to cause stress, which will, in turn, reduce its resistance so that it cannot effectively protect itself from beetle attacks and then the beetles introduce a fungus that eventually kills the tree. In this case the primary (first) agent of mortality is fire. If you can determine the primary cause of mortality for the tree record in Field 16 using the codes in Table TD-8. If you cannot determine the primary cause of mortality use the U code.

Table TD-8. Use these mortality codes to identify the primary (first) cause that killed the tree.

| Mortality Code | Description |
|---|---|
| F | Fire caused |
| I | Insect caused |
| D | Disease caused |
| A | Abiotic (flooding, erosion) |
| H | Harvest caused |
| U | Unable to determine |
| X | Did not assess |

## Precision Standards

Use these precision standards for the TD sampling.

Table TD-9. Precision guidelines for TD sampling.

| Component | Standard |
|---|---|
| DBH | ±0.1 in./0.25 cm |
| Height | ±1 ft/0.3 m |
| Live crown percent | ± 1 class |
| Live crown base height | ±1 ft/0.3 m |
| Crown class | ±1 class |
| Age | ± 10 percent of total years |
| Growth rate | ±0.01 in./0.1 mm |
| Decay class | ±1 class |
| Mortality code | Best guess |
| Damage code | Appropriate category |
| Severity code | ±1 severity class |
| Char height | ±1 ft/0.3 m |
| Crown scorch | ±1 class |
| Count | ± 10 percent of total count |
| Average height (saplings) | ±1 ft/0.3 m |
| Average live crown percent | ±1 class |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the TD sampling method can be modified to collect more detailed information or streamlined to collect only the most important tree characteristics. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Recommended TD Sampling Design

The recommended TD sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

**Breakpoint diameter**: 4 inches (10 cm)
**Macroplot Size**: 0.1 acre (0.04 ha) [37.24 ft radius, (11.28 m)]
**Subplot radius**: 11.77 ft (3.57 m)
Measure all fields EXCEPT Growth Rate, and only measure Age for one tree for each species-4 in.(species-10 cm) diameter class.

### Streamlined TD Sampling Design

The streamlined TD sampling design follows the Simple FIREMON sample strategy and is designed below:

**Breakpoint diameter**: 6 in. (15 cm)
**Plot Size**: 0.1 acre (0.04 ha) [37.24 ft radius, (11.28 m)]
**Subplot radius**: 5.89 ft (1.78 m)
Only measure Fields 1-11, Fields 20-21, Fields 21-32.

Do not measure Table 1 fields Age, Growth Rate, Damage, Damage Severity, Snags.

### Comprehensive TD Sampling Design

The comprehensive TD sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Breakpoint diameter**: 4 in. (10 cm)
**Plot Size**: 0.1 ac (0.04 ha) [37.24 ft radius, (11.28 m)]
**Subplot radius**: 5.89 ft (1.78 m)

Measure all fields, but measure Age for one tree in each species-4 in. (species –10cm) diameter class. Measure growth rate on all tagged trees but only drill deep enough to measure 10-year record.

**User-specific TD Sampling Design**

There are optional fields in each of the TD Field Form tables called Local Code. These will allow the sampler to record some local characteristic that is important to evaluating fire severity and effects. For example, a sampler might be concerned about the height of dead branches above the ground to describe the vertical fuel ladder. Or, maybe the sampler wishes to describe the value of the timber in this tree (e.g., sweep, crook, broken top) for salvage reasons. The Local Code field allows the sampler to design the TD Data Form to local situations and objectives. These codes must be recorded in the FIREMON meta-database to ensure that future users know their meaning.

There are many ways the user can adjust the TD sample fields to make sampling more efficient and meaningful for local situations. First, be sure the plot is big enough and the breakpoint diameter is large enough to get an ecologically valid sample. Use the 20 tree threshold for most cases (each macroplot should contain at least 20 trees above breakpoint DBH) but that should be adjusted based on the advice of local experts. Next, be sure to measure age and growth rate often enough to get a meaningful description for the plot, but not so detailed that it subsumes all sample time.

Use the Local Code for any other characteristic that is of interest in fire monitoring. Note that there is only one field so measuring two tree characteristics will take some creative thinking. For example, you could combine both measurements into one code. For example, the code 11 might indicate a code 1 for tree taper and a code 1 for timber value.

**Sampling Hints and Techniques**

Many times the sampler will encounter more trees than the Mature Trees table can accept. Another plot sheet can be started and the note taker can record at the top of the form that this is the second page of two (or maybe more?). It would be better if the TD plot sheet were copied to both sides of the waterproof paper. That way, the two or more plot sheets do not need to be attached for organization. The same situation happens when there are more species below breakpoint diameter than the Seedling or Sapling tables on the TD Data Form can accept. Again, if this happens, start another TD Data Form.

# Tree Data (TD) Form

TD Page _ _ of _ _

(Field 1) Macroplot Size : _ . _ _ (ac / ha)
(Field 2) Microplot Size : _ . _ _ (ac / ha)
(Field 3) Snag Plot Size : _ . _ _ (ac / ha)
(Field 4) Breakpoint Diameter : _ _ (in / cm)

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _

Notes

Crew

## TD Table 1 - Mature Trees
Trees >Breakpoint Diameter

| Field 5 | Field 6 | Field 7 | Field 8 | Field 9 | Field 10 | Field 11 | Field 12 | Field 13 | Field 14 | Field 15 | Field 16 | Field 17 | Field 18 | Field 19 | Field 20 | Field 21 | Field 22 | Field 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tag Number | Species | Tree Status | DBH (in/cm) | Height (ft/m) | Live Crown Ratio | CrwnFuel Base Ht (ft/m) | Crown Class | Age | Growth Rate | Decay Class | Mortality Code | Damage Code 1 | Severity Code 1 | Damage Code 2 | Severity Code 2 | Char Height (ft/m) | Crown Scorch % | Local Code |
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# Tree Data (TD) Form

(Field 1) Macroplot Size : _ . _ _ (ac / ha)
(Field 2) Microplot Size : _ . _ _ (ac / ha)
(Field 3) Snag Plot Size : _ . _ _ (ac / ha)
(Field 4) Breakpoint Diameter : _ _ (in / cm)



Plot Key
Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/ _ _/_ _ _ _

## TD Table 2 - Saplings

Trees <Breakpoint Diameter & >4.5 ft

| Field 24 | Field 25 | Field 26 | Field 27 | Field 28 | Field 29 | Field 30 |
|---|---|---|---|---|---|---|
| Diameter Class (in/cm) | Species | Status | Count | Average Height (ft/m) | Average Live Crown % | Local Code |
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## TD Table 3 - Seedlings

Trees <4.5 ft

| Field 31 | Field 32 | Field 30 | Field 33 | Field 34 |
|---|---|---|---|---|
| Height Class (ft/m) | Species | Status | Count | Local Code |
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Notes

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# FIREMON
# TREE DATA (TD) FIELD DESCRIPTIONS

Field 1: **Macroplot Size**. Macroplot size. (ac/ha).

Field 2: **Microplot Size**. The size of the microplot where trees less the 4.5 feet tall are sampled. (ac/ha).

Field 3: **Snag plot size**. The size of the plot where dead trees greater than breakpoint diameter are measured. (ac/ha).

Field 4: **Breakpoint Diameter**. DBH above which trees are measured individually and below which trees are tallied by diameter-species-status classes. (in./cm).

**Table 1: Mature Trees. Trees greater than breakpoint diameter at breast height**

Field 5: **Tag Number.** Tag number attached to mature trees. The tagged numbers need not be in sequence.

Field 6: **Species Code.** Either the NRCS plants species code or the local code for that species. Precision: No error.

Field 7: **Tree Status.** Tree status code that best describes the current health of the tree. Precision: ±1 class.

- **H** – **Healthy** tree with very little biotic or abiotic damage.
- **U** – **Unhealthy** tree with some biotic or abiotic damage, and this damage will reduce growth. However, it appears the tree will fully recover from this damage.
- **S** – **Sick** tree with extensive biotic or abiotic damage and this damage will ultimately cause death within the next 5-10 years.
- **D** – **Dead** tree or snag with no living tissue visible.

Field 8: **DBH**. The diameter of the tree at breast height. (in./cm). Precision: ±0.1 in./0.25 cm.

Field 9: **Tree Height**. The vertical height of the tree. (ft/m). Precision: ±1 ft/0.3 m.

Field 10: **Live Crown Ratio.** The percent class that best describes the percent of the tree stem that is supporting live crown based on the distance from the ground to the top of the live foliage. Valid classes are in table TD-5 of the TD sampling method. Precision: ±1 class.

Field 11: **Crown Fuel Base Height.** Height above the ground of the lowest live and/or dead fuels that have the ability to move fire higher in the tree. (ft/m). Precision: ±1 ft/0.3 m.

Field 12: **Crown Class.** Code that describes the tree crown's position in forest canopy. Precision: ±1 class.

**O – Open grown,** or the tree is not near any other tree
**E – Emergent**, or the crown is totally above the canopy of the stand
**D – Dominant**, or the crown receives light from at least 3-4 directions
**C – Codominant**, or the crown receives light from at least 1-2 directions
**I – Intermediate**, or the crown only receives light from the top
**S – Suppressed**, or the crown is entirely shaded and underneath the stand canopy

Field 13: **Tree Age.** Tree age taken from sample core. Precision: ±10 percent of total years.

Field 14: **Growth Rate.** The distance measured across the ten most recent growth rings. (in./mm). Precision: ±0.01 in./0.1 mm.

Field 15: **Decay Class**. Decay measure of snags. Valid classes are in table TD-7 of the sampling method. Precision: ±1 class.

Field 16: **Mortality Code**. Damage that initiated the tree mortality. (i.e. the first damage to the tree causing its reduced vigor). Valid codes are in table TD-8 of the sampling method. Precision: best guess.

Field 17 to Field 20: **Damage and Severity Codes**. Enter the codes that describe evidence of a damaging agent on the tree and the severity of the damage in order of prevalence on the tree. See the Damage and Severity Code Appendix. Precision: Correct damage category, ±1 severity class.

Field 21: **Bole Char Height**. Enter the height of the highest contiguous char on measured on the downhill side of the tree. Precision: ±0.1 ft/0.3 m.

Field 22: **Percent Crown Scorched**. Enter the percent of crown that has been killed by fire. Include both scorched and consumed foliage. Valid codes are in table TD-5 of the sampling method. Precision: ±1 class.

Field 23: **Local Variable**. User defined value or code.

**Table 2: Saplings -Trees less than breakpoint diameter and taller than 4.5 feet.**

Field 24: **Diameter Class**. Class of the trees being sampled. The Analysis Tools program assumes that the diameter class value in this field represents the midpoint of the DBH range of the trees being sampled. Precision: No error

Field 25: **Species Code**. Code of sampled entity. Either the NRCS plants species code or the local code for that species. Precision: No error

Field 26: **Status Code**. Tree status code that best describes the current health of the tree. Codes presented above in the Field 7 description. Precision: ±1 class

Field 27: **Count**. The number of trees tallied for the appropriate diameter-species-status class. Precision: ±10 percent of total count.

Field 28: **Average Height**. The average height of all trees tallied for this diameter-species-status class. Precision: ±1 ft/0.3 m.

Field 29: **Average Live Crown Ratio**. Enter the average live crown percent of the trees tallied for this diameter-species-status class. Valid classes are in table TD-5 of the TD sampling method. Precision: ±1 class.

Field 30: **Local Code**. User defined value or code.

**Table 3: Seedlings - Trees less than 4.5 feet tall.**

Field 31: **Height Class**. Class of the trees being sampled. The Analysis Tools program assumes that the height class value in this field represents the midpoint of the height range of the trees being sampled. Precision: No error

Field 32: **Species Code.** Code of sampled entity. Either the NRCS plants species code or the local code for that species. Precision: No error

Field 33: **Count.** The number of trees tallied for the appropriate height-species-status class. Precision: ±10 percent of total count.

Field 34: **Local Code**. User defined value or code.

**FIREMON**
**TREE DATA (TD) EQUIPMENT LIST**

Camera with film
Clear plastic ruler (2)
Clipboard
Clinometer (2)
Cloth tape (2)
Compass (2)
Diameter Tape (2)
Flagging
Hammer (2)
Hard hat
Hatchet (1)
Increment Corer (2)
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Masking tape
Mount boards or plastic straws
Logger's tape (2 plus steel tape refills)
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Previous measurement plot sheets
Field notebook
Steel nails (many)
TD Plot Forms
Tree chalk or tree marker crayons
Tree tags (many) -- casket tags

# FIREMON TD Cheat Sheet

**Tree Status**

**H – Healthy** tree with very little biotic or abiotic damage.
**U – Unhealthy** tree with some biotic or abiotic damage, and this damage will reduce growth. However, it appears the tree will fully recover from this damage.
**S – Sick** tree with extensive biotic or abiotic damage and this damage will ultimately cause death within the next 5-10 years.
**D – Dead** tree or snag with no living tissue visible.

**Crown Class**

**O – Open grown**, or the tree is not near any other tree
**E – Emergent**, or the crown is totally above the canopy of the stand
**D – Dominant**, or the crown receives light from at least 3-4 directions
**C – Codominant**, or the crown receives light from at least 1-2 directions
**I – Intermediate**, or the crown only receives light from the top
**S – Suppressed**, or the crown is entirely shaded and underneath the stand canopy

**Live Crown Ratio and Crown Scorch Classes**

| Code | Live Crown Percent |
|---|---|
| 0 | Zero percent |
| 0.5 | >0-1 percent |
| 3 | >1-5 percent |
| 10 | >5-15 percent |
| 20 | >15-25 percent |
| 30 | >25-35 percent |
| 40 | >35-45 percent |
| 50 | >45-55 percent |
| 60 | >55-65 percent |
| 70 | >65-75 percent |
| 80 | >75-85 percent |
| 90 | >85-95 percent |

**Mortality Codes**

| Mortality Code | Description |
|---|---|
| F | Fire caused |
| I | Insect caused |
| D | Disease caused |
| A | Abiotic (flooding, erosion) |
| H | Harvest caused |
| U | Unable to determine |
| X | Did not assess |

**Snag Code Descriptions**

| Snag Code | Limbs | Top of Bole | Bark | Sapwood | Other |
|---|---|---|---|---|---|
| 1 | All present | Pointed | 100% remains | Intact | Height intact |
| 2 | Few, limbs | May be broken | Some loss, variable | Some Decay | Some loss in height |
| 3 | Limb stubs only | Usually broken | Start of sloughing | Some sloughing | Broken top |
| 4 | Few or no limb stubs | Always broken some rot | 50% or more loss of bark | Sloughing Evident | Loss in height always |
| 5 | No limbs or limb stubs | Broken and usually rotten | 20% bark remaining | Sapwood gone | Decreasing height with rot |

**Damage and Severity Codes - Short List**

| Damage Code | Description | Severity Code |
|---|---|---|
| 00000 | No Damage | No Damage |
| 10000 | General Insects | 101 – Minor – Bottlebrush or shortened leaders or <20% of branches affected, 0 - 2 forks on stem or <50% of the bole with larval galleries |
| | | 102 – Severe – 3 or more forks on bole, or 20% or more branches affected or terminal leader dead or 50% or more ion the bole with visible larval galleries. |
| 19000 | General Diseases | 191 – Minor – Short-term tree vigor probably not affected |
| | | 192 – Severe – Tree vigor negatively impacted in the short-term |
| 25000 | Foliage Diseases | 251 – Minor – <20% of the foliage affected or <20% of crown in brooms. |
| | | 252 – Severe - >20% of the foliage affected or >20% of the crown in brooms. |
| 50000 | Abiotic Damage | 501 – Minor – <20% of the crown affected, bole damage is <50% circumference. |
| | | 502 – Severe - >20% of the crown affected bole damage is >50% circumference. |
| 90000 | Unknown | 900 – 0-9% affected |
| | | 901 – 10-19% affected |
| | | 902 – 20-29% affected |
| | | 903 – 30-39% affected |
| | | 904 – 40-49% affected |
| | | 905 – 50-59% affected |
| | | 906 – 60-69% affected |
| | | 907 – 70-79% affected |
| | | 908 – 80-89% affected |
| | | 909 – 90-99% affected |

**Sapling Classes**

| Midpoint Diameter Class (in.) | | Midpoint Diameter Class (cm) | |
|---|---|---|---|
| Class | Diameter Range | Class | Diameter Range |
| 0.5 | >0 - 1 | 1.2 | >0 - 2.5 |
| 1.5 | >1 - 2 | 3.8 | >2.5 - 5 |
| 2.5 | >2 - 3 | 6.2 | >5 - 7.5 |
| 3.5 | >3 - 4 | 8.8 | >7.5 - 10 |

**Seedling Classes**

| Midpoint Height Class (ft) | | Midpoint Height Class (m) | |
|---|---|---|---|
| Class | Height Range | Class | Height Range |
| 0.2 | >0.0 – 0.5 | 0.1 | >0.0 – 0.2 |
| 1 | >0.5 – 1.5 | 0.3 | >0.2 – 0.5 |
| 2 | >1.5 – 2.5 | 0.6 | >0.5 – 0.8 |
| 3 | >2.5 – 3.5 | 0.9 | >0.8 – 1.0 |
| 4 | >3.5 – 4.5 | 1.2 | >1.0 – 1.4 |

**Precision**

| Component | Standard |
|---|---|
| DBH | ±0.1 in./0.25 cm |
| Height | ±1 ft/0.3 m |
| Live crown ratio | ± 1 class |
| Crown fuel base height | ±1 ft/0.3 m |
| Crown class | ±1 class |
| Age | ± 10 percent of total years |
| Growth rate | ±0.01 in./0.1 mm |
| Decay class | ±1 class |
| Mortality code | Best guess |
| Damage code | Appropriate category |
| Severity code | ±1 severity class |
| Char height | ±1 ft/0.3 m |
| Crown scorch | ±1 class |
| Count | ± 10 percent of total count |
| Average height (saplings) | ±1 ft/0.3 m |
| Average live crown percent | ±1 class |

# Fuel Load (FL)
## Sampling Method

EXECUTIVE SUMMARY

The Fuel Load methods (FL) are used to sample dead and down woody debris, depth of the duff/litter profile, estimate the proportion of litter in the profile, and estimate total vegetative cover and dead vegetative cover. Down woody debris (DWD) is sampled using the planar intercept technique based on the methodology developed by Brown (1974). Pieces of dead and down woody debris are tallied in the standard fire size classes: 1-hour (0 to 0.25 in. or 0 to 0.6 cm), 10-hour (0.25 to 1.0 in. or 0.6 to 2.5 cm), 100-hour (1.0 to 3.0 in. or 2.5 to 8 cm). Pieces greater than 3 in. (8 cm) in diameter are recorded by diameter and decay class. Duff and litter depth are measured at two points along each 60-foot (20-meter) sampling plane. Litter depth is estimated as a proportion of total duff and litter depth. Cover of live and dead vegetation is estimated at two points along each 60-foot (20-meter) sampling plane. Biomass of DWD, duff, litter and vegetation is calculated using the Analysis Tools software.

## INTRODUCTION

The Fuel Load (FL) methods are used to quantify three general components of the fuel complex: dead and down woody debris (DWD), duff and litter, and understory vegetation. Biomass estimates of dead and down woody debris are collected for the size classes that fire scientists have found important for predicting fire behavior – 1-hour, 10-hour, 100-hour and, 1000-hour and greater. DWD measurements are based on the planar intercept methods published by Brown (1974). The sampling area is an imaginary plane extending from the ground, vertically from horizontal (not perpendicular to the slope) to a height six feet above the ground. Pieces that intercept the sampling plane are measured and recorded. Frequently the term "line transect sampling" is used when discussing the planar intercept method. As far as the FL methodology is concerned the two terms can be interchanged as long as samplers recognize that the 'line' is really the measuring tape laid on the litter layer while the 'plane' extends above and below the tape, from the top of the litter layer to a height of six feet. Duff and litter are assessed by measuring the depth of the duff/litter profile down to mineral soil, and estimating the proportion of the total duff/litter depth that is litter. The biomass of live and dead, woody and non-woody understory vegetation is estimated using cover and average height estimations. The data collected using the FL methods are used to model fire behavior or to indicate potential fire effects. Forest managers often prescribe fuel treatments, at least partially, on the data collected using the FL methodology. The load of DWD can also be used to estimate the total carbon pool that is stored in the dead material, or DWD data can be used as an indicator of habitat for wildlife. Standing dead trees (snags) are sampled using the FIREMON Tree Data (TD) methods.

The FL methods allow data collection for a wide number of fuel characteristics on each plot. However, field crews are not required to sample every characteristic represented on the field form. In fact, FIREMON was developed specifically so that crews only sample the characteristics they are interested in, as determined by the goals and objectives of the project. In most cases the data collected from plot to plot will be the same although there are situations when some characteristic may be sampled on subset of the sampling plots.

Dead wood is important in many forest processes. Fire managers need to have an estimate of down dead fuel because it substantially influences fire behavior and fire effects. Smaller pieces of DWD are generally associated with fire *behavior* because they reach ignition temperature more readily than larger pieces. The time it takes for a flaming front to move across a fuel complex is an example of fire behavior influenced by the smaller DWD. Larger pieces of DWD, on the other hand, are usually associated with fire *effects* because, once ignited, these large pieces generally burn longer in both the flaming and smoldering phases of combustion. Soil heating and emissions from combustion are two fire effects closely tied to large DWD. Fire intensity and duration are directly related to fuel load and influence fire *severity* (a general term used to describe the amount of change in the floral and faunal components of a burned site). Logs contribute to forest diversity by providing important nutrient and moisture pools in forest ecosystems. These pools support microfauna and provide sites for the regeneration of understory plants. Logs are frequently used by animals for food storage and cover as well as feeding and nesting sites. Duff and litter are rich in nutrients and microfauna, both of which are intrinsically related to the overall vigor of herbaceous and woody species. Disturbance that substantially reduces the amount of DWD, duff and litter, and understory vegetation can increase soil movement and cause siltation into streams. Duff and litter also provide a layer of insulation during fire, which reduces heat transfer to the soils below. In the absence of an insulating layer of duff and litter, the high levels of soil heating can reduce soil nutrients, and kill microfauna and underground living plant tissues.

A full description of the FL method is provided in the Sampling Procedure section below however, to help the sampling crew understand the research behind and the uses for the FL sampling there is a brief overview provided here.

Two specific components of dead woody fuel are measured using the FL methods: fine woody debris (FWD) and coarse woody debris (CWD). Ecologists often refer to FWD and CWD independently because they function differently in forest ecosystems. FWD are pieces less than 3 (8 cm) inches diameter, and include 1-hour, 10-hour, and 100-hour fuels. CWD includes pieces 3 inches (8 cm) or greater in diameter and at least 3 feet (1 m) in length, also called 1000-hour and greater fire fuels (table FL-1).

Table FL-1. Ecologists and fire managers often use different terms to define the same dead woody debris. Typically 1-, 10- and 100-hour fuels are grouped together by ecologists and called fine woody debris. They term 1000-hour fuels and larger, coarse woody debris.

| Dead Woody Class | | | Piece Diameter (in.) | Piece Diameter (cm) |
|---|---|---|---|---|
| DWD | FWD | 1-hr | 0 to 0.25 | 0 to 0.6 |
| | | 10-hr | 0.25 to 1.0 | 0.6 to 2.5 |
| | | 100-hr | 1.0 to 3.0 | 2.5 to 8.0 |
| | CWD | 1000-hr and greater | 3.0 and greater | 8.0 and greater |

Pieces of DWD are sampled if they pass through the 6-foot (2-meter) high sampling plane. Fine woody pieces are recorded as simple counts. Diameter and decay class are recorded for each piece of CWD. DWD biomass estimation is made using equations published in Brown (1974). FIREMON provides five optional fields for CWD: 1) diameter of the large end of the log, 2) log length, 3) distance along the tape where the piece intercepts the plane, 4) the proportion of diameter lost to decay in hollow logs, 5) the proportion of log length lost to decay in hollow logs and 6) proportion of the surface of CWD that is charred.

At two points along the base of each sampling plane, measurements of duff/litter depth and estimation of the proportion of the duff/litter profile that is litter are made. At these same locations the sampling crew will also estimate the cover of live and dead, herbs and shrubs as well as average height of herbs and shrubs.

The planar intercept sampling methodology used in the FL protocol was originally developed by Warren and Olson (1963) for sampling slash. Brown (1974) revised the original sampling theory to allow for more rapid fuel measurement while still capturing the intrinsic variability of forest fuels. Brown's method was developed strictly to provide estimates of fuel load in the size classes important to fire behavior. He determined the length of the sampling plane needed for each size class and, for FWD, determined quadratic mean diameter for several species. Planar sampling has been reduced to its most fundamental and efficient level while still providing good estimates of DWD.

The planar intercept technique assumes that DWD is randomly oriented directionally on the forest floor. Typically, this assumption does not hold true (for instance in areas of high wind, trees tend to fall with the prevailing winds). FIREMON uses a sampling scheme that reduces bias introduced from non-randomly oriented pieces by orienting the DWD sampling planes in different directions (figure FL-15). This sampling design greatly reduces or eliminates the bias introduced by non-randomly oriented DWD (Van Wagner 1968, Howard and Ward, 1972).

The planar intercept method also assumes that pieces are lying horizontal on the forest floor. Brown (1974) developed a non-horizontal correction for FWD and noted that a correction for CWD would not substantially improve biomass estimates; therefore samplers do not record piece angle as part of the FL methodology.

DWD is notoriously variable in its distribution within and between forest stands. Frequently, the standard deviation of DWD samples exceeds the mean. This variability requires large numbers of samples for statistical tests.

There are many ways to streamline or customize the FL sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **Optional Fields** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

The FL sampling procedure is presented in the order of the fields that need to be completed on the FL data form, so it is best to reference the FL data form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

**Preliminary Sampling Tasks**

Before using the FL methods in the field we suggest that you find a place close by where you can lay out at least one plot of three transects. This will give the field crew an opportunity to practice and learn the FL methods in a controlled environment where they are not battling steep slopes and tall vegetation. Even if the spot you chose does not have DWD you can find some branches to lie on the ground to simulate the sampling environment. Be sure to pick a spot where you will be able to make estimates of vegetation cover, vegetation height, and depth of the duff/litter profile. Use the FL Equipment List to determine the materials you will need.

There are a number of preparations that need to be made before proceeding into the field for FL sampling. First, all equipment and supplies in the FL Equipment list must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All FL Plot Forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

If the sampling project is to re-measure previously installed FIREMON plots, then it is recommended that plot sheets from the first measurement be copied and brought to the field for reference. These data can be valuable for help in relocating the FIREMON plot.

It is recommended that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future re-measurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook.

Plot locations and/or directions should be readily available and provided to the crews in a timely fashion. It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Plots should be referenced on maps and aerial photos using pinpricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

Three people allow the most efficient sampling of down debris. There should never be a one-person field crew for safety reasons, and any more than three people will probably result in some people waiting for tasks to be done and cause unnecessary trampling on the plot. Assign one person as data recorder and the other two as samplers. Samplers count FWD and measure CWD pieces that intercept the sampling plane, make duff/litter measurements and make cover and height estimates along each sampling plane. One sampler should count the 1-hour, 10-hour and 100-hour size classes while the other measures the CWD. The remainder of the sampling tasks - duff/litter measurements and vegetation cover and height estimates - can be divided between the samplers after they have completed their first tasks.

The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency, but sampling tasks should be modified as the field crew gains experience and shared to limit monotony.

**Determining Piece Size**

An important task when sampling fuels is to properly determine whether each piece is in the 1-hour, 10-hour, 100-hour or 1000-hour and greater size class. Often it will be clear by just looking what size class the pieces belong in. This is especially true as field crews gain experience sampling fuels. However while samplers are calibrating their eyes or when pieces are clearly on the boundary between two size classes, samplers need to take the extra effort to measure pieces and assign them to the proper class. Each sampling crew should have at least one set of sampling dowels for this task. The set is made up of two dowels. One measures 0.25 in. (0.6 cm) in diameter and 3 in. (8 cm) long. Use this dowel to determine whether pieces are in the 1-hour or 10-hour class. The second dowel is 1 in. (2.5 cm) in diameter and 3 in. (8 cm) long. Use this dowel to separate the 10-hour from the 100-hour fuels. Cutting the dowels into 3-inch (8 cm) lengths makes them useful to discern 100-hour and 1000-hour fuels. The go/no-go gauge is a tool that can speed up the sampling process (figure FL-1). The gaps in the tool correspond to the 1-hour and 10-hour fuel sizes and they allow quick assessment of fuel size. Make it out of sheet aluminum (about 0.063 in.) so that it is lightweight and durable. Or, make one out of an old grocery store card (Safeway, Albertson's, etc.) card. It won't be as durable as an aluminum one but it is easier to make because you can cut the openings using a scissors.

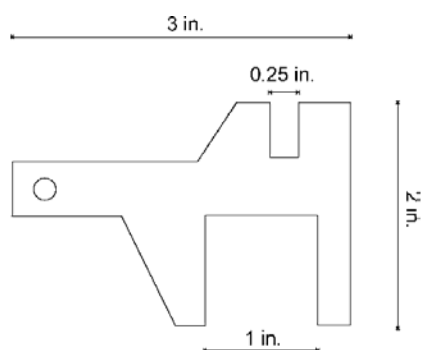


Figure FL-1. A go/no-go gauge can help samplers tally 1-hr, 10-hr and 100-hr fuels more quickly and accurately than wooden dowels.

FL sampling requires 12 specific tasks for each sampling plane:

1) Layout the measuring tape, which defines the sampling plane.
2) Measure the slope of the sampling plane.
3) Count FWD.
4) Measure CWD.
5) Measure depth of the duff/litter profile.
6) Estimate the proportion of the profile that is litter.
7) Estimate cover of live woody species.
8) Estimate cover of dead woody species.
9) Estimate average height of live and dead woody species.
10) Estimate cover of live non-woody species.
11) Estimate cover of dead non-woody species.
12) Estimate average height of live and dead non-woody species.

Tasks 5 through 12 are made at two points along each line. Data is recorded on the FL plot forms after completing each of steps, 2 through 12. You will learn that sampling in order 1 through 12 is not the fastest way to sample a plot. Instead, use task list provided in table FL-2 as a general guide for sampling and modify it as needed to make for the most efficient sampling.

Table FL-2. General task list for sampling with the FL method.

| | Crew member - task number | | |
|---|---|---|---|
| Task | Recorder | Sampler 1 | Sampler2 |
| Organize materials | 1 | | |
| Layout tape | | 1 (guider) | 1 (guidee) |
| Measure slope | 2 (record data) | 2 | 2 |
| Count FWD | 3 (record data) | 3 | |
| Measure duff/litter and veg. at 75-foot mark | 4 (record data) | | 3 |
| Measure CWD | 5 (record data) | | 4 |
| Measure duff/litter and veg. at 45-foot mark | 6 (record data) | 4 | |
| Check for complete forms | 7 | | |
| Collect equipment | | 5 | 5 |

**Modifying FL Sampling**

In the FL method we suggest sampling over a 60-foot (20-meter) distance with an addition 15 feet (5 meters) of buffer provided to keep from disturbing fuels around the plot center (figure FL-8). The 60-foot (20-meter) plane is the shortest recommended for sampling CWD however, there are instances of high fuel loads, in slash for instance, where shorter planes for DWD may be justified. If the FIREMON architect wants to use shorter (or longer) sampling planes based on research or expert knowledge the database can accommodate that data. This write-up assumes that the FIREMON crew is using the suggested FL method.

Additionally, the field crew does not have to use the suggested locations for sampling duff/litter and vegetation. As long as they are thoughtfully placed (for instance, do not sample duff/litter in an area where you will be sampling FWD) these measurements can be made elsewhere along the sampling plane.

**Laying Out the Measuring Tape**

A measuring tape laid close to the soil surface defines the sampling plane. The sampling plane extends from the top of the litter layer, duff layer or mineral soil; whichever is visible, to a height of six feet. When laying out the tape, crew members need to step so that they minimize trampling and compacting fuels – DWD, duff/litter and vegetation. While the data recorder is arranging field forms and so forth, the other two crew members can lay out the measuring tape for the first sampling plane. Have one crew member stand at plot center (see **How to Locate a FIREMON Plot**) holding the zero end of the tape, then, using a compass, he or she will guide second crew member (see **How to Use a Compass - Sighting and Setting Declination**) on an azimuth of 090 degrees true north. The second sampler will move away from plot center, following the directions of the first crew member, until he or she reaches the 75-foot (25-meter) mark on the tape. The process of laying out the tape is typically more difficult than it sounds because the tape needs to be straight, not zigzagging around vegetation and trees (figure FL-2). It pays to sight carefully with the compass and identify potential obstructions before rolling out the tape.

