



United States  
Department  
of Agriculture

Forest Service

Rocky Mountain  
Research Station

General Technical  
Report RMRS-GTR-XXX

January 2005



# LANDFIRE

## Handbook of Field Methods



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*A Handbook of Standardized Field Data Collection Techniques*

THIS ENTIRE DOCUMENT IS IN  
**DRAFT FORM**

1/19/2005

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# Introduction



LANDFIRE is a five-year, multi-partner wildland fire, ecosystem, and fuel mapping project that will generate consistent, comprehensive, landscape-scale maps and data describing vegetation, fire, and fuel characteristics across the United States. Specific end-products include maps of departure from the historical range of variability in existing vegetation and fire regimes, which are needed to prioritize and evaluate the restoration of forests and rangelands as directed by the National Fire Plan and the Healthy Forests legislation. Partners in this effort include the USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory in Missoula, Montana (MFSL), the USGS Earth Resources Observation System (EROS) Data Center (EDC) in Sioux Falls, South Dakota, and The Nature Conservancy (TNC) in Boulder, Colorado.

At the heart of the LANDFIRE effort is a database containing geo-referenced field data that characterize vegetation communities and fuel nationwide. Such data include cover type assignments, coverages and heights of plant species, and counts of fine and coarse woody debris. These and other plot-based data stored in the LANDFIRE reference database (LFRDB) provide the foundation for all maps and models of vegetation, fire, and fuel conditions developed for the project.

The LANDFIRE Project relies heavily upon existing inventory, monitoring, and research programs for the reference data that populate the LFRDB. Gaps in the national coverage of these existing data are filled through coordinated field campaigns in target areas. Efforts to acquire data by either means are focused in a manner consistent with project milestones defined by the Wildland Fire Leadership Council (WFLC), the project's sponsor. LANDFIRE's first five-year cycle began in April 2004, with efforts slated to progress from the western states to the eastern states and then to Alaska and Hawaii. LANDFIRE's first-year efforts, therefore, have been focused in the West, with Utah State University and the Student Conservation Association (SCA) contracted to improve data coverage in the region.

This handbook was developed to guide SCA field crews through the requisite sampling and data management procedures for LANDFIRE during the field campaigns of 2004-2005. In the sections that follow, we summarize field objectives and then detail methods for the collection and management of field data for LANDFIRE. Appendices include documents further detailing certain aspects of the sampling protocols, tables and keys to inform decisions and assignments made in the field, and a glossary of important LANDFIRE terms.

# Field Objectives



In this section we: 1) explain the role of field-reference data in LANDFIRE, (2) describe how data are to be collected and compiled over the life of the project, and (3) describe the LANDFIRE sampling design.

## **The Role of Field Data in LANDFIRE**

Field data form the basis for LANDFIRE vegetation and fuel classifications and inform the characterizations, or models, of related mapping attributes, including historical fire regimes. We cannot, however, rely on field data alone to map LANDFIRE attributes on a national, or even regional, scale. Complete, wall-to-wall maps of the U.S. must be derived largely from a mosaic of remotely sensed data. These data permit accurate mapping of land cover on regional, continental, and even global scales. Moreover, we can describe changes in land cover characteristics by comparing remotely sensed data and images collected over various periods at the same location. A myriad of high-quality, geo-referenced field data are essential, however, to enable or “train” the satellite imagery to discriminate between the various classes of LANDFIRE mapping attributes. And finally, a second set of reference data is needed to independently assess the accuracy of the resulting maps.

## **LANDFIRE Timeline**

The Wildland Fire Leadership Council requires that LANDFIRE achieve its national production goals within five years, beginning in April of 2004. To meet this five-year project deadline, all field-reference data must be in-hand by fall of 2006. Field-data campaigns, therefore, will be conducted from summer 2004 through summer 2006 only. These campaigns will progress from west to east, via USGS mapping zones (figure 1), which are based loosely on ecological regions of the country.

## **Target Areas for 2004-2005**

In 2004-2005, we are focusing LANDFIRE field-data collection efforts to rangelands (in other words, grasslands and shrublands, as defined by the 1992 National Land Cover Dataset) of the western and central U.S. In 2004, SCA field crews targeted rangelands within zones 10, 15, 18, 24, and 28 (figure 1). In 2005, the LANDFIRE field campaigns managed by SCA will be focused within under-sampled rangelands in the remainder of the West and portions of the Great Plains.



## Sampling Design

Although statistically ideal, it is impractical (if not impossible) to access field plots that have been randomly positioned throughout the targeted rangeland. We have chosen the most reasonable alternative to the simple-random ideal, which is to stratify the target area by land ownership and road access and to exclude private land and roadless areas from further sampling consideration. We then blanket this focal area with 3-kilometer-by-3-kilometer blocks, which are the primary sampling units (PSUs) for the LANDFIRE field campaign (figure 2).

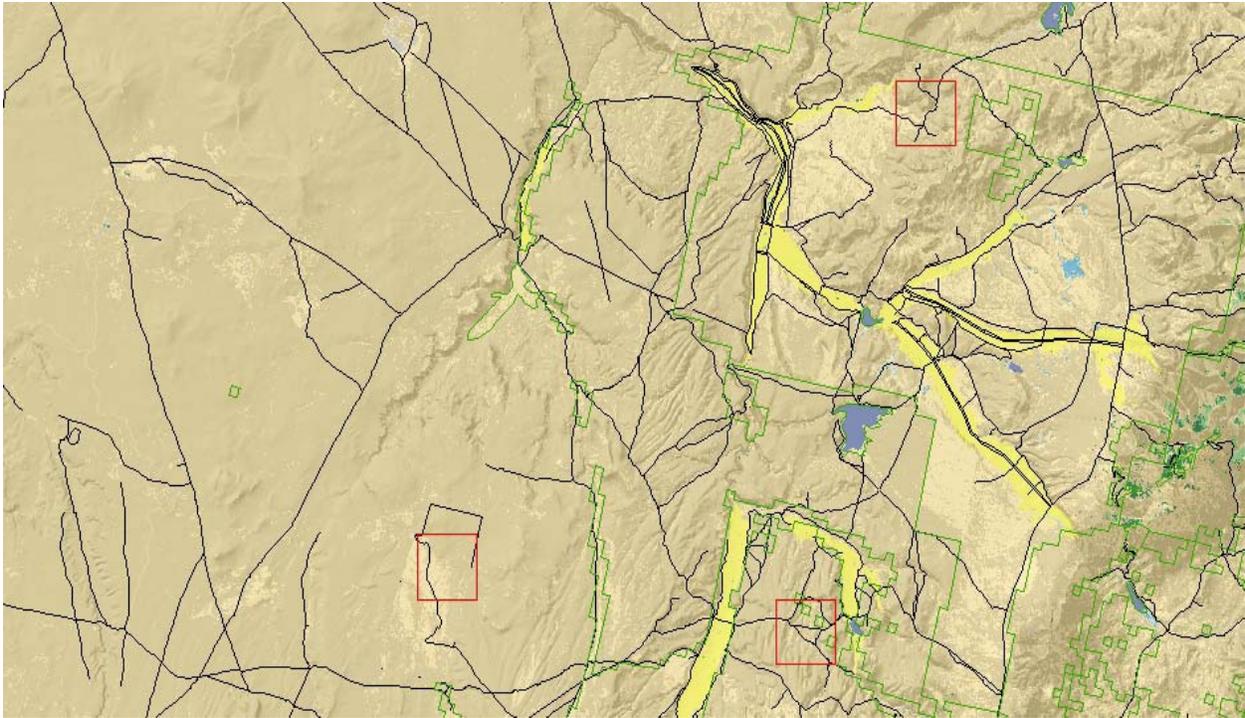


Figure 2. Land cover map showing an example distribution of Primary Sample Units in LANDIFRE Mapping Zone 18. The 3-kilometer-square PSUs are outlined in red, roads are in black, and the green lines show property boundaries.

Each LANDFIRE field team is assigned a set of PSUs within which it is to collect data. These data are collected within 10-meter diameter (0.1-acre) field plots set along transects that traverse each PSU. In other words, all LANDIFRE field data come from 10-meter diameter (0.1-acre) field plots, which are *nested* within and used to describe the larger PSUs (figure 3). Protocols for data collection and management are described throughout the remainder of this Handbook.