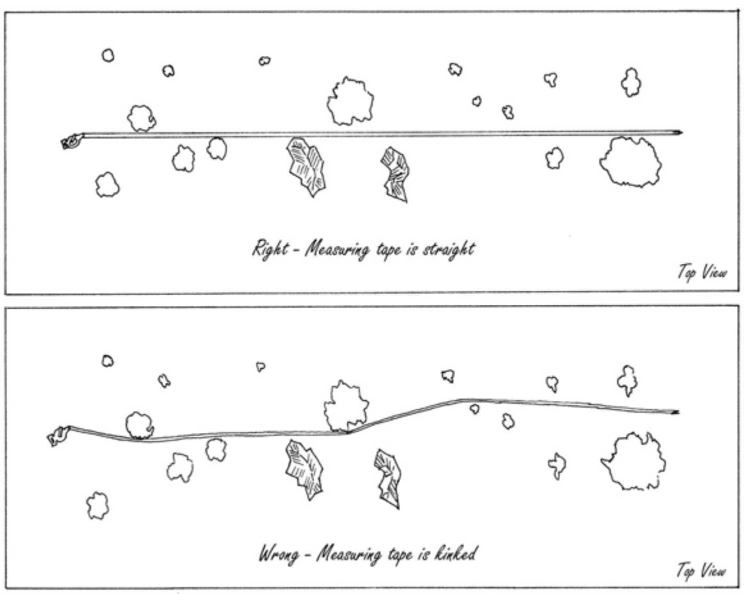


Figure FL-2. The measuring tape, which represents the lower portion of the sampling plane, should be as straight as possible. If the tape is not straight it needs to be offset left or right until it can be established without kinks or bends.

The second crew member must follow the directions given by the first in order to stay on line and that can take him or her under low branches of trees and shrubs, through thick brush…or worse. The smallest crew member generally has the greatest success at this task but be sure everyone gets an opportunity. Once the second crew member is at the appropriate location, the first crew member will hold the zero end of the tape over plot center while the second crew member pulls the tape tight. Together, move the tape down as close to the ground as possible without struggling to get it so close to the ground that the debris to be measured is disturbed. In most cases, the tape will end up resting on some of the DWD and low vegetation but below the crowns of shrubs, seedlings, etc. It is not unusual to get to this point and realize that a large tree, rock, or other obstruction won't allow the tape to be laid straight; instead there is a kink where it hits an obstruction. DWD shouldn't be sampled over a tape that isn't straight so crew members need to lift the tape above the vegetation, move both ends of the line left or right (i.e. keep it oriented at the same azimuth) until the tape won't be influenced by any obstructions, then place it back down and straight on the soil surface. Usually this offset won't need to be more than a few feet left or right but on sites with even moderate amounts of tall vegetation offsetting the tape can mean considerable work.

Once established, anchor the tape and do not move its position until all sampling is finished for the sampling plane. Most tapes have a loop on the zero end that a spike can be placed through to keep it anchored, and a spike or stick though the handle on the other end of the tape will hold it in place. Roll-up tapes (Figure FL-3) usually have a winding crank that can be flipped so that the knob points toward the reel. In this position the knob will lock the reel so the tape won't unwind when it is pulled tight.

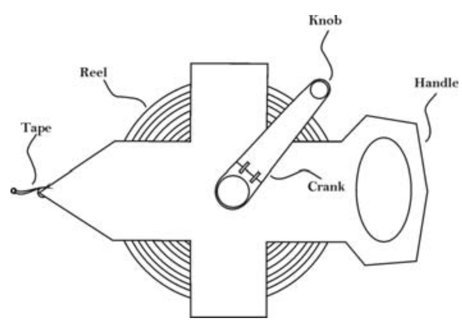


Figure FL-3. Parts of a roll-up measuring tape. The crank can usually be flipped in the opposite direction allowing the knob to lock the reel. This will keep more tape from being pulled off.

Mark the 0-foot and 75-foot (25-meter) marks along the tape so that the plane can be easily re-established. This is especially true when sampling will be done both pre- and post-treatment. Bridge spikes, 8 to 10 inches long, work well because they are relatively permanent when driven completely into the ground and can be relocated with a good metal detector, if needed. Animals, like deer and elk, tend to pull survey flags out of the ground so they should not be used as the only indicator of tape position. If spikes and flags are used together do not wrap the survey flag wire around the spike.

**Determining the Slope of the of the Measuring Tape**

Once the tape has been secured, use a clinometer to measure the percent slope of the line. Aim the clinometer at the eye level of sampler at the other end of the line (figure FL-4). If there is a height difference of the samplers adjust the height where you are aiming so that the slope reading is accurate. Carefully, read the percent slope from the proper scale in the instrument and report to the data recorder who will enter it in Field 7 on the FL Field Form.

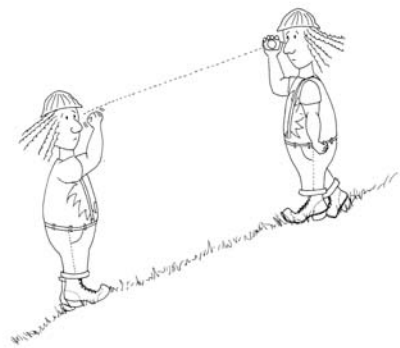

Figure FL-4. Measure the slope of each line by aiming the clinometer at eye level on the sampler at the opposite end of the measuring tape, then reading and recording the percent slope seen on the scale in the instrument.

**What are “woody”, “dead” and “down” debris?**

Before sampling any DWD the terms “woody”, “dead” and “down” need to be understood so data gathered with the FL methods is consistent between field crews. “Woody” refers to a plant with stems, branches or twigs that persist from year to year. The structural parts support leaves, needles, cones and so forth and it’s these structural components that are tallied along the sampling plane.

“Dead” DWD has no live foliage. Sampling deciduous species in the dormant season can be a challenge and should only be done by crews with the expertise to identify dormant vs. dead trees and shrubs.

*CWD*

CWD at an angle of greater than 45 degrees above horizontal where it passes through the sampling plane should only be considered “down” if it is the broken bole of a dead tree where at least one end of the bole is touching the ground (not supported by its own branches, or other live or dead vegetation). If CWD is at an angle of 45 degrees or less above horizontal where it passes through the sampling plane then it is “down” regardless of whether or not it is broken, uprooted or supported in that position (figures FL-5 and FL-6).

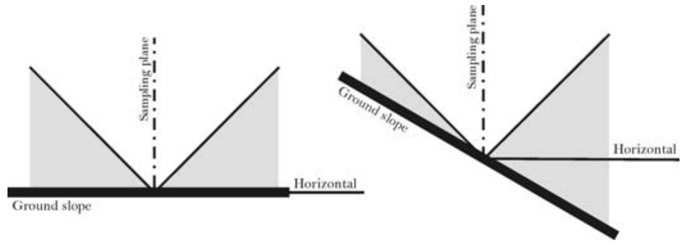


Figure FL-5. CWD pieces crossing through the sampling plane at an angle less than 45 degrees from horizontal (represented by the shaded areas in the figure) are always considered to be "down". Some CWD leaning greater than 45 degrees may be considered “down”. See the text for details.

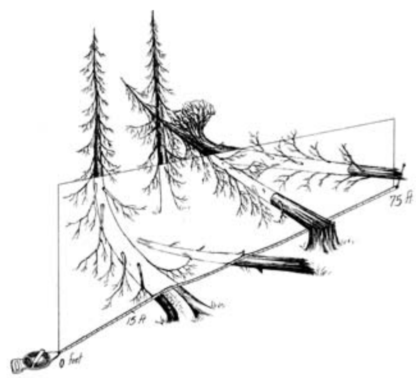

Figure FL-6. All of the pieces crossing through the sampling plane in this illustration would be considered "down".

Do not sample a piece of CWD if you believe the central axis of the piece is lying in or below the duff layer where it passes through (actually, under) the sampling plane (figure FL-7). These pieces burn more like duff and the duff/litter methodology will allow field crews to collect a representative sample of this material.

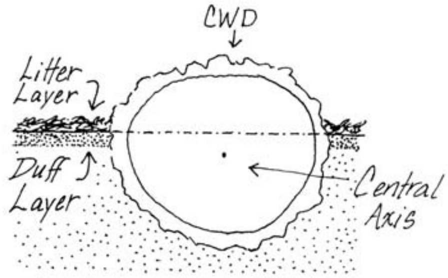


Figure FL-7. Do not sample CWD when the central axis of the piece lies in or below the duff layer.

*FWD*

Pieces of FWD that are “woody”, “dead” and “down” fall into three general categories: 1) pieces that are not attached to the plant stems or tree boles where they grew and have fallen to the ground, 2) pieces that are not attached to the plant stems or tree boles where they grew but are supported above the ground by live or dead material and 3) pieces attached to stems or boles of shrubs or trees that are themselves considered “dead” and “down”. Note that it is possible for FWD to be considered “dead” even though it has green foliage attached because the rules consider any piece severed from the plant where it grew to be both “dead” and “down”. Fresh slash and broken branches are examples of green material considered “dead”. Do not sample dead pieces that are still attached to dead (unless “down”) and live shrubs and trees, even if those pieces are broken and hanging from the plant where they grew. Piece angle of FWD is not critical in determining whether or not it is “down”. Do not tally needles, grass blades, pine cones, cone scales, bark pieces, etc., as they are not “woody” in nature. This material is considered litter and is measured as part of the duff/litter profile.

**DWD Sampling Distances**

DWD is sampled along a certain portion of the sampling plane based on the size of the piece (figure FL-8). The 1-hour and 10-hour fuels are sampled from the 15-foot (5-meter) to the 21-foot (7-meter) marks along the plane, the 100-hr fuels are sampled from the 15-foot (5-meter) to the 30-foot (10-meter) marks and pieces 3 inches (8 cm) and larger are sampled between the 15-foot (5-meter) and 75-foot (25-meter) marks along the plane. The distances for sampling FWD are shorter than for CWD because pieces of FWD are more numerous, so a representative sample can be obtained with a shorter sampling distance. DWD is not measured along the first 15 feet (5 meters) of the tape because fuels are usually disturbed around plot center by the activity of the sampling crew as they get organized to lay out the tape. The Analysis Tools program will accept different sampling plane lengths than the ones suggested here. If you use different lengths record the reason for changing them in the Metadata (MD) table. Enter the sampling plane length for 1-, 10-, 100- and 1000-hr fuels in Fields 1 through 4 of the FL field form. If you are using a predetermined number of sampling planes per plot enter that value in Field 5, otherwise the field will be filled in at the end of the plot sampling. This issue covered more completely in later sections.

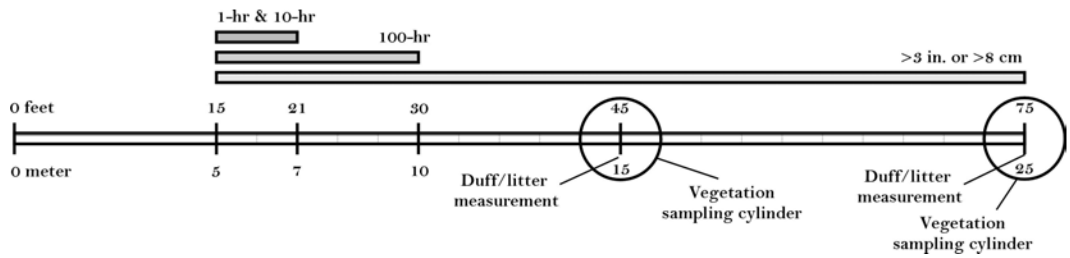


Figure FL-8. Dead fuels, duff/litter, and vegetation data are recorded at specific locations on or along each sampling plane. The 1-hour and 10-hour fuels are sampled from the 15-foot (5-meter) to the 21-foot (7-meter) marks along the plane, the 100-hr fuels are sampled from the 15-foot (5-meter) to the 30-foot (10-meter) marks and pieces 3 inches (8 cm) and larger are sampled between the 15-foot (5-meter) and 75-foot (25-meter) marks along the plane. Duff/litter measurements are made in a representative area within a 6-foot (2-meter) diameter circular area at the 45-foot (15-meter) and 75-foot (25-meter) marks. The cover of live and dead vegetation is estimated within an imaginary 6-foot (2-meter) diameter by 6-foot (2-meter) high sampling cylinder at the 45-foot (15-meter) and 75-foot (25-meter) marks.

## Sampling FWD

The crew member at the zero end of the tape should sample FWD to maximize sampling efficiency. Count the 1-hour and 10-hour fuels that pass through the sampling plane from the 15-foot (5-meter) to the 21-foot (7-meter) marks on the measuring tape. Remember the plane extends from the top of the litter layer vertically to a height of six feet (two meters). The best way to identify the pieces intercepting the plane is to lean over the tape so that your eye is positioned vertically a few feet over the measuring tape at the 15-foot (5-meter) mark. Then, while looking at one edge of the tape, maintain your head in that same vertical position over the line and move ahead to the 21-foot mark while making separate counts for the 1-hour and 10-hour fuels that cross under or above the edge of the tape. Each piece needs to be classified as 1-hour or 10-hour fuel by the diameter where it intercepts the sampling plane, defined by one edge of the measuring tape. Samplers should use the dowels or the go/no-go gauge discussed earlier to classify fuels that are close to the size class bounds. Often pieces above the ground will cover pieces below. It is important to locate all the pieces that intercept the plane in order to get accurate fuel load data (figure FL-9). When finished tallying the 1-hour and 10-hour fuels, report the counts to the data recorder who will enter them in Fields 8 and 9 on the data sheet.

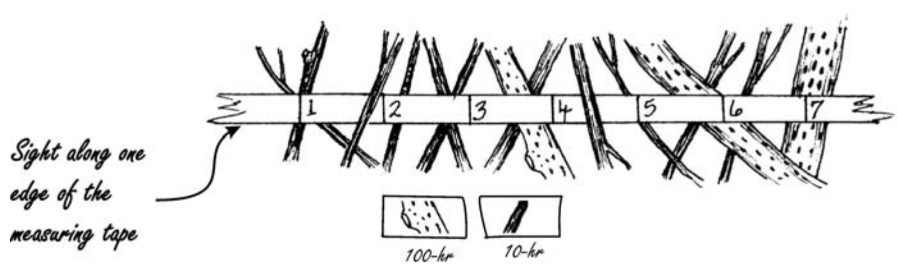


Figure FL-9. Tally pieces that intercept the sampling plane both above and below the measuring tape. Focus on one edge of the tape to make counting easier. Be sure to note any lower fuels that are hidden by pieces above. In this illustration there are 11 1-hour and 3 10-hour fuels.

Use the same basic procedure to count the 100-hour fuels that pass through the sampling plane from the 15-foot (5-meter) to the 30-foot (10-meter) marks on the tape. Report the information to the data recorder who will enter the count in Field 10 on the data sheet.

**Sampling CWD**

The CWD sampling plane is six feet (two meters) high and extends from the 15-foot (5-meter) mark to the 75-foot (25-meter) mark along the measuring tape. Sample CWD that intercepts the sampling plane and meets the dead, down and woody requirements discussed above. In general, at least two fields are recorded for each piece of CWD: diameter and decay class. Proportion of char, log length, diameter of the large end, point of intersect and estimations of volume lost to decay are additional data fields that may be collected for each piece of CWD. See the **Design Customization** section at the end of this document for more information. CWD sampling should be done by the crew member that is standing at the 75-foot (25-meter) end of the tape while moving toward the zero end. This will keep him or her out of the way of the other sampler and will reduce the chances of the FWD being inadvertently disturbed before being sampled.

Diameter measurement and decay class are determined on each piece of CWD where it passes through the sampling plane. Measure diameter perpendicular to the central axis of each piece to the nearest 0.5 inch (1 cm) (figure FL-10). If a piece crosses through the sampling plane more than once, measure it at each intersection. A diameter tape or caliper work best for diameter measurements but a ruler can give good results if it is used so that parallax error does not introduce bias (See **How to Measure Diameter with a Ruler**).

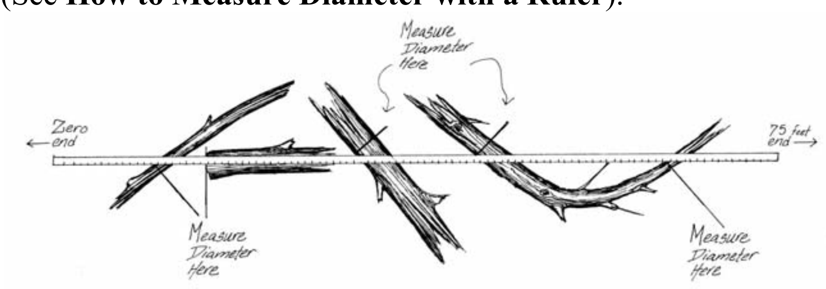


Figure FL-10. Measure the diameter of CWD crossing through the sampling plane perpendicular to the central axis of the piece. If a curved piece passes through the plane more than once measure its diameter at each intersection.

Use the descriptions in table FL-3 to determine the decay class for CWD at the same point where diameter measurement was made. Decay class can change dramatically from one end of a piece of CWD to the other and often the decay class at the point where the diameter measurement was taken does not reflect the overall decay class of the piece. However by recording the decay class at the point where diameter was measured the field crew will collect a representative sample of decay classes along each sampling plane. The transect number, sequential piece number (log number), diameter and decay class for each piece are entered in Fields 16 through 19, respectively.

Table FL-3. Use these descriptions to determine the decay class where the log crosses the sampling plane.

| Decay Class | Description |
|---|---|
| 1 | All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked |
| 2 | Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked |
| 3 | Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked |
| 4 | Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances. |
| 5 | Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned. |

**What are, "duff", "litter" and the "duff/litter profile"?**

Duff and litter are two components of the fuel complex made up of small, woody and non-woody pieces of debris that have fallen to the forest floor. Technically, packing ratio, moisture content and mineral content are used to discriminate the litter and duff layers. Samplers will find it easier identify each layer by using the following, more general, criteria. "Litter" is the loose layer made up of twigs, dead grasses, recently fallen leaves, needles 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. The duff layer is generally darker than the litter layer and is more aggregated because of the fine plant roots growing in the duff material.

The "duff/litter profile" is the cross-sectional view of the litter and duff layers. It extends vertically from the top of the mineral soil to the top of the litter layer. The FL methods use the depth of the duff/litter profile and estimation of the proportion of the total duff/litter depth that is litter to estimate the load of each component.

Litter usually burns in the flaming phase of consumption because it is less densely packed and has lower moisture and mineral content than duff, which is typically consumed in the smoldering phase. Litter is usually associated with fire *behavior* and duff, fire *effects*.

**Sampling Duff and Litter**

The duff and litter layers lie below the sampling plane so they are not sampled using the planar intercept method. Instead, duff/litter measurements are made using a duff/litter profile at two points along each sampling plane. The goal is to develop a vertical cross-section of the litter and duff layers without compressing or disturbing the profile. As samplers finish collecting DWD data they can start making the duff/litter measurements.

Duff/litter depth measurements are made at a point within 3 feet (1 meter) of the 45-foot (15-meter) and 75-foot (25-meter) marks along the tape. Follow the same instructions for each duff/litter measurement. At location, select a sampling point within a 3-foot (1-meter) radius circle that best represents the duff/litter characteristics inside the entire circle. Samplers can make the profile using a trowel or boot heel. Using a boot heel in deep duff and litter generally results in poor profiles, which, in turn, makes measurement difficult. Use the blade of the trowel to lightly scrape just the litter layer to one side. Then, return the blade to the point where the litter scrape was started, push the trowel straight down as far as possible through the duff layer and move the material away from the profile. Use the trowel to work through the duff layer until mineral soil is noted at the bottom of the profile. Mineral soil is usually lighter in color than the duff and more coarse in composition, often sandy or gravelly. If a boot is used, drive the heel down and drag it toward you. As with the trowel, continue working through the duff until mineral soil is noted. It is important to not disturb the profile by compacting it on successive scrapes. The profile that is exposed should allow an accurate measurement of duff/litter depth (figure FL-11).

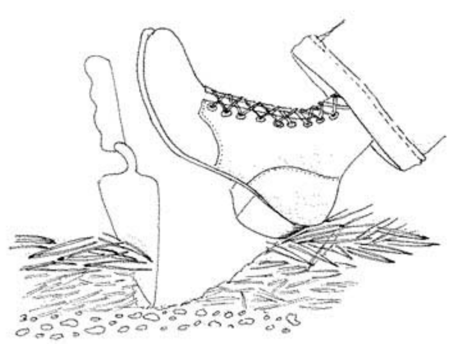

Figure FL-11. Use you boot to carefully pull the litter and duff layers away, until you are down to mineral soil.

Use a plastic ruler to measure total depth of the duff/litter profile to the nearest 0.1 in. (0.2 cm). Place the zero end at the point where the mineral soil meets the duff layer, then move either your index finger or thumb down the ruler until it is level with or just touches the top of the litter (figure FL-12). While keeping your finger in the same position on the ruler, lift the ruler out of the profile and note the duff/litter depth indicated by your finger. If your ruler is not long enough to measure the duff/litter depth use the ruler to make marks on a stick and measure the profile with the stick. If you use the stick measurement method often, get a longer ruler. Next examine the duff/litter profile and estimate the proportion of the total depth that is made up of litter, to the nearest 10 percent. Finally, report the duff/litter depth measurement and litter proportion estimate to the data recorder who will enter the data in Fields 11 and 12 or Fields 13 and 14, depending on measurement point, on the FL field form.

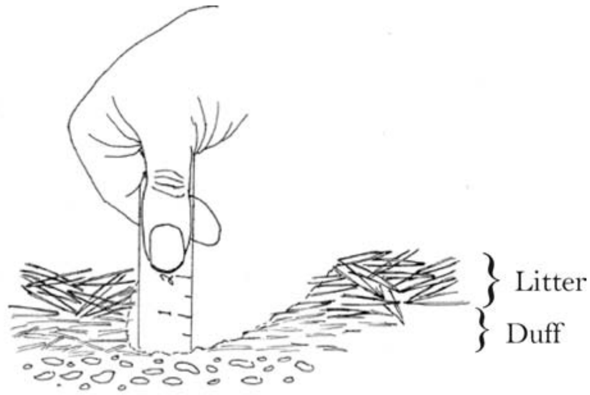


Figure FL-12. Use a plastic ruler to estimate duff and litter depth. Place the zero end at the intersection of the mineral soil and duff layer, then mark top of the litter layer using your thumb or finger. In this illustration the duff/litter depth is 2 in. (5 cm). and the proportion of that depth that is litter is about 50 percent.

Duff and litter measurements are most easily and accurately made on the vertical portion of the profile as long as that portion of the profile is representative of the true duff/litter depth (it wasn't negatively impacted when the profile was developed). Sometimes the most vertical part is where the back of the trowel blade or boot heel went in, as depicted in figures FL-11 and FL-12 and sometimes it is along one side of the profile.

**What is "woody" and "non-woody" vegetation?**

The last fuel characteristics that field crews will sample along each sampling plane are the covers of trees, shrubs and herbs. These can be divided into woody and non-woody species. Both trees and shrubs are woody species. They are easily identified because their stems persist and growth does not have to start at ground level each growing season. Trees generally have a single, unbranched stem near ground level and shrubs generally have multiple stems near ground level. Woody species can be evergreen or deciduous. Deciduous species lose their foliage at the end of the growing season, but the aerial woody portions of the plant remain. Herbs are non-woody plants whose aerial portions die back at the end of the growing season. Most field samplers will have an intuitive idea of which vegetation is woody and which is not. One way to help identify non-woody plants is to remember that, in general, weather factors, like wind, rain, snow and so forth, collapse herb foliage and stems back to or near the ground between growing seasons.

Small trees, shrubs and herbs influence fire behavior because their branches and foliage are suspended above the ground allowing more efficient heating and burning of the parts. Dense, suspended fuels can lead to fires that are difficult or impossible to control. The fires in chaparral vegetation in the western U.S. are an example. By estimating the cover and heights of woody and non-woody vegetation, fire managers can estimate the volume, density and biomass of vegetation. All three of the characteristics are strongly associated with fire behavior.

**Sampling Vegetation Cover and Height**

Estimate vegetation cover and height at the 45-foot (15-meter) and 75-foot (25-meter) marks on the measuring tape. Field crews will estimate the vertically projected cover of vegetation within a 6-foot (2-meter) tall by 6-foot (2-meter) diameter imaginary sampling cylinder. Use the marks on the measuring tape to help visualize the 6-foot (2-meter) diameter. For instance, when standing at the 45-foot (15-meter) mark, the 42-foot (14-meter) and 48-foot (16-meter) marks will identify the boundary of the cylinder along the tape. Use that measurement to get a good idea of the distance needed on each side, perpendicular to the tape, required to form the imaginary base of the cylinder. Most people have an arm's width spread that is about six feet (two meters). Each sampler should measure his or her arm span and use that measurement to help them visualize the sampling cylinder.

The cover of plants, especially of the foliage, is a function of the phenological stage of the plant. Early in the season many plants may not have completely leaved out, in mid-season plant cover reaches its maximum and then in late season plant material, especially herbaceous vegetation, moves from the live to dead class. Clearly, where vegetation is concerned, it is important to sample at the same phenological stage when monitoring and this should be taken into account when starting a monitoring program. For example, in the western U.S. fires typically burn late in the season, after maximum biomass has been reached so the best assessment of surface fuels, in terms of potential fire fuels, probably would be made later in the season. The biomass equations in FIREMON are based on oven-dry weight so when cover is equal there is no difference in biomass between live and dead plants. Fire behavior, however, may be significantly different between mid and late season because of the lower plant moisture and that is why we recommend sampling plant condition (live or dead/dormant).

Six attributes are measured at each vegetation sampling point: four cover estimations for vegetation: 1) live woody species (trees and shrubs), 2) dead woody species, 3) live non-woody species (herbs) and 4) dead non-woody species; and two height estimations are made for: 5) the woody component and 6) the non-woody component. "Cover" is the vertically projected cover contributed by each of the four categories within the sampling cylinder. It includes plant parts from plants rooted in the sampling cylinder and plant parts that project into the sampling cylinder from plants rooted outside, for instance, live and dead branches. Estimate cover by imagining all the vegetation in the class being sampled, say live shrub cover, compressed straight down to the ground. The percent of the ground covered by the compressed vegetation inside the 6-foot (2-meter) diameter sampling area what is being sampled. The cover of dead branches on a live plant should be included in the dead cover estimate. We recommend not including the cover of the cross-sectional area of vertically oriented single stemmed trees in the live or dead woody cover estimate. The stems don't really count as surface fuel because they do not contribute much to fire behavior or fire effects. Also, if the sampling cylinder was located on an area with an unusually high number of tree stems the vertical projection of the foliage would probably be overlapping the area of the stems, thus the actual cover would be the same with or without the stems. See **How To Estimate Cover** for hints on how to estimate cover accurately.

Two conditions make cover estimations difficult and, frequently, inaccurate. First, the equations used to estimate biomass assume that all of the plant parts for each species are included in the cover and height estimation. In other words, if looking at the cover of a woody shrub species, samplers need to estimate the cover of all the parts, even things like the foliage, which are not "woody". Second, estimating cover is not something people do very often; it is only with practice and experience that good estimations of plant cover can be made. Fortunately, the cover classes used in FIREMON are typically 10 percent so the precision of cover estimates are secondary to accuracy (table FL-4).

Table FL-4. Cover of each of the four vegetation categories is recorded on the field form in one of the following classes.

| Code | Cover |
|---|---|
| 0 | No cover |
| 0.5 | >0-1 percent cover |
| 3 | >1-5 percent cover |
| 10 | >5-15 percent cover |
| 20 | >15-25 percent cover |
| 30 | >25-35 percent cover |
| 40 | >35-45 percent cover |
| 50 | >45-55 percent cover |
| 60 | >55-65 percent cover |
| 70 | >65-75 percent cover |
| 80 | >75-85 percent cover |
| 90 | >85-95 percent cover |
| 98 | >95-100 percent cover |

In addition to the cover estimates, samplers will make two height estimates at each vegetation sampling location, one for the average height of the live and dead woody species and one for the average height of the live and dead non-woody species. Make your height estimate by noting the maximum height of all the plants in the class and then recording the typical or average of all the maximum heights. Some people like to envision a piece of plastic covering just the plants in one class then estimating the average height of the plastic above the ground. Either method will work and give answers that are of adequate precision. Estimate height to the nearest 0.5 foot (0.2 m). Remember, for both the cover and height estimation; only include the vegetation that is within the sampling cylinder. A fast way to make accurate height assessments is for samplers to measure their ankle, knee and waist heights then estimate vegetation height based on those points. See **How To Measure Plant Height** for more information.

Record the vegetation cover classes and height data in Fields 22 through 33 on the FL Field Form.

**Finishing Tasks**

The most critical task before moving to the next sampling plane or plot is to make certain that all of the necessary data has been collected. This task is the responsibility of the data recorder. Also, the recorder should write down any comments that might be useful. For instance, you might comment on some unique characteristic on or near the plot that will help samplers relocate the plot. Include notes about other plot characteristics such as, "evidence of deer browse" or, "deep litter and duff around trees". Finally, collect the sampling equipment and move ahead to start sampling the next plane.

**Successive Sampling Planes**

On each FL plot the field crew will collect data for at least three sampling planes. (If you are re-sampling an existing FL plot read the **Re-sampling FL Plots** section, below). Follow the FL plot design in figure FL-13. The first sampling plane is always oriented at an azimuth of 090 degrees true north, the second is oriented 330 degrees and the third, 270 degrees.

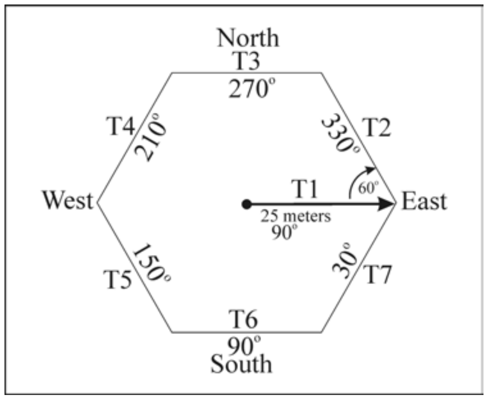


Figure FL-13. The FL plot design allows a representative sample of DWD to be obtained while reducing or eliminating the bias introduced by non-randomly oriented pieces. Data are collected on and along three to seven sampling planes.

Planes are oriented in multiple directions to avoid bias that could be introduced by DWD pieces that are not randomly oriented on the forest floor. The DWD biomass estimate with the FL methods is an average across all of the sampling planes.

It is not necessary for one sampling plane to start at the exact 75-foot (25-meter) mark of the previous one. In fact it is better if the start of the new line is five or so feet away from the end of the last so that the activity around the new start does not adversely impact the fuel characteristics at the end of the last one. The duff/litter layer and woody and non-woody vegetation at the 75-foot (25-meter) mark, in particular, can be disturbed by field crew traffic and that can bias the data when the plot is re-sampled. Make sure that no portion of the new sampling plane will be crossing fuels that were sampled on the previous plane. Once the start of the new sampling plane has been determined, collect the data as you did on the first plane. Look ahead and see which starting point will guarantee a straight line before you start laying out the next sampling plane. If the sample sampling planes are going to be re-measured be sure to carefully mark 0-foot and 75-foot end of each sampling plane.

**Determining the Number of Sampling Planes**

After the crew has finished sampling three planes the data recorder will sum up the counts of all the DWD pieces (1-hour, 10-hour, 100-hour and 1000-hour pieces) and if that number is greater than 100 then the crew is finished sampling DWD for the plot. If the count is less than 100 then the crew needs to sample another line. If another line is needed, refer to the FL plot design (figure FL-13), lay out the next sampling plane and collect the FL data. When finished with that plane, recalculate the DWD piece count. Again, if the count is greater than then 100 the sampling is finished; if not, another plane needs to be sampled. Continue sampling until either total piece count is greater than 100 or seven planes have been sampled. Once sampling has begun on a sampling plane, data must be collected for the *entire* plane. When the sampling is completed record the number of planes that you sampled in Field 5 of the FL data form.

DWD is only one part of the surface fuels complex. The 100-piece rule is also meant to help guide the sample size for the duff, litter and vegetation components of the complex. Thus, even if there is little DWD, the duff, litter and vegetation should be sampled sufficiently. Conversely, if you are sampling numerous pieces of DWD, in principal that material should be carrying most of the fire so a reduced number litter, duff and vegetation assessments should not be an issue. If this is not the case modify your plot level sampling so you get dependable estimates of all the FL components. Record any sampling modifications in the Metadata table for the project.

There are two potential shortcomings that can be encountered when using the 100-piece rule. First, the greater the clumping or aggregation of fuels on the forest floor the greater the opportunity of having a high number of piece counts on one or more sampling planes. These clumps can lead to an overestimation of DWD biomass. For example, say that as an experiment a field crew wants to compare biomass values using the 100-piece rule vs. sampling with five sampling planes. The first three sampling planes are in the exact same location for the comparison. In the experiment it just happens that the third plane crosses over a spot where there is an accumulation of FWD and when the third sampling plane was finished the crew had sampled 112 pieces – the end of sampling for the 100-piece rule data. They continued to sample two more planes for their five-plane comparison but recorded no more data because the planes crossed a small grassy area. Back at the office they ran their data through the FIREMON database and noted that they sampled 5.3 tons/acre of material using the 100-piece rule but only 3.2 tons/acre when five sampling planes were used even though in the field they sampled exactly the same pieces. This is because the tons/acre value that comes from the planar intercept calculation is the average across all of the planes sampled. In the first case the denominator was 3 and in the second it was 5. The example presents an extreme case but recognize that any aggregation of fuels can lead to overestimation - and always an overestimation - and the earlier in the sampling plane sequence that the aggregation is encountered the greater the opportunity for overestimation. The second shortcoming of the 100-piece rule is that, for comparison, when plots are re-sampled the number of sampling planes has to be the same as the first time the plot was sampled. It can be time consuming (and presents an opportunity for errors) to look up all of the original plots in the database and note the number of planes sampled at each. Despite these shortcomings, the 100-piece rule works well most of the time and frees the FIREMON architect from determining the number of planes that will need to be sampled on each plot of the project. Finally, the 100-piece rule is especially useful in inventory sampling where plots are sampled only once.

If the 100-piece rule is not used for the DWD sampling then the architect must determine the number of sampling planes that will be used throughout the project. The task is to sample with sufficient intensity to capture the variation while not wasting time sampling too intensively. This is made more difficult when fuels vary greatly across the project area. Assuming that the project funding is not limiting the sampling intensity, we suggest determining the number of sampling planes per plot using a pilot study. Install pilot plots in the study area or a similar ecosystem and sample using the 100-piece rule (you don't need to measure any attributes, just count pieces of DWD). Be sure to put plots in areas representing the range of DWD piece densities you will be sampling in your study area. Depending on the variability of the fuels, after sampling 10 or 20 plots you will be able to identify a good number of sampling planes to use in your project. You should pick the number that lets you meet the 100-piece limit on at least 80 percent of you plots. For example, say that you had 20 plots in your pilot study and the number of sampling planes needed to count 100 pieces at each plot was:

| | |
|---|---|
| 3 sampling planes | 2 plots |
| 4 sampling planes | 5 plots |
| 5 sampling planes | 10 plots |
| 6 sampling planes | 3 plots |

Then for your project you could use five sampling planes per plot and be getting sufficient estimates of DWD. (Be sure to enter this information in Field 5 on each plot form and make a note of the methods used to determine the number of sampling planes for the project in the Metadata table.) We suggest an absolute minimum of three planes per plot be sampled for the DWD. Generally, DWD is the most variable of the FL attributes so the duff, litter and vegetation sampling intensity should be adequate when sampled at the DWD intensity.

**Re-sampling FL Plots**

The FL methods are unique in FIREMON in that they allow a variable number of sampling planes on each FL plot, based on piece count. When re-sampling a FL plot always sample the same number of planes as were sampled when the plot was sampled the *first* time. Never use the 100-piece rule when re-sampling. Instead look through the FIREMON database and record the number of sampling planes that were used when each plot was first sampled, and then sample only that number in subsequent sampling.

**What If…**

'No matter where I start my next line, it runs off a cliff'. There is no way that we can foresee every problem samplers will encounter in the field. The best way for a crew to deal with unique situations is to apply the FL methods as well as they can in order to sample the appropriate characteristics based on the project objectives, then make a record in the comments section of what was encountered and how it was handled. For instance, if a crew *were* going to lay out a line that was headed off a cliff then the crew would use the next azimuth from the FL plot design and lay out the sampling plane in that direction.

## Precision Standards

Use these standards when collecting data with the FL methods (table FL-5).

Table FL-5. Precision guidelines for FL sampling.

| Component | Standard |
|---|---|
| Slope | ±5 percent |
| FWD | ±3 percent |
| CWD diameter | ±0.5 in./1 cm |
| CWD decay class | ±1 class |
| Duff/litter depth | ±0.1 in./0.2 cm |
| Percent litter estimation | ±10 percent |
| Vegetation cover estimation | ±1 class |
| Vegetation height estimation | ±0.5 ft/0.2 m |

## SAMPLING DESIGN CUSTOMIZATION

### Recommended FL Sampling Design

**Number of sampling planes:** Minimum: 3, Maximum: 7. Continue sampling until count of pieces, across all sizes, is greater than 100. If you are re-sampling an existing plot use the same number of planes as were used in the initial survey.
**Duff/Litter depth measurements per plane:** 2
**Vegetation assessments per plane:** 2
**Large debris piece measurements:** Diameter and decay class

### Streamlined FL Sampling Design

**Number of line sampling planes:** 3. If you are re-sampling an existing plot use the same number of planes as were used in the initial survey.
**Duff/Litter depth measurements per plane:** 2
**Vegetation assessments per plane:** 2
**Large debris piece measurements:** Diameter and decay class

### Comprehensive FL Sampling Design

**Number of sampling planes:** 7. If you are re-sampling an existing plot use the same number of planes as were used in the initial survey.
**Duff/Litter depth measurements per plane:** 2
**Vegetation assessments per plane:** 2
**Large debris piece measurements:** Diameter and decay class

**Optional Fields**

**Proportion of log that is charred** – Measured to assess extent and severity of fire. Record the proportion of the surface, of each individual piece of CWD passing through the sampling plane, that has been charred by fire using the classes in table FL-6.

Table FL-6. Assign the amount of surface charred by fire, for each piece of CWD; into one of these char classes.

| Class | Char |
|---|---|
| 0 | No char |
| 0.5 | >0-1 percent charred |
| 3 | >1-5 percent charred |
| 10 | >5-15 percent charred |
| 20 | >15-25 percent charred |
| 30 | >25-35 percent charred |
| 40 | >35-45 percent charred |
| 50 | >45-55 percent charred |
| 60 | >55-65 percent charred |
| 70 | >65-75 percent charred |
| 80 | >75-85 percent charred |
| 90 | >85-95 percent charred |
| 98 | >95-100 percent charred |

**Diameter at large end of log –** Measured for wildlife concerns. Record the diameter of the large end of the log to the nearest inch (2 cm). If a piece is broken but the sections are touching consider that one log. If the broken sections are not touching then consider them two logs and record the diameter of the large end of the piece that is passing through the sampling plane.

**Log length** – Important for wildlife concerns and useful for rough determination of piece density. Record length of CWD to the nearest 0.5 feet (0.1 m). If a piece is broken but the two parts are still touching then record the length end-to-end (A) or sum the lengths for broken pieces not lying in a straight line (B). If piece is broken and the two parts are not touching then only measure the length of the piece that intercepts the sampling plane (C).

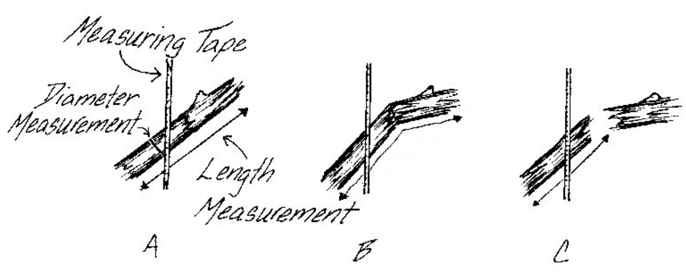


Figure FL-14. Log length and diameter measurement for optional CWD data. In each case the diameter measurement is made at the same point. In A and B the broken pieces are touching so length includes both pieces. In C, only the piece crossed by the measuring tape is measured for length.

**Distance from beginning of line to log** – This measurement makes relocation of specific logs easier which is especially important when calculating fuel consumption on a log-by-log basis. Frequently, logs that were included in pre-fire sampling roll away from the sampling plane during a fire while other logs, not originally sampled, roll into the plane. Recording the distance from the start of the line, in addition to permanently marking the logs with tags, will make post-fire sampling easier. Record the distance from the start of the measuring tape to the point where the diameter was measured.

**Proportion of log that is hollow** – This characteristic is important for wildlife concerns but also allows more accurate estimates of carbon. Estimate the percent diameter and percent length that has been lost to decay. Record data using the classes in table FL-7.

Table FL-7. Use these classes for recording the percent of diameter and length lost to rot in CWD.

| Class | Lost to decay |
|---|---|
| 0 | No Loss |
| 0.5 | >0-1 percent lost |
| 3 | >1-5 percent lost |
| 10 | >5-15 percent lost |
| 20 | >15-25 percent lost |
| 30 | >25-35 percent lost |
| 40 | >35-45 percent lost |
| 50 | >45-55 percent lost |
| 60 | >55-65 percent lost |
| 70 | >65-75 percent lost |
| 80 | >75-85 percent lost |
| 90 | >85-95 percent lost |
| 98 | >95-100 percent lost |

# Fuel Load (FL) Form



Plot Key

RegistrationID: _ _ _ _
ProjectID: _ _ _ _ _ _ _ _ _
PlotID: _ _ _
Date: _ _/_ _/_ _ _ _

| Measurement Distances ft / m | Field 1 | Field 2 | Field 3 | Field 4 | Field 5 |
|---|---|---|---|---|---|
| | 1-hour | 10-hr | 100-hr | 1000-hr | # of Transects |
| | | | | | |

## FL Table 1 - Fine Woody Debris (<3in / <8cm) - Duff & Litter

| Field 6 | Field 7 | Field 8 | Field 9 | Field 10 | Field 11 | Field 12 | Field 13 | Field 14 | Field 15 |
|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Slope % | 1-hr | 10-hr | 100-hr | Duff/Litter Depth 1 (in/cm) | Litter % 1 | Duff/Litter Depth 2 (in/cm) | Litter % 2 | Local Code |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |

Notes/Dot Tally Space:

Crew:

## FL Table 2 - Coarse Woody Debris (>3in / >8cm)

| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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# Fuel Load (FL) Form

FL Page _ _ of _ _

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _

PlotID: _ _ _

Date: _ _/_ _/_ _ _ _

Notes

## FL Table 2 - Continuation
## Coarse Woody Debris - Duff & Litter (<3in / <8cm)

| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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| Field 16 | Field 17 | Field 18 | Field 19 | Field 20 |
|---|---|---|---|---|
| Transect Number | Log Number | Diameter (in/cm) | Decay Class | Local Code |
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# Fuel Load (FL) Form

Plot Key
RegistrationID: _ _ _ _
ProjectID: _ _ _ _ _ _ _ _ _ _
PlotID: _ _ _
Date: _ _/_ _/_ _ _ _

FL Page _ _ of _ _

## FL Table 3 - Vegetation Data

| Field 21 | Field 22 | Field 23 | Field 24 | Field 25 | Field 26 | Field 27 | Field 28 | Field 29 | Field 30 | Field 31 | Field 32 | Field 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect | Live Tree/Shrub Cover 1 | Dead Tree/Shrub Cover 1 | Average Tree/Shrub Height 1 (ft/m) | Live Herb Cover 1 | Dead Herb Cover 1 | Average Herb Height 1 (ft/m) | Live Tree/Shrub Cover 2 | Dead Tree/Shrub Cover 2 | Average Tree/Shrub Height 2 (ft/m) | Live Herb Cover 2 | Dead Herb Cover 2 | Average Herb Height 2 (ft/m) |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |

Notes:

# FIREMON
# FUEL LOAD (FL) FIELD DESCRIPTIONS

Field 1: **1-Hr.** Sampling plane length for the 1-hour fuels (ft/m).

Field 2: **10-Hr.** Sampling plane length for the 10-hour fuels (ft/m).

Field 3: **100-Hr.** Sampling plane length for the 100-hour fuels (ft/m).

Field 4: **1000-Hr.** Sampling plane length for the 1000-hour fuels (ft/m).

Field 5: **Number of Planes.** Number of sampling planes/transects that the data was recorded along. (One "plane" includes data for the 1-hr through 1000-hr fuels.)

**Table 1. FWD, litter and duff.**

Field 6: **Plane/Transect Number.** Sampling plane/transect number for data recorded in Fields 7 to 15.

Field 7: **Slope.** (percent). Slope of the sampling plane. Precision: ±5 percent.

Field 8: **1-hour Count.** Count of pieces in the 1-hour size class (0-0.25 in.). Precision: ±3 percent total count.

Field 9: **10-hour Count.** Count of pieces in the 10-hour size class (0.25-1.0 in.). Precision: ±3 percent total count.

Field 10: **100-hour Count.** Count of pieces in the 100-hour size class (1.0-3.0 in.). Precision: ±3 percent total count.

Field 11: **D/L Depth 1.** (in./cm). Duff/litter depth measured at the first location. Precision: ±0.1 in./0.2 cm.

Field 12: **Litter Percent 1.** Percent of the total duff/litter depth that is litter at the first location. Precision: ±10 percent.

Field 13: **D/L Depth 2.** (in./cm) Duff/litter depth measured at the second location. Precision: ±0.1 in./0.2 cm.

Field 14: **Litter Percent 2.** Percent of the total duff/litter depth that is litter, at the second location. Precision: ±10 percent.

Field 15: **Local Code.** Optional data field.

**Table 2. CWD**

Field 16: **Plane/Transect Number.** Sampling plane/transect number for CWD data recorded in Fields 17 to 20.

Field 17: **Log Number.** Log number, numbered sequentially by transect.

Field 18: **Diameter.** (in./cm). Diameter of the piece measured perpendicular to the longitudinal axis. Precision: ±0.5 in/1 cm.

Field 19: **Decay Class.** Decay class of the log where it crosses the plane. Valid classes are in table FL-3 of the sampling method. Precision: ±1 class

Field 20: **Local Code.** Optional data field.

**Table 3. Vegetation.**

Field 21: **Plane/Transect.** Sampling plane/transect number for vegetation measurements recorded in Fields 22 to 33.

Field 22: **Live Tree/Shrub Cover 1.** Cover class of live trees and shrubs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 23: **Dead Tree/Shrub Cover Class 1.** Cover class of dead trees and shrubs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 24: **Average Tree/Shrub Height 1.** (ft/m). Average height of live and dead tree/shrub component at the first sampling location. Precision: ±0.5 ft/0.2 m.

Field 25: **Live Herb Cover 1.** Cover class of live herbs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 26: **Dead Herb Cover 1.** Cover class of dead herbs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 27: **Average Herb Height 1.** (ft/m). Average height of live and dead herb component at the first sampling location. Precision: ±0.5 ft/0.2 m.

Field 28: **Live Tree/Shrub Cover 2.** Cover class of live trees and shrubs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 29: **Dead Tree/Shrub Cover 2.** Cover class of dead trees and shrubs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 30: **Average Tree/Shrub Height 2.** (ft/m). Average height of live and dead tree/shrub component at the second sampling location. Precision: ±0.5 ft/0.2 m.

Field 31: **Live Herb Cover 2.** Cover class of live herbs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 32: **Dead Herb Cover 2.** Cover class of dead herbs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.

Field 33: **Average Herb Height 2.** (ft/m). Average height of live and dead herb component at the second sampling location. Precision: ±0.5 ft/0.2 m.

## FIREMON
## FUEL LOAD (FL) EQUIPMENT LIST

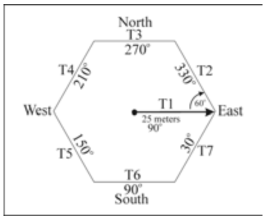
0.25 in. diameter by 3 in. long dowel.
1.0 in. diameter by 3 in. long dowel.
75-foot tape
Bridge spikes
Clipboard
Compass
Clear plastic six-inch ruler (w/0.1 in. gradations)
Clinometer (with percent scale)
Diameter tape, caliper, yardstick or similar (w/0.1 in. gradations)
    for measuring large log diameter
Field Notebook
FL cheatsheet
FL data forms
Hard hat
Pencils/pens
Small stakes or rebar
Survey flags

Optional

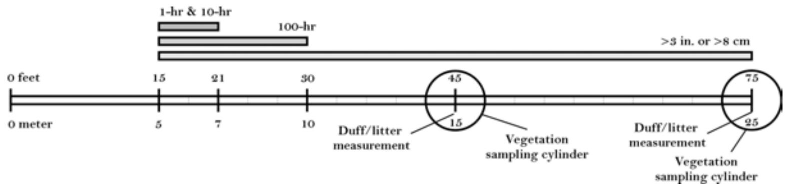
Go/No-Go gauge (see DF Sampling Methods for details)
Hammer, hatchet or big rock to pound in bridge spikes.

# FIREMON FL Cheat Sheet

**Plot layout**




**Sampling plane layout**




**Cover Classes**

| Class | Cover |
|---|---|
| Code | Canopy cover |
| 0 | Zero percent canopy cover |
| 0.5 | >0-1 percent of canopy cover |
| 3 | >1-5 percent canopy cover |
| 10 | >5-15 percent canopy cover |
| 20 | >15-25 percent canopy cover |
| 30 | >25-35 percent canopy cover |
| 40 | >35-45 percent canopy cover |
| 50 | >45-55 percent canopy cover |
| 60 | >55-65 percent canopy cover |
| 70 | >65-75 percent canopy cover |
| 80 | >75-85 percent canopy cover |

**Piece Sizes**

| Dead Woody Class | | | Piece Diameter (in.) |
|---|---|---|---|
| DWD | FWD | 1-hr | 0 to 0.25 |
| | | 10-hr | 0.25 to 1.0 |
| | | 100-hr | 1.0 to 3.0 |
| | CWD | 1000-hr and greater | 3.0 and greater |

**CWD Decay Class**

| Decay Class | Description |
|---|---|
| 1 | All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked |
| 2 | Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked |
| 3 | Most of the bark is missing and most of the branches less than 1 in. in diameter also missing. Still hard when kicked |
| 4 | Looks like a class 3 log but the sapwood is rotten. Sounds hollow when kicked and you can probably remove wood from the outside with your boot. Pronounced sagging if suspended for even moderate distances. |
| 5 | Entire log is in contact with the ground. Easy to kick apart but most of the piece is above the general level of the adjacent ground. If the central axis of the piece lies in or below the duff layer then it should not be included in the CWD sampling as these pieces act more like duff than wood when burned. |

**Task list**

| | Crew member - task number | | |
|---|---|---|---|
| Task | Recorder | Sampler 1 | Sampler2 |
| Organize materials | 1 | | |
| Layout tape | | 1 (guider) | 1 (guidee) |
| Measure slope | 2 (record data) | 2 | 2 |
| Count FWD | 3 (record data) | 3 | |
| Measure duff/litter and veg. at 75-foot mark | 4 (record data) | | 3 |
| Measure CWD | 5 (record data) | | 4 |
| Measure duff/litter and veg. at 45-foot mark | 6 (record data) | 4 | |
| Check for complete forms | 7 | | |
| Collect equipment | | 5 | 5 |

**Precision**

| Component | Standard |
|---|---|
| Slope | ±5 percent |
| FWD | ±3 percent |
| CWD diameter | ±0.5 in./1 cm |
| CWD decay class | ±1 class |
| Duff/litter depth | ±0.1 in./0.2 cm |
| Percent litter estimation | ±10 percent |
| Vegetation cover estimation | ±1 class |
| Vegetation height estimation | ±0.5 ft/0.2 m |

# **Species Composition (SC)**
# Sampling Method

EXECUTIVE SUMMARY

The FIREMON Species Composition (SC) method is used to provide ocular estimates of cover and height measurements for plant species on a macroplot. The SC method provides plant species composition and cover estimates to describe a stand or plant community and can be used to document changes over time. It is suited for a wide variety of vegetation types and is especially useful in plant communities with tall shrubs or trees. The method is relatively fast and efficient to conduct in the field and facilitates sampling many sites over large areas using few examiners. The SC method does not quantify the variability within a plot and cannot be used to detect statistically significant changes over time.

## INTRODUCTION

The Species Composition (SC) method is designed to provide plant species composition, and cover and height estimates to describe the plant community found on the FIREMON plot. This method uses a circular macroplot to record plant species characteristics. Cover, height, and optional user specific attributes are recorded for each plant species or ground cover within the macroplot. Plant height is measured in feet or meters.

This method is primarily used when the user wants to acquire inventory data over large areas using few examiners. The SC method is useful for documenting important changes in plant species cover and composition over time. However, this method is not designed to monitor statistically significant changes in vegetation over time due to the subjective nature of the cover estimations. The SC sampling method primarily addresses individual plant species cover and height for vascular and non-vascular plants, by size class.

Cover is an important vegetation attribute which is used to determine the relative influence of each species on a plant community. Cover is a commonly measured attribute of plant community composition because small, abundant species and large, rare species have comparable cover values. In FIREMON we record foliar cover as the vertical projection of the foliage and supporting parts onto the ground. Therefore, total cover on a plot can exceed 100 percent due to overlapping layers in the canopy. When cover is summed by size class, the total cover can equal more than 100 percent for a plant species due to overlap in the canopy between the different size classes.

Ocular estimates of cover are usually based on cover classes. The two most common are Daubenmire (1959) and Braun-Blanquet (1965). The range of cover values, 0 to 100 percent, are divided into classes, and each class is assigned a rating or number. In broadly defined cover classes, there is little chance for consistent human error in assigning the cover class (Daubenmire, 1959). The lowest cover classes are sometimes split into finer units (Jensen and others 1994, Bailey and Poulton 1968), since many species fall into the lowest cover classes. These systems are more sensitive to species with low cover. A finer breakdown of scale toward the lower scale values allows better estimation of less abundant species. In FIREMON we use a cover class system which splits the lowest classes into finer units. The midpoint of each class can be used for numerical computations. The use of midpoints for actual values is based on the assumption that actual cover values are distributed symmetrically about the midpoint.

Plant height measurements are used to estimate the average height of individual species or species by size class. Plant heights give detailed information about the vertical distribution of plant species cover on the plot. In addition, height measurements allow the examiner to calculate plant species volume (cover x height) and to estimate biomass using the appropriate biomass equations based on cover and height. Plant height is measured with a yard stick (or meter stick) for small plants (<10 ft or 3 m) and with a clinometer for larger plants (>10 ft or 3 m).

There are many ways to streamline or customize the SC sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific SC Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

The SC sampling procedure is presented in the order of the fields that need to be completed on the SC data form, so it is best to reference the SC data form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Preliminary Sampling Tasks

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation life form you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, use the test plot as an opportunity to check sampler's cover estimates by applying the point intercept method on the same plot and comparing the two. It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.

Many preparations must be made before proceeding into the field for SC sampling. First, all equipment and supplies in the **SC Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All SC Plot Forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future remeasurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. We found that it is very easy to transpose UTM coordinate digits when recording georeferenced positions on the plot sheet, so marked maps can help identify any erroneous plot positions. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

A field crew of two people is probably the most efficient for implementation of the SC sampling method. There should never be a one-person field crew for safety reasons, and any more than two people will probably result in some people waiting for critical tasks to be done and unnecessary trampling within the macroplot. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most cover and height measurements. However, the SC form can easily be completed by one person, so it may be best for the other crew member to fill out other data forms or perform other FIREMON tasks. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency, but sampling tasks should be modified as the field crew gains experience. Tasks should also be shared to limit monotony.

**Designing the SC Sampling Method**

There is a set of general criteria recorded on the SC Plot form that forms the user-specified design of the SC sampling method. Each general SC field must be designed so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be determined before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project.

*Plot ID construction*

A unique plot identifier must be entered on the CF data form.  This is the same plot identifier used to describe general plot characteristics in the Plot Description or PD sampling method. See **How to Construct a Unique Plot Identifier** for details on constructing a unique plot identifier. Enter the plot identifier at the top of the SC data form.

*Macroplot size*

The typical macroplot sampled in the SC method is a 0.10 acre (0.04 ha) circular plot having a radius of 37.2 ft. (11.28 m). This plot size will be sufficient for most forest ecosystems and should be used if no other information is available. It is more efficient to use the same macroplot shape and size for all the FIREMON sampling methods on the plot so if you are using other FIREMON sampling methods which require a baseline and transects then a rectangular plot of 66 ft. x 66 ft. (20 m x 20 m) should be used. For example, if the FIREMON DE method is being used to estimate density for some species, or if ocular cover is being calibrated using the FIREMON CF or LI methods, then use a rectangular macroplot. The macroplot radius or length and width are recorded in Fields 7 and 8 on the PD data form. See **How To Establish Plots with Multiple Methods** if you are sampling with more than one method.

*Plant species ID level*

This field is used to determine the sampling level intensity for the SC method. Enter the percent cover above which all plants are identified in Field 1 on the SC data form. For example, if you were interested in only sampling plants with at least 5 percent cover then the number 5 would be entered in Field 1. Entering a 0 (zero) in this field indicates that all plant species on the plot will be identified (i.e. a full species will be recorded). Since most changes in plant species cover occur in species that are already present on the plot, full species lists should be collected when feasible. Full species lists are especially useful if your data will be analyzed for biodiversity calculations, community classification, or species inventory. For example, since biodiversity calculations use the number of individual species as part of the calculation, it is important that each species be recorded.

## Conducting the SC Sampling Tasks

*Initial plot survey*

Once the plot boundary is delineated (see **How to Define the Boundaries of a Macroplot)**, walk around the plot and become familiar with the plant species and vegetation layers. As you go, use Field 2 to record species and ground cover codes you identify. Only record the items that you are interested in sampling. For example, if you are only interested in monitoring the cover of noxious weeds you only have to record those species in Field 2.

FIREMON provides plant species codes from the NRCS Plants database. However, local or customized plant species codes are also allowed in FIREMON. See **How to Customize Plant Species Codes** for more details. Codes other than plant species codes may also be entered in this field. For example, users may enter codes for estimating cover of snags or downed wood on the plot. See the section on **User-specific SC sampling design** below for more details.

After examining the macroplot, return to the center and start to record cover and height for all appropriate plant species as described below.

*Sampling cover*

Starting with the first species on you list, enter the plant species status in Field 3 on the SC data form. Status describes the general health of the plant species as live or dead using the following codes:

**L – Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

Plant status is purely qualitative but it does provide an adequate characteristic for stratification of pre-burn plant health and in determining post-burn survival.

*Size class*

Plant species size classes represent different layers in the canopy. For example, the upper canopy layer could be defined by large trees, while pole size trees and large shrubs might dominate the middle layer of the canopy, and the lower canopy layer could include seedlings, saplings, grasses and forbs. Size class data provide important structural information such as the vertical distribution of plant cover. Size classes for trees are typically defined by height for seedlings and diameter at breast height (DBH) for larger trees. Size classes for shrubs, grasses, and forbs are typically defined by height. If the vegetation being sampled has a layered canopy structure, then cover can be recorded by plant species and by size class. Total size class cover for a plant species can equal more than 100 percent due to overlap between different size classes.

FIREMON uses a size class stratification based on the ECODATA sampling methods (Jensen and others, 1994). Group individual plants by species into one or more tree size classes (table SC-1) or shrub, grass, and forb size classes (table SC-2). There can be multiple size classes for each plant species. See **How To Measure DBH** for detailed information on measuring DBH to group trees into size classes. See **How to Measure Plant Height** for detailed information on measuring height for grouping shrubs into size classes.

Table SC-1. Tree size class codes.

| Tree Size Class Codes | Tree Size Class English | Tree Size Class Metric |
|---|---|---|
| TO | Total cover | Total cover |
| SE | Seedling (<1 in. DBH or <4.5 ft height) | Seedling (<2.5 cm DBH or <1.5 m height) |
| SA | Sapling (1.0 in. - < 5.0 in. DBH) | Sapling (2.5 - <12.5 cm DBH) |
| PT | Pole Tree (5.0 in. – <9.0 in. DBH) | Pole Tree (12.5 – <25 cm DBH) |
| MT | Medium Tree (9.0 in. – <21.0 in. DBH) | Medium Tree (25 – <50 cm DBH) |
| LT | Large Tree (21.0 in. – <33.0 in. DBH) | Large Tree (50 – <80 cm DBH) |
| VT | Very Large Tree (33.0+ in. DBH) | Very Large Tree (80+ cm DBH) |
| NA | Not Applicable | Not Applicable |

Table SC-2. Shrub, grass, and forb size class codes.

| Shrub / Herb Size Class Codes | Shrub / Herb Size Class English | Shrub / Herb Size Class Metric |
|---|---|---|
| TO | Total cover | Total cover |
| SM | Small (<0.5 ft height) | Small (<0.15 m height) |
| LW | Low (0.5 - <1.5 ft height) | Low (0.15 - <0.5m height) |
| MD | Medium (1.5 – <4.5 ft height) | Medium (0.5 – <1.5 m height) |
| TL | Tall (4.5 – <8 ft height) | Tall (1.5 – <2.5 m height) |
| VT | Very Tall (8+ ft height) | Very Tall (2.5+ m height) |
| NA | Not Applicable | Not Applicable |

If you are recording cover by size class, enter the size class code for each plant species in Field 4 on the SC data form. If size class data is not recorded, then record only the total cover for each plant species. When recording total cover for a species, use the code "TO", for "total" Cover.

*Estimating cover*

Cover is the vertical projection of the foliage and supporting parts onto the ground (figure SC-1). See **How to Estimate Cover** for more details. When estimating total cover for a plant species, do not include overlap between canopy layers of the same plant species (figure SC-2). When estimating cover by size classes for a plant species, the cover for each size class is recorded and includes canopy overlap between different size classes (figure SC-3). Select one of the following cover class codes (table SC-3) to describe the cover estimate for the species. Enter the cover class code in Field 5 on the SC data form.

Table SC-3. Cover class codes.

| Code | Cover Class |
|---|---|
| 0 | Zero percent cover |
| 0.5 | >0-1 percent cover |
| 3 | >1-5 percent cover |
| 10 | >5-15 percent cover |
| 20 | >15-25 percent cover |
| 30 | >25-35 percent cover |
| 40 | >35-45 percent cover |
| 50 | >45-55 percent cover |
| 60 | >55-65 percent cover |
| 70 | >65-75 percent cover |
| 80 | >75-85 percent cover |
| 90 | >85-95 percent cover |
| 98 | >95-100 percent cover |

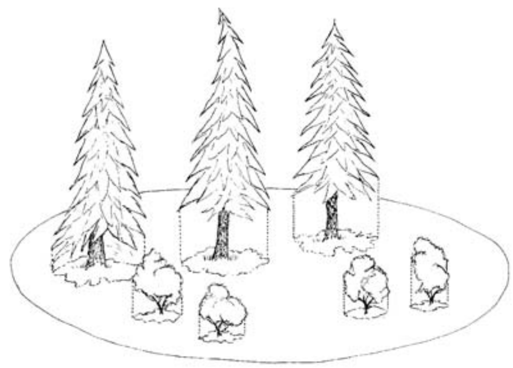


Figure SC-1. Cover is estimated as the vertical projection of vegetation onto the ground.

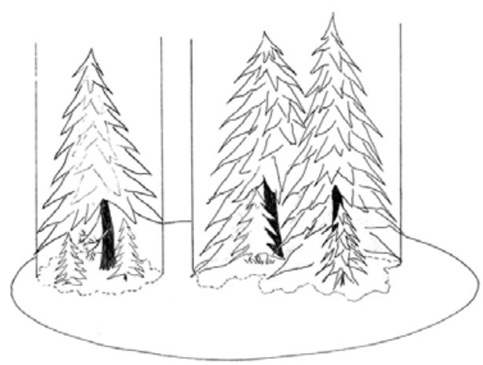


Figure SC-2. Estimating total cover for plant species with overlapping canopies. In this figure the small trees underneath the canopy of the larger trees are the same plant species. Cover is estimated as the projection of the large tree canopy onto the ground, which overlaps the canopy of the smaller trees.

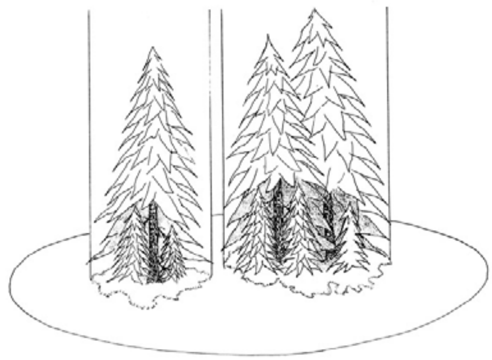


Figure SC-3. Estimating cover by size class for plant species. In this figure the small trees underneath the canopy of the larger trees are the same plant species but a different size class (e.g. seedlings and saplings). Cover is estimated separately for each size class.

*Measuring average height*

Measure the average height for each plant species in feet (meters) within +/- 10 percent of the mean plant height. If plant species are recorded by size class, measure the average height for a plant species by each size class. See **How to Measure Plant Height** for more details. Enter plant height in Field 6 of the SC data form.