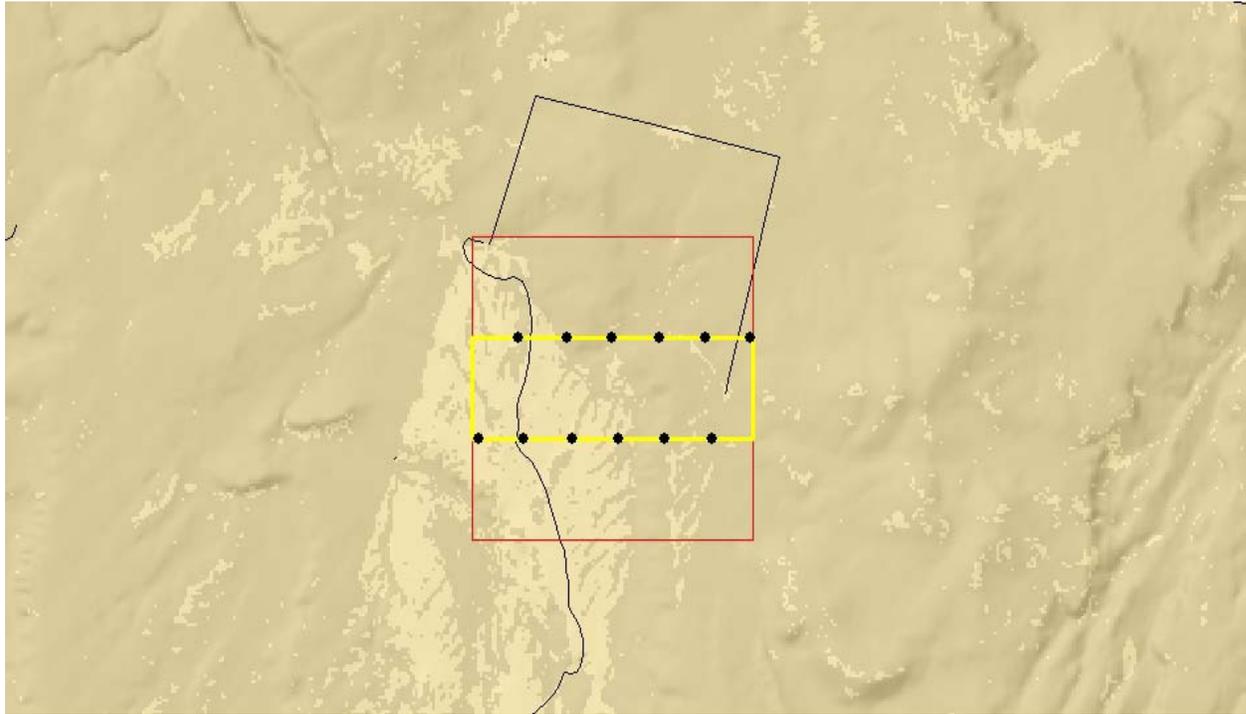


Figure 3. Detail of figure 2, showing a 3-kilometer-square PSU in red, road access in black, and a set of “Training PSU” transects in yellow. Field plots are shown as black dots along the transects in this example.

# LANDFIRE Field Methods

## Overview



The LANDFIRE field methods are a subset of the Fire Effects Monitoring and Inventory System (FIREMON) protocol. The FIREMON protocol (v.2.1.0), developed by Lutes and others (in press) includes a comprehensive and flexible set of recognized field and office methods that have been adopted by agencies and non-governmental organizations throughout the U.S. to characterize fire effects on vegetation and fuels.

For work conducted in 2004 and 2005, LANDFIRE field crews use three of the ten sets of sampling methods described by FIREMON: (1) Plot Description (PD), (2) Fuel Load (FL), and (3) Species Composition (SC). The **Plot Description** set includes a generalized sampling scheme to describe the biophysical characteristics of each sampling unit. The **Fuel Load** set includes a planar intercept (or line transect) technique to sample dead and downed woody debris in the 1-hour, 10-hour, 100-hour, and 1000-hour and greater size classes. Litter and duff depths are measured at two points along the base of each sampling plane. Cover and height of live and dead, woody and non-woody vegetation are estimated at two points along each sampling plane. **Species Composition** methods include protocols for estimating the heights and canopy coverages of plant species and various groupings of plants within a plot.

In the sections that follow, we explain how to locate and define sample plots in the field and guide users through each of the three LANDFIRE protocols to follow therein.

# LANDFIRE Field Methods

## Positioning and Defining Boundaries of Field Plots



### Positioning Field Plots

Prior to each field campaign, LANDFIRE staff members locate a set of 3-by-3 kilometer PSUs within which field crews are to collect vegetation and fuel data. Within each of these PSUs, a series of 0.1-acre field plots are to be located systematically (at 300-meter intervals) along TWO parallel transects that are positioned 1500 meters apart (figure 3). These transects must be oriented according to the following “rules”: Both transects must traverse the PSU and therefore should run parallel to either the north-south (N-S) or east-west (E-W) “sides” of the block. If the road or road network tends to run N-S (or E-W) through the PSU, orient the transects so they are generally *perpendicular* to (in other words, they cross) the road(s). By crossing instead of running alongside roads, the transects are more likely to traverse the PSU in vegetation representative of the true variety in the block and less likely to describe plant communities associated with roadside disturbance.

#### *Positioning transects in a PSU*

Once you’ve oriented your transects, determine which of the two “sides” of the PSU that parallel your transects is nearest your planned entry into the block. Then, select a random number between 1 and 1500 to correspond to the distance in meters that you position the first transect from your “entry side” of the PSU. Position the second transect 1500 meters from the first, away from your “entry side.” A list of random numbers between 1 and 1500 is provided in *Appendix A*.

#### *Positioning field plots along transects*

You must center four, 0.1-acre field plots at 300-meter intervals along each of the transects for a total of 8 plots per Training PSU. Locate the first plot on each transect a random distance between 1 and 3000 meters in from either “end” of each transect (in other words, the point at which the transect intersects the PSU boundary). Position the remaining three field plots along each transect at 300- (or multiples of 300-; see *Moving or adding field plots* below) meter intervals. *Appendix A* includes a list of random numbers between 1 and 500.

#### *Moving or adding field plots*

If a candidate field plot falls on private land or in an otherwise unsafe location, or if the plot would not yield useful training data (for example, it falls on a road or in a stock pond), *do not* sample at that location. Instead, move on to the next candidate plot, 300 meters down the

transect. Repeat this process until you have sampled at four locations along that transect. If four locations, spaced at least 300-m apart, cannot be sampled on that transect, make up for the number omitted on the one transect by adding that same number of field plots on the next transect. In other words, keep trying to sample at each 300-m interval, until you've collected data from up to 8 plots within the PSU. If it is impossible collect useful data from 8 plots at 300-m intervals (or multiples thereof) along the transects, try repositioning the candidate plots within 50 meters or so and record the reason for doing so. If no reasonable alternatives exist (in other words, after following these rules, you still can't sample at 8 locations), sample where you can and simply note the problem.

These rules apply to your first, randomly selected field plot as well. If this plot should fall less than 100 meters from a road, reposition it so that it lies at least 100 meters away from the road. This change should affect the locations of the other plots along that transect. Remember: *Always establish the 300-meter sampling interval from your first (and randomly chosen) plot on each transect.*

### **Defining the Boundaries of a Field Plot**

Define the boundaries of each 0.1-acre field plot by tying flagging on branches or vegetation at a distance of 37.2 feet from the plot center. To do so, fasten one end of a cloth or loggers' tape at plot center (in other words, have a crew member hold the tape), walk out 37.2 feet, and tie a flag to a semi-permanent structure, such as a branch or downed log, that is visible (preferably at eye level) from plot center (figure 4).

Place flags at intervals along the plot boundary that will enable you and your crew members to accurately measure plant cover within the 0.1 acre of interest. You will usually need four to eight flags along the plot perimeter to do so. Plots with dense undergrowth, extreme tree densities, or severe topography might require additional flagging. If the slope of the ground is greater than 30 percent, plot boundary distances must be adjusted by multiplying the fixed distances by a slope correction factor. *Appendix D: Measuring and Adjusting for Slope* explains and provides correction factors.

It is very important that the flagging identify which plants are inside and which are outside the plot boundaries. If a tree outside of the boundary has foliage that overlaps the boundary, tie the flagging on the plot-center side of the tree; for trees within the boundary, tie the flagging on the side away from plot-center.