*Using the optional fields*

There are two optional fields for user defined codes or measurements. For example, codes can be entered to record plant species phenology or wildlife utilization of plant species. If standing dead trees (snags) were recorded on the SC data form, one could enter a decay class code in one of the optional fields. Enter the user defined codes or measurements in Fields 7 and 8 on the SC data form.

**Precision Standards**

Use these precision standards for the SC sampling.

Table SC-4. Precision guidelines for SC sampling.

| Component | Standard |
|---|---|
| Size class | ±1 class |
| Cover | ±1 class |
| Height | ±10 percent average height |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the SC sampling method can be modified to collect more detailed information or streamlined to collect only the most important tree characteristics. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Recommended SC Sampling Design

The recommended SC sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

**Macroplot Size**: 0.10 acre circular plot (0.04 hectare circular plot)

**Collect plant species cover. Species ID level = "0"; record all species present in the plot.**

Streamlined SC Sampling Design

The streamlined SC sampling design follows the Simple FIREMON sample strategy and is designed below:

**Macroplot Size**: 0.10 acre circular plot (0.04 hectare circular plot)

**Collect plant species cover. Species ID level = "5"; record all species with 5 percent cover or greater in the plot.**

### Comprehensive SC Sampling Design

The comprehensive SC sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Macroplot Size**: 0.10 acre circular plot (0.04 hectare circular plot)

**Collect plant species cover and average height by size class. Species ID level = "0"; record all species present in the plot.**

### User-specific SC Sampling Design

There are several ways the user can adjust the SC sample fields to make sampling more efficient and meaningful for local situations. Use the species ID level (Field 1) to reduce the number of species recorded. Higher species ID levels yield smaller plant lists. For example, only plant species with 5 percent cover or greater are recorded with a species ID level of 5, while a species ID level of 10 limits the plant list to species with 10 percent cover or greater. Sampling a reduced species list can be accomplished in a very short time. The SC method can be even more selective by entering 99 in the species ID level, indicating that only specific plant species are being recorded. For example, you might be interested in documenting the presence or absence of rare plants or the invasion of noxious weeds after a fire. In this case only the rare plants or noxious weeds are recorded.

Ocular estimates of cover can be recorded to the nearest 1 percent (i.e., 17 percent) instead of a cover class. This will allow values to be grouped into different cover classes later when conducting data analysis. Since not all examiners use the same cover classes, this allows the actual estimated cover values to be grouped into any cover class convention. Actual cover values are useful when monitoring changes in species with very low cover values. If cover changes from 3 to 6 percent, recording 6 percent cover is more accurate than recording 10 percent, the midpoint of the next cover class (5 to 15percent). However, it is doubtful that cover can be accurately estimated to a 1 percent level using the human eye. If actual cover values are recorded, or if different cover classes are used than the classes listed in the FIREMON SC methods, record the information in the Metadata table.

You can also make ocular estimates of cover for items other than just plant species. In addition, the optional fields give the user flexibility to record their own codes or measurements. Some examples of information recorded in the optional fields might be maturity and vigor for plant species, decay classes for snags, and wildlife utilization of plants.

**Sampling Hints and Techniques**

Examiners must be knowledgeable in plant identification.

It is relatively easy to learn to estimate cover to the nearest cover class. Examiners can calibrate their ocular estimates by periodically double sampling with the FIREMON Cover/Frequency (CF) or Point Intercept (PO) method for small shrubs, grasses, and forbs and the FIREMON Line Intercept (LI) method for large shrubs and trees. Even an experienced investigator may assign an item to the wrong cover. Calibration of ocular estimates should be conducted at the outset of inventory projects and occasionally (usually every 5 to 10 ocular macroplots) during the project. Variability of cover estimates between trained examiners is usually minimal and is negated by the large number of samples that can be obtained with this method.

Examiners can calibrate their eyes for estimating cover by using the various size cutouts, circular subplots, within the circular macroplot. They should also become familiar with all the subplot sizes and the percent of the entire macroplot each circular subplot represents. Samplers can then mentally grouped species into a subplot and use the subplot size to estimate percent cover. See **How to Estimate Cover** for more details.

Height can be difficult to measure for plant species or species by size class since the value must represent an average for all individual plants on the macroplot. One solution is to measure the height of a representative plant. Another solution, which requires more time, is to take additional measurements of individual plants and average the height values.

When entering data on the SC plot form, examiners might run out of space on the first page. The form was designed to print multiple copies and more plant species are recorded on the additional plot forms.

# Species Composition (SC) Form

SC Page _ _ of _ _

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _ _

PlotID: _ _ _

Date: _ _ / _ _ / _ _ _ _

Field 1

Species ID Level:________ %

| Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Field 7 | Field 8 |
|---|---|---|---|---|---|---|
| Item Code | Status | Size Class | Cover | Height (ft/m) | Local Field 1 | Local Field 2 |
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| Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Field 7 | Field 8 |
|---|---|---|---|---|---|---|
| Item Code | Status | Size Class | Cover | Height (ft/m) | Local Field 1 | Local Field 2 |
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# FIREMON
# SPECIES COMPOSITION (SC) FIELD DESCRIPTIONS

Field 1: **Species ID level.** Enter the minimum canopy cover level used to record plant species.

Field 2: **Item Code.** Code of sampled entity. Either the NRCS plants species code, the local code for that species, ground cover code, or other item code. Precision: No error.

Field 3: **Status**: Plant status - Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

Field 4: **Size Class**. Size of the sampled plant. Valid classes are in tables SC-1 and SC-2 of the sampling method. Precision: ±1 class.

Field 5: **Cover.** Enter the cover class code for the sampled entity. Precision: ±1 class.

Field 6: **Height**. Enter the average height for each plant species or life-form on the plot. (ft/m). Precision: ±10 percent mean height.

Field 7: **Local Field 1.** Enter a user specific code or measurement for the plant species or item being recorded.

Field 8: **Local Field 2.** Enter a user specific code or measurement for the plant species or item being recorded.

**FIREMON**
**SPECIES COMPOSITION (SC) EQUIPMENT LIST**

Camera with film
SC plot forms
Clinometer
Clipboard
Compass
Diameter Tape (inches or cm) (2)
Field notebook
Flagging
Graph paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Reinforcing bar (to mark plot center)
Tape 75 ft (25 m) or longer (2)
Yard (meter) stick

# FIREMON SC Cheat Sheet

**Cover Classes**

| Code | Cover Class |
|---|---|
| 0 | Zero percent cover |
| 0.5 | >0-1 percent cover |
| 3 | >1-5 percent cover |
| 10 | >5-15 percent cover |
| 20 | >15-25 percent cover |
| 30 | >25-35 percent cover |
| 40 | >35-45 percent cover |
| 50 | >45-55 percent cover |
| 60 | >55-65 percent cover |
| 70 | >65-75 percent cover |
| 80 | >75-85 percent cover |
| 90 | >85-95 percent cover |
| 98 | >95-100 percent cover |

**Status Codes**

| **Code** | **Description** |
|---|---|
| L | Live |
| D | Dead |
| NA | Not Applicable |

**Tree Size Classes**

| **TREE SIZE CLASS CODES** | **TREE SIZE CLASS DESCRIPTIONS (English)** | **TREE SIZE CLASS DESCRIPTIONS (Metric)** |
|---|---|---|
| TO | Total cover | Total cover |
| SE | Seedling (<1 in. dbh or <4.5 ft. height) | Seedling (<2.5 cm dbh or <1.5 m height) |
| SA | Sapling ( 1.0 in. - <5.0 in. dbh) | Sapling ( 2.5 - <12.5 cm dbh) |
| PT | Pole Tree ( 5.0 in. – < 9.0 in. dbh) | Pole Tree ( 12.5 – <25 cm dbh) |
| MT | Medium Tree ( 9.0 in. – <21.0 in. dbh) | Medium Tree ( 25 – <50 cm dbh) |
| LT | Large Tree ( 21.0 in. – <33.0 in. dbh) | Large Tree ( 50 – <80 cm dbh) |
| VT | Very Large Tree (33.0 + cm dbh) | Very Large Tree (80 + cm dbh) |
| NA | Not Applicable | Not Applicable |

**Shrub and Herbaceous Size Classes**

| **SHRUB / HERB SIZE CLASS CODES** | **SHRUB / HERB SIZE CLASS DESCRIPTIONS (English)** | **SHRUB / HERB SIZE CLASS DESCRIPTIONS (Metric)** |
|---|---|---|
| TO | Total cover | Total cover |
| SM | Small (< 0.5 ft. height) | Small (< 0.25 m height) |
| LW | Low (0.5 - <1.5 ft. height) | Low (0.25 - <0.5m height) |
| MD | Medium (1.5 – < 4.5 ft. height) | Medium (0.5 – < 1.5 m height) |
| TL | Tall (4.5 – < 8 ft. height) | Tall (1.5 – < 2.5 m height) |
| VT | Very Tall (8 ft. + height) | Very Tall (2.5 m + height) |
| NA | Not Applicable | Not Applicable |

**Precision**

| Component | Standard |
|---|---|
| Size class | ±1 class |
| Cover | ±1 class |
| Height | ±10 percent average height |

# Cover/Frequency (CF)
## Sampling Method

EXECUTIVE SUMMARY

The FIREMON Cover/Frequency (CF) method is used to assess changes in plant species cover and frequency for a macroplot. This method uses multiple quadrats to sample within plot variation and quantify statistically valid changes in plant species cover, height, and frequency over time. Since it is difficult to estimate cover in quadrats for larger plants, this method is primarily suited for grasses, forbs, and shrubs less than 3 feet (1 m) in height. Quadrats are placed systematically along randomly located transects. Cover is assessed by visually estimating the percent of a quadrat occupied by the vertical projection of vegetation onto the ground. Plant species frequency is recorded as the number of times a species occurs within a given number of quadrats. Frequency is typically recorded for plant species that are rooted within the quadrat.

## INTRODUCTION

The Cover/Frequency (CF) method is designed to sample within plot variation and quantify changes in plant species cover, height, and frequency over time. This method uses quadrats that are systematically placed along transects located within the macroplot. First, a baseline is established along the width of the plot. Transects are oriented perpendicular to the baseline and are placed at random starting points along the baseline. Quadrats are then placed systematically along each transect. Characteristics are recorded about the general CF sample design and for individual plant species within each quadrat. First the transect length, number of transects, quadrat size, and number of quadrats per transect are recorded. Within each quadrat, depending on the project objectives, any combination of cover, frequency, and height are recorded for each plant species.

This method is primarily used when the manager wants to monitor statistically significant changes in plant species cover, height, and frequency. The CF sampling method is most appropriate for vascular and non-vascular plants less than 3 feet (1 m) in height. The FIREMON line intercept (LI) method is better suited for estimating cover of shrubs greater than 3 feet (1 m) in height (e.g. western U.S. shrub communities, mixed plant communities of grasses, trees, and shrubs, and open grown woody vegetation). The CF methods can also be used to estimate ground cover, however, the FIREMON point intercept (PO) methods are better suited for estimating ground cover. We suggest you use the PO method if you are primarily interested in monitoring changes in ground cover. The PO method may be used in conjunction with the CF method to sample ground cover by using the CF sampling quadrat as a point frame. The PO method is also better suited for sampling fine textured herbaceous communities (e.g. dense grasslands and wet meadows). However, if rare plant species are of interest the CF methods are preferred since it is easier to sample rare species with quadrats than with points or lines.

### Estimating Cover and Height

Cover is an important vegetation attribute which is used to determine the relative influence of each species on a plant community. Cover is a commonly measured attribute of plant community composition because small, abundant species and large, rare species have comparable cover values. In FIREMON we record foliar cover as the vertical projection of the foliage and supporting parts onto the ground. Therefore, total cover on a plot can exceed 100 percent due to overlapping layers in the canopy.

Estimating cover in quadrats is more accurate than estimating cover on a macroplot because samplers record cover in small quadrats more consistently than in large areas. Sampling with quadrats is also more effective than the point intercept (PO) method at locating and recording rare species. Point intercept sampling requires many points to sample rare species (e.g. 200 points to sample at 0.5 percent cover). Quadrats sample more area and have a greater chance of detecting rare species.

Cover is typically based on a visual estimate of cover classes that range from 0 to 100 percent. These classes are broadly defined, lowering the chance for consistent human error in assigning the cover class. The lowest cover classes are sometimes split into finer units, since many species fall into the lowest cover classes. These systems are more sensitive to species with low cover. A finer breakdown of scale toward the lower scale values allows better estimation of less abundant species. In FIREMON we use a cover class system, which splits the lowest classes into finer units. The midpoint of each class can be used for numerical computations. The use of midpoints for actual values is based on the assumption that actual cover values are distributed symmetrically about the midpoint.

Plant height measurements are used to estimate the average height of individual plant species. Plant heights give detailed information about the vertical distribution of plant species cover on the plot. In addition, height measurements allow the examiner to calculate plant species volume (cover x height) and to estimate biomass using the appropriate bulk density equations. Plant height is measured with a yardstick (meter stick) for plants less than 10 feet tall (3 m) and with a clinometer and tape measure for taller plants.

**Estimating Frequency**

Frequency is used to describe the abundance and distribution of species and can be used detect changes in vegetation over time. It is typically defined as the number of times a species occurs in the total number of quadrats sampled, usually expressed as a percent. Frequency is one of the fastest and easiest methods for monitoring vegetation because it is objective, repeatable and requires just one decision: whether or not a species is rooted within the quadrat frame. Frequency is a useful tool for comparing two plant communities or to detect change within one plant community over time.

Frequency is most commonly measured with square quadrats. The size and shape of the frequency quadrat influences the results of the frequency recorded. If a plot is too small, rare plants may not be recorded. If you use a large quadrat, you will have individual species in all quadrats and frequency values of 100 percent which will not allow you to track increases in frequency. If you have small quadrats, you will record low frequency values which are not very sensitive to declining frequency values for a species. A reasonable sensitivity to change results from frequency values between 20 to 80 percent. Frequencies less than 5 percent or greater than 95 percent typically result in heavily skewed distributions.

For this reason, nested plots, or subplots, are usually used to sample frequency. Plot sizes are nested in a configuration that gives frequencies between 20 and 80 percent for the majority of species. Nested subplots allow frequency data to be collected in different size subplots of the main quadrat. Since frequency of occurrence can be analyzed for different sized plots, this eliminates the problems of comparing data collected from different size quadrats. In FIREMON, we use a nested plot design of four subplots within one quadrat, and record the smallest subplot number in which the plant is rooted. This frequency measurement is typically referred to as nested rooted frequency (NRF).

Since plant species frequency is highly sensitive to the size and shape of quadrats, changes in frequency can be difficult to interpret, possibly resulting from changes in cover, density, or pattern of distribution. For this reason, if money and time are available we recommend you collect cover data along with frequency data. However, if you are only concerned about documenting that a change in vegetation has occurred, then frequency is the most rapid method.

There are many ways to streamline or customize the CF sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific CF Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

The sampling procedure is described in the order of the fields that need to be completed on the CF data form, so it is best to reference the data form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Preliminary Sampling Tasks

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation lifeform you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, how will you account for boundary plants? It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.

A number of preparations must be made before proceeding into the field for CF sampling. First, all equipment and supplies in the **CF Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All CF data forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future re-measurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook. For example, snow on the plot might be described in the notebook, which would be very helpful in plot re-measurement.

Plot locations and/or directions should be readily available and provided to the crews in a timely fashion. It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

A field crew of two people is probably the most efficient for implementation of the CF sampling method. There should never be a one-person field crew for safety reasons, and any more than two people will probably result in part of the crew waiting for tasks to be completed and unnecessary trampling on the FIREMON macroplot. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most quadrat measurements. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency. As the field crew gains experience switch tasks so that the entire crew is familiar with the different sampling responsibilities and to limit monotony.

## Designing the CF Sampling Method

There is a set of general criteria recorded on the CF Plot form that forms the user-specified design of the CF sampling method. Each general CF field must be designed so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be determined before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project.

### *Plot ID construction*

A unique plot identifier must be entered on the CF data form. This is the same plot identifier used to describe general plot characteristics in the Plot Description or PD sampling method. Details on constructing a unique plot identifier are discussed in the **How to Construct a Unique Plot Identifier** section. Enter the plot identifier at the top of the CF data form.

*Determining the Sample Size*

The size of the macroplot ultimately determines the length of the transects and the length of the baseline along which the transects are placed. The amount of variability in plant species composition and distribution determines the number and length of transects and the number of quadrats required for sampling. The typical macroplot sampled in the CF method is a 0.10 acre (0.04 ha) square measuring 66 x 66 feet (20 x 20 m), which is sufficient for most forest understory and grassland monitoring applications. Shrub dominated ecosystems will generally require larger macroplots when sampling with the CF method. Dr. Rick Miller has sampled extensively in shrub dominated systems and we have included a write-up of his method in **Appendix C: Rick Miller Method for Sampling Shrub Dominated Systems**. If you are not sure of the plot size to use contact someone that as sampled the same vegetation that you will be sampling. The size of the macroplot may be adjusted to accommodate different numbers and lengths of transects. In general it is more efficient if you use the same plot size for all FIREMON sampling methods on the plot, however we recognize that this is not always feasible.

We recommend sampling five transects within the macroplot, and this should be sufficient for most studies. However, there are situations when more transects should be sampled. See **How To Determine Sample Size** for more details. Enter the number of transects in Field 1 on the CF data form. The recommended transect length is 66 feet (20 m) for a 66 x 66 feet (20 x 20 m) macroplot. However, the macroplot size may be adjusted to accommodate longer or shorter transects based on the variability in plant species composition and distribution. For example, transects may be lengthened to accommodate more quadrats per transect or to allow more distance between quadrats. Enter the transect length in Field 2 of the CF data form. The FIREMON CF data form and data entry screen allow an unlimited number of transects.

We recommend sampling at least five quadrats per transect, and this should be sufficient for most studies. However, there are situations when more quadrats should be sampled. Additional quadrats may be sampled by placing more quadrats along a transect or by sampling more transects within the macroplot. See **How To Determine Sample Size** for more details. Enter the number of quadrats per transect in Field 3 of the CF data form. The FIREMON CF data form and data entry screen allow up to 25 quadrats per transect.

*Determining the Quadrat Size*

Frequency is typically recorded in square quadrats. The standard quadrat for measuring nested rooted frequency in a 20 x 20 inch (50 x 50 cm) square with four nested subplot sizes. A nested frame allows frequency data to be collected in different size subplots of the main quadrat. Measuring frequency this way is commonly referred to as nested rooted frequency (NRF). Plot sizes are nested in a configuration that gives frequencies between 20 to 80 percent for the majority of species. Tables CF-1 and CF-2 list common quadrat and subplot sizes in English and metric dimensions for recording nested rooted frequency. See **How To Construct a Quadrat Frame** for instructions on building and using quadrat frames. Cover can be estimated using the same quadrat frames and recorded at the same time frequency is recorded.

Table CF-1. Commonly used quadrat sizes for recording nested rooted frequency (english dimensions).

| NRF Numbers | Standard | Grassland Communities | Sagebrush Communities | Pinyon-Juniper |
|---|---|---|---|---|
| Subplot 1 | 2 x 2 in. | ------- | 2 x 2 in. | ------- |
| Subplot 2 | 10 x 10 in. | 2 x 2 in. | 4 x 4 in. | 8 x 8 in. |
| Subplot 3 | 10 x 20 in. | 4 x 4 in. | 8 x 8 in. | 20 x 20 in. |
| Subplot 4 | 20 x 20 in. | 8 x 8 in. | 20 x 20 in. | 40 x 40 in. |

Table CF-2. Commonly used quadrat sizes for recording nested rooted frequency (metric dimensions).

| NRF Numbers | Standard | Grassland Communities | Sagebrush Communities | Pinyon-Juniper |
|---|---|---|---|---|
| Subplot 1 | 5 x 5 cm | ------- | 5 x 5 cm | ------- |
| Subplot 2 | 25 x 25 cm | 5 x 5 cm | 10 x 10 cm | 20 x 20 cm |
| Subplot 3 | 25 x 50 cm | 10 x 10 cm | 20 x 20 cm | 50 x 50 cm |
| Subplot 4 | 50 x 50 cm | 20 x 20 cm | 50 x 50 cm | 100 x 100 cm |

Enter the quadrat length (Field 4) and quadrat width (Field 5) in inches (cm) on the CF data form.

*Recording the Subplot Size Ratio and NRF Numbers*

If nested rooted frequency is being recorded, then enter the percent area of the quadrat contained by each subplot in Field 6 on the CF data form.  Start with the smallest subplot and end with the largest subplot.  For example, the subplot ratio for the standard 20 x 20 inch (50 x 50 cm) quadrat would be 1:25:50:100. Subplot 1 is 2 x 2 inches (5 x 5 cm) and is 1 percent of the quadrat. Subplot 2 is 10 x 10 inches (25 x 25 cm) and is 25 percent of the quadrat. Subplots 3 and 4 are 10 x 20 inches (25 x 50 cm) and 20 x 20 inches (50 x 50 cm), which correspond to 50 and 100 percent of the quadrat, respectively. See **How To Construct a Quadrat Frame** for more details about subplot sizes.

If nested rooted frequency is being recorded, then enter the corresponding frequency numbers for each subplot in Field 7 of the CF data form.  Start numbering with the smallest subplot and end with the largest subplot. For example, 1:2:3:4 would correspond with the 1:25:50:100 percentages of total plot when using the standard 20 x 20 inch (50 x 50 cm) quadrat.

## Conducting CF Sampling Tasks

*Establishing the baseline for transects*

Once the plot has been monumented, a permanent baseline is set up as a reference from which you will orient all transects. The baseline should be established so that the sampling plots for tall of the methods overlap as much as possible. See **How To Establish Plots with Multiple Methods**. The recommended baseline is 66 feet (20 m) long and is oriented upslope with the 0-foot (0 m) mark at the lower permanent marker and the 66-foot (20 m) mark at the upper marker. On flat areas, the baseline runs from south to north with the 0-foot (0 m) mark on the south end and the 66-foot (20 m) mark on the north end. Transects are placed perpendicular to the baseline and are sampled starting at the baseline. On flat areas, transects are located from the baseline to the east. See **How To Establish a Baseline for Transects** for more details.

*Locating the Transects*

Locate transects within the macroplot perpendicular to the baseline and parallel with the slope. For permanent plots, determine the compass bearing of each transect and record these on the plot layout map or the comment section of the PD form. Permanently mark the beginning and ending of each transect (for example, using concrete reinforcing bar). Starting locations for each transect can be determined randomly on every plot or systematically with the same start locations used on every plot in the project. In successive re-measurement years, it is essential that transects be placed in the same locations as in previous visits. If the CF method is used in conjunction with other replicated sampling methods (LI, PO, RS or DE), use the same transects for all methods, whenever possible. See **How To Locate Transects and Quadrats** for more details.

*Locating the Quadrats*

We recommend sampling five quadrats located at 12 foot (4 m) intervals along a transect, with the first quadrat placed 12 feet (4 m) from the baseline. See **How To Locate Transects and Quadrats** for more details. If macroplots are being sampled for permanent remeasurement, quadrats must be placed at specified intervals along a measuring tape, which is placed along each, transect. In successive years for remeasurement, quadrats *must* be placed in the same location. When sampling macroplots that are not scheduled for permanent remeasurement, the distance between quadrats may be estimated by pacing after the examiner measures the distance between quadrats.

Each quadrat is placed on the uphill side of the transect line with quadrat frame placed parallel to the transect. The lower left corner of the quadrat frame will be placed at the foot (meter) mark for the quadrat location. Figure CF-1 displays the proper placement of a quadrat frame.

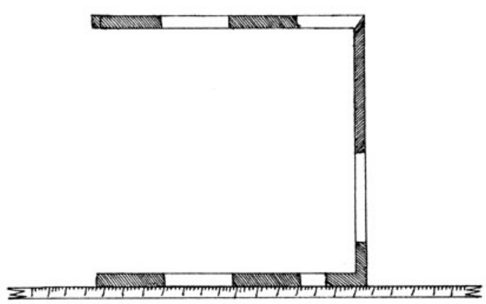

Figure CF-1. An example of quadrat placement along a transect.

## Quadrat Sampling

First, enter the transect number which is being sampled in Field 8 of the CF plot form. Next, enter the plant species or item code in Field 9. FIREMON uses the NRCS Plants species codes, however you may use your own species codes. See **How to Customize Plant Species Codes** for more details. If ground cover is being sampled, we recommend using the ground cover codes listed in table CF-3.

Table CF-3. FIREMON Ground Cover Codes

| Ground Cover Code | Ground Cover Description | Ground Cover Code | Ground Cover Description |
|---|---|---|---|
| ASH | Ash (organic, from fire) | LICH | Lichen |
| BAFO | Basal forb | LITT | Litter and Duff |
| BAGR | Basal graminoid | MEGR | Medium gravel (5-20 mm) |
| BARE | Bare soil (soil particles < 2 mm) | MOSS | Moss |
| BARR | Barren | PAVE | Pavement |
| BASH | Basal shrub | PEIC | Permanent Ice |
| BATR | Basal tree | PEIS | Permanent Ice and Snow |
| BAVE | Basal vegetation | PESN | Permanent Snow |
| BEDR | Bedrock | ROAD | Road |
| BOUL | Boulders (round and flat) | ROBO | Round boulder (> 600 mm) |
| CHAN | Channers (2-150 mm long) | ROCK | Rock |
| CHAR | Char | ROST | Round stone (250-600 mm) |
| CML | Cryptogams, mosses and lichens | STON | Stones (Round and flat) |
| COBB | Cobbles (75-250 mm) | TEPH | Tephra volcanic |
| COGR | Coarse gravel (20-75 mm) | TRIC | Transient Ice |
| CRYP | Cryptogamic Crust | TRIS | Transient Ice and Snow |
| DEVP | Developed Land | TRSN | Transient Snow |
| FIGR | Fine gravel (2-5 mm) | UNKN | Unknown |
| FLAG | Flag stones (150-380 mm long) | WATE | Water |
| FLBO | Flat boulders (>600 mm long) | WOOD | Wood |
| FLST | Flat Stone (380-600mm long) | X | Not Assessed |
| GRAV | Gravel (2-75 mm) | | |

Next enter the plant species status in Field 10 on the CF data form. Status describes the general health of the plant species as live or dead using the following codes:

**L – Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

Plant status is purely qualitative but it does provide an adequate characteristic for stratification of pre-burn plant health and in determining post-burn survival. Be careful when making this assessment on plant in their dormant season.

*Cover*

Cover is the vertical projection of the vegetation foliage and supporting parts onto the ground (figure CF-2). Estimating cover within quadrats is made easier by using subplot sizes and the percent of quadrat area they represent (figure CF-3). Subplots are used to estimate cover for a plant species by mentally grouping cover for all individuals of a plant species into one of the subplots. The percent size of that subplot, in relation to the size of the quadrat being sampled, is used to make a cover class estimate for the species. See **How to Estimate Cover** for more details.

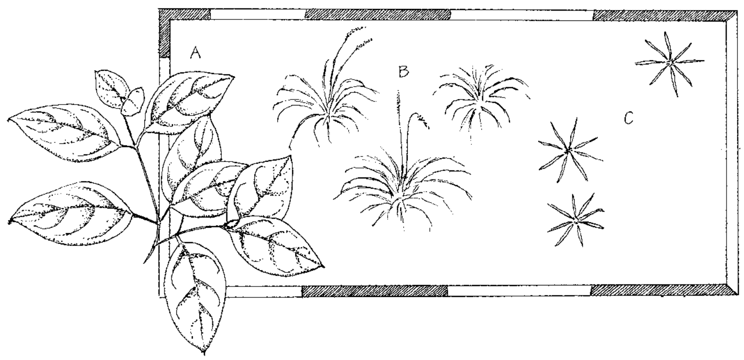


Figure CF-2. Cover from species A is estimated even though this species is not actually rooted within the quadrat.

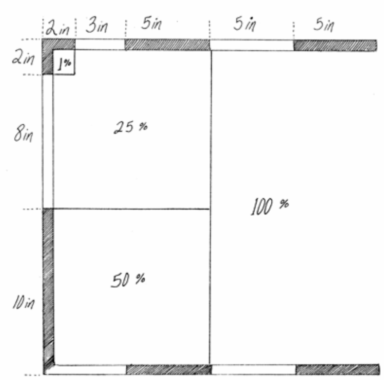


Figure CF-3. Subplot dimensions and respective percent of the total plot. Subplots aid the sampler in estimating cover by mentally grouping cover for all individuals of a plant species into one of the subplots.

For each plant species or ground cover class in the quadrat, estimate its percent cover within the quadrat and enter a cover class code (table CF-4) to denote that value. Enter the cover class for each quadrat.

Table CF-4. FIREMON Cover Class Codes.

| Code | Cover Class |
|---|---|
| 0 | Zero percent cover |
| 0.5 | >0-1 percent cover |
| 3 | >1-5 percent cover |
| 10 | >5-15 percent cover |
| 20 | >15-25 percent cover |
| 30 | >25-35 percent cover |
| 40 | >35-45 percent cover |
| 50 | >45-55 percent cover |
| 60 | >55-65 percent cover |
| 70 | >65-75 percent cover |
| 80 | >75-85 percent cover |
| 90 | >85-95 percent cover |
| 98 | >95-100 percent cover |

*Nested Rooted Frequency*

The standard 20 x 20 inch (50 x 50 cm) quadrat is partitioned into four subplots for recording nested rooted frequency (figure CF-4 and table CF-5). Species located in the smallest subplot are given the frequency value of 1. Plants in successively larger subplots have frequency values of 2, 3 and 4. Decisions about counting boundary plants, plants that have a portion of basal vegetation intersecting the quadrat, need to be applied systematically to each quadrat. See **How to Count Boundary Plants** for more details.

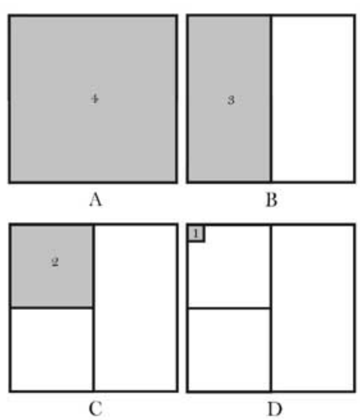


Figure CF-4. The numbers inside the plot frame denote the value recorded if a plant is present in that area of the frame. The number 4 corresponds to the entire quadrat (A). The sampling area for number 3 is the entire top half of the quadrat (B). The sampling areas for the numbers 2 and 1 are the upper left quarter and the upper left corner (1%) of the quadrat, respectively (C and D). Each larger subplot contains all smaller subplots. Subplots aid the sampler in estimating cover by mentally grouping cover for all individuals of a plant species into one of the subplots.

Table CF-5. Percent of quadrat represented by the four subplots used to record nested rooted frequency within the standard 20 x 20 in. (50 x 50 cm) quadrat.

| **Subplot Number for Rooted Frequency** | **Size of Subplot** | **Percent area of a 20 x 20 in. (50 x 50 cm) Quadrat** |
|---|---|---|
| 1 | 2 x 2 in. (5 x 5 cm) | 1 percent |
| 2 | 10 x 10 in. (25 x 25 cm) | 25 percent |
| 3 | 10 x 20 in. (25 x 50 cm) | 50 percent |
| 4 | 20 x 20 in. (50 x 50 cm) | 100 percent |

Record the smallest size subplot in which each plant species is rooted (figure CF-5 and table CF-6). Begin with subplot 1, the smallest subplot. If the basal portion of a plant species is rooted in that subplot, record 1 for the species. Next find all plant species rooted in subplot 2, which were not previously recorded for subplot 1, and record a 2 for these plant species. Then identify all plant species, which are rooted in subplot 3, which were not previously recorded for subplots 2 and 1, and record a 3 for these species. Finally, record a 4 for each species rooted in subplot 4, the remaining half of the quadrat, which were not previously recorded in subplots 3, 2, and 1. Enter the subplot number in the NRF field for each species on the CF data form.

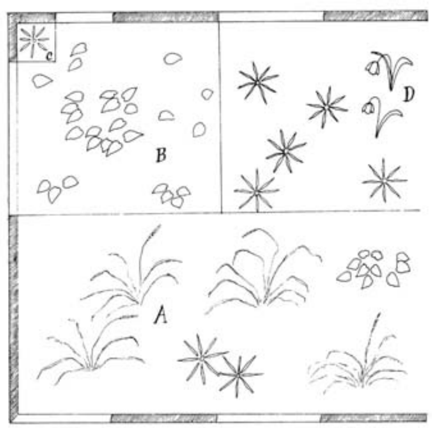


Figure CF-5. Example of recording nested rooted frequency values for plant species in a 20 x 20 inch (50 x 50 cm) quadrat frame. Table CF-6 lists the nested rooted frequency value for each plant species displayed in this figure.