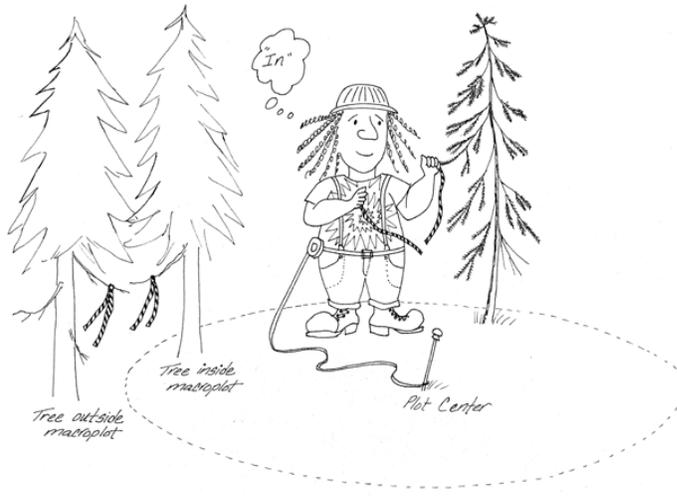


Figure 4. Mark the plot boundary with flagging.

# LANDFIRE Field Methods

## Plot Description



The Plot Description (PD) methods describe general characteristics of the LANDFIRE field plot, including its location (in other words, geo-reference) and some broad attributes of vegetation and fuels. PD methods are used to describe the entire 37.2-foot-radius field plot and should be estimated accordingly.

In this section we describe the PD sampling procedures with references to the database fields they are used to populate. We group these fields according to the information they contain. These groups include the: 1) database key that uniquely identifies the plot, 2) plot location and sampling event, 3) vegetation, 4) fuels, and 5) plot photo-documentation. Additional information can be entered into the *Comments* field.

### Sampling Procedure

Refer to the previous section on *Positioning and Defining Boundaries of Field Plots* for guidance on setting up your sampling unit.

### Required Plot Description Fields (Database Key)

The following four fields uniquely identify the plot data within the LANDFIRE reference database. (Note: the field numbers and names provided are from the PD Table in the FIREMON database.)

*Field 1: RegID* – The Registration ID is a 4-character code assigned to you or your field team. Each SCA field team, for example, will be assigned a Registration Code of the format SC##, in which ## is your team number. Thus, Team 1 would enter SC01, Team 2 would enter SC02, and so forth.

*Field 2: ProjID* – The Project ID is an 8-character code used to identify project work that is done by each field team. You are not required to use all eight characters. SCA teams are to simply use the format LFZ##, which denotes the LANDFIRE map zone in which the current sampling plot falls (figure 1). For example, if your team's current plot falls in Map Zone 18, you would enter LFZ18.

*Field 3: PlotID* – The Plot ID is a long-integer value that uniquely identifies the field plot in which data are being collected. With no spaces, enter the PSU number followed by the two-digit number of the field plot (for example, 01-12) in which you are collecting data. Thus, at the first

plot you sample within PSU 2235, you would enter “223501”. At plot “3” in that same PSU, you would enter “223503,” and so forth.

*Field 4: Date* – Enter the date of sampling in the MM/DD/YYYY format where MM is the month’s number, DD is the day of the month and YYYY is the current year. For example, April 01, 2005 would be entered 04/01/2005.

### **Plot and Sampling Information Fields**

*Field 9: Examiner* - The last name of the field worker entering data – up to 20 characters – is recorded here.

*Field 10: Units* – All LANDFIRE field data must be recorded in English – not Metric – units. Thus, enter an “E” in this field. (Note: GPS error may be in English or Metric units, regardless of what is entered in Field 6.)

*Field 11: Radius* – Enter 37.2 feet, which is the fixed radius of the LANDFIRE field plot.

*Field 13: Plot Type* – Select “T” for Training.

*Field 14: SEvent* – The Sampling Event field is used to document the reason why the plot is being measured at this particular time (as recorded by Date). FIREMON accepts one of three codes: 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 marked and will not be re-sampled. LANDFIRE sampling events must be coded as “IV” because plots will not be permanently marked, nor will they be re-sampled.

*Field 17: LocType* – This specifies the coordinate system being used. Select “A” for Albers. (Please confirm that your GPS device is set accordingly.)

*Field 20: Northing* – Enter the Albers Northing of plot center.

*Field 21: Easting* – Enter the Albers Easting of plot center.

*Field 22: Datum* – Enter “NAD83,” which is the LANDFIRE Map Datum. (Please confirm that your GPS device is set accordingly.)

## Vegetation Fields

These PD fields describe general aspects of the vegetation using the percentage of canopy cover as the measurement unit. All vegetation fields require an estimate of the percentage of canopy cover, coded according to the classes in table 1.

Table 1. Canopy cover codes.

Code	Percentage of Canopy Cover
0	0
0.5	>0-1
3	>1-5
10	>5-15
20	>15-25
30	>25-35
40	>35-45
50	>45-55
60	>55-65
70	>65-75
80	>75-85
90	>85-95
98	>95

Note: In the following fields, canopy cover must be estimated for plants grouped by life-form (in other words, trees, shrubs, grasses, and forbs, as defined in *Appendix I: Glossary* and any supplemental documents we have provided). It can be challenging to mentally “group” plants for these estimates. If you are not confident in your ability to make an accurate estimate, leave the field blank (don’t enter “0”) and note the reason in the comments section (field 85). Enter “0” only when there is no cover of a particular life-form.

Note: We do not expect your cover estimates for the different life-forms to total 100 percent.

Further guidance in cover estimation is included in *Appendix B: Estimating Canopy Cover*.

If you’re unsure about the life-form of a particular species (for example, is that Gambel oak on your plot a shrub or a tree?), refer to the zone-specific supplement to this handbook. If the life-form is not listed therein, identify the life-form based on: (1) the tree, shrub, grass, and forb definitions in *Appendix I Glossary*, (2) the plant’s typical morphology, and (3) the height that the plant appears capable of attaining within the map zone you’re in – in other words, if you’ve encountered tree-sized specimens elsewhere in that zone, then call it a “tree” even if it’s shrubby on the plot you’re presently sampling. **Then, make a note to ask your supervisor to get the “official” life-form assignment from LANDFIRE staff as soon as possible.** In the meantime, be consistent with your assignments within each map zone (in other words, don’t identify the same species as a “tree” on one plot and as a “shrub” on another in the same map zone).

*Field 37: Tree Cover* - Enter the percentage of canopy cover of all trees within the plot using the

canopy cover codes in table 1. 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 44: Shrub Cover* - Enter the percentage of canopy cover of all shrubs in the plot using the canopy cover codes in table 1. This cover estimate includes vertically projected cover of all shrub species of all heights.

*Field 48: Grass Cover* - Enter the percentage of canopy cover of all graminoid species in the plot using the codes in table 1. Graminoids include all grasses, sedges, and rushes.

*Field 49: Forb Cover* - Enter the percentage of canopy cover of all forbs (in other words, all non-graminoid herbaceous plants) in the plot using the cover codes in table 1.

### **General Fuel Characteristics Fields**

These fields are designed to describe general plot-level fuel attributes used for mapping and modeling fuel characteristics to predict fire behavior and effects. For example, these fields provide the information needed to run the FARSITE model. The crown fuel description fields (fields 68-70) are often used as input in models to determine crown fire spread rates – especially in the FARSITE fire-growth model. Because these fields pertain only to crown fuels, they should be completed only if there is a significant tree canopy layer (greater than 10 percent) above the surface fuel layer (>6 feet tall) on the plot. The tree canopy layer must extend above the surface fuel layer to be considered canopy fuels instead of surface fuels. The canopy layer may extend down to the surface fuel layer (below 6 feet).

*Field 70: Anderson FB Fuel Model (FBFM)* – Choose the appropriate fire behavior fuel model from the 13 options in the drop-down menu. Use Anderson’s 1982 publication, *Aids for Determining Fuel Models for Estimating Fire Behavior*, and the Fire Behavior Fuel Model key provided in *Appendix G* to assign the appropriate model.

*Field 72: Stand Height* – Estimate the typical height of the overstory vegetation. Include only vegetation taller than 6 feet in your estimate. This estimate is used, for example, in calculating wind reductions and computing volume of crown fuels in the FARSITE fire-behavior prediction system. Estimate the top of the layer to the nearest 3 feet. If there are no plants taller than 6 feet on the plot, enter “999.”

*Field 73: Canopy Fuel Base Height* - Estimate the typical lowest point above the ground at which there is a sufficient amount of live and/or dead tree-canopy fuel to spread a fire vertically into the overstory vegetation. Include all vegetation on the plot in your estimate. Canopy fuel base height is a stand-level measurement used by FARSITE to initiate crown fire in the model and includes the dense, dead vertical fuels (such as lichens, draped needles, or dense, dead branches) that could allow a surface fire to morph into a crown fire. Take into account the dead fuels attached to standing trees or shrubs that, when intermingled with branches from other plants, could move flames up into the overstory. Estimate canopy base height to the nearest foot. If there are no trees or shrubs on the plot, enter “999.”

Note: One way to estimate canopy base height for the entire plot is to envision a sheet on the ground with a hole for each tree and shrub. Then, mentally lift the sheet until it touches the first dense section of the crown of each tree or shrub (the part of the crown having burnable biomass that could catch fire, including dead and draped fuels). The average height of the imaginary sheet would be the canopy fuel base height for the plot.

*Field 74: Canopy Cover* - Estimate the percentage of cover of the overstory (from trees, shrubs, or both) above 6.5 feet using the codes in table 1. This value is used by FARSITE, for example, in calculating wind reductions and calculating variation in fuel moisture due to canopy shading. Be sure to estimate vertically projected canopy cover for all species as a whole. Refer to *Appendix B: Estimating Canopy Cover* for guidance.

*Field 83: Major Disturbances* – Note natural disturbances and management activities that have affected more than half of the dominant vegetation within the plot sometime in the last 10 years. Enter the single-digit code(s) for up to three types from those listed in table 2. If there is no evidence of a major disturbance, enter only “0.”

Indicators of disturbance include: stumps, standing dead trees or shrubs, uprooted trees or shrubs, broken branches or tops of trees, dead foliage on living trees or shrubs, lack of foliage on most trees or shrubs, and burned or charred vegetation. Recent mining activity would be indicated by significant disturbance to the soil and other ground substrate in order to extract minerals.

Table 2. Codes for natural disturbance agents or management activities that may have influenced the vegetation composition or structure within a LANDFIRE field plot.

Code	Natural Disturbance Agent or Management Activity
0	No evidence of major disturbance or activity
1	Chaining or other deliberate uprooting of trees or shrubs
2	Insects or disease
3	Fire
4	Harvest (firewood cutting, commercial logging)
5	Grazing
6	Mining
7	Weather (blowdown)
8	Other

*Field 84: FCCS Prototype Fuelbed* - Choose the appropriate fire behavior fuel model from the 113 options in the drop-down menu. Use the fuelbed descriptions (provided in a supplemental document) to assign the “best matching” fuelbed. If none accurately describe the plot, select “None of the Above.”

### Photo Fields

Photographs, conventional or digital, are a useful means to document attributes of the

LANDFIRE plot. Two photographs of each plot are to be taken: one facing north and one facing east. For the north-facing photo, move about 10 feet south of plot center and take the photo facing north. Make sure that the plot center stake and a dry-erase board with the concatenated *RegID*, *ProjID*, *PlotID*, *Date*, and letter “N” (to indicate that it is the north-facing photo) are clearly visible in the picture (figure 5). Then, move west of the plot center about 10 feet and take a second photo facing east. Once again, make sure that the plot center stake and dry-erase board with the concatenated *RegID*, *ProjID*, *PlotID*, *Date*, and letter “E” (to indicate that it is the east-facing photo) are clearly visible in the picture. Be sure that the camera is focused on the plot at-large, not the distance or foreground, and that the camera is set for the correct exposure and aperture for existing light conditions. A flash may be needed in low-light conditions.



Figure 5. Take your plot photos so that they show the plot center and the general plot conditions.

*Field 79: North Photo* – Enter the unique photo ID generated from the Database Key (the concatenated *RegID*, *ProjID*, *PlotID*, *Date*, and letter “N”), which you included on the dry-erase board in your north-facing photo. This field in the FIREMON PD Table will be linked to the actual digital photo once you download and rename the image with the code in the photo.

*Field 80: East Photo* – Enter the unique photo ID generated from the Database Key (the concatenated *RegID*, *ProjID*, *PlotID*, *Date*, and letter “E”), which you included on the dry-erase board in your east-facing photo. This field in the FIREMON PD Table will be linked to the actual digital photo once you download and rename the image with the code in the photo.

### **Comments Field**

The Comments field is provided so that the field crew can record any information associated with the LANDFIRE plot not captured elsewhere.

*Field 85: Comments* – Enter up to a 256-character comment. For instance, if you cannot measure the slope because the clinometer is broken, leave the Slope field empty and note in the Comments field, “No slope measurements taken as clinometer was broken.” This will explain empty fields to future users of the data. Never enter “0” (zero) in a field that could not be

assessed. Either leave the field blank or enter the code indicating that you were not able to assess the attribute.

Use shorthand and abbreviations to conserve space as long as the comments are still understandable. Organize comments in a standard order with appropriate punctuation. For example, you might describe weather first and use colons to separate major comment categories.

# LANDFIRE Field Methods

## Fuel Load



The Fuel Load (FL) methods are used to quantify the three general components of the fuel complex: (1) dead and downed woody debris (DWD), (2) duff and litter, and (3) understory vegetation. The overall FL protocol is derived from the planar intercept sampling strategy developed by Warren and Olson (1963) and revised by Brown (1974). In the planar intercept strategy, an imaginary “plane” extends vertically six feet from horizontal, or level, ground (not from the actual slope), and DWD intercepted by the sampling plane is measured and recorded. For our purposes, additional measures of duff and litter are taken, and estimates of the coverages and heights of live and dead herbs and shrubs are made at two points along the base of each sampling plane.

The term “line transect sampling” is often used to describe the planar intercept method. The two terms can be interchanged as long as one recognizes 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 duff layer to a height of six feet.

### Sampling Procedure

Collect FL data according to the following protocol FROM EVERY OTHER FIELD PLOT ONLY (in other words, from *only 4* of the 8 field plots in each PSU).

Refer to the previous section on *Positioning and Defining Boundaries of Field Plots* for guidance on setting up your sampling unit.

There are 12 general procedures within the FL methods:

- |   |  |                                 |
|---|--|---------------------------------|
| <ul style="list-style-type: none"><li>• Laying out the measuring tape to define the sampling plane</li><li>• Measuring the slope of the sampling plane</li><li>• Counting fine woody debris</li><li>• Measuring coarse woody debris</li><li>• Measuring depth of the duff-and-litter profile</li><li>• Estimating the proportion of the profile that consists of litter</li><li>• Estimating cover of live woody species</li><li>• Estimating cover of dead woody species</li><li>• Estimating average height of live and dead woody species</li><li>• Estimating cover of live non-woody species</li><li>• Estimating cover of dead non-woody species</li><li>• Estimating average height of live and dead non-woody species</li></ul> |  | Measuring DWD                   |
|   |  | Measuring duff and litter       |
|   |  | Measuring understory vegetation |

(Note: The latter eight tasks are conducted at only two locations along each fuel transect.)

## 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 duff layer to a height of six feet. When laying out the tape, crew members need to step so that they minimize any trampling and compacting of fuels.

Have one crew member stand at plot center holding the zero end of the tape. Then, using a compass, he or she will guide second crew member (see *Appendix C: Using a Compass*) 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 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 6). It's advantageous to sight carefully with the compass and to identify potential obstructions before rolling out the tape.

The second crew member must adhere to the directions given by the first to stay on line. This 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 disturbing the debris to be measured.

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. Because DWD shouldn't be sampled over a tape that isn't straight, crew members need to lift the tape above the vegetation, move both ends of the line left or right (in other words, keeping it oriented at the same azimuth) until the tape won't be influenced by any obstructions. Then place it down straight on the soil surface. Usually this offset won't need to be more than a few feet left or right; however, 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 through the handle on the other end of the tape will hold it in place. Roll-up tapes (figure 7) 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 pulled tight.