Table CF-6. Standard NRF frame subplot sizes and NRF numbers for the plants illustrated in figure CF-5.

| **Species Symbol** | **Smallest Subplot Size in which Species is Rooted** | **NRF Value** |
|---|---|---|
| C | Smallest, 2 x 2 in. (5 x 5 cm) | 1 |
| B | Next largest,10 x 10 in. (25 x 25 cm) | 2 |
| D | Next largest, 10 x 20 in. (25 x 50 cm) | 3 |
| A | Largest, 20 x 20 in. (50 x 50 cm) | 4 |

### Estimating Height

Measure the average height for each plant species in feet (meters) within +/- 10 percent of the mean plant height. See **How to Measure Plant Height** for more details. Enter plant height in the Height field for each quadrat.

### Precision Standards

Use these precision standards for the CF sampling.

Table CF-7. Precision guidelines for CF sampling.

| Component | Standard |
| --- | --- |
| Cover | ± 1 class |
| NRF | No error |
| Height | ± 10 percent |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the CF sampling method can be modified to collect more detailed information or streamlined to collect basic information. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Recommended CF Sampling Design

The recommended CF sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

**Measure only plant species cover and nested rooted frequency within each quadrat.**

**Macroplot Size**: 0.1 acre, 66 ft x 66 ft. (400 square meters, 20 x 20 m)
**Quadrat Size**: 20 x 20 in. (50 x 50 cm)
**Number of Transects:** 5
**Number of Quadrats / Transect:** 5

The quadrat size should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

### Streamlined CF Sampling Design

The streamlined CF sampling design follows the Simple FIREMON sample strategy and is designed below:

**Measure only nested rooted frequency within each quadrat.**

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Quadrat Size**: 20 x 20 in. (50 x 50 cm)
**Number of Transects:** 5
**Number of Quadrats / Transect:** 5

The quadrat size should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

### Comprehensive CF Sampling Design

The comprehensive CF sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Measure plant species cover , nested rooted frequency, and average plant species height within each quadrat.**

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Quadrat Size**: 20 x 20 in. (50 x 50 cm)
**Number of Transects:** 5
**Number of Quadrats / Transect:** 5

The quadrat size should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

**User-specific CF Sampling Design**

There are many ways the user can modify the CF sample fields to make sampling more efficient and meaningful for local situations. Examiners may adjust the number of transects, transect length, and number of quadrats as needed for the specific task.

Quadrat sizes other than the standard 20 x 20 n. (50 x 50 cm) frame can be used for sampling. Small, 4 x 4 in (10 x 10 cm), quadrats can be used in dense wet meadow communities and large, 40 x 40 in. (1 x 1 m), quadrats can be used in sparse or large vegetation (e.g., shrub communities). Nested subplots are not needed when sampling rooted frequency when the plant species being sampled have similar distribution and abundance within the macroplot. Plant species frequency may simply be recorded as presence within the quadrat. The FIREMON sampling forms and databases will accommodate most sampling variations of the recommended procedure.

Ocular estimates of cover can be recorded to the nearest 1 percent (i.e., 17%) instead of a cover class. This will allow values to be grouped into different cover classes later when conducting data analysis. Since not all examiners use the same cover classes, this allows the actual estimated cover values to be grouped into any cover class convention. However, it is doubtful that cover can be accurately estimated to a 1% level using the human eye. If actual cover values are recorded, or if different cover classes are used than the classes listed in the FIREMON CF methods, record this information with the Metadata (MD) method.

**Sampling Hints and Techniques**

Examiners must be able to identify many plant species and be able to determine whether a plant species occurs within a quadrat. Examiners must also be familiar with the cover classes used to estimate cover. When collecting rooted frequency data, herbaceous plants (grasses and forbs) must be rooted within the quadrat. However, on many occasions trees and shrubs rooted within the quadrat will provide an inadequate sample size. Counting plants whose canopy overhangs the quadrat may increase tree and shrub sample size.

Examiners can calibrate their eyes for estimating cover by using the various subplots within a quadrat frame. Examiners should become familiar with all the subplot sizes and the percent of the entire quadrat each subplot represents. Species are mentally grouped into a subplot and the subplot size is used to estimate percent cover. See **How to Estimate Cover** for more details.

Measuring tapes come in a variety of lengths, increments, and materials. Examiners should choose tapes with the appropriate units and at least as long, or a little longer, than the transect length being sampled. Since, steel tapes do not stretch they are the most accurate over long remeasurement intervals. Steel is probably the best choice for permanent transects where remeasurement in exactly the same place each time is important. Cloth and fiberglass tapes will stretch over the life of the tape, but are easier to use than steel tapes since they are lighter and do not tend to kink.

The sampling crew may encounter an obstacle, such as a large rock or tree, along one of the transect lines that interferes with the quadrat sampling. If that happens offset using the directions described in **How To Offset a Transect**.

When entering data on the CF data forms, examiners may run out of space on the first page or sample more than 5 quadrats per transect. The first page allows only 5 quadrats per transect. If more quadrats per transect are sampled, use the CF continuation form. The form was designed to print one copy of the first page, and several copies of the second page. The second page of the data form allows the examiner to write the quadrat number on the form. This allows the examiner to design the form to accommodate the number of transects sampled. Print out enough pages to record all species on all transects for the required number of transects.

# Cover/Frequency (CF) Form

CF Page _ _ of _ _

| Field 1 | Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Field 7 |
|---|---|---|---|---|---|---|
| Number of Transects | Transect Length | Number of Quad/Tran. | Quadrat Length (in/cm) | Quadrat Width (in/cm) | NRF Subplot Ratio | NRF Numbers |
| | | | | | | |

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _

PlotID: _ _ _

Date: _ _/_ _/_ _ _ _

| Field 8 | Field 9 | Field 10 | Quadrat 1 | | | Quadrat 2 | | | Quadrat 3 | | | Quadrat 4 | | | Quadrat 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) |
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# Cover/Frequency (CF) Form

## Continuation

CF Page _ _ of _ _

| Field 1 | Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Field 7 |
|---|---|---|---|---|---|---|
| Number of Transects | Transect Length | Number of Quad/Tran. | Quadrat Length (in/cm) | Quadrat Width (in/cm) | NRF Subplot Ratio | NRF Numbers |
| | | | | | | |

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _

PlotID: _ _ _

Date: _ _/_ _/_ _ _ _

| Field 8 | Field 9 | Field 10 | Quadrat __ | | | Quadrat __ | | | Quadrat __ | | | Quadrat __ | | | Quadrat __ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) | Cover Class | Nested Rooted Frequency | Height (ft/m) |
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## FIREMON
## COVER / FREQUENCY (CF) FIELD DESCRIPTIONS

Field 1: **Number of Transects**. Total number of transects on the plot.

Field 2: **Transect Length**. Length of transect. (ft/m).

Field 3: **Number of Quadrats per Transect**. Number of quadrats sampled per transect.

Field 4: **Quadrat Length**. Length of the quadrat. (in./cm).

Field 5: **Quadrat Width**. Width of the quadrat. (in./cm).

Field 6: **NRF Subplot Ratio**. Percent of the quadrat covered by each subplot starting from the largest subplot to the smallest subplot. For example, the subplot ratio for a typical 20 x 20 in. (50 x 50 cm) quadrat would be 100:50:25:1.

Field 7: **NRF Numbers.** Frequency numbers for the subplots starting from largest to smallest. For example, the frequency numbers for a typical 20 x 20 in. (50 x 50 cm) quadrat would be 4:3:2:1.

Field 8: **Transect Number.** Sequential number of the sample transect.

Field 9: **Item Code.** Code of sampled entity. Either the NRCS plants species code, the local code for that species, ground cover code, or other item code. Or, ground cover code. Precision: No error.

Field 10: **Status**: Plant status - Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

**Cover Class.** Enter the cover class of sampled entity. Valid classes are in table CF-4 of the sampling methods. Precision: $\pm$1 class.

**Nested Rooted Frequency.** Enter the NRF number of sampled entity. Precision: No error.

**Height.** Enter the average height for each plant species or life-form in the quadrat. Precision: $\pm$10 percent of average height.

**FIREMON**
**COVER / FREQUENCY (CF) EQUIPMENT LIST**

Camera with film
CF Plot Forms
Clipboard
Compass
File
Field notebook
Graph Paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Quadrat Frame
Reinforcing bar (2) for baseline plus 2 for each transect
Steel fence posts (2) and driver (to mark endpoints of baseline)
Tape 75 ft. (25 m) or longer (2)

# FIREMON CF Cheat Sheet

**Ground Cover Codes**

| Ground Cover Code | Ground Cover Description |
|---|---|
| ASH | Ash (organic, from fire) |
| BAFO | Basal Forb |
| BAGR | Basal graminoid |
| BARE | Bare soil (soil particles < 2 mm) |
| BARR | Barren |
| BASH | Basal shrub |
| BATR | Basal tree |
| BAVE | Basal vegetation |
| BEDR | Bedrock |
| BOUL | Boulders (round and flat) |
| CHAN | Channers (2-150 mm long) |
| CHAR | Char |
| CML | Cryptogams, mosses and lichens |
| COBB | Cobbles (75-250 mm) |
| COGR | Coarse gravel (20-75 mm) |
| CRYP | Cryptogamic Crust |
| DEVP | Developed Land |
| FIGR | Fine gravel (2-5 mm) |
| FLAG | Flag stones (150-380 mm long) |
| FLBO | Flat boulders (>600 mm long) |
| FLST | Flat Stone (380-600mm long) |
| GRAV | Gravel (2-75 mm) |
| LICH | Lichen |
| LITT | Litter and Duff |
| MEGR | Medium gravel (5-20 mm) |
| MOSS | Moss |
| PAVE | Pavement |
| PEIC | Permanent Ice |
| PEIS | Permanent Ice and Snow |
| PESN | Permanent Snow |
| ROAD | Road |
| ROBO | Round boulder (> 600 mm) |
| ROCK | Rock |
| ROST | Round stone (250-600 mm) |
| STON | Stones (Round and flat) |
| TEPH | Tephra volcanic |
| TRIC | Transient Ice |
| TRIS | Transient Ice and Snow |
| TRSN | Transient Snow |
| UNKN | Unknown |
| WATE | Water |
| WOOD | Wood |
| X | Did not assess |

**Canopy Cover Classes**

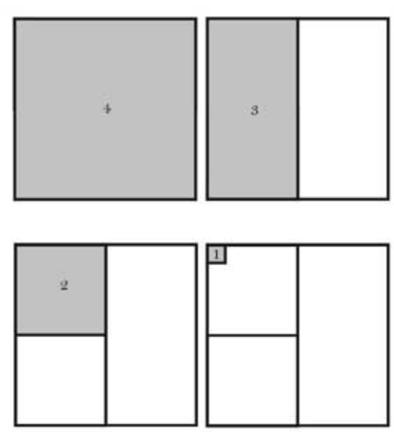
| Code | Cover Class |
|---|---|
| 0 | Zero percent cover |
| 0.5 | >0-1 percent cover |
| 3 | >1-5 percent cover |
| 10 | >5-15 percent cover |
| 20 | >15-25 percent cover |
| 30 | >25-35 percent cover |
| 40 | >35-45 percent cover |
| 50 | >45-55 percent cover |
| 60 | >55-65 percent cover |
| 70 | >65-75 percent cover |
| 80 | >75-85 percent cover |
| 90 | >85-95 percent cover |

**Status Codes**

| Code | Description |
|---|---|
| L | Live |
| D | Dead |
| NA | Not Applicable |

**Precision**

| Component | Standard |
|---|---|
| Cover | ± 1 class |
| NRF | No error |
| Height | ± 10 percent |



# Point Intercept (PO)
## Sampling Method

EXECUTIVE SUMMARY

The FIREMON Point Intercept (PO) method is used to assess changes in plant species cover or ground cover for a macroplot. This method uses a narrow diameter sampling pole or sampling pins, placed at systematic intervals along line transects to sample within plot variation and quantify statistically valid changes in plant species cover and height over time. Plant species or ground cover classes which touch the pin are recorded as "hits" along a transect. Percent cover is calculated by dividing the number of hits for each plant species or ground cover class by the total number of points along a transect. This method is primarily suited for vegetation types less than 3 feet (1 m) in height and is particularly useful for recording ground cover.

## INTRODUCTION

The Point Intercept (PO) method is designed to sample within plot variation and quantify changes in plant species cover and height, and/or ground cover over time. This method uses transects located within the macroplot. First, a baseline is established from which to orient the transects then transects are placed randomly along the baseline. Characteristics, such as transect length, number of transects, and number if points per transect, are recorded about the general sample design. A sampling pole or sampling pins are systematically lowered along each transect and "hits" are tallied when contact is made with a plant species or ground cover class. Percent cover is calculated as the number of hits for each plant species or ground cover class divided by the total number of points per transect. Height is also recorded for each plant species along the transect.

This method is primarily used when managers want to monitor changes in plant species cover and height or ground cover and is best suited for sampling ground cover and grasses, forbs, and shrubs less than 3 feet (1 m) in height. The Point Intercept method works well for fine textured herbaceous communities, fine leaved plant species, and species with open canopies (e.g. pastures, dense grasslands and wet meadows), which can be more difficult to estimate with the line intercept (LI) method. It provides a more objective estimate of cover than the ocular estimates used in the CF sampling method. It can be difficult to detect rare plants with the PO method unless many points are used for sampling. Point intercept sampling requires many points to sample rare species (e.g. 200 points to sample at .5 percent cover). Quadrats sample more area and have a greater chance of detecting rare species. If rare plant species are of interest the CF or RS methods are preferred since it is more effective to sample rare species using quadrats or marking individual plants than with points or lines. We suggest you use the PO method if you are primarily interested in monitoring changes in ground cover. The PO method may be used in conjunction with the CF method to sample ground cover by using the CF sampling quadrat as a point frame.

The Point Intercept method is considered one of the most objective ways to sample cover (Bonham, 1989). The observer only needs to decide whether a point intercepts a plant species or the ground. No cover estimates are required. Points offer quick and efficient data collection and can be used to estimate cover values with minimal bias and error. However, errors can be caused by plants moving in the wind or sampling poles lowered incorrectly. The points themselves have dimensions and can be considered very small quadrats. In theory, if you sampled an infinite number of points in an area, you could measure the exact cover for each plant species. Points are either the end of the sampling pole or the intersection of cross-hairs in a sampling frame.

Cover or ground cover is estimated using individual points or collections of points. Collections of points are sampled either with sampling pins, grouped into a pin frame (typically 10 pins) or cross-hairs grouped into a rectangular sighting frame. When using pin frames the sampling pole is replaced with a pin. Pins are generally smaller in diameter than a sampling pole so are less prone to sampling error (see below). The pin frame itself helps protect sampling pins from damage. Pin spacing should be determined according to plant species and vegetation patterns. For instance, pins in a collection should not be placed so close together that all pins hit bare ground between clumps of grasses or all fall on one clump of grass. The number of points used determines the percent cover values that can be estimated. For example, if 50 points are sampled along a transect, then cover can be estimated in 2 percent intervals (1/50, 2/50, etc.) for that transect. Cover is estimated by counting the number of "hits" per species or ground cover category divided by total number of points measured. More than one species may be tallied for each pin location depending on project objectives.

Sampling pole and pin diameter can influence the accuracy of cover estimates. This is mostly an issue with large diameter sampling poles, which overestimate cover, especially for narrow or small-leafed species. Pins less than 0.1 in. (2.5 mm) are impractical in the field because they move in the wind and are easily damaged (Bonham, 1989). Overestimation of cover is not a problem if the monitoring objective is to note relative cover changes rather than absolute change in cover. Because of the affect of sampling pole and pin diameter on cover estimations, it is necessary to always use same diameter poles or pins when re-measuring cover.

**Point Sampling Techniques**

*Single points*

Each sample point is defined by a sampling pole guided vertically to the ground. We recommend using a sturdy 0.25 in. (0.635 cm) diameter sampling pole when sampling with the FIREMON PO method. Smaller diameter poles (e.g. 0.125 in. (.3175 cm) ) may be used for more precise measurements and less observer decisions. However, thin poles are more flexible, require more finesse to place in a straight line, and are easily bent in the field. A fiberglass tent pole, wooden dowel or aluminum rod could all be used as a sampling pole. It should be longer than the vegetation that will be sampled is tall and long enough that field crews can sample without leaning over (40 in., 100 cm), sharpened on one end with a loop or bend on the other.

Individual points placed at systematic intervals along a transect can give a more precise cover estimate than points grouped into point frames or grid frames, given the same number of points are sampled. (Blackman 1935, Goodall 1952, Greig-Smith 1983). Using individual points requires approximately one third the number of points than using points in groups (Bonham, 1989). The distance between systematically located pins along a transect depends on plant size, plant distribution, and the distance between plants. The recommended FIREMON PO sampling method uses the single point sampling approach.

*Point frame*

Point frames are more practical and more commonly used than grid-frames. Point frames are built using wood or metal and consist of two legs and two cross arms, typically containing 10 pins (figure PO-1). The pins can be made of any material as long as it is relatively small diameter (0.25 in, 0.635 cm) and rigid enough not to bend or break, and long enough to touch the ground.

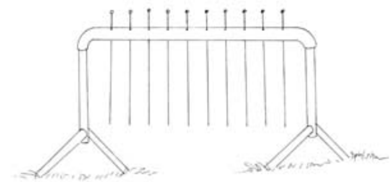


Figure PO-1. Example of a point frame with 10 pins.

When sampling, the pins are lowered to the ground cover through the holes and the interceptions are tallied. The size of the frame needs to be designed to suit local vegetation conditions because plant height and distribution patterns affect the spacing of pins and height of the frame. In vegetation types with large plants or clumped distributions, groups of points may intercept plants more frequently with more hits per frame resulting in an overestimation of cover. Some point frames are built to allow the pins to be slid at an angle into the vegetation and this can have some sampling benefits in certain types of vegetation. FIREMON provides an alternative data entry form and data entry software to accommodate data gathered with the point frame method. See the section on **Customizing the PO sampling design** for more details. See **How to Construct Point and Grid Frames** for more information.

*Grid quadrat frame*

A grid frame is made from metal or wood. Rows of thin wire or light string are attached to the inside vertical and horizontal pieces of the frame resulting in a number of intersections or "cross-hairs". Cross-hairs of a grid quadrat are considered point quadrats and the vertical interception of cross-hairs with plant parts are considered hits. A double grid of cross-hairs prevents error due to observers viewing the cross-hairs at different angles (figure PO-2).

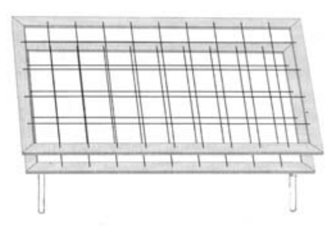


Figure PO-2. Example of a grid frame with 36 points (4 x 9).

Stanton (1960) designed a grid frame for estimating cover in shrub communities. This grid of cross-hairs consisted of 25 points spaced 7.5 cm. apart and was supported with metal legs. This type of frame is good for measuring cover up to 4.5 feet (1.5 m) tall in sparse vegetation. FIREMON provides an alternative data entry form and data entry software to accommodate data gathered with the grid quadrat frame method. See the section on **Customizing the PO sampling design** for more details.

There are a number of ways to streamline or customize the PO sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific PO Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

The sampling procedure is described in the order of the fields that need to be completed on the PO Transect Data form, so it is best to reference the data form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Preliminary Sampling Tasks

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation life form you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, will you be recording the plant status – dead or alive – for the part of the plant hit by the sampling pin or the entire plant? It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.

Many preparations must be made before proceeding into the field for PO sampling. First, all equipment and supplies in the **PO Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All PO Data forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Data forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future remeasurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. We found that it is very easy to transpose UTM coordinate digits when recording georeferenced positions on the plot sheet, so marked maps can help identify any erroneous plot positions. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

A field crew of two people is probably the most efficient for implementation of the PO sampling method. There should never be a one-person field crew for safety reasons, and any more than two people will probably result in part of the crew waiting for tasks to be completed and unnecessary trampling on the FIREMON macroplot. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most quadrat measurements. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency. As the field crew gains experience switch tasks so that the entire crew is familiar with the different sampling responsibilities and to limit monotony.

## Designing the PO Sampling Method

There is a set of general criteria recorded on the PO Data form that allows the user to customize the design of the PO sampling method so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be decided before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project. However, some of these fields, in particular the number of points per transect and number of transects, might be adjusted after preliminary sampling is conducted in the field to determine a sufficient sample size.

*Plot ID construction*

A unique plot identifier must be entered on the PO sampling form. This is the same plot identifier used to describe general plot characteristics in the Plot Description or PD sampling method. Details on constructing a unique plot identifier are discussed in the **How to Construct a Unique Plot Identifier** section. Enter the plot identifier at the top of the PO data form.

*Determining sample size*

The size of the macroplot ultimately determines the length of the transects and the length of the baseline along which the transects are placed. The amount of variation in plant species composition and distribution determines the number and length of transects and the number of quadrats required for sampling. The typical macroplot sampled in the PO method is a 0.10 acre (0.04 hectare) square measuring 66 x 66 feet (20 x 20 meters), which is sufficient for most monitoring applications. If you are not sure of the plot size to use contact someone that as sampled the same vegetation that you will be sampling. The size of the macroplot may be adjusted to accommodate different numbers and lengths of transects, and number of points per transect. It is more efficient if you use the same plot size for all FIREMON sampling methods on the plot.

The sampling unit for Point Intercept is the transect. We recommend sampling five transects within the macroplot, however, there are situations when more transects should be sampled. See **How To Determine Sample Size** for more details. Enter the number of transects in Field 1 on the PO Transect Option data form. The recommended transect length is 66 ft. (20 m) for a 66 x 66 ft. (20 x 20 m) macroplot. However, the macroplot size may be adjusted to accommodate longer or shorter transects based on the variability in plant species composition and distribution. For example, transects may be lengthened to accommodate more points per transect or more widely spaced points. Enter the transect length in Field 2 of the PO Transect data form. The FIREMON PO data form and data entry screen allow a maximum of 10 transects.

We recommend that 66 points be placed 1 foot (0.3 m) apart along each 66 foot (20 m) transect. However, when sampling with a metric tape, we recommend sampling at every 0.25 m for a total of 80 points per transect. The number of points and spacing should be adjusted based on plant species size and spacing. For example, points should not be placed so close together that all sample points hit bare ground between clumps of grasses or all sample points fall on grass clumps. The number of points along a transect determines the resolution of cover recorded. If 50 points are recorded along a transect, cover values can be recorded in increments of 2 percent (1/50, 2/50, etc). At a minimum, you want enough points to sample at least some of the species of interest along each transect. Enter the number of points per transect in Field 3 of the PO data form.

## Conducting PO Sampling Tasks

*Establish the baseline for transects*

Once the plot has been monumented, a permanent baseline is set up as a reference from which you will orient all transects. The baseline should be established so that the sampling plots for tall of the methods overlap as much as possible. See **How To Establish Plots with Multiple Methods**. The recommended baseline is 66 feet (20 m) long and is oriented upslope with the 0-foot (0 m) mark at the lower permanent marker and the 66-foot (20 m) mark at the upper marker. On flat areas, the baseline runs from south to north with the 0-foot (0 m) mark on the south end and the 66-foot (20 m) mark on the north end. See **How To Establish a Baseline for Transects** for more details.

*Locating the transects*

Transects are placed perpendicular to the baseline and are sampled starting at the baseline. On flat areas, transects are laid out east starting at the baseline. For permanent plots, determine the compass bearing of each transect, record these on the plot layout map and permanently mark each and of the transect. Starting locations for each transect are determined by selecting a sampling scheme using the FIREMON random transect locator or from supplied tables. If the PO method is used in conjunction with other replicated sampling methods (CF, LI, RS or DE), use the same transects for all methods. In successive remeasurement years, it is essential that transects be placed in the same location. See **How To Locate Transects and Quadrats** for more details.

*Sampling points*

Points are sampled at equal intervals along the length of a transect by lowering the sampling pole vertically to the ground, not perpendicular to the slope (figure PO-3). If 66 points are sampled along a 66-foot transect, the first point is recorded at 1 foot, then every foot to the end of the tape. If 80 points are sampled at 0.25 meters along a 20 meter transect the first point is sampled at 0.25 meter and the last point at 20 meters.

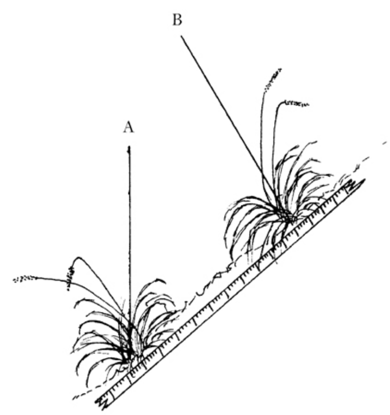



Figure PO-3. Points are sampled by lowering the pin vertically to the ground (point A) and not perpendicular to the slope (point B).

## Point Intercept Sampling

*Recording hits*

The FIREMON PO method may be used to sample just species cover, just ground cover or species and ground cover together. If the sampling crew is collecting species cover data, record only the plant species that are “hit” by the sampling pole. FIREMON provides plant species codes from the NRCS Plants database. However, local or customized plant species codes are allowed in FIREMON. See **How to Customize Plant Species Codes** for more details. When using the PO method to sample species cover in clumped or sparse vegetation, you may find that data is only recorded at a subset of the sampling locations because there may not be vegetation at every point that is sampled. If ground cover is being sampled, use the cover codes in table PO-1 to record sampling hits. Unlike species sampling, every point should have a ground cover code recorded.

Table PO-1. FIREMON Ground Cover Codes

| Ground Cover Code | Ground Cover Description | Ground Cover Code | Ground Cover Description |
|---|---|---|---|
| ASH | Ash (organic, from fire) | LICH | Lichen |
| BAFO | Basal forb | LITT | Litter and Duff |
| BAGR | Basal graminoid | MEGR | Medium gravel (5-20 mm) |
| BARE | Bare soil (soil particles < 2 mm) | MOSS | Moss |
| BARR | Barren | PAVE | Pavement |
| BASH | Basal shrub | PEIC | Permanent Ice |
| BATR | Basal tree | PEIS | Permanent Ice and Snow |
| BAVE | Basal vegetation | PESN | Permanent Snow |
| BEDR | Bedrock | ROAD | Road |
| BOUL | Boulders (round and flat) | ROBO | Round boulder (> 600 mm) |
| CHAN | Channers (2-150 mm long) | ROCK | Rock |
| CHAR | Char | ROST | Round stone (250-600 mm) |
| CML | Cryptogams, mosses and lichens | STON | Stones (Round and flat) |
| COBB | Cobbles (75-250 mm) | TEPH | Tephra volcanic |
| COGR | Coarse gravel (20-75 mm) | TRIC | Transient Ice |
| CRYP | Cryptogamic Crust | TRIS | Transient Ice and Snow |
| DEVP | Developed Land | TRSN | Transient Snow |
| FIGR | Fine gravel (2-5 mm) | UNKN | Unknown |
| FLAG | Flag stones (150-380 mm long) | WATE | Water |
| FLBO | Flat boulders (>600 mm long) | WOOD | Wood |
| FLST | Flat Stone (380-600mm long) | X | Did not assess |
| GRAV | Gravel (2-75 mm) | | |

If species and ground cover are being sampled at the same time, record the appropriate species for each pin that hits a plant and the appropriate ground cover code in table PO-1 (figure PO-4). For instance, if a sampling pole hits a blade of blue grama grass and the basal portion of the plant, record the NRCS species code, BOGR2, and the ground cover code, BAGR or BAVE. Enter the plant species and ground cover code in Field 4 on the PO Transect data form.

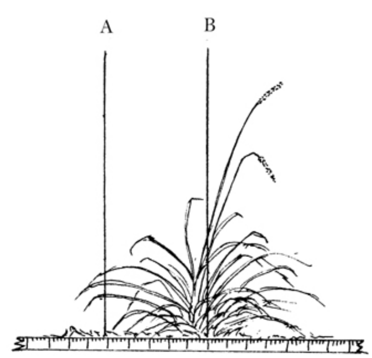



Figure PO-4. If the sampling pole eventually hits ground instead of the basal portion of the plant, then the appropriate ground cover code is recorded, even if it intercepts the aerial portion of the plant (A). Basal vegetation is recorded for ground cover when the pin hits the basal portion of the plant (B).

The number of hits that are recorded for each sampling point is dependent on the project objectives. If the objective is just to monitor ground cover, samplers only need to record the ground cover hits. To develop a complete species list samplers should record all unique species hits at each sampling point. Multiple hits for each species can be recorded if measuring biomass, volume, or species composition. Again, this is important information to be recorded in the Metadata table.

The angle of the sampling pole has an effect on cover estimates. Vertically lowered sampling poles hit flat bladed species (forbs) more often than grasses. A pole lowered at an angle tends to favor grasses (Winkworth 1955). Most cover measurements use vertical placement of poles, but will underestimate narrow leafed species (e.g. grasses). Other angles are used to increase the number of hits. However, angled sampling eliminates the intuitive visualization of a vertical projection of vegetation onto the ground. In FIREMON we recommend using the vertical orientation of the sampling pole. The angle used in sampling is the type of information that should be entered in the FIREMON Metadata table so that data collected in subsequent visits is compatible – especially if some orientation other than vertical pole placement is used for point sampling.

At each interval, lower a 0.25 in. (0.635 cm) diameter sampling pin to the ground and record one hit for each plant species that touches the pole. Only record one hit for each plant species, even if the pole touches the same plant or plant species more than once (figure PO-5). When measuring ground cover you will generally record only the first or upper most hit. For instance, if the pin passes through an ash layer to bare soil, record only the ash layer.

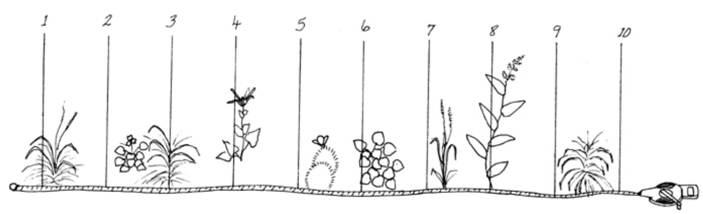



Figure PO-5. In this illustration points 1, 3, 4, 6, and 8 intersect plants and are recorded as "hits" for each species. Points 2, 5, 9 and 10 "miss" plants and are only recorded if ground cover is being sampled. Samplers will usually record just the first ground cover hit at each sampling point.

Tally the "hits" for each species using a dot tally in the workspace column for each transect on the PO Transect data form. See **How to Dot Tally** for more details. Enter the total number of hits for each species or ground cover class, by transect, in the HITS field on the PO Transect data form.

*Recording plant status*

Next enter the plant species status in field 5 on the PO Transect data form. Status describes the general health of the plant species as live or dead using the following codes:

**L** – **Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

This may be an evaluation of the entire plant or just the part of the plant that comes in contact with the sampling pole depending on the project objectives. In FIREMON we recommend recording the status of the plant part that touches the sampling pole. Recognize that an accurate assessment of plant status may be difficult during the dormant season.

Plant status is purely qualitative but it does provide an adequate characteristic for stratification of pre-burn plant health and in determining post-burn survival.

*Estimating average height*

At the end of each transect estimate the average height of each plant species you tallied, in feet (meters) within +/- 10 percent of the mean plant height. This is not the height of above the ground where the sampling pole touches the vegetation but the average total height of the plants that are tallied. See **How to Measure Plant Height** for more details. Enter plant height in the HT field for each transect.

**Precision Standards**

Use these precision standards for the PO sampling.

Table PO-2. Precision guidelines for PO sampling.

| Component | Standard |
|---|---|
| Hits | ±3 percent total hits |
| Height | ±10 percent average height |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the PO sampling method can be modified to collect more detailed information or streamlined to collect only the most important tree characteristics. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Recommended PO Sampling Design

The recommended PO sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 5
**Number of Points per Transect:** 66 per 66 ft. transect or 80 per 20 m transect, vertically oriented

The number of transects sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual. The number of points per transect should be adjusted based on plant species size and spacing.

Collect plant species cover data and ground cover data.

### Streamlined PO Sampling Design

The streamlined PO sampling design follows the Simple FIREMON sample strategy and is designed below:

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 3
**Number of Points per Transect:** 66 per 66 ft. transect or 80 per 20 m transect, vertically oriented

The number of transects sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual. The number of points per transect should be adjusted based on plant species size and spacing.

Collect plant species cover and average plant height data.

**Comprehensive PO Sampling Design**

The comprehensive PO sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 5
**Number of Points per Transect:** 100 placed at 8 in. intervals on a 66 ft. transect or placed at .20 m intervals on a 20 m transect, vertically oriented

The number of transects sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual. The number of points per transect should be adjusted based on plant species size and spacing.