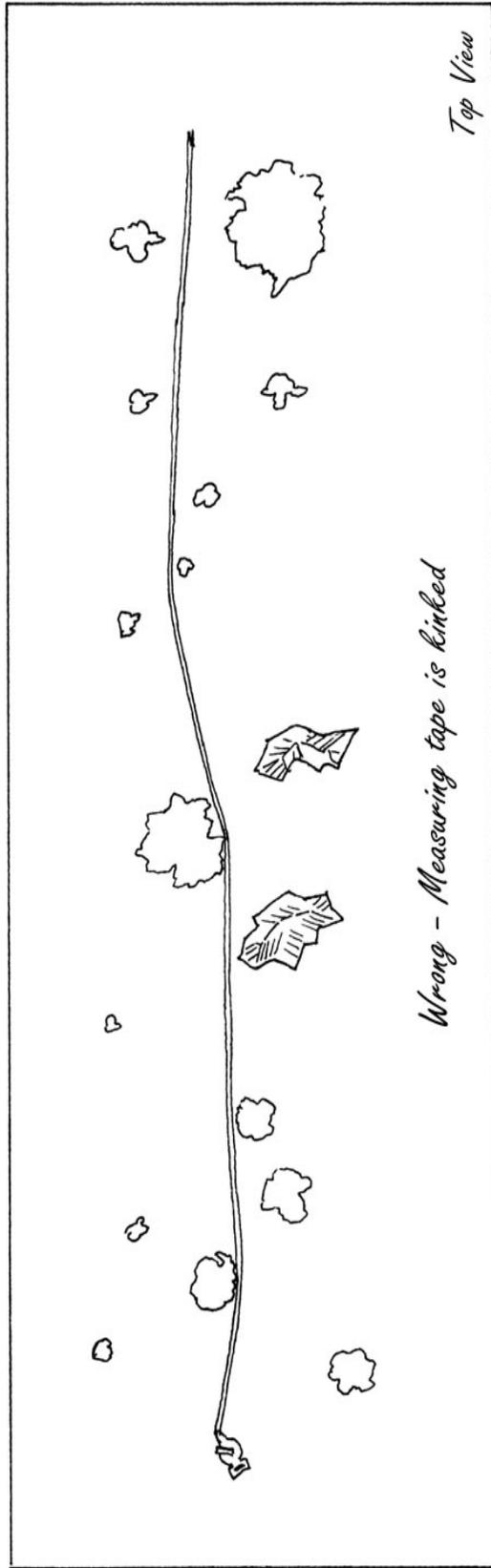
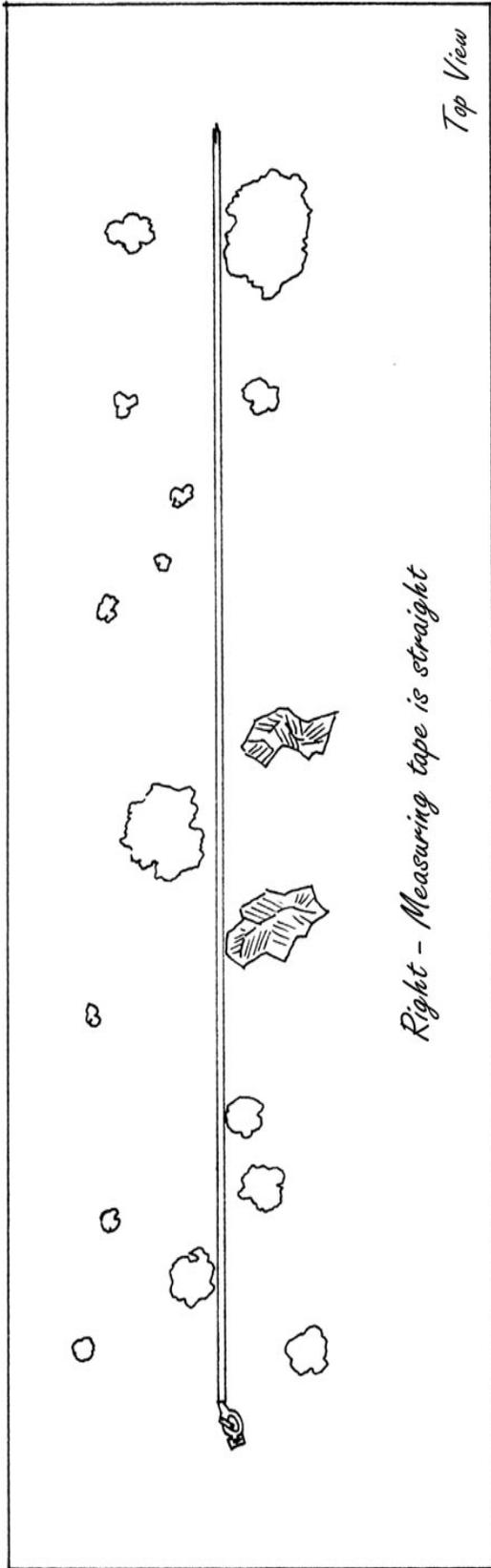


Figure 6. The measuring tape, which represents the lower portion of the sampling plane, should be as straight as possible. If the tape is not straight it must be offset left or right until it can be established without kinks or bends.

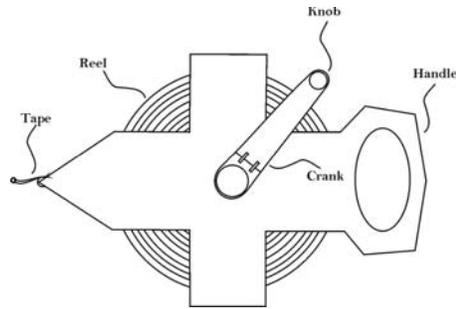


Figure 7. Parts of a roll-up measuring tape.

### Determining the Slope of the Measuring Tape

Once the tape has been secured, use a clinometer to measure the slope of the tape. Aim the clinometer at the eye level of sampler at the other end of the line (figure 8). If there is a height difference between 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 then enter it in the appropriate field within the FL Data Form (and ultimately in *Field 6* in the FIREMON FLFineDL Table).

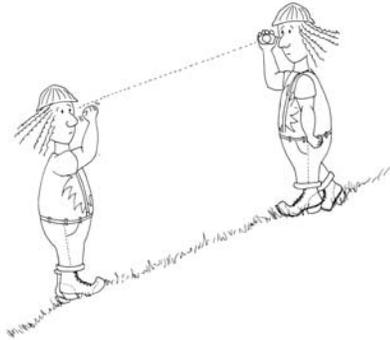


Figure 8. Measure the slope of each line by aiming the clinometer at eye level of the sampler at the opposite end of the measuring tape, then read and record the percent slope seen on the scale in the instrument.

### Measuring Dead and Downed Woody Debris

Fire managers need to have an estimate of downed, dead fuel because it substantially influences

fire behavior and fire effects. Smaller pieces of DWD, collectively termed fine woody debris (FWD), are generally associated with fire *behavior* because they reach ignition temperature faster than larger pieces. The time it takes for a flaming front to move across a fuel complex is an example of FWD's influence on fire behavior. In contrast, larger pieces of DWD, called coarse woody debris (CWD), 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 related to large DWD.

For LANDFIRE, we will classify DWD as either FWD or CWD according to the following rules: FWD must be pieces of DWD less than 3 inches diameter. These include 1-hour, 10-hour, and 100-hour fuels. CWD must be 3 inches in diameter or greater with a minimum length of 3 feet. These are called 1000-hour and greater fire fuels (table 3).

Table 3. Diameter size classes for dead and downed woody debris.

Woody Debris Class			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

#### *Determining piece size*

Brown's (1974) methods provide estimates of fuel load in the DWD size classes important to fire behavior and effects: 1-hour, 10-hour, 100-hour, and 1000-hour or greater. 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. It will often be clear which size class the pieces belong in by just looking. This is especially true as field crews gain experience sampling fuels. However, while samplers are calibrating their eyes or when pieces are on the boundary between two size classes, samplers need to measure pieces and assign them to the proper class.

Each sampling crew should have a go/no-go gauge (figure 9) to help distinguish between size classes. 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 0.06 in. thick) so that it is lightweight and durable. Or, make one out of an old plastic card (like the one you get at a grocery store). It won't be as durable as one made of aluminum, but it is easier to make because you can cut the openings with scissors.

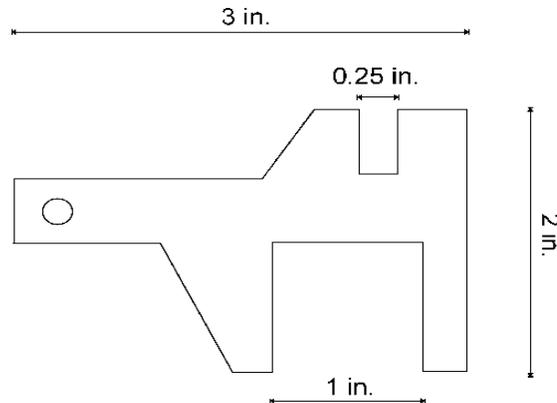


Figure 9. A go/no-go gauge. This tool can help samplers tally 1-hr, 10-hr and 100-hr fuels more quickly and accurately than wooden dowels.

### *Definitions of “woody”, “dead,” and “downed”*

Before sampling any DWD, the terms “woody,” “dead,” and “downed” need to be understood so that data gathered with the FL methods is consistent between field crews.

“Woody” describes stems, branches, or twigs that persist from year to year and that are usually covered with bark. Woody plant parts may be either live or dead and either attached to or detached from the plants themselves. Woody plant parts usually support leaves, needles, cones and so forth, and it’s these structural components that are tallied along the sampling plane.

“Dead” describes a plant part that is no longer living (in other words, is incapable of conducting water, sugars, and nutrients). Dead plants or dead plant parts that have been shed are commonly called debris. Remember, plants shed their leaves when dormant. Do not confuse “dormant” with “dead.”

“Downed” refers to materials that are no longer attached to plant material that is firmly rooted in the ground (meaning secured as in its live state).

Coarse woody debris at an angle of greater than 45 degrees above horizontal where it passes through the sampling plane should be considered “downed” only if it is the broken bole (trunk) 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 “downed” regardless of whether it is broken, uprooted, or supported in that position (figures 10 and 11).

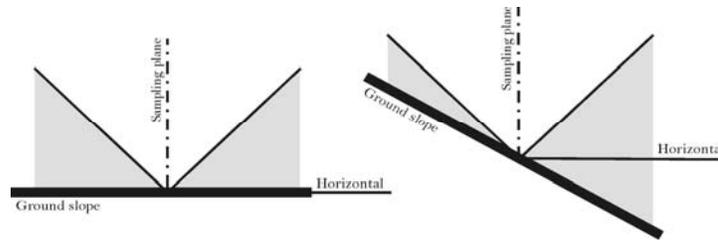


Figure 10. CWD pieces crossing through the sampling plane at an angle less than 45 degrees from horizontal (represented by the shaded areas in the figure) are always considered to be "downed." Some CWD leaning at an angle greater than 45 degrees may be considered "downed." See the text for details.

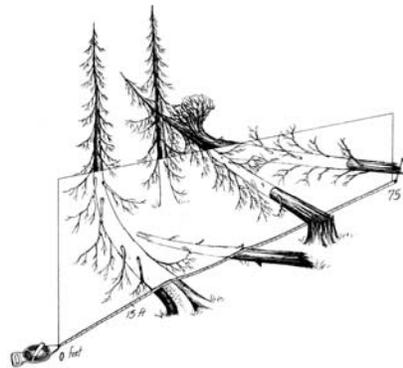


Figure 11. All of the pieces crossing through the sampling plane in this illustration would be considered "downed."

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 12).

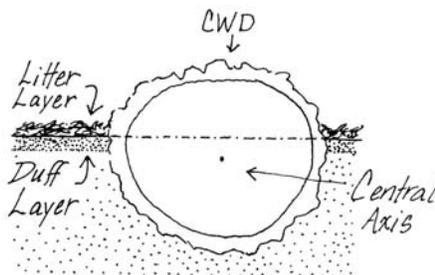


Figure 12. Do not sample CWD when the central axis of the piece lies in or below the duff layer.

Pieces of FWD that are “woody”, “dead,” and “downed” fall into three general categories: 1) pieces that are not attached to the plant stems or tree trunks (boles) where they grew and have fallen to the ground, 2) pieces that are not attached to the plant stems or tree trunks 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 “downed.”

Note: 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 “downed.” Fresh slash and broken branches are examples of green material considered “dead.” Sample dead pieces still attached to vegetation only if they are attached to “dead” and “downed” trees and shrubs. Do not sample dead branches attached to live trees and shrubs, even if those branches are broken but hanging from the plant from which they grew. Piece angle of FWD is not critical in determining whether or not it is “downed.” 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-and-litter profile.

*Sampling plane lengths (fields 5 through 8 in the FIREMON FLMacro Table)*

DWD is sampled along a certain portion of the sampling plane based on the size of the piece (figure 13). The 1-hour and 10-hour fuels are sampled from the 15-foot to the 21-foot marks along the plane, the 100-hour fuels are sampled from the 15-foot to the 30-foot marks, and the 1000-hour and greater fuels are sampled between the 15-foot and 75-foot marks along the plane. Because pieces of FWD are usually more numerous than CWD, a representative sample of FWD can be obtained with a shorter sampling distance. DWD is not measured along the first 15 feet of the tape because fuels are usually disturbed around plot center by the activities of the sampling crew.

*Counting fine woody debris (fields 7 through 9 in the FIREMON FLFineDL Table)*

All pieces of FWD that pass through the 6-foot high sampling plane must be counted along the entire length of the fuel transect. Count the 1-hour and 10-hour fuels that pass through the sampling plane from the 15-foot to the 21-foot marks on the measuring tape. (The team member at the zero end of the tape should sample FWD to maximize sampling efficiency.)

Remember: the plane extends from the top of the duff layer vertically to a height of six feet. The best way to identify the pieces intercepting the plane is to lean over the measuring tape so that your eye is positioned vertically a few feet over the measuring tape at the 15-foot 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

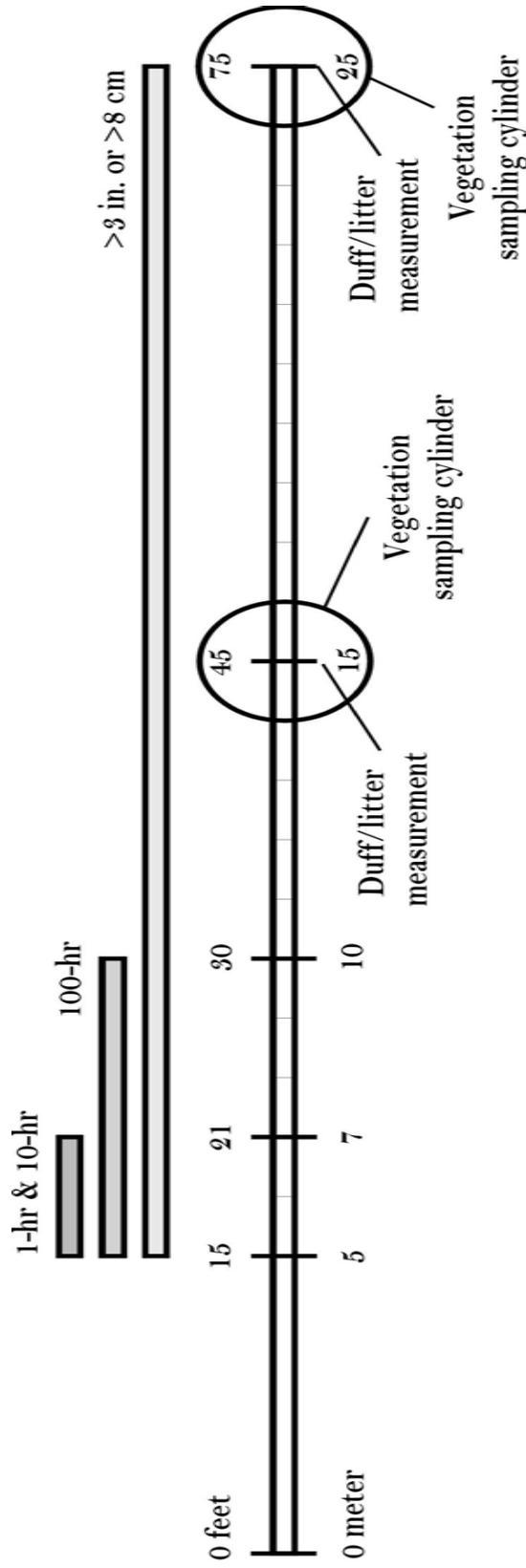


Figure 13. Dead fuels, duff/litter, and vegetation data are recorded at specific locations on or along each sampling plane. The 1-hour and 10-hour fuels are sampled from the 15-foot to the 21-foot marks along the plane, the 100-hr fuels are sampled from the 15-foot to the 30-foot marks and pieces 3 inches and larger are sampled between the 15-foot and 75-foot marks along the plane. Duff/litter measurements are made in a representative area within a 6-foot diameter circular area at the 45-foot and 75-foot marks. The cover of live and dead vegetation is estimated within an imaginary 6-foot diameter by 6-foot high sampling cylinder at the 45-foot and 75-foot marks.

go/no-go gauge described above to categorize fuels that are close to the size classifications. Often pieces above 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 14). After tallying the 1-hour and 10-hour fuels, report the counts to the data recorder, who will then enter them in the appropriate sections of the FL Data Form (and *fields 7 and 8* in the FIREMON FLFineDL Table).