Collect plant species cover, ground cover, and measure average plant height.

**Customizing the PO Sampling Design**

There are a number of ways the user can adjust the PO sample fields to make sampling more efficient and meaningful for local situations. Examiners may adjust the number of transects and points per transect based on plant species size and distribution.

Points can be sampled in quadrats or frames placed along a transect rather than using individual points. Collections of points are pins grouped into a pin frame (usually 10 pins) or cross-hairs grouped into a sighting frame. See **How To Construct Point Frames and Grid Frames** for more details. If 10 pins are used in a frame, percent cover can be estimated within 10 percent intervals (1/10, 2/10, etc.) for each frame. If the point frames or grid frames are placed far enough apart (i.e., are independent), the frames can be the sample units rather than the transects.

The PO method may be used in conjunction with the CF method to sample ground cover by using the CF sampling quadrat as a point frame. A pencil or pen is used to record ground cover "hits" at the four corners and the four midpoints on each side of the quadrat. A total of eight points are recorded for each quadrat.

If grid frames or point frames are being sampled along transects rather than individual points, then determine the number of quadrats or point frames sampled per transect using the methods in **How To Determine Sample Size**. Record the number of frames per transect in Field 3, the number of points per frame in Field 4, and the transect number in Field 5 on the PO Point Frames data form. The FIREMON data entry screen and database accommodates 25 frames per transect and an unlimited number of transects.

The PO method is typically used for grasses, forbs, and small shrubs less than 3 feet (1 m) in height. However, this method can be modified to sample large shrubs and trees as well. Instead of using pins which drop to the ground or a grid frame which the observer looks down on, you can use a sighting device, such as a sighting tube or “moosehorn” which allows you to look down for small plants and look up into the canopy for larger species.

The type of cover typically estimated by points is total cover. Cover can also be measured within defined vegetation layers, or by different species. If measuring cover, record only the first hit of each pin. Multiple hits for each species can be recorded if measuring biomass, volume, or species composition.

**Sampling Hints and Techniques**

Examiners must be able to identify plant species, be familiar with ground cover category codes, and know how to collect cover data using a pin. If only ground cover is being sampled, plant identification skills are not required since examiners are only recording basal vegetation as part of ground cover.

Measuring tapes come in a variety of lengths, increments, and materials. Examiners should choose english (metric) tapes for this method and select a tape that is at least as long, or a little longer, than the transect length being sampled. Steel tapes do not stretch and are the most accurate over the life of the tape. Steel is probably the best choice for permanent transects where remeasurement in exactly the same place each time is important. Cloth and fiberglass tapes will stretch over the life of the tape, but are easier to use than steel tapes since they are lighter and do not tend to kink.

Point intercept cover is easily calculated if 100 points are sampled per transect. Cover values are equal to the number of “hits” for each item on the transect. Metric tapes are easily divided into 100 intervals and sampling a 20-meter tape at 20 cm intervals is relatively simple. However, if sampling with English tapes marked in inches and feet, sampling 100 points is impractical unless the transect length is a multiple of 100 (e.g. 50, 100, 200). On a 66-foot transect, 100 points must be placed at 8 inch intervals, which is time consuming to place the point at the right mark on the tape. If a high resolution of cover is desired (e.g. 1 percent), one solution is to sample along a 66 foot transect at every 0.5 feet for 132 points. Another solution is to increase the transect length to 100 feet, and place a point at every foot. When deciding how many points to sample per transect, it is better to sample more transects than place more points per transect. Sampling with fewer points and more transects will often sample more variability within the plot at a slightly lower resolution of cover (e.g. 1/66 = 1.5 percent vs. 1/100 = 1 percent).

The sampling crew may encounter an obstacle, such as a large rock or tree, along one of the transect lines that interferes with the quadrat sampling. If that happens offset using the directions described in **How To Offset a Transect**.

When entering data on the PO Transect data forms, examiners will most likely run out of space on the first page. The form was designed to print one copy of the first page, and several copies of the second page. The second page can be used to record more plant species on the first three transects or to record data for additional transects. The second page of the data form allows the examiner to write the transect number on the form. This allows the examiner to design the form to accommodate the number transects sampled. Print out enough pages to record all species on all transects for the required number of intercepts. The FIREMON data entry screens and database allow a maximum of 10 transects.

When entering data on the PO Point Frames data forms, examiners will most likely run out of space on the first page. As with the PO Transect form, the Frame form was designed to print one copy of the first page, and several copies of the second page. The second page can be used to record more plant species on the first five point frames or to record data for additional frames. The second page of the data form allows the examiner to write the frame number on the form. This allows the examiner to design the form to accommodate the number frames sampled per transect. Print out enough pages to record all species on all transects for the required number of intercepts. The FIREMON data entry screens and database allow a maximum of 25 frames per transect and an unlimited number of transects.

# Point Intercept (PO) Form
## Transects

PO Page _ _ of _ _

| Field 1 | Field 2 | Field 3 |
| --- | --- | --- |
| Number of Transects | Transect Length | Number of Pts./Tran. |
| | | |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _

| Field 4 | Field 5 | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | | Transect 5 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Item Code | Status | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) |
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# Point Intercept (PO) Form
## Transcect continuation

| Field 1 | Field 2 | Field 3 |
|---|---|---|
| Number of Transects | Transect Length | Number of Pts./Tran. |
| | | |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _

PO Page _ _ of _ _

| Field 4 | Field 5 | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | | Transect 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item Code | Status | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) |
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# Point Intercept (PO) Form

## Point Frames

PO Page _ _ of _ _

Plot Key

Registration Code: _ _ _ _

Project Code: _ _ _ _ _ _ _ _

Plot Number: _ _ _

Date: _ _/_ _/_ _ _ _

| Field 1 | Field 2 | Field 3 | Field 4 |
|---|---|---|---|
| Number of Transects | Transect Length | Number of Frames/Trans | Number of Pts./Frame |
| | | | |

| Field 5 | Field 6 | Field 7 | Frame 1 | | Frame 2 | | Frame 3 | | Frame 4 | | Frame 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) |
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# Point Intercept (PO) Form

## Point Frames Continuation

PO Page _ _ of _ _

Plot Key

Registration Code: _ _ _ _

Project Code: _ _ _ _ _ _ _ _ _

Plot Number: _ _ _

Date: _ _/_ _/_ _ _ _

| Field 1 | Field 2 | Field 3 | Field 4 |
|---|---|---|---|
| Number of Transects | Transect Length | Number of Frames/Trans | Number of Pts./Frame |
| | | | |

| Field 5 | Field 6 | Field 7 | Frame _ | | Frame _ | | Frame _ | | Frame _ | | Frame _ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) | Hits | Height (ft/m) |
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# FIREMON
# POINT INTERCEPT (PO) FIELD DESCRIPTIONS

## Transect Form

Field 1: **Number of Transects**. Total number of transects on the plot.

Field 2: **Transect Length.** Length of transect. (ft/m).

Field 3: **Number of Points per Transect**. Number of points sampled per transect.

Field 4: **Item Code.** Code of sampled entity. Either the NRCS plants species code, local code for that species, ground cover code, or other item code.

Field 5: **Status**: Plant status - Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

**Hits.** Enter the total number of hits for the item on the transect. Precision: ±3 percent of total

**Average Height**. Enter the average height for each plant species or life-form on the transect. (ft/m). Precision: ±10 percent mean height.

## Point Frame Form

Field 1: **Number of Transects**. Total number of transects on the plot.

Field 2: **Transect Length**. Length of transect. Length of transect. (ft/m).

Field 3: **Number of Frames per Transect**. Number of frames sampled per transect.

Field 4: **Number of Points per Frame**. Number of points sampled per frame.

Field 5: **Transect Number.** Sequential number of the sample transect.

Field 6: **Item Code**. Code of sampled entity. Either the NRCS plants species code, local code for that species, ground cover code, or other item code.

Field 7: **Status**: Plant status - Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

**Hits.** Enter the total number of hits for the item in the frame. Precision: ±3 percent of total.

**Average Height**. Enter the average height for each plant species or life-form in the frame. (ft/m). Precision: ±10 percent mean height.

**FIREMON**
**POINT COVER (PO) EQUIPMENT LIST**

Camera with film
PO Plot Forms
Clipboard
Compass
File
Field notebook
Graph Paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Pocket calculator
Point Frame (Pin or Grid) (optional)
Pole – ¼ inch diameter
Plot sheet protector or plastic bag
Rebar stakes (2) for baseline plus 2 for each transect
Steel fence post (2) and driver (to mark endpoints of baseline)
Tape 75 ft (25 m) or longer (2)

# FIREMON PO Cheat Sheet

**Ground Cover Codes**

| Ground Cover Code | Ground Cover Description |
|---|---|
| ASH | Ash (organic, from fire) |
| BAFO | Basal Forb |
| BAGR | Basal graminoid |
| BARE | Bare soil (soil particles < 2 mm) |
| BARR | Barren |
| BASH | Basal shrub |
| BATR | Basal tree |
| BAVE | Basal vegetation |
| BEDR | Bedrock |
| BOUL | Boulders (round and flat) |
| CHAN | Channers (2-150 mm long) |
| CHAR | Char |
| CML | Cryptogams, mosses and lichens |
| COBB | Cobbles (75-250 mm) |
| COGR | Coarse gravel (20-75 mm) |
| CRYP | Cryptogamic Crust |
| DEVP | Developed Land |
| FIGR | Fine gravel (2-5 mm) |
| FLAG | Flag stones (150-380 mm long) |
| FLBO | Flat boulders (>600 mm long) |
| FLST | Flat Stone (380-600mm long) |
| GRAV | Gravel (2-75 mm) |
| LICH | Lichen |
| LITT | Litter and Duff |
| MEGR | Medium gravel (5-20 mm) |
| MOSS | Moss |
| PAVE | Pavement |
| PEIC | Permanent Ice |
| PEIS | Permanent Ice and Snow |
| PESN | Permanent Snow |
| ROAD | Road |
| ROBO | Round boulder (> 600 mm) |
| ROCK | Rock |
| ROST | Round stone (250-600 mm) |
| STON | Stones (Round and flat) |
| TEPH | Tephra volcanic |
| TRIC | Transient Ice |
| TRIS | Transient Ice and Snow |
| TRSN | Transient Snow |
| UNKN | Unknown |
| WATE | Water |
| WOOD | Wood |
| X | Did not assess |

**Status Codes**

| Code | Description |
|---|---|
| L | Live |
| D | Dead |
| NA | Not Applicable |

**Precision**

| Component | Standard |
|---|---|
| Cover | ± 1 class |
| NRF | No error |
| Height | ± 10 percent |

# Line Intercept (LI)
## Sampling Method

EXECUTIVE SUMMARY

The FIREMON Line Intercept (LI) method is used to assess changes in plant species cover for a macroplot. This method uses multiple line transects to sample within plot variation and quantify statistically valid changes in plant species cover and height over time. This method is suited for most forest and rangeland communities, but is especially useful for sampling shrub cover greater than 3 feet (1 m) tall, since it is difficult to ocularly estimate the cover of tall shrubs. The LI method can be used in conjunction with cover-frequency transects when vegetation over 3 feet (1 m) exists. Line intercept can also be used to calibrate ocular estimates of shrub cover when the Species Composition (SC) method is used. Cover is recorded as the number of feet (m) intercepted by each plant species along a transect. Percent cover is calculated by dividing the number of feet (m) intercepted by each species by the total length of the transect.

## INTRODUCTION

The Line Intercept (LI) method is designed to sample within plot variation and quantify changes in plant species cover and height over time using transects located within the macroplot. Transects have random starting points and are oriented perpendicular to the baseline. First, samplers record the transect length and number of transects. Then, along each transect,. cover intercept and average height are recorded for each plant species.

This method is primarily used when the fire manager wants to monitor changes in plant species cover and height. This method is primarily designed to sample plant species with dense crowns or large basal areas. The LI method works best in open grown woody vegetation (e.g. western US shrub communities), especially shrubs greater than 3 feet (1 m) in height. The CF method is generally preferred for sampling herbaceous plant communities with vegetation less than 3 feet (1 m) in height, however, the LI method can be used in junction with the CF method if shrubs greater than 3 feet (1 m) exist on the plot (e.g. CF quadrats can be used to sample herbaceous vegetation then the transect used to locate the quadrats can be used to sample shrubs using the LI methods). This is probably the best method of sampling cover in mixed plant communities with grasses, shrubs, and trees. This method is not well suited for sampling single stemmed plants or dense grasslands. The PO method is better suited for sampling fine textured herbaceous communities such as dense grasslands and wet meadows. Cover measured with line intercept is less prone to observer bias than ocular estimates of cover in quadrats, CF method. However, if rare plant species are of interest the CF methods are preferred since rare species are easier to sample with quadrats than with points or lines.

Tansley and Chipp (1926) introduced the line intercept method. A line transect, typically a measuring tape stretched taut on the ground or at a height which contacts the vegetation canopy, is used to make observations of plant cover. The method consists of measuring the length of intercept for each plant that occurs over or under the tape. If basal cover is of interest, then the tape is placed at ground level. Percent cover is sampled by recording the length of intercept for each plant species measured along a tape by noting the point on the tape where the plant canopy or basal portion begins and the plant canopy or basal portion ends. When these intercept lengths are summed and divided by the total tape length, the result is a percent cover for the plant species along the transect.

The line transect can be any length and, if modified, is usually done so based on the type of vegetation being sampled (Bonham, 1989). In general, cover in herbaceous communities can be estimated with short lines (typically less than 50 m), while longer lines (50 m or greater) should be used in some shrub and tree communities. Canfield (1941) recommended using a 15 m transect for areas with 5 to 15 percent cover and using a 30 m line when cover is less than 5 percent. The amount of time needed to measure a transect can also be used to determine the length of the transect (Bonham, 1989). Canfield recommended a transect length in which canopy intercepts can be measured by two people in approximately 15 minutes.

The line intercept method is most efficient for plant species that have a dense crown cover (e.g. shrubs or matted plants) or have a relatively large basal area (e.g. bunch grasses) and is best suited where the boundaries of individual plants are easily determined. Line intercept is not an effective method for estimating the cover of single-stemmed plant species or dense grasslands (e.g. rhizomatous species).

Most plant species have some gaps in their canopies, such as bunchgrasses with dead centers or shrubs with large spaces between branches. Rules for dealing with gaps must be clearly defined, since observers treat gaps differently. One solution is for the observer to assume a plant has a closed canopy unless a gap is greater than some predetermined width. We recommend that gaps less than 2 inches (5 cm) be considered part of the canopy.

There are many ways to streamline or customize the LI sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific LI Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

The sampling procedure is described in the order of the fields that need to be completed on the LI data form, so it is best to reference the LI data form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Preliminary Sampling Tasks

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation life form you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, how will you take into account gaps in the foliage of the same plant? It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.

A number of preparations must be made before proceeding into the field for LI sampling. First, all equipment and supplies in the **LI Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All LI Plot Forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future remeasurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook. For example, snow on the plot might be described in the notebook, which would be very helpful in plot remeasurement.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is closed. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. We found that it is very easy to transpose UTM coordinate digits when recording georeferenced positions on the plot sheet, so marked maps can help identify any erroneous plot positions. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

A field crew of two people is probably the most efficient for implementation of the LI sampling method. There should never be a one-person field crew for safety reasons, and any more than 2 people will probably result in some people waiting for critical tasks to be done and unnecessary trampling on the plot. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most point intercept measurements. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency, but sampling tasks can be modified as the field crew gains experience and shared to limit monotony.

**Designing the LI Sampling Method**

There is a set of general criteria recorded on the LI Plot form that forms the user-specified design of the LI sampling method. Each general LI field must be designed so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be decided before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project. However, some of these fields, in particular the number and length of transects might be adjusted after a pilot study is conducted in the field to determine a sufficient sample size.

*Plot ID construction*

A unique plot identifier must be entered on the LI sampling form. This is the same plot identifier used to describe general plot characteristics in the Plot Description or PD sampling method. Details on constructing a unique plot identifier are discussed in the **How to Construct a Unique Plot Identifier** section. Enter the plot identifier at the top of the LI data form.

*Determining the sample size*

The size of the macroplot ultimately determines the length of the transects and the length of the baseline along which the transects are placed. The amount of variation in plant species composition and distribution determines the number and length of transects required for sampling. The typical macroplot sampled in the LI method is a 0.10 acre (0.04 ha) square measuring 66 x 66 feet (20 x 20 m), which is sufficient for most monitoring applications. Shrub dominated ecosystems will generally require larger macroplots when sampling with the LI method. Dr. Rick Miller has sampled extensively in shrub dominated systems and we have included a write-up of his method in **Appendix C: Rick Miller Method for Sampling Shrub Dominated Systems**. If you are not sure of the plot size to use contact someone that as sampled the same vegetation that you will be sampling. The size of the macroplot should be adjusted to accommodate the size of the vegetation. However, it is more efficient if you use the same plot size for all FIREMON sampling methods on the plot.

The recommended transect length is 66 ft. (20 m) for a 66 x 66 ft. (20 x 20 m) macroplot. However, the macroplot size may be adjusted to accommodate longer or shorter transects based on the variability in plant species composition and distribution.

We recommend sampling five transects within the macroplot, however, there are situations when more transects should be sampled. See **How To Determine Sample Size** for more details. Enter the number of transects in Field 1 on the LI data form.

The following section is designed to help the sampling crew lay out the FIREMON LI sampling plot. For simplicity these directions assume that the crew has decided to use the recommended macroplot size. However, the size of the LI plot may need to be modified based on resource constraints and vegetation attributes. Permanent sampling plots will only need to be laid out once. On subsequent sampling visits field crews will simply need to locate each end of the line intercept transects, stretch the measuring tape between them and resample the vegetation.
Once the permanent FIREMON plot has been monumented (see **How To Permanently Establish a FIREMON Plot**) the sampling crew can begin laying out the LI sampling plot, which is accomplished in general two steps: 1) locate the baseline and 2) locate the transects where vegetation will be sampled.

**Conducting LI Sampling Tasks**

*Locating the baseline for transects*

Once the plot has been monumented, a permanent baseline is set up as a reference from which you will orient all transects. The baseline should be established so that the sampling plots for tall of the methods overlap as much as possible. See **How To Establish Plots with Multiple Methods**. The recommended baseline is 66 feet (20 m) long and is oriented upslope with the 0-foot (0 m) mark at the lower permanent marker and the 66-foot (20 m) mark at the upper marker. On flat areas, the baseline runs from south to north with the 0-foot (0 m) mark on the south end and the 66-foot (20 m) mark on the north end. See **How To Establish a Baseline for Transects** for more details.

*Locating the transects*

Transects are located within the macroplot, perpendicular to the baseline and across the slope. For permanent plots, determine the compass bearing of the transects and record it on the plot layout map.  All transects should be at the same azimuth. Starting locations for each transect are determined using the FIREMON random transect locator or from supplied tables. If the LI method is used in conjunction with other replicated sampling methods (CF, PO, RS or DE), use the same transects for all methods. Remember that in successive re-measurement years, it is essential that transects be placed in the same location. See **How To Locate Transects and Quadrats** for more details.

Carefully stretch a measuring tape, which represents the transect, from the starting point on the baseline out 66 feet (20 m) at an azimuth perpendicular to the baseline. The measuring tape will be stretched taut and straight on the ground or at a height above the vegetation canopy (figure LI-1) if measuring crown cover. If basal cover is recorded, then the tape is always placed at ground level.

Figure LI-1. The measuring tape is stretched tight below, in or above the canopy vegetation, whatever position allows the easiest estimation of cover without the tape zigzagging around plants.

For two reasons the tape must be as straight as possible and not zigzagging around the vegetation. First, a tape stretched straight between the permanently marked transect ends will ensure that the same vegetation sampled during the initial visit will be re-sampled on subsequent visits. Second, the crown cover estimate could be biased if the tape is bent around the stems because more of the tape lies under the plant canopy.

If the tape is to be stretched above vegetation the crew will need some way to hold it tight and above the canopy. One method is to drive a rebar at each of the transect then slip a piece of metal electrical conduit over the bar and attach the tape ends to the conduit with wire, hooks or tape. Rebar is an excellent way to permanently mark the ends of the transects however it should not be left in place if there are horses, other livestock or people that frequent the study site because the rebar can injure feet and legs. Also, in areas where people are recreating, any visible rebar may be objectionable because it is incongruous with natural surroundings.

**Line Intercept Sampling**

First enter the transect number in Field 2 on the LI data form. Next, enter the plant species or item code for each item recorded in Field 3. FIREMON provides plant species codes from the NRCS Plants database. However, local or customized plant species codes are allowed in FIREMON. See **How to Customize Plant Species Codes** for more details.

Next enter the plant species status in Field 4 on the LI data form. Status describes the general health of the plant species as live or dead using the following codes:

**L** – **Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

Plant status is purely qualitative but it does provide an adequate characteristic for stratification of pre-burn plant health and in determining post-burn survival.

*Size class*

Plant species size classes represent different layers in the canopy. For example, the upper canopy layer could be defined by large trees, while pole size trees and large shrubs might dominate the middle layer of the canopy, and the lower canopy layer could include seedlings, saplings, grasses and forbs. Size class data provide important structural information such as the vertical distribution of plant cover. Size classes for trees are typically defined by height for trees less than 4.5 feet (1.37 m) tall and diameter at breast height (DBH) for larger trees. Size classes for shrubs, grasses, and forbs are typically defined by height. If the vegetation being sampled has a layered canopy structure, then cover can be recorded by plant species and by size class. Total size class cover for a plant species can equal more than 100 percent for each plant species due to overlap between different size classes.

FIREMON uses a size class stratification based on the ECODATA sampling methods (Jensen and others, 1994). Field crews can group individual plants by species into one or more trees size classes (table LI-1) or shrub, grass, and forb size classes (table LI-2). There can be multiple size classes for each species. See **How To Measure DBH** for detailed information on measuring

DBH to group trees into size classes. See **How to Measure Plant Height** for detailed information on measuring height for grouping shrubs into size classes.

Table LI-1. Tree size class codes.

| Tree Size Class Codes | Tree Size Class English | Tree Size Class Metric |
|---|---|---|
| TO | Total cover | Total cover |
| SE | Seedling (<1 in. DBH or <4.5 ft height) | Seedling (<2.5 cm DBH or <1.5 m height) |
| SA | Sapling (1.0 in. - < 5.0 in. DBH) | Sapling (2.5 - <12.5 cm DBH) |
| PT | Pole Tree (5.0 in. – <9.0 in. DBH) | Pole Tree (12.5 – <25 cm DBH) |
| MT | Medium Tree (9.0 in. – <21.0 in. DBH) | Medium Tree (25 – <50 cm DBH) |
| LT | Large Tree (21.0 in. – <33.0 in. DBH) | Large Tree (50 – <80 cm DBH) |
| VT | Very Large Tree (33.0+ in. DBH) | Very Large Tree (80+ cm DBH) |
| NA | Not Applicable | Not Applicable |

Table LI-2. Shrub, grass, and forb size class codes.

| Shrub / Herb Size Class Codes | Shrub / Herb Size Class English | Shrub / Herb Size Class Metric |
|---|---|---|
| TO | Total cover | Total cover |
| SM | Small (<0.5 ft height) | Small (<0.15 m height) |
| LW | Low (0.5 - <1.5 ft height) | Low (0.15 - <0.5m height) |
| MD | Medium (1.5 – <4.5 ft height) | Medium (0.5 – <1.5 m height) |
| TL | Tall (4.5 – <8 ft height) | Tall (1.5 – <2.5 m height) |
| VT | Very Tall (8+ ft height) | Very Tall (2.5+ m height) |
| NA | Not Applicable | Not Applicable |

If cover is being recorded by size class, enter the size class code for each plant species in Field 5 on the LI data form. If size class data is not recorded, then record only the total cover for each plant species. When recording total cover for a species, enter the TO code in Field 5 to indicate that the cover estimate is for all of the size classes.

Enter the transect length in Field 6 of the LI data form. Transect length is entered by item and size class allowing transect length to vary by species and size class.

*Estimating cover (intercept)*

The procedure for measuring the live crown intercept bisected by the transect line is illustrated in figure LI-2. Proceed from the baseline toward the opposite end of the tape and measure the horizontal linear length of each plant that intercepts the line. The start and stop point for each intercept are recorded in feet (m). When measuring intercepts in feet, use a tape which is marked in 10ths and 100ths of feet. Measure the intercept of grasses and grass-like plants, along with rosette-forming plants, at ground level. For forbs, shrubs, and trees measure the vertical projection of the vegetation intercepting one side of the tape. Be sure not to inadvertently move the tape and carefully look under tall dense crowns to be sure you are sampling all species and size classes. The measurements are recorded by plant species or item in Start and Stop fields on the LI data form to the nearest 0.1 ft (0.03 m). The FIREMON data entry screens populate the Intercept field automatically when the start and stop points are entered.

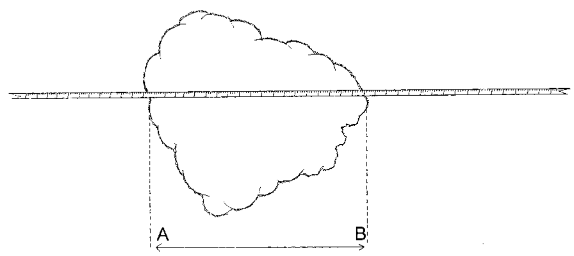


Figure LI-2. Measure canopy intercept in feet (m) along the measuring tape. Since canopy intercept can vary on each side of the measuring tape, measure intercept on one side of the measuring tape only. We suggest using the right side as you move along the tape. Record the start of the plant intercept (A) in the Start field and the end intercept (b) in Stop field.

Canopy overlap within a species is not distinguished but canopy overlap between different species *is* recorded (figure LI-3).

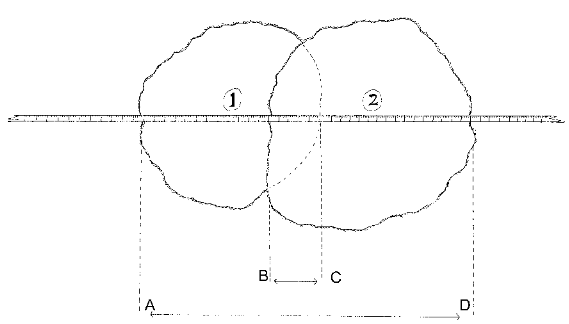


Figure LI-3. Canopy overlap (points B to C) is not measured if the canopy of two or more plants of the same species overlap. For example, if shrubs 1 and 2 are the same species, then the canopy intercept is measured from points A to D. If shrubs 1 and 2 are different species, then canopy intercept is measured from points A to C for shrub species 1 and from points B to D for shrub species 2.

Percent cover is calculated by totaling the intercept measurements for all individuals of that species (in the Intercept field) along the transect and dividing by the total length of the transect. Most plant species have some gaps in their canopies, such as bunchgrasses with dead centers or shrubs with large spaces between branches. Examiners must determine how to deal with gaps in the canopy. One solution is for the observer to assume a closed canopy unless the gap is greater than some predetermined length. We recommend that gaps less than 2 inches (5 cm) be considered part of the canopy (figure LI-4).

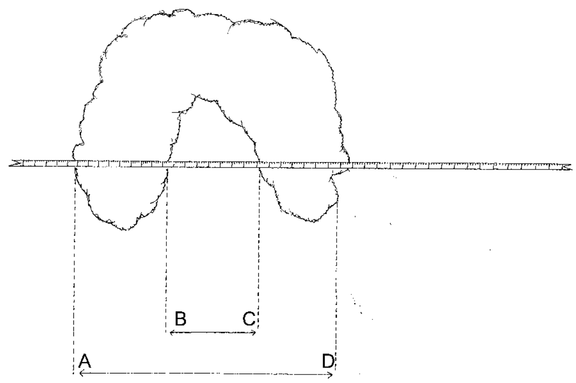


Figure LI-4. Gaps in the canopy (points B to C) greater than 2 inches (5 cm) are not measured. The canopy intercept for this shrub is measured from point A to D if the distance from B to C is less than or equal to 2 inches (5 cm) or measured from points A to B and points C to D if the gap is greater than 2 inches (5 cm).

The FIREMON data entry screens and database allow an unlimited number of intercepts for each plant species along a transect.

*Estimating average height*

Estimate the average height in feet (meters), within +/- 10 percent, for each plant species (figure LI-5). The estimation should only be for the part of the plant that is intercepted by the tape, not the entire plant.

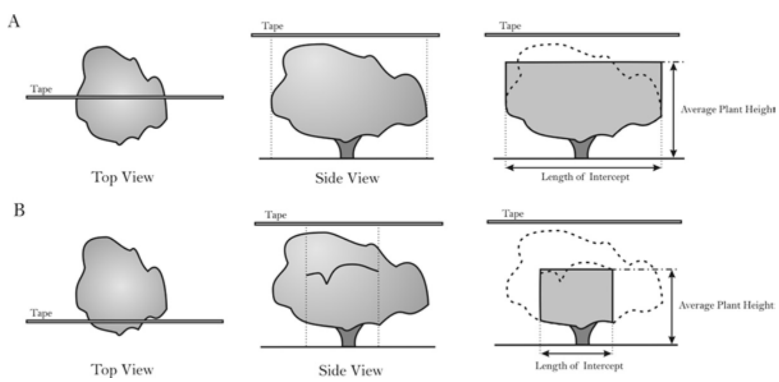


Figure LI-5. Estimate the average plant height only for the portion of the plant intercepted by the tape. If the tape crosses the entire plant then average the height for the entire plant (A). If the tape only crosses a portion of the plant, estimate the average height for only the part that is intercepted (B).

Enter plant height in the Height on the LI field form for each item or species intercept. If plant species are recorded by size class, measure the average height for the plant species by each size class recorded. See **How to Measure Plant Height** for more details. Plant height may be recorded at one intercept representing an average for the entire transect, at a few intercepts, or at every intercept. Be sure to record this information in the FIREMON Metadata table.

**Precision Standards**

Use these precision standards for the LI sampling.

Table LI-3. Precision guidelines for LI sampling.

| Component | Standard |
|---|---|
| Size class | ±1 class |
| Start | ±0.1 ft/0.03 m |
| Stop | ±0.1 ft/0.03 m |
| Height | ±10 percent average height |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the LI sampling method can be modified to collect more detailed information or streamlined to collect only the most important tree characteristics. First, the suggested or recommended sample design is detailed, then modifications are presented.

### Recommended LI Sampling Design

The recommended LI sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

Collect plant species data. Make one estimate of height for each species that is representative of the entire transect.

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 5

The number of transects sampled should be adjusted according to the sample size determination described in the "How To" section of the FIREMON manual.

### Streamlined LI Sampling Design

The streamlined LI sampling design follows the Simple FIREMON sample strategy and is designed below:

Collect plant species data.

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 3

### Comprehensive LI Sampling Design

The comprehensive LI sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

Collect plant species data by size class and measure average plant height at each intercept.

**Macroplot Size**: 0.1 acre, 66ft x 66ft. (400 square meters, 20 x 20 m)
**Number of Transects:** 5

The number of transects sampled should be adjusted according to the sample size determination described in the "How To" section of the FIREMON manual.

**User-specific LI Sampling Design**

There are many ways the user can adjust the LI sample fields to make sampling more efficient and meaningful for local situations. Adjust the number and length of transects based on plant species size and distribution. Longer transects capture more variability in plant species cover, reducing the number of transects required to accurately estimate cover (Elzinga and others 1998).

The LI method is generally used for sampling shrub communities with vegetation greater than 3 feet 1m in height. However, this method can be used to sample taller vegetation if sighting devices are used to record the start and stop points for each intercept along a transect. Sighting devices may be mounted to a tripod and pointed downward to sample shorter vegetation (e.g. grasses, forbs, and small shrubs) and pointed upward to sample taller vegetation (e.g. tall shrubs and trees).

**Sampling Hints and Techniques**

Examiners must be able to identify plant species and know how to collect cover data by measuring canopy intercepts along a measuring tape. Line intercepts should be recorded only along one edge of the measuring tape; the right side as you proceed to the end of the tape. It is important to prevent the tape from moving so that certain plants are inadvertently included or excluded. For instance it can be very difficult to sample using the LI method when it is windy because the tape will not be stationary.

The accuracy of this method depends on how well the FIREMON crew can estimate the vertical projection of vegetation along the tape. Observer bias occurs because the sighting line used to determine canopy starts and stops is not perpendicular to the tape. This bias can be minimized by using two measuring tapes (one above and one below) and sighting along the right side of the top tape to the right side of the bottom tape. Another solution is to suspend the measuring tape above the vegetation and use a plumb bob to record intercepts. For overhead vegetation, a pole with a level can be used. When measuring low and high vegetation, the most accurate method is to use a type of optical sighting device.

Measuring tapes come in a variety of lengths, increments, and materials. Examiners should choose english (metric) tapes for this method and select a tape that is at least as long, or a little longer, than the transect length being sampled. When measuring plant species intercepts in feet, use a tape which is marked in 10ths and 100ths of feet. Steel tapes do not stretch and are the most accurate over the life of the tape. Steel is probably the best choice for permanent transects where remeasurement in exactly the same place each time is important. Cloth and fiberglass tapes will stretch over the life of the tape, but are easier to use than steel tapes since they are lighter and do not tend to kink.

The sampling crew may encounter an obstacle, such as a large rock or tree, along one of the transect lines that interferes with the quadrat sampling. If that happens offset using the directions described in **How To Offset a Transect**.

When entering data on the LI plot forms, examiners will most likely run out of space on the first page. The form was designed to print one copy of the first page, and several copies of the second page. The second page can be used to record more plant species intercepts for the plant species or items recorded on the first page or for additional plant species and items. The second page of the data form allows the examiner to write the intercept number on the form. This allows the examiner to design the form to accommodate the number of intercepts sampled. Print out enough pages to record all species on all transects for the required number of intercepts. The FIREMON data entry screens and database allow a maximum of 25 intercepts for each plant species along a transect.

# Line Intercept (LI) Form

| Field 1 |
|---|
| Number of Transects:___________ |

Plot Key

Registration Code: _ _ _ _

Project Code: _ _ _ _ _ _ _ _ _

Plot Number: _ _ _

Date: _ _/_ _/_ _ _ _



| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field 2 | Transect Number | | Field 2 | Transect Number | | Field 2 | Transect Number | | Field 2 | Transect Number | | Field 2 | Transect Number | | Field 2 | Transect Number | |
| Field 3 | Item Code | | Field 3 | Item Code | | Field 3 | Item Code | | Field 3 | Item Code | | Field 3 | Item Code | | Field 3 | Item Code | |
| Field 4 | Status | | Field 4 | Status | | Field 4 | Status | | Field 4 | Status | | Field 4 | Status | | Field 4 | Status | |
| Field 5 | Size Class | | Field 5 | Size Class | | Field 5 | Size Class | | Field 5 | Size Class | | Field 5 | Size Class | | Field 5 | Size Class | |
| Field 6 | Transect Length (ft/m) | | Field 6 | Transect Length (ft/m) | | Field 6 | Transect Length (ft/m) | | Field 6 | Transect Length (ft/m) | | Field 6 | Transect Length (ft/m) | | Field 6 | Transect Length (ft/m) | |
| Start | Stop | Height | Start | Stop | Height | Start | Stop | Height | Start | Stop | Height | Start | Stop | Height | Start | Stop | Height |
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## LINE INTERCEPT (LI) FIELD DESCRIPTIONS

Field 1: **Number of Transects**. Total number of transects on the plot.

Field 2: **Transect Number**. Sequential number of the sample transect.

Field 3: **Item Code.** Code of sampled entity. Either the NRCS plants species code or the local code for that species. Or, ground cover code. Precision: No error.

Field 4: **Status**: Plant status - Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

Field 5: **Size Class**. Size of the sampled plant. Valid classes are in tables LI-1 and LI-2 of the sampling method. Precision: ±1 class

Field 6: **Transect Length**. Length of transect. May be different for different species/life forms. (ft/m)

**Start**. Enter the starting point of each intercept for the plant species or life-form along the transect. (ft/m). Precision: ±0.1 ft/0.03 m

**Stop.** Enter the stopping point of each intercept for the plant species or life-form along the transect. (ft/m). Precision: ±0.1 ft/0.03 m

**Height**. Enter the average height for each plant species or life-form at one or more intercepts along the transect. Precision: ±10 percent of average height

**FIREMON**
**LINE INTERCEPT (LI) EQUIPMENT LIST**

Camera with film
LI Plot Forms
Clipboard
Compass
File
Graph Paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Field notebook
Reinforcing bar (2) to mark baseline
Reinforcing bars or bridge spikes to mark transects
Metal electrical conduit (lengths) to attach tape
Tape 75 ft (25 m) or longer, marked in 0.01 units (2)
Yardstick or meter stick

# FIREMON LI Cheat Sheet

**Status Codes**

| Code | Description |
|---|---|
| L | Live |
| D | Dead |
| NA | Not Applicable |

**Tree Size Classes**

| TREE SIZE CLASS CODES | TREE SIZE CLASS DESCRIPTIONS (English) | TREE SIZE CLASS DESCRIPTIONS (Metric) |
|---|---|---|
| TO | Total cover | Total cover |
| SE | Seedling (<1 in. dbh or <4.5 ft. height) | Seedling (<2.5 cm dbh or <1.5 m height) |
| SA | Sapling ( 1.0 in. - <5.0 in. dbh) | Sapling ( 2.5 - <12.5 cm dbh) |
| PT | Pole Tree ( 5.0 in. – < 9.0 in. dbh) | Pole Tree ( 12.5 – <25 cm dbh) |
| MT | Medium Tree ( 9.0 in. – <21.0 in. dbh) | Medium Tree ( 25 – <50 cm dbh) |
| LT | Large Tree ( 21.0 in. – <33.0 in. dbh) | Large Tree ( 50 – <80 cm dbh) |
| VT | Very Large Tree (33.0 + cm dbh) | Very Large Tree (80 + cm dbh) |
| NA | Not Applicable | Not Applicable |

**Shrub and Herbaceous Size Classes**

| SHRUB / HERB SIZE CLASS CODES | SHRUB / HERB SIZE CLASS DESCRIPTIONS (English) | SHRUB / HERB SIZE CLASS DESCRIPTIONS (Metric) |
|---|---|---|
| TO | Total cover | Total cover |
| SM | Small (< 0.5 ft. height) | Small (< 0.25 m height) |
| LW | Low (0.5 - <1.5 ft. height) | Low (0.25 - <0.5m height) |
| MD | Medium (1.5 – < 4.5 ft. height) | Medium (0.5 – < 1.5 m height) |
| TL | Tall (4.5 – < 8 ft. height) | Tall (1.5 – < 2.5 m height) |
| VT | Very Tall (8 ft. + height) | Very Tall (2.5 m + height) |
| NA | Not Applicable | Not Applicable |

**Precision**

| Component | Standard |
|---|---|
| Size class | ±1 class |
| Start | ±0.1 ft/0.03 m |
| Stop | ±0.1 ft/0.03 m |
| Height | ±10 percent average height |

# **Density (DE)**
## Sampling Method

EXECUTIVE SUMMARY

The FIREMON Density (DE) method is used to assess changes in plant species density and height for a macroplot. This method uses multiple quadrats and belt transects (transects having a width) to sample within plot variation and quantify statistically valid changes in plant species density and height over time. Herbaceous plant species are sampled with quadrats while shrubs and trees are sampled with belt transects. Quadrats for sampling herbaceous plants are placed systematically along randomly located transects. Belt transects for sampling shrub and tree density use the same randomly located transects. The number of individuals for each plant species in a quadrat or belt transect are calculated. Density is calculated as the number of individuals per unit area using the area of the sampling unit, quadrat or belt transect. This method is primarily suited for grasses, forbs, shrubs, and small trees in which individual plants or stems can be distinguished. However, we recommend using the FIREMON TD sampling methods for estimating tree density.

## INTRODUCTION

The Density (DE) method was designed to sample within plot variation and quantify changes in plant species density and height over time. This method uses multiple quadrats to sample herbaceous plant density and belt transects to sample shrub and tree density. First, a baseline is established from which to run the transects from. Transects are placed randomly along the baseline. Quadrats for sampling herbaceous plants are then placed systematically along each transect. Belt transects for sampling shrub and tree density are placed along the length of each transect. Characteristics are recorded about the general sample design and for individual plant species. First the transect length, number of transects, and number of quadrats per transect are recorded. Within each quadrat or belt transect, density and average height are recorded for each plant species. The quadrat length and width or belt transect width is also recorded for each species. Different size quadrats and belts can be used for different plant species.

This method is primarily used when the fire manager wants to monitor changes in plant species numbers. This method is primarily suited for grasses, forbs, shrubs, and small trees which are easily separated into individual plants or counting units, such as stems. However, we recommend using the FIREMON TD sampling method for estimating tree density. This sampling method uses density to assess changes in plant species numbers over time. The quadrat size and belt width varies with plant species or item and size class, allowing different size sampling units for different size plants or items. Quadrat size and belt width should be adjusted according to plant size and distribution.

Density is defined as the number of items per unit area. When sampling density, the examiner must be able to recognize and define individual plants. This may be relatively easy for single stemmed plants, but is more difficult for plants which reproduce vegetatively such as rhizomatous plants (e.g. western wheatgrass) or clonal species (e.g. aspen). It is critical to define exactly what item will be counted before sampling. The item counted may be individual plants for single stem plants or individual stems for a clonal species such as quaking aspen.

Density is used for monitoring an increase or decrease in the number of individuals or counting units. Density is more effective for detecting changes in recruitment or mortality than changes in vigor. It is not a practical monitoring method when plants respond to management treatments or disturbance with decreased cover rather than mortality. In such cases, density may not change much although cover and biomass may change considerably.

The accuracy of the density estimate depends largely on the size and shape of the quadrat or belt transect. Note that a belt transect is essentially a long, narrow quadrat. Pound and Clements (1898) considered plant dispersion, quadrat size and shape, and number of observations required as important characteristics to sample design. Van Dyne (1963) reviewed results from studies on quadrat sizes and shapes used to sample grassland communities of the western United States. Long narrow quadrats tend to include more species since vegetation tends to occur in clumps rather than be randomly distributed. The desired size and shape for a quadrat depends largely on the distribution of plant species being sampled. In general, sampling in sparse vegetation requires the use of larger quadrats. However quadrats should not be too large, since counting large numbers of plants in a quadrat can be overwhelming, and can lead to errors. In order to increase the sampling area, it is better to sample more quadrats than to use overly large quadrats.

With small quadrats, there is a greater chance of boundary error because of the greater perimeter to area ratio. Boundary problems are due to erroneously including or excluding plants near the quadrat perimeter. Some portion of basal vegetation must intersect the quadrat boundary for a plant to be considered a boundary plant. Boundary rules must be established before sampling. We recommend counting boundary plants “in” on two adjacent sides of a quadrat and “out” on the other adjacent sides. See **How to Count Boundary Plants**.

There are many ways to streamline or customize the DE sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency. See the sections on **User Specific DE Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

The sampling procedure is described in the order of the fields that need to be completed on the DE field form, so it is best to reference the DE Field form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

### Preliminary Sampling Tasks

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation life form you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, how close do two bunchgrasses have to be before they are counted as one? It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.
Many preparations must be made before proceeding into the field for DE sampling. First, All equipment and supplies in the DE Equipment List must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that

supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All DE Field forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future re-measurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook. For example, snow on the plot might be described in the notebook, which would be very helpful in plot re-measurement.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Locations and/or directions to the plots you will be sampling should be readily in order to reduce travel times. If the FIREMON plots were randomly located within the sampling unit it is critical that the crew is provided plot coordinates before going into the field. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. It is easy to mis-record latitude and longitude coordinates and marked maps can help identify any erroneous plot positions.

A field crew of two people is probably the most efficient for implementation of the DE sampling method. There should never be a one-person field crew for safety reasons, and any more than two people will probably result in some people waiting for critical tasks to be done. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most quadrat measurements. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency, but sampling tasks should be modified as the field crew gains experience. Tasks should also be shared to limit monotony.

**Designing the DE Sampling Design**

There is a set of general criteria recorded on the DE Plot form that forms the user-specified design of the DE sampling method. Each general DE field must be designed so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be determined before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project.

*Plot ID construction*

A unique plot identifier must be entered on the DE sampling form. This is the same plot identifier used to describe general plot characteristics in the Plot Description or PD sampling method. Details on constructing a unique plot identifier are discussed in the **How to Construct a Unique Plot Identifier** section. Enter the plot identifier at the top of the DE field form.

*Determining sample size*

The size of the macroplot ultimately determines the length of the transects and the length of the baseline along which the transects are placed. The amount of variability in plant species composition and distribution determines the number and length of transects and the number of quadrats required for sampling. The typical macroplot sampled in the DE method is a 0.10 acre (0.04 hectare) square measuring 66 x 66 feet (20 x 20 meters), which is sufficient for most monitoring applications. The size of the macroplot may be adjusted to accommodate different numbers and lengths of transects. However, it is more efficient if you use the same plot size for all FIREMON sampling methods on the plot.

If you are sampling shrubs and trees we recommend sampling five belt transects within the macroplot. This should be sufficient for most studies however, there are situations when more transects should be sampled. See **How To Determine Sample Size** for more details. Enter the number of transects in Field 1 on the DE Belt Transect field form. The recommended transect length is 66 ft (20 m) for a 66 x 66 ft (20 x 20 m) macroplot. However, the macroplot size may be adjusted to accommodate longer or shorter transects based on the variability in plant species composition and distribution. The FIREMON DE field form and data entry screen allow a maximum of 10 transects per macroplot

We recommend sampling at least five quadrats per transect for herbaceous plants, and this should be sufficient for most studies. There are situations when more quadrats should be sampled. Additional quadrats may be sampled by placing more quadrats along a transect or by sampling more transects within the macroplot. Enter the number of quadrats per transect in Field 2 of the DE Quadrat field form. The FIREMON DE Quadrat field form and data entry screen allow a maximum of 25 quadrats per transect.

*Determining the belt transect size and quadrat Size*

Density is typically recorded in quadrats for herbaceous species and in belt transects for shrubs. We recommend using a 66 x 3 foot (20 x 1 m) belt width for sampling smaller shrubs (< 3 ft. (1 m) average diameter) and a 66 x 6 foot (20 x 2m) belt width for larger shrubs (> 3 ft. (1 m) average diameter). Belt length and width may be adjusted to accommodate different sizes and densities of shrubs and trees. Longer, wider transects can be sampled for larger or sparsely distributed shrubs and trees, and shorter, narrower transects can be sample for smaller, and more dense shrubs and trees. Enter the belt transect length in Field 5 and width in Field 6 of the DE Transect field form. You may vary the belt length and width for different plant species you encounter on the macroplot but be sure to enter the appropriate length and width for each species on the field form.

We recommend using 3 x 3 ft (1 x 1 m) quadrats for sampling herbaceous vegetation, however quadrat size and transect length may be adjusted to accommodate the size and spacing of the plants being sampled. Larger plants can be counted in larger quadrats on longer transects and smaller plants in smaller quadrats on shorter transects. See **How To Construct a Quadrat Frame** for instructions on building and using quadrat frames. Enter the quadrat length and width in feet (m) in Fields 7 and 8 on the DE Quadrat field form. Quadrat length and width is entered by item and size class and can may vary for different items and size classes. Be sure to record all of the length and width measurements on the field form.

**Conducting DE Sampling Tasks**

*Establish the baseline for transects*

Once the plot has been monumented, a permanent baseline is set up as a reference from which you will orient all transects. The baseline should be established so that the sampling plots for tall of the methods overlap as much as possible. See **How To Establish Plots with Multiple Methods**. The recommended baseline is 66 feet (20 m) long and is oriented upslope with the 0-foot (0 m) mark at the lower permanent marker and the 66-foot (20 m) mark at the upper marker. On flat areas, the baseline runs from south to north with the 0-foot (0 m) mark on the south end and the 66-foot (20 m) mark on the north end. See **How To Establish a Baseline for Transects** for more details.

*Locating the transects*

Transects are placed perpendicular to the baseline and are sampled starting at the baseline. On flat areas, transects are located from the baseline to the east. Starting locations for each transect are determined using the FIREMON random transect locator or from supplied tables. If the CF method is used in conjunction with other replicated sampling methods (LI, PO, RS or CF), use the same transects for all methods, if possible. In successive remeasurement years, it is essential that transects be placed in the same location. See **How To Locate Transects and Quadrats** for more details.

*Locating the quadrats*

There will typically be five 3 x 3 ft (1 x 1 m) quadrats located at 12 ft (4 m) intervals along a transect, with the first quadrat placed 12 ft. (4 m) from the baseline. However, the spacing of the quadrats will depend on the size of the quadrat and the length of the transect. See **How To Locate Transects and Quadrats** for more details. If macroplots are being sampled for permanent remeasurement, quadrats must be placed in the same location in successive sampling. When sampling macroplots that are not scheduled for permanent remeasurement, the distance between quadrats may be estimated by pacing.

**Density Sampling**

When sampling herbaceous species, enter the transect number in Field 3 on the DE Quadrat field form. The transect number is not entered on the DE Transect field form for sampling shrub or tree species using belt transects. Enter the species code or item code (e.g. moose pellets) in Field 4 on the DE Quadrat Option field form or Field 2 on the Transect Option field form. FIREMON uses the NRCS Plants species codes, however you may use your own species codes. See **How to Customize Plant Species Codes** for more details.

Next enter the plant species status in Field 5 on the DE Quadrat Field form and Field 3 on the DE Transect field form. Status describes the general health of the plant species as live or dead using the following codes:

**L – Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

Plant status is purely qualitative but it does provide an adequate characteristic for stratification of pre-burn plant health and in determining post-burn survival. Use care in determining plant status during the dormant season.

*Size class*

Plant species size classes represent different layers in the canopy. For example, the upper canopy layer could be defined by large trees, while pole size trees and large shrubs might dominate the middle layer of the canopy, and the lower canopy layer could include seedlings, saplings, grasses and forbs. Size class data provide important structural information such as the vertical distribution of plant cover. Size classes for trees are typically defined by height for seedlings and diameter at breast height (dbh) for larger trees. Size classes for shrubs, grasses, and forbs are typically defined by height. If the vegetation being sampled has a layered canopy structure, then density can be recorded by plant species and by size class.

FIREMON uses a size class stratification based on the ECODATA sampling methods (Jensen and others, 1994). Group individual plants by species into one or more trees size classes (table DE-1) or shrub, grass, and forb size classes (table DE-2). There can be multiple size classes for each species. See **How To Measure DBH** for detailed information on measuring DBH to group trees into size classes. See **How to Measure Plant Heights** for detailed information on measuring height for grouping shrubs into size classes.

Table DE-1. Tree size class codes.

| Tree Size Class Codes | Tree Size Class English | Tree Size Class Metric |
|---|---|---|
| TO | Total count | Total count |
| SE | Seedling (<1 in. DBH or <4.5 ft height) | Seedling (<2.5 cm DBH or <1.5 m height) |
| SA | Sapling (1.0 in. - < 5.0 in. DBH) | Sapling (2.5 - <12.5 cm DBH) |
| PT | Pole Tree (5.0 in. – <9.0 in. DBH) | Pole Tree (12.5 – <25 cm DBH) |
| MT | Medium Tree (9.0 in. – <21.0 in. DBH) | Medium Tree (25 – <50 cm DBH) |
| LT | Large Tree (21.0 in. – <33.0 in. DBH) | Large Tree (50 – <80 cm DBH) |
| VT | Very Large Tree (33.0+ in. DBH) | Very Large Tree (80+ cm DBH) |
| NA | Not Applicable | Not Applicable |

Table DE-2. Shrub, grass, and forb size class codes.

| Shrub / Herb Size Class Codes | Shrub / Herb Size Class English | Shrub / Herb Size Class Metric |
|---|---|---|
| TO | Total count | Total count |
| SM | Small (<0.5 ft height) | Small (<0.15 m height) |
| LW | Low (0.5 - <1.5 ft height) | Low (0.15 - <0.5m height) |
| MD | Medium (1.5 – <4.5 ft height) | Medium (0.5 – <1.5 m height) |
| TL | Tall (4.5 – <8 ft height) | Tall (1.5 – <2.5 m height) |
| VT | Very Tall (8+ ft height) | Very Tall (2.5+ m height) |
| NA | Not Applicable | Not Applicable |

If recording density by size class, enter the size class code for each plant species in Field 6 on the DE Quadrat field form and Field 4 on the DE Transect field form. If size class data is not recorded, indicate that by entering using the code “TO”.

*Density*

Record the number of individual plants for each plant species or individual plants for each plant species by size class within the quadrat (figure DE-1). Decisions about counting boundary plants (plants which have a portion of basal vegetation intersecting the quadrat) need to be applied systematically to each quadrat. See **How to Count Boundary Plants** for more details. Enter the count for each plant species or plant species by size class in the Count field by quadrat on the DE Quadrat field form or by transect on the DE Transect field form. Use the workspace below each Count field for a dot tally. See **How to Dot Tally** for more details.

Figure DE-1. Count individual plants by plant species or plant species by size class. In this example there are five individuals of a grass species, three individuals of a tree species, and two individuals of a forb species.

*Estimating average height*

Measure the average height for each plant species in feet (meters) within +/- 10 percent of the mean plant height. If plant species are recorded by size class, measure the average height for individual species by each size class recorded. See **How to Measure Plant Heights** for more details. Enter plant height in the Height field for each transect on the DE Transect form or for each quadrat on the DE quadrat form.

**Precision Standards**

Use these precision standards for the DE sampling.

Table DE-3. Precision guidelines for DE sampling.

| Component | Standard |
|---|---|
| Count | ±10 percent total count |
| Average height | ±10 percent average height |
| Size class | ±1 class |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the DE sampling method can be modified to collect more detailed information or streamlined to collect basic information.

### Recommended DE Sampling Design

The recommended DE sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:

**Macroplot Size**: 0.1 acre, 66 ft x 66 ft. (400 square meters, 20 x 20 m)
**Quadrat Size (herbaceous plant sampling):** 3 x 3 ft. (1 x 1 m)
**Belt Transect Width (shrubs and tree sampling):** 3 feet (1 m) or 6 feet (2m)
**Number of Transects:** 5
**Number of Quadrats / Transect:** 5

**Count plant species within each quadrat.**

The quadrat size and shape and belt transect width should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

### Streamlined DE Sampling Design

The streamlined DE sampling design follows the Simple FIREMON sample strategy and is designed below:

**Macroplot Size**: 0.1 acre, 66 ft x 66 ft. (400 square meters, 20 x 20 m)
**Quadrat Size (herbaceous plant sampling):** 3 x 3 ft. (1 x 1 m)
**Belt Transect Width (shrubs and tree sampling):** 3 feet (1 m) or 6 feet (1m)
**Number of Transects:** 3
**Number of Quadrats / Transect:** 5

**Count plant species within each quadrat.**

The quadrat size and shape and belt transect width should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

**Comprehensive DE Sampling Design**

The comprehensive DE sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Macroplot Size**: 0.1 acre, 66 ft x 66 ft. (400 square meters, 20 x 20 m)
**Quadrat Size (herbaceous plant sampling):** 3 x 3 ft. (1 x 1 m)
**Belt Transect Width (shrubs and tree sampling):** 3 feet (1 m) or 6 feet (2 m)
**Number of Transects:** 5
**Number of Quadrats / Transect:** 5

**Count plant species by size class and measure average plant species height by size class within each quadrat.**

The quadrat size and shape and belt transect width should be adjusted according to the plant community being sampled.

The number of transects and quadrats sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

**User-specific DE Sampling Design**

The user can modify the DE sample fields a number of ways in order to make sampling more efficient and meaningful for local situations. This will usually mean adjusting the number of transects, transect length, transect width, quadrat size, or number of quadrats as needed for the specific task. Use the MD form to record any changes in sampling methods that are modified from the standard or to remark on any other DE matter that needs to be explained or defined for subsequent sampling and data use.

Many different sizes and shapes of quadrats and belt transects can be used to sample density. It is probably most efficient to conduct a pilot study to determine the size and shape of quadrat or belt transect that allows number of plants to be easily counted and also minimizes the variance between sampling units. See Elzinga and others (1998) for a detailed discussion on this topic. Plant species density may be sampled using quadrats of various sizes, belt transects of various sizes, or a combination of both belts and quadrats. If circular plots are being used to count plants, then enter the radius of the plot in the quadrat length field and leave the quadrat width field blank on the DE field forms. The FIREMON sampling forms and databases will accommodate most sampling variations of the DE method.

**Sampling Hints and Techniques**

Examiners must be able to identify plant species, identify individual plants, and be able to determine whether a plant species occurs within a quadrat. It can be difficult to distinguish individual plants for some species such as sod-forming grasses. If individual plants are difficult to identify, guidelines should be determined before sampling as to what constitutes the individual counting unit. Some examples include counting individual stems in aspen communities, culm groups in rhizomatous grasses, and flowering stems for mat-forming forbs. However, the counting unit chosen to monitor should reflect a real change in the plant community.

Measuring tapes come in a variety of lengths, increments, and materials. Examiners should choose English (metric) tapes for this method and select a tape that is at least as long, or a little longer, than the transect length being sampled. Steel tapes do not stretch and are the most accurate over the life of the tape. Steel is probably the best choice for permanent transects where remeasurement in exactly the same place each time is important. Cloth and fiberglass tapes will stretch over the life of the tape, but are easier to use than steel tapes since they are lighter and do not tend to kink.

The sampling crew may encounter an obstacle, such as a large rock or tree, along one of the transect lines that interferes with the quadrat sampling. If that happens offset using the directions described in **How To Offset a Transect**.

When entering data on the DE Transect Option plot forms, examiners will most likely run out of space on the first page. The form was designed to print one copy of the first page, and several copies of the second page. The second page can be used to record more plant species on the first three transects or to record data for additional transects. The second page of the field form allows the examiner to write the transect number on the form. This allows the examiner to design the form to accommodate the number transects sampled. Print out enough pages to record all species on all transects for the required number of intercepts. The FIREMON data entry screens and database allow a maximum of 10 transects.

When entering data on the DE Quadrat Option plot forms, examiners will most likely run out of space on the first page. If so, use the DE continuation form. The continuation page can be used to record more plant species on the first five quadrats or to record data for additional frames. The continuation page allows the examiner to write the quadrat number on the form, thus allowing the examiner to design the form to accommodate the number frames sampled per transect. Print out enough pages to record all species on all transects for the required number of counts. The FIREMON data entry screens and database allow a maximum of 25 frames per transect and an unlimited number of transects.

# Density (DE) Form

## Quadrats

| Field 1 | Field 2 |
|---|---|
| Number of Transects | Number of Quad/Tran |
| | |

Plot Key

Registration Code: _ _ _ _

Project Code: _ _ _ _ _ _ _ _

Plot Number: _ _ _

Date: _ _/_ _/_ _ _ _

DE Page _ _ of _ _

| Field 3 | Field 4 | Field 5 | Field 6 | Field 7 | Field 8 | Quadrat 1 | | Quadrat 2 | | Quadrat 3 | | Quadrat 4 | | Quadrat 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Size Class | Quadrat Length (ft/m) | Quadrat Width (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) |
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# Density (DE) Form
## Quadrats - continuation

| Field 1 | Field 2 |
|---|---|
| Number of Transects | Number of Quad/Tran |
| | |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _



| Field 3 | Field 4 | Field 5 | Field 6 | Field 7 | Field 8 | Quadrat 1 | | Quadrat 2 | | Quadrat 3 | | Quadrat 4 | | Quadrat 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transect Number | Item Code | Status | Size Class | Quadrat Length (ft/m) | Quadrat Width (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) |
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Notes:

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# Density (DE) Form

**Belt Transects**

| Field 1 |
|---|
| Number of Transects |
| |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _

DE Page _ _ of _ _

| Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Transect 1 | | Transect 2 | | Transect 3 | | Transect 4 | | Transect 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item Code | Status | Size Class | Transect Length (ft/m) | Transect Width (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) |
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# Density (DE) Form
## Belt Transects Continuation

| Field 1 |
|---|
| Number of Transects |
| |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _



| Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Transect _ | | Transect _ | | Transect _ | | Transect _ | | Transect _ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Item Code | Status | Size Class | Transect Length (ft/m) | Transect Width (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) | Count | Height (ft/m) |
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# FIREMON
# DENSITY (DE) FIELD DESCRIPTIONS

## Quadrat Form

Field 1: **Number of Transects**. Total number of transects on the plot.

Field 2: **Number of Quadrats per Transect**. Number of quadrats sampled per transect.

Field 3: **Transect Number**. Sequential number of the sample transect.

Field 4: **Item Code.** Code of sampled entity. Either the NRCS plants species code or the local code for that species. Precision: No error.

Field 5: **Status**: Plant status – Live, Dead or Not Applicable. (L, D, NA). Precision: No error.

Field 6: **Size Class**. Size of the sampled plant. Valid classes are in tables DE-1 and DE-2 of the sampling method. Precision: ±1 class.

Field 7: **Quadrat Length.** Length of the quadrat. May be different for different species/life forms. (ft/m).

Field 8: **Quadrat Width**. Width of the quadrat. May be different for different species/life forms. (ft/m).

**Count**. Total number of individuals for the plant species or life-form inside the transect. Precision: ±10 percent of total count.

**Average Height**. Average height for each plant species or life-form in transect. (ft/m). Precision: ±10 percent mean height.

## Belt Transect Form

Field 1: **Transect Number.** Sequential number of the sample transect.

Field 2: **Item Code**. Code of sampled entity. Either the NRCS plants species code or the local code for that species. Precision: No error.

Field 3: **Status**: Plant status - Live or Dead. Precision: No error.

Field 4: **Size Class**. Size of the sampled plant. Valid classes are in tables DE-1 and DE-2 of the sampling method. Precision: ±1 class.

Field 5: **Transect Length**. Length of transect. May be different for different species/life forms. (ft/m).

Field 6: **Transect Width**. Width of transect. May be different for different species/life forms. (ft/m).

**Count**. Enter the total number of individuals for the plant species or life-form inside the transect. Precision: ±10 percent total count.

**Average Height**. Enter the average height for each plant species or life-form in transect. (ft/m). Precision: ±10 percent mean height.

**FIREMON**
**DENSITY (DE) EQUIPMENT LIST**

Camera, film and flash
DE Plot Forms
Clipboard
Compass
Field notebook
File
Graph Paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Pocket calculator
Plot sheet protector or plastic bag
Rebar (2) for baseline plus 2 for each transect
Steel fence posts (2) and driver (to mark endpoints of baseline)
Tape 75 ft. (25 m) or longer (3)
Folding Rulers 6 ft. (2 m) (2-3)

**Status Codes**

| Code | Description |
|---|---|
| L | Live |
| D | Dead |
| NA | Not Applicable |

**Tree Size Classes**

| TREE SIZE CLASS CODES | TREE SIZE CLASS DESCRIPTIONS (English) | TREE SIZE CLASS DESCRIPTIONS (Metric) |
|---|---|---|
| TO | Total count | Total count |
| SE | Seedling (<1 in. dbh or <4.5 ft. height) | Seedling (<2.5 cm dbh or <1.5 m height) |
| SA | Sapling ( 1.0 in. - <5.0 in. dbh) | Sapling ( 2.5 - <12.5 cm dbh) |
| PT | Pole Tree ( 5.0 in. – < 9.0 in. dbh) | Pole Tree ( 12.5 – <25 cm dbh) |
| MT | Medium Tree ( 9.0 in. – <21.0 in. dbh) | Medium Tree ( 25 – <50 cm dbh) |
| LT | Large Tree ( 21.0 in. – <33.0 in. dbh) | Large Tree ( 50 – <80 cm dbh) |
| VT | Very Large Tree (33.0 + cm dbh) | Very Large Tree (80 + cm dbh) |
| NA | Not Applicable | Not Applicable |

**Shrub and Herbaceous Size Classes**

| SHRUB / HERB SIZE CLASS CODES | SHRUB / HERB SIZE CLASS DESCRIPTIONS (English) | SHRUB / HERB SIZE CLASS DESCRIPTIONS (Metric) |
|---|---|---|
| TO | Total count | Total count |
| SM | Small (< 0.5 ft. height) | Small (< 0.25 m height) |
| LW | Low (0.5 - <1.5 ft. height) | Low (0.25 - <0.5m height) |
| MD | Medium (1.5 – < 4.5 ft. height) | Medium (0.5 – < 1.5 m height) |
| TL | Tall (4.5 – < 8 ft. height) | Tall (1.5 – < 2.5 m height) |
| VT | Very Tall (8 ft. + height) | Very Tall (2.5 m + height) |
| NA | Not Applicable | Not Applicable |

**Precision**

| Component | Standard |
|---|---|
| Count | ±10 percent total count |
| Average height | ±10 percent average height |
| Size class | ±1 class |

# Rare Species (RS)
## Sampling Method

EXECUTIVE SUMMARY

The FIREMON Rare Species (RS) method is used to assess changes in uncommon, perennial plant species when other monitoring methods are not effective. This method monitors individual plants and statistically quantifies changes in plant survivorship, growth, and reproduction over time. Plants are spatially located using distance along and from a permanent baseline and individual plants are marked using a permanent tag. Data are collected for status (living or dead), stage (seedling, non-reproductive, or reproductive), size (height and diameter), and reproductive effort (number of flowers and fruits). This method is primarily used for Threatened and Endangered species and uncommon grass, forb, shrub, and tree species of special interest.