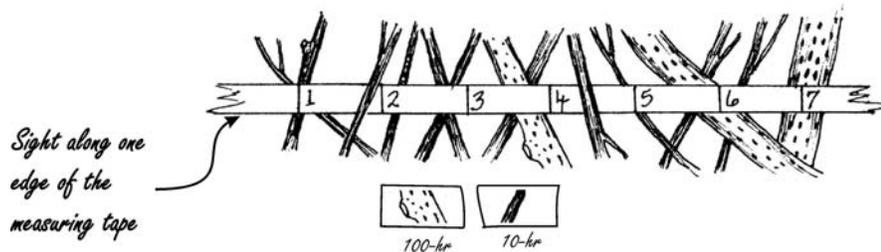


Figure 14. Tally pieces that intercept the sampling plane both above and below the measuring tape. Focus on one edge of the tape to make counting easier. Be sure to note any lower fuels that are hidden by pieces above. In this illustration there are eleven 1-hour fuels and three 10-hour fuels.

Use the same basic procedure to count the 100-hour fuels that pass through the sampling plane from the 15-foot to the 30-foot marks on the tape. Report the information to the data recorder who will then enter the count in the appropriate sections of the FL Data Form (and *Field 9* in the FIREMON FLFineDL Table).

### Measuring Duff and Litter

Duff and litter are two components of the fuel complex made up of small, non-woody pieces of debris that have fallen to the forest floor. For our purposes, “litter” is the loose layer made up of dead and flattened or detached grass blades, recently fallen leaves, needles, and so forth in which 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 (clumped) because of the fine plant roots growing in the duff material.

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*, whereas duff is associated with fire *effects*.

For the LANDFIRE Fuel Load methods, you are to assess duff and litter loads by measuring the depth of the duff-and-litter profile down to mineral soil and then estimate the percentage of that total depth that consists of litter only. The “duff-and-litter profile” is the cross-sectional view of the litter and duff layers combined. It extends vertically from the top of the mineral soil to the top of the litter layer.

*Measuring depth of the duff-and-litter profile (fields 10 and 12 in the FIREMON FLFineDL Table)*

The duff and litter layers are not sampled using the planar intercept method. Instead, they are described by duff-and-litter profiles taken 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 taking the duff-and-litter measurements.

Duff-and-litter depth is gauged at points within 3 feet of the 45-foot and 75-foot marks along the fuel-transect tape. At each of the 45- and 75-foot marks, delineate a 3-foot radius circle and select a sampling point that best represents the duff/litter characteristics inside the entire circle.

Use the blade of the trowel to lightly scrape only 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 (cross-section). 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 coarser in composition, often sandy or gravelly. Do your best not disturb the profile by compacting it on successive scrapes. The exposed profile should allow accurate measurement of duff-and-litter depth

Use a plastic ruler to measure the total depth of the duff-and-litter profile to the nearest 0.1 inch. 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 15). While keeping your finger in the same position on the ruler, lift the ruler out of the profile and note the depth indicated by your finger. If your ruler is not long enough to measure the duff-and-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.

Enter the total depth of the duff-and-litter profile to the nearest 0.1 inch in the appropriate section (based on your location along the fuel transect) of the FL Data Form (and either *Field 10* or *Field 12* in the FIREMON FLFineDL Table).

*Estimating the proportion of the profile that consists of litter (fields 11 and 13 in the FIREMON FLFineDL Table)*

Examine the duff-and-litter profile and estimate to the nearest 10 percent the proportion of the total depth that is made up of litter. Enter this number in the appropriate section (based on your location along the fuel transect) of the FL Data Form (and either *Field 11* or *Field 13* in the FIREMON FLFineDL Table).

Note: Duff and litter measurements are most easily and accurately taken on the vertical portion of the profile as long as that portion of the profile is representative of the true duff-and-litter depth (in other words, the depth wasn't altered as you exposed the profile). Sometimes the most-vertical part is where the back of the trowel blade went in, as depicted in figure 15, and sometimes it is along one side of the profile.

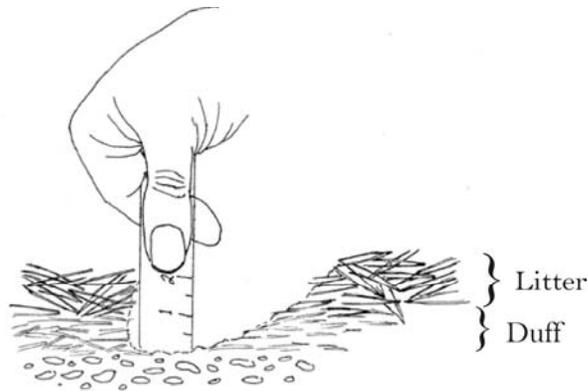


Figure 15. Use a plastic ruler to estimate duff and litter depth. Place the “zero-end” at the intersection of the mineral soil and duff layer, then mark top of the litter layer using your thumb or finger. In this illustration, the duff-and-litter depth is 2 inches, and the proportion of the depth that is litter is about 50 percent.

*Measuring coarse woody debris (fields 5 through 8 in the FIREMON FL1000hr Table)*

The CWD sampling plane is six feet high and extends from the 15-foot mark to the 75-foot mark along the measuring tape. Tally the CWD that intercepts the sampling plane and meets the dead, downed, and woody requirements discussed above. Then, record the diameter and decay class of 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 (figure 16). 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 straight tape can give good results if it is used so that parallax error does not introduce bias (See *Appendix E: Measuring Diameter with a Straight Tape*).

CWD sampling should be performed by the crew member that is standing at the 75-foot 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 inadvertent disturbance of the FWD before it has been sampled.

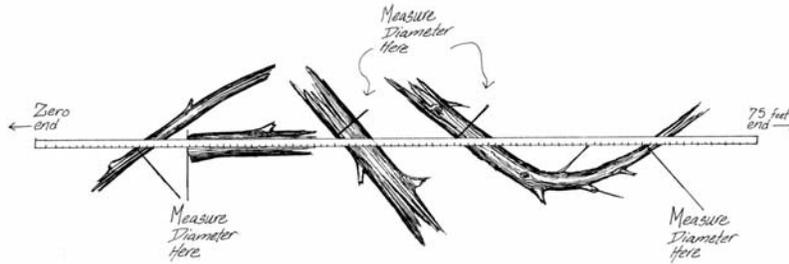


Figure 16. Measure the diameter of CWD perpendicular to the central axis of the piece. If a curved piece passes through the plane more than once, measure its diameter at each intersection.

Select the decay class from table 5 that best describes the location along the CWD piece (or “log”) at which you measure diameter. 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, log number, a diameter measurement, and decay class assignment for each piece must be entered in the appropriate sections of the FL Data Form (and in *fields 5 through 8* of the FIREMON FL1000hr Table, respectively).

Table 5. Use these descriptions to determine the decay class at the point at which each piece of coarse woody debris, or “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 inch 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, it should not be included in the CWD sampling as these pieces act more like duff than wood when burned.

## Measuring Understory Vegetation

The volume, density, and biomass (tons per acre) of understory vegetation all strongly influence fire behavior. For LANDIFRE, these characteristics are derived from measured estimates of cover percentages and average heights of trees, shrubs, and herbs.

### *Distinguishing “woody” from “non-woody” vegetation*

Woody plants include trees, shrubs, and some vines. These plants generally take multiple years to complete their life cycles, have persistent stems (or trunks), and may have persistent foliage (they can be either evergreen or deciduous). Trees generally have a single main stem (or trunk) and have relatively well-defined crowns. Shrubs tend to have multiple stems that can be erect, spreading, or prostrate, creating a “bushy” appearance.