## INTRODUCTION

When plants become rare, most sampling methods are not effective because the species does not occur in the sampling unit. Therefore, it becomes necessary to follow individual plants in order to determine fire effects for that species. The Rare Species (RS) method was designed to quantify temporal changes in plant survivorship, growth, and reproduction for uncommon, perennial plant species. This method is not effective for rare annual species. First, a permanent baseline is established and baseline length and characteristics about the general sample design are recorded. For each plant, a unique ID number, distance along the baseline, and perpendicular distance from the baseline is recorded. Data are collected for status (living or dead), stage (seedling, non-reproductive, or reproductive), size (height and diameter), and reproductive effort (number of flowers and fruits) for each individual plant.

This method is primarily used when the fire manager wants to monitor changes in Threatened and Endangered perennial plant species and uncommon species of special interest. This method is suited for rare grass, forb, shrub, and tree species that are not effectively monitored by other methods.  This sampling method uses attributes of individual plants to assess changes in survivorship, growth, and reproduction over time.

There are many ways to streamline or customize the RS sampling method. The FIREMON three-tier sampling design can be employed to optimize sampling efficiency.
See the sections on **User Specific RS Sampling Design** and **Sampling Design Customization** below.

## SAMPLING PROCEDURE

This method assumes that the sampling strategy has already been selected and the macroplot has already been located. If this is not the case, then refer to the FIREMON **Integrated Sampling Strategy** and for further details.

More than any of the other FIREMON methods, the RS method is especially sensitive to the timing of sampling in relation to the phenological stage of the plants being sampled. Plant size, stage and, stem, flower and fruit counts change as the growing season progresses. A monitoring plan that includes rare species sampling and does not take phenological stage into consideration will probably not result in useful data. This topic is covered more thoroughly in Chapter 12 of Measuring and Monitoring Plant Populations (Elzinga and others, 1998). The publication is free and is available for download from the BLM library website:

http://www.blm.gov/nstc/library/techref.htm

Select T.R. number 1730-1.

The sampling procedure is described in the order of the fields that need to be completed on the RS field form, so it is best to reference the RS Field form when reading this section. The sampling procedure described here is the recommended procedure for this method. Later sections will describe how the FIREMON three-tier sampling design can be used to modify the recommended procedure to match resources, funding, and time constraints. A field-by-field description of the sampled elements is provided in the RS Field Descriptions.

See **How To Locate a FIREMON Plot**, **How To Permanently Establish a FIREMON Plot** and **How to Define the Boundaries of a Macroplot** for more information on setting up your macroplot.

**Preliminary Sampling Tasks**

Before setting out for your field sampling, layout a practice area with easy access. Try and locate an area with the same species or vegetation lifeform you plan on sampling. Get familiar with the plot layout and the data that will be collected. This will give you a chance to assess the method and will help you think about problems that might be encountered in the field. For example, will you really be able to identify the species of interest once you are in the field? It is better to answer these questions before the sampling begins so that you are not wasting time in the field. This will also let you see if there are any pieces of equipment that will need to be ordered.

Many preparations must be made before proceeding into the field for RS sampling. First, all equipment and supplies in the **RS Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. It is also important that there be spares of each piece of equipment so that an entire day of sampling is not lost when something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as plot forms, map cases, and pencils.

All RS Field forms should be copied onto waterproof paper because inclement weather can easily destroy valuable data recorded on standard copier paper. Plot forms should be transported into the field using a plastic, waterproof map protector or plastic bag. The day's sample forms should always be stored in a dry place (i.e., office or vehicle) and not be taken back into the field for the next day's sampling.

We recommend that one person on the field crew, preferably the crew boss, have a waterproof, lined field notebook for recording logistic and procedural problems encountered during sampling. This helps with future remeasurements and future field campaigns. All comments and details not documented in the FIREMON sampling methods should be written in this notebook. For example, snow on the plot might be described in the notebook, which would be very helpful in plot remeasurement.

It is beneficial to have plot locations for several days of work in advance in case something happens, such as the road to one set of plots is washed out by flooding. Plots should be referenced on maps and aerial photos using pin-pricks or dots to make navigation easy for the crew and to provide a check of the georeferenced coordinates. We found that it is very easy to transpose UTM coordinate digits when recording georeferenced positions on the plot sheet, so marked maps can help identify any erroneous plot positions. If possible, the spatial coordinates should be provided if FIREMON plots were randomly located.

A field crew of two people is probably the most efficient for implementation of the RS sampling method. There should never be a one-person field crew for safety reasons, and any more than two people will probably result in some people waiting for critical tasks to be done. The crew boss is responsible for all sampling logistics including the vehicle, plot directions, equipment, supplies, and safety. The crew boss should be the note taker and the technician should perform most quadrat measurements. The initial sampling tasks of the field crew should be assigned based on field experience, physical capacity, and sampling efficiency, but sampling tasks should be modified as the field crew gains experience. Tasks should also be shared to limit monotony.

## Designing the RS Sampling Design

There is a set of general criteria recorded on the RS Plot form that forms the user-specified design of the RS sampling method. Each general RS field must be designed so that the sampling captures the information needed to successfully complete the management objective within time, money and personnel constraints. These general fields should be determined before the crews go into the field and should reflect a thoughtful analysis of the expected problems and challenges in the fire monitoring project.

### *Plot ID Construction*

A unique plot identifier must be entered on the RS sampling form. his is the same plot identifier used to describe general plot characteristics in the Plot Description (PD) sampling method. Details on constructing a unique plot identifier are discussed in the **How to Construct a Plot ID** section. Enter the plot identifier at the top of the DE field form.

### *Determining the Sample Size*

The size of the rare species population ultimately determines the length of the baseline from which the individual plants are located. The baseline length is recorded in Field 1on the RS field form. If the population is divided along several patches, several baselines can be established. The size of the rare species population also determines the number of individuals sampled. We recommend sampling 25 individuals within the population; this should be sufficient for most studies. However, there are situations when more individuals should be sampled and in these cases the project objectives should identify the sampling intensity. The FIREMON RS field form and data entry screen allow an unlimited number of individuals to measured per baseline. If the population is smaller than 25 individuals, measure all individuals. This will then be a census rather than a sample, and a statistical analysis will not be necessary.

**Conducting RS Sampling Tasks**

*Establish the Baseline for Locating Individual Plants*

The baseline serves as a georeferenced starting point for relocating individual plants. If there are other FIREMON methods implemented at the same sample site then, as much as possible, the plots should be set up so that they correspond with one another. See **How To Establish Plots with Multiple Methods**. In most cases, this will not be possible when monitoring rare plants. Once the rare species population is located, a permanent baseline is set up as a reference from which you will locate individual plants. On flat areas, the baseline runs from south to north with the 0-foot (0 m) mark on the south end. On slopes, the baseline runs upslope with the 0-foot (0 m) mark on the bottom (down slope) end. The length of the baseline will be determined by the size of the rare species population.

*Locating Individual Plants*

Locate individual plants within the rare species population by running a tape perpendicular to the baseline to the plant. If the rare species population being sampled is to the right of the baseline when looking up hill (or, north on flat ground) then distances to plants are recorded as positive (+) numbers and distances to plants to the left are recorded as negative (-) numbers. Because the distance along the baseline and the distance from the baseline will be used to relocate plants in successive years, it is essential that these measurements are exact and the lines are perpendicular (figure RS-1). Measure the distances to the nearest 0.1 foot (0.02 m)

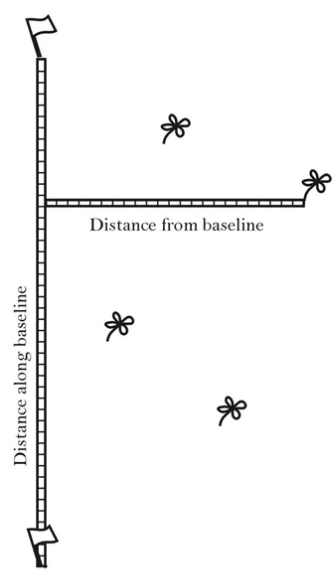


Figure RS-1. Measuring the location of rare plants. It is critical that the distance locating each plant – along and from the baseline – be accurately measured and that the measuring tapes are perpendicular.

*Tagging the Individual Plants*

Individual plants need to be permanently tagged with a unique plant number. If the plant is woody (shrub or tree) the tag can be attached to the plant. If the plant is herbaceous (grass or forb), the tab should be anchored in the soil adjacent to the plant in standard location (for example, directly down slope of the plant). Because these tags will uniquely identify the individual plant, it is essential that they be located in a manner that will eliminate any confusion between individuals.

**Rare Species Sampling**

*Plant Identity*

First enter the species code in Field 2 on the RS field form. FIREMON uses the NRCS Plants species codes, however you may use your own species codes. See **How to Customize Plant Species Codes** for more details.

To uniquely identify each individual of the rare species, enter the plant number in Field 3, distance along baseline in Field 4, and distance from the baseline in Field 5 in the RS field form.

*Status*

Next enter the plant status in Field 6 on the RS Field form. Status describes the individual plant as live or dead using the following codes:

**L – Live:** plant with living tissue
**D – Dead:** plant with no living tissue visible
**NA – Not Applicable**

Plant status is purely qualitative but determines post-burn survivorship and population health. Use care in determining plant status during the dormant season.

*Stage*

Enter the plant species stage in Field 7 on the RS Field form. Stage describes the individual plant as a seedling, non-reproductive adult, or reproductive adult.

**S – Seedling**: plant less than 1 year old
**NR – Non-Reproductive adult**: plant one year old or older without flowers or fruits
**R - Reproductive adult**: plant one year old or older with flowers or fruits

Plant stage is also qualitative but provides information on plant growth and reproduction and population health. Use care in determining plant reproductive status during the dormant season.

*Size*

Size information provides data on growth rates and population vigor. There are four measures of plant size that will be entered on the RS field data form: two diameter measures, maximum height, and number of stems.

For grasses, forbs, shrubs, and tress less than 1 in. (2 cm) DBH, measure the diameter of the plant (canopy) at two places. First, measure the widest part and record the diameter in Field 8. Make a second measurement at a right angle to the first and record in Field 9. Make both measurements in inches (cm) to the nearest 0.1 inch (0.2 cm).

For trees at least 1 inch (2 cm) DBH, record DBH in Field 8. Measure the maximum height of the plant in feet (m) and record in Field 10 to the nearest 0.1 feet (0.03 m). For more information on measuring plant heights see **How to Measure Plant Height**.

Regardless of the plant size, in Field 11 record the number plant stems for the individual you are measuring. Use care in determining individual plants when measuring size.

*Reproduction*

Flower and fruit counts provide data on reproductive rates and population viability. Count the number of flowers and fruits on the plant and record in Fields 12 and 13, respectively, of the RS field data form.

## Precision Standards

Use these precision standards for the RS sampling.

Table RS-3. Precision guidelines for DE sampling.

| Component | Standard |
|---|---|
| Distance along baseline | ±0.1 ft/0.03 m |
| Distance from baseline | ±0.1 ft/0.03 m |
| Maximum diameter | ±0.1 in./0.2 cm |
| Diameter 2 | ±0.1 in./0.2 cm |
| Height | ±0.1 ft/0.03 m |
| Stems | ±3 percent total count |
| Flowers | ±3 percent total count |
| Fruits | ±3 percent total count |

## SAMPLING DESIGN CUSTOMIZATION

This section will present several ways that the RS sampling method can be modified to collect more detailed information or streamlined to collect basic information.

### Recommended RS Sampling Design

The recommended RS sampling design follows the Recommended FIREMON Sampling Strategy and is listed below:
**Number of Individual Plants Sampled:** 25
**Record:** Status and Stage
**Measure:** Maximum Diameter, Diameter at right angles, Height
**Count:** Stems, Flowers, Fruits

The baseline length should be adjusted according to the size of the rare species population being sampled.

The number of individual plants sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual.

### Streamlined RS Sampling Design

The streamlined RS sampling design follows the Simple FIREMON sample strategy and is designed below:

**Number of Individual Plants Sampled:** 15
**Record:** Status and Stage
**Measure:** Maximum Diameter, Height

The baseline length should be adjusted according to the size of the rare species population being sampled.

The number of individual plants sampled should be adjusted according to the appropriate methods in the "How To" section of the FIREMON manual..

### Comprehensive RS Sampling Design

The comprehensive DE sampling design follows the Detailed FIREMON sampling strategy and is detailed below:

**Number of Individual Plants Sampled:** 25 per stage (25 seedlings, 25, non-reproductive adults, and 25 reproductive adults) adding additional plants to the stage categories as individuals die or move into another stage (for example seedling to non-reproductive adult).
**Record:** Status and Stage
**Measure:** Maximum Diameter, Diameter at right angles, Height

**Count:** Stems, Flowers, Fruits, Seeds, Vegetative Reproduction

These data could be used to conduct a population viability analysis; see Elzinga and others (1998) or a detailed discussion on this topic.

The baseline length should be adjusted according to the size of the rare species population being sampled.

**User-specific RS Sampling Design**

The user can modify the RS sample fields a number of ways in order to make sampling more efficient and meaningful for local situations. This will usually mean adjusting the number of individuals sampled as needed for the specific task. Use the Metadata form to record any changes in sampling methods that are modified from the standard or to remark on any other RS matter that needs to be explained or defined for subsequent sampling and data use.

**Sampling Hints and Techniques**

Examiners must be able to identify the target plant species and identify individual plants. It can be difficult to distinguish individual plants for some species such as sod-forming grasses. If individual plants are difficult to identify, guidelines should be determined before sampling as to what constitutes the individual counting unit. Some examples include counting individual stems in aspen communities, culm groups in rhizomatous grasses, and flowering stems for mat-forming forbs. However, the counting unit chosen to monitor should reflect a real change in the plant community.

Measuring tapes come in a variety of lengths, increments, and materials. Examiners should choose English (metric) tapes for this method and select a tape that is at least as long, or a little longer, than the baseline length being sampled. Steel tapes do not stretch and are the most accurate over the life of the tape. Steel is probably the best choice where re-measurement in exactly the same place each time is important. Cloth and fiberglass tapes will stretch over the life of the tape, but are easier to use than steel tapes since they are lighter and do not tend to kink.

The sampling crew may encounter an obstacle, such as a large rock or tree, along one of the transect lines that interferes with the quadrat sampling. If that happens offset using the directions described in **How To Offset a Transect**.

Because the purpose of resampling is to determine change over time, it is essential that the plots are resampled when then plants are in the same phonologic condition as when they were originally sampled. Typically this means resampling on the same date as when you originally sampled. If you do not resample when the plants are in the same phonologic condition, then you may be documenting annual growth cycles rather than fire effects.

When entering data on the RS field forms, examiners will most likely run out of space on the first page. The form was designed to print one copy of the first page, and several copies of the second page. The second page can be used to record more plant species on the first three transects or to record data for additional transects. The second page of the field form allows the examiner to write the transect number on the form. This allows the examiner to design the form to accommodate the number transects sampled. Print out enough pages to record all species on all transects for the required number of intercepts.

# Rare Species (RS) Form



| Field 1 |
|---|
| Baseline Length (ft/m) |
| |

Plot Key

Registration Code: _ _ _ _
Project Code: _ _ _ _ _ _ _ _ _ _
Plot Number: _ _ _
Date: _ _/_ _/_ _ _ _

| Field 2 | Field 3 | Field 4 | Field 5 | Field 6 | Field 7 | Field 8 | Field 9 | Field 10 | Field 11 | Field 12 | Field 13 | Field 14 | Field 15 | Field 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Plant Number | Dist Along Baseline (ft/m) | Dist From Baseline (ft/m) | Status | Stage | Maximum Diameter (in./cm) | Diameter 2 (in./cm) | Maximum Height (ft/m) | Stems | Flowers | Fruits | Local Code 1 | Local Code 2 | Local Code 3 |
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Notes

Crew

## FIREMON
## RARE SPECIES (RS) FIELD DESCRIPTIONS

Field 1: **Baseline Length.** Length of baseline. (ft/m).

Field 2: **Species Code.** Code of sampled species. Either the NRCS plants species code or the local code for that species.

Field 3: **Plant Number.** Sequential number for individual plants.

Field 4: **Distance Along Baseline.** Measured distance from 0 foot (m) mark on baseline to point at which a perpendicular line intersects the individual plant location. (ft/m). Precision: ±0.1 ft/0.02 m.

Field 5: **Distance From Baseline.** Measured perpendicular distance from baseline to individual plant location. (ft/m). Precision: ±0.1 ft/0.02 m

Field 6: **Status**: Plant status - Live, Dead or Not Applicable. (L, D or NA). Precision: No error.

Field 7: **Stage**. Plant stage – Seedling, Non-Reproductive adult, Reproductive adult (S, NR or R). Precision: No error.

Field 8: **Maximum Diameter.** Maximum plant canopy diameter. (in./cm). Precision: 0.1 in./0.2 cm.

Field 9: **Diameter 2.** Plant canopy diameter measured at right angles to maximum canopy diameter. (in./cm). Precision: 0.1 in./0.2 cm.

Field 10: **Height**. Height for each plant marked on the plot. (ft/m). Precision: 0.1 ft/0.03 m.

Field 11: **Stems. N**umber of stems for each plant marked on the plot. Precision: ±3 percent.

Field 12: **Flowers. N**umber of flowers for each plant marked on the plot. Precision: ±3 percent.

Field 13: **Fruits. N**umber of fruits for each plant marked on the plot. Precision: ±3 percent.

Field 14: **Local Field 1.** User specific code or measurement for the individual plant being recorded.

Field 15: **Local Field 2.** User specific code or measurement for the individual plant being recorded. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Metadata table.

Field 16: **Local Field 3.** User specific code or measurement for the individual plant being recorded. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Metadata table.

**FIREMON**

**RARE SPECIESY (RS) EQUIPMENT LIST**

Camera, film and flash
RS plot forms
Clipboard
Compass
Field notebook
File
Folding Rulers 6 ft. (2 m) (2-3)
Graph Paper
Hammer
Indelible ink pen (e.g., Sharpie, Marker)
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Magnifying glass
Markers to mark small plants (at least 25 per plot)
Pocket calculator
Plot sheet protector or plastic bag
Rebar (2) for baseline plus 2 for each transect
Steel fence posts (2) and driver (to mark endpoints of baseline)
Tags to mark large plants (at least 25 per plot)
Tape 75 ft. (25 m) or longer (3)

# Fire Behavior (FB)

## Sampling Method

### EXECUTIVE SUMMARY

The Fire Behavior (FB) methods are used to describe the behavior of the fire and the ambient weather conditions that influence the fire behavior. Fire behavior methods are not plot based and are collected by fire event and time-date. In general, the fire behavior data are used to interpret the fire effects documented in the plot-level sampling. Unlike the other plot-level sampling methods, the Fire Behavior methods are documented observations taken for one fire event, not for the FIREMON macroplots. The FireID field in the PD method links this database to the plot level data. The Flame Length, Spread Rate and Fire Behavior Picture fields in the PD method allow you to enter plot specific fire behavior data.

## INTRODUCTION

Fire managers achieve desired fire effects (e.g., 50 percent mortality, 60 percent fuel consumption) by burning under narrow environmental conditions that create desired fire behavior. In fact, fire behavior is the only direct observation that the fire manager can use to judge the outcome for desired fire effect. Fire managers must juggle weather conditions such as temperature, humidity, and wind, with fuel moistures and topography to get a flame length or fireline intensity that will ultimately satisfy the burn objectives by generating the desired fire effects. The only way the fire manager can successfully perform this complex balancing act is to get extensive experience burning across the wide range environmental conditions *and* to review the results of others who burn under the same conditions. One way that fire managers can document their experience is to record environmental conditions and resultant fire behavior in a database so that others can reference the conditions and then compare them with the actual results of the burn or the fire effects.

The FIREMON Fire Behavior (FB) methods were designed to document the weather conditions at the time of the fire and the fire behavior that resulted from those conditions. The data are linked to the plot level sampling by a common field so that they can then be used to interpret the effects of that burn. For example, it is very informative to know that the 50 percent fuel consumption measured using the FL methods was achieved with 70 degrees F temperature, 30 percent relative humidity, and 12 percent 1000-hr fuel moistures.

The Fire Behavior methods are unlike the other FIREMON methods in that the FB methods are recorded by fire rather than plot. For example, 50 FIREMON macroplots located in a 500-acre prescribed fire unit are all burned with the same fire, then they all will be linked to that fire in the FB table. The Fire Behavior method and database table are used to document the fire behavior at the time of the burn. Each macroplot is linked to this fire behavior information via the Fire ID in the PD form. The fire manager can query the Fire Behavior data to determine the burning conditions, fire behavior and resultant fire effects on each of the burned plots.

Obviously, not all fields in the Fire Behavior database need to be filled or recorded, only the ones actually measured or observed at the fire.

## SAMPLING PROCEDURE

The sampling procedures for all FB procedures are documented in many other publications, most notably the Fire Observer's Handbook, and will not be described here. This method is presented in the order of the fields in the FB data table.

### Fire Information

**Field 1: Fire ID** – Enter a Fire ID of up to 15 characters. The ID number or name that relates the fire to plots in the PD table. This field links this fire scale data with the plot scale data in the PD method.

**Field 2: Fire Date** – Enter the date of fire as an 8-digit number in the MM/DD/YYYY format where MM is the month number, DD is the day of the month and YYYY is the current year. For example, April 01, 2001 would be entered 04/01/2001.

**Field 3: Fire Time –** Enter the time of day that these observations were recorded. Use 24-hr time. For example if it is 8 am enter 0800 id it is 8 pm enter 2000.

**Field 4: Fire Name** - The name of the fire is entered in this field as a 25-character (or less) code in this field. This is a non-standardized field so anything can be entered here, but we suggest the name follow the convention used by fire management where it is derived from the drainage or major landmark where the fire starts.

**Field 5: Reference Fire ID** – Enter a unique 20-character fire code taken from the database of other fire management agencies. Record the source of this reference ID in the FIREMON metadata table.

**Field 6: Units** (E/M) – Units of measure. **E** - English or **M** - Metric.

### Ambient Weather Conditions

The next set of fields allows the fire manager to store the weather conditions at various times during the burn. These weather data can be measured onsite or downloaded from a RAWS station or other weather station near the burn. The source of this data is recorded in the FIREMON metadata table.

**Field 7: Temperature** (degrees F/degrees C) – Enter the temperature at the time and date listed in Fields 2 and 3.

**Field 8: Relative Humidity** (percent) – Enter the relative humidity measured at the specified date and time.

**Field 9: Windspeed** (miles/hr or km/hr) – Enter the typical windspeed recorded at the specified date and time.

**Field 10: Percent Cloudy** (percent) – Enter the percent cloudiness at the specified date and time.

**Fuel Moistures**

The next set of fields describes the measured fuel moistures at the date and time of burn. Standard fuel moisture measurement techniques should be employed. Basically there are two methods of measuring fuel moistures. The oven-dry method requires that multiple samples of all the fuels class sizes be collected in the field, stored in airtight containers (e.g. zip-close bags) and brought back promptly to be weighed and dried. The mass of the individual samples is measured first, and then the samples are put in an oven at 100 degrees C. The 1- and 10-hr fuels, and litter and duff should be dry in 24 hours. Weight a few selected samples of the larger fuels every 24 hours until they reach equilibrium. When the piece weights of a class, for example the 100-hr fuel class, reach equilibrium then you can make a final weight of all of the pieces in the class. Calculate the percent moisture (by weight) for each fuel class by taking the difference of the wet and dry weights and dividing by the dry weight. The fuel moisture for a class is the average moisture measured across all of the samples. When cutting pieces off logs for fuel samples you do not need to cut them thicker than 3 inches (7.5 cm). Doing so will unnecessarily extend the drying time. If you use this method you will not be able to enter the fuel moisture data the day of the fire.

The second method involves indirect measurements of fuel moisture using probes or other instrumentation.

Record the method of fuel moisture measurement in the FIREMON metadata table.

**Field 11: 1 Hour Fuel Class Moisture** (percent) – Enter the fuel moisture of the 1 hour downed dead woody fuel class (less than 0.25 inches or 1 cm in diameter).

**Field 12: 10 Hour Fuel Class Moisture** (percent) – Enter the fuel moisture of the 10 hour downed dead woody fuel class (0.25-1.0 inches or 1-2.5 cm in diameter).

**Field 13: 100 Hour Fuel Class Moisture** (percent) – Enter the fuel moisture of the 100 hour downed dead woody fuel class (1.0-3.0 inches or 2.5-7.5 cm in diameter).

**Field 14: 1000 Hour Fuel Sound Class Moisture** (percent) – Enter the fuel moisture of the sound 1000 hour downed dead woody fuel class (greater than 3.0 inches or 7.5 cm in diameter).

**Field 15: 1000 Hour Fuel Rotten Class Moisture** (percent) – Enter the fuel moisture in percent of the rotten 1000 hour downed dead woody fuel class (greater than 3.0 inches or 7.5 cm in diameter).

**Field 16: Litter Moisture** (percent) – Enter the moisture of the litter layer. This is the layer that contains recognizable needles, cone scales and leaves.

**Field 17: Duff Moisture** (percent) **–** Enter the moisture of the duff layer. This is the layer that contains unrecognizable decomposing organic material. Try to get a moisture for the entire duff profile.

**Field 18: Soil Moisture** (percent) **–** Enter the moisture of the uppermost soil layer. This is the top 10 cm of mineral soil just below the duff layer.

**Field 19: Live Shrub Moisture** (percent) **–** Enter the moisture of the live shrubs.

**Field 20: Live Herb Moisture** (percent) **–** Enter the moisture of the live herbaceous plants.

**Field 21: Live Crown Moisture** (percent) **–** Enter the moisture of the live tree crown foliage. Take samples from all parts of the tree crowns.

**Fire Behavior**

The last set of fields describes the measured or observed fire behavior of the fire at the selected time and date. Fire behavior is often observed rather than measured. Follow the directions in the Fire Observers Handbook when estimating these standard fire behavior characteristics.

**Field 22: Fire Type –** Enter the code that best describes the fire that is described by the following observations in Fields 23 through 27.

**F** – Flanking
**B** – Backing
**H** – Head
**C** – Crown.

**Field 23: Flame Length** (ft/m) **–** Estimate flame length at this time and date of this.
Precision: $\pm$1 ft/0.3 m

**Field 24: Flame Depth** (ft/m) **–** Estimate flame depth at this time and date of this fire.
Precision: $\pm$1 ft/0.3 m

**Field 25: Spread Rate** (ft/min. or m/min.) **–** Estimate the average speed of the fire at this time and date. To estimate this parameter, using a watch, note the time it takes the flame front to go 30 feet or 10 meters and then divide 10 by the number of minutes (or fraction of).

**Field 26: Plume Behavior –** Estimate the dynamics of the plume using the following codes.

**WV** –Plume well ventilated, rising, and dispersing high above burn
**US** – Plume unstable and its behavior is erratic.
**PD** – Plume is dropping and going downhill into the valleys

**Field 27: Spotting Observations –** Estimate the spotting behavior of the fire at this time and date using the following codes.

**SD** – Spotting downslope or downwind
**SU** – Spotting upslope or upwind.
**SE** – Spotting is erratic and very random
**NS –** No spotting observed
**NA –** Difficult to determine spotting due to smoke or obstruction

**Local Codes and Comments**

**Field 28: Local Code 1 –** Enter a user designed code that is up to 20 characters in length, and uniquely describes some condition on the FIREMON plot. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Comments field.

**Field 29: Local Code 2 –** Enter a user designed code that is up to 20 characters in length, and uniquely describes some condition on the FIREMON plot. Do not to embed blanks in your codes to avoid confusion and database problems. Document your coding method in the Comments field.

**Field 30: Comments –** Memo field. 60,000+ characters used to record any information pertinent to the FB information. Text information can be pasted from word documents, Access databases, Excel spreadsheets or any other software that can copy text to the windows clipboard.

# Fire Behavior (FB) Form



**Fire Information**

| Field 1 | Field 2 | Field 3 | Field 4 | Field 5 | Field 6 |
|---|---|---|---|---|---|
| FireID | Fire Date | Fire Time | Fire Name | Reference Fire ID | Units (E/M) |
| | | | | | |

**Fuel Moistures**

| Field 11 | Field 12 | Field 13 | Field 14 | Field 15 | Field 16 | Field 17 | Field 18 | Field 19 | Field 20 | Field 21 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-hr Moisture | 10-hr Moisture | 100-hr Moisture | 1000-hr Sound Moisture | 1000-hr Rotten Moisture | Litter Moisture | Duff Moisture | Soil Moisture | Shrub Moisture | Herb Moisture | Crown Moisture |
| | | | | | | | | | | |

**Fire Behavior**

| Field 22 | Field 23 | Field 24 | Field 25 | Field 26 | Field 27 |
|---|---|---|---|---|---|
| Fire Type | Flame Length (ft/m) | Flame Depth (ft/m) | Spread Rate (ft/min. or m/min.) | Plume | Spotting |
| | | | | | |

**Ambient Weather Conditions**

| Field 7 | Field 8 | Field 9 | Field 10 |
|---|---|---|---|
| Temp. (F/C) | Rel. Humidity | Wind (mi/hr or km/hr) | Percent Cloudy |
| | | | |

**Local Codes**

| Field 28 | Field 29 |
|---|---|
| Local Code 1 | Local Code 2 |
| | |

Field 30: Comments

**FIREMON**
**FIRE BEHAVIOR (FB) EQUIPMENT LIST**

Camera with film
Clipboard
FB field forms
Field notebook
Flagging
Hammer (2)
Hatchet (1)
Chain saw or hand saw
Labels
Lead pencils with lead refills
Maps, charts and directions
Map protector or plastic bag
Masking tape
Pocket calculator
Plot sheet protector or plastic bag
Plot sheets for plots that will be burned (to fill in Fire ID)
Watch with second hand
Weather kit
Zip-close bags or other plastic containers

# **Metadata (MD)**
# Description

EXECUTIVE SUMMARY

The Metadata (MD) table in the FIREMON database is used to record any information about the sampling strategy or data collected using the FIREMON sampling procedures. The MD method records metadata pertaining to a group of FIREMON plots, such as all plots in a specific FIREMON project. FIREMON plots are linked to metadata using a unique metadata identifier which is entered in the MD table and in the PD data for each FIREMON plot. Metadata pertaining to a single plot is recorded in the comments field on the FIREMON PD data form.

## INTRODUCTION

The Metadata (MD) method is used to record metadata, information about data, for FIREMON sampling strategies and sampling methods. Metadata is recorded for multiple FIREMON plots. The data are linked to individual plots using a unique metadata identifier (MDID) which is entered in the MD table and in the Plot Description (PD) table for each plot. Specific comments on a single FIREMON plot are entered in the comments field on the PD data form. The MD table is for commenting on a number of plots, usually in one project.

Metadata are entered in the MD table by subject. A subject may be a FIREMON sampling method, the FIREMON Integrated Sampling Strategy, or any other aspect of a FIREMON project. The MD table allows FIREMON users the flexibility to record metadata on any subject related to a FIREMON project. Any text-based information that can be copied to the Windows clipboard, such as Word documents, Excel spreadsheets, or Access databases, can be pasted into the MD Comments field. The metadata field in can store up to 64,000 characters.

Some examples of FIREMON metadata include:

1) General information about how FIREMON Integrated Sampling Strategy was applied to the plots in the project.

2) Specific metadata for each FIREMON sampling method such as the transect locations and quadrat placement for the FIREMON replicated vegetation sampling methods (CF, LI, PO, RS and DE).

3) User defined codes for fields, which differ from the standard FIREMON codes.

4) Units of measure for fields, which differ from the standard FIREMON units of measure.

## SAMPLING PROCEDURE

**Field 1: Metadata ID** – Enter a unique 15-character code to identify the metadata records. This code is also entered in the PD table to link FIREMON plots to these metadata.

**Field 2: Subject –** Enter a unique 20-character code for the metadata. Use the Subject field to divide you comments into logical groups. For example, if you entered “TD” in the Subject field you would organize all of the notes about tree sampling in the Comments field below. Then you could enter “FL-veg” in the Subject field and compile your notes in the Comments field on how vegetation was sampled when you were doing the FL method. Other subject codes may be entered by the user to record metadata on any other aspect of a FIREMON project.

**Field 3: Comments –** Memo field. 60,000+ characters used to record any information pertinent to project plots. Text information can be pasted from word documents, Access databases, Excel spreadsheets or any other software that can copy text to the windows clipboard.

# Metadata (MD) Form

MD Page _ _ of _ _

**Metadata Information**

| Field 1 | Field 2 |
| --- | --- |
| Metadata ID | Subject |
| | |

Field 3: Comments