Non-woody vegetation (collectively termed “herbaceous” in LANDFIRE field protocols), includes graminoids, forbs, soft-stemmed vines, and ferns. Graminoids include grasses and grass-like plants with linear or strap-like leaves, such as sedges and rushes. Forbs and ferns are broadleaved. The foliage of these plants seldom persists year-round in cold or dry climates. Perennial herbaceous plants (or “perennial herbs”), however, take multiple years to complete their life cycles and therefore may have persistent stems. These stems are generally less substantial than those of woody species and lack an outer covering of corky bark. Annual herbs complete their life cycles in a single year. Mosses and lichens are non-vascular plants (they lack specialized conducting tissues) and are definitely non-woody. However, they are not included as herbaceous plants in the LANDFIRE FL methods.

### *Estimating vegetation cover and height (fields 6 through 17 in the FIREMON FLVeg Table)*

Measure the percentages of vegetation cover and average heights of various groups of understory vegetation at the 45-foot and 75-foot marks on the measuring tape. Cover is estimated within a 6-foot tall by 6-foot diameter imaginary sampling cylinder. Use the measuring tape to help envision this cylinder. Centered on the 45-foot mark, this cylinder would be bounded on its “sides” by the 42- and 48-foot marks and extend upward that same distance. In addition, each sampler should measure his or her arm span and use that measurement to help envision the sampling cylinder.

Six attributes are measured at each vegetation sampling point:

1. Cover of live shrubs and trees
2. Cover of dead shrubs and trees
3. Average height of live and dead shrubs and trees
4. Cover of live herbaceous plants
5. Cover of dead herbaceous plants
6. Average height of live and dead herbaceous plants

“Cover” is the vertically projected canopy in each of the four categories (in other words, live/dead herbaceous and live/dead shrub) 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 the cylinder (live and dead branches). Estimate cover by imagining all the vegetation in the class that's being sampled as if it were compressed down to the ground. The percentage of the ground covered by the compressed vegetation inside the 6-foot diameter sampling area constitutes the cover. The cover of dead branches on a live plant should be included in the dead cover estimate.

Do not include the cross-sectional area of tree trunks in the live or dead woody cover estimate. The trunks don't count as surface fuel because they seldom influence fire behavior or fire effects. In fact, stems are one of the few components of the pre-fire vegetation that are reliably present after an intense burn. Moreover, if the sampling cylinder were located in an area with an unusually high number of tree trunks, the vertical projection of the foliage would probably be overlapping the area of the trunks; thus, the actual cover would be the same with or without the trunks. See *Appendix B: Estimating Canopy Cover* for more information.

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. Therefore, when looking at the cover of a woody shrub species, for example, samplers need to estimate the cover of all the parts, even the foliage, which is not technically "woody." Second, it is only with practice and experience that accurate estimations of plant cover can be made.

In addition to cover estimates, samplers will collect 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. Estimate height by noting the maximum height of all the plants in the class and then recording the average of all the maximum heights. Or, envision a piece of plastic covering the plants in just one class and then estimate the average height of the plastic above the ground. Estimate height to the nearest 0.5 foot. Remember: for both cover and height estimation, include only the vegetation within the sampling cylinder. See *Appendix F: Measuring Plant Height* for more information.

Record the vegetation cover classes and height data in the appropriate section of the FL Data Form (and *fields 6 through 17* in the FIREMON FLVeg Table). Also, write any comments that might be useful to those analyzing the data in the *Notes* field on your data form. For example, you might note "evidence of deer browse" or "deep litter and duff around trees." Then, collect your sampling equipment and move ahead to start sampling the next plane.

### **Successive Sampling Planes**

FL methods must be applied along at least THREE sampling planes within each LANDFIRE plot. The first sampling plane is always oriented at an azimuth of 90 degrees true north, the second is oriented at 330 degrees, and the third at 270 degrees (figure 17). Planes are oriented in multiple directions to avoid bias that could be introduced by DWD pieces not randomly oriented on the forest floor.

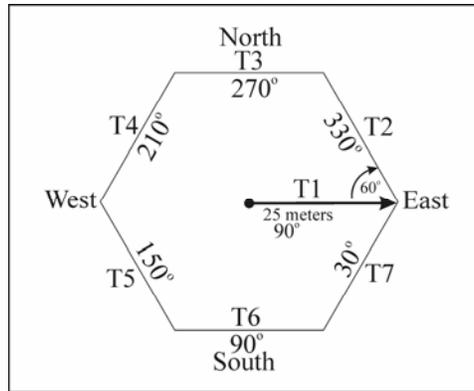


Figure 17. The FL plot design allows a representative sample of DWD to be obtained while reducing or eliminating the bias introduced by non-randomly oriented pieces. Data are collected on and along three to seven sampling planes.

It is not necessary for a sampling plane to begin at the exact 75-foot mark of the previous one. In fact, it is better if the beginning of the new line is approximately five feet away from the end of the last so that the activity around the new line does not adversely impact the fuel characteristics at the end of the previous line. Make sure that no portion of the new sampling plane will be crossing fuels that were sampled on the previous plane. Once the location of the beginning 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 laying out the next sampling plane.

### Determining the Number of Sampling Planes

After sampling three planes, count the number of all the DWD pieces (1-hour, 10-hour, 100-hour, and 1000-hour pieces). If that number is greater than 100, you are finished sampling DWD within that field plot. If the count is less than 100, you must install and sample along another FL transect. Refer to the FL plot design (figure 17), lay out the next sampling plane, and collect the FL data. When finished, recalculate the DWD piece count. Again, if the count exceeds 100, then you've sampled sufficiently. If not, install and sample along another plane. Continue installing and sampling FL transects until either (1) total piece count exceeds 100 or (2) seven planes have been sampled. Once initiated, all transects must be completed (in other words, data must be collected for the *entire* plane). DO NOT stop sampling in the middle of a transect once you've counted your 100th piece of DWD. After you have *completed* the last transect necessary to count the minimum 100 pieces of DWD, record the total number of planes sampled in the appropriate cell within your FL Data Form (and *Field 9* of the FIREMON FLMacro Table).

### 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 possible and then note problems and “fixes” in the comments section. For example, instead of installing a transect that heads off a cliff, a crew could use the next azimuth from the FL plot design and lay out the sampling plane in that direction, noting the problem and these changes in the *Notes* field on the FL Data Form.

### **Plot-Wide Estimates (NEWMDL)**

In addition to the variables you have described along the fuels transects, we ask that you make a few plot-wide estimates of variables to be input to the NEWMDL software program developed by Burgan and Rothermel (1984). These data must be recorded onto your FL Data Form in the field and entered into the NEWMDL Access database at the end of each day. *See Appendix H: NEWMDL* for further explanation of the NEWMDL program and supplemental documents for photos referred to in the instructions below.

#### *Graminoid type (GT)*

Compare the grass type photos (provided in a supplement to this handbook) to your plot area. Record the number of the grass type image that best depicts the typical morphology of the grasses and grass-like plants within your plot. You are selecting a general grass type category for the plot so just pick the “best” match.

1. Fine – examples: cheatgrass, Idaho fescue
2. Medium – examples: rough fescue, blue grama (NM, CO, AZ, UT)
3. Coarse – examples: fountaingrass, *Sorghastrum spp.*, smooth brome
4. Very Coarse – examples: sawgrass, big sacaton

#### *Graminoid bulk density (GBD)*

After you have selected the grass type, define the bulk density class by matching bulk density photos of the appropriate grass type (provided in a supplement to this handbook) to that within your plot area. Record the appropriate density-class number on the FL Data Form.

#### *Proportion live grass (PLG)*

Record the number from the following list that best describes the proportion of grass by volume that is live at the time of sampling on your plot. Imagine separating all the grass material into two piles, one of live material and one of dead material. Estimate the proportion the live grass pile is of the two piles combined [Proportion Live Grass = Live Grass / (Live Grass + Dead Grass)].

1. None or almost none
2. Approximately a quarter
3. Approximately one-third
4. Approximately one-half
5. Approximately two-thirds
6. Approximately three-quarters
7. All or almost all

### *Shrub type (ST)*

Compare the shrub type photos (provided in a supplement to this handbook) to your plot area. Record the number of the shrub type image that best depicts the typical morphology of the shrubs within your plot. You are selecting a general shrub type category for the plot so just pick the “best” match.

1. Fine stems, thin leaves – example: huckleberry
2. Medium stems, thin leaves – example: ninebark
3. Medium stems, thick leaves – examples: ceanothus, kinnikinnick
4. Densely packed fine stems and leaves – example: chamise
5. Thick stems and leaves – examples: greenleaf manzanita, pringle manzanita

### *Shrub bulk density (SBD)*

After you have selected the shrub type, define the bulk density class by matching bulk density photos of the appropriate shrub type (provided in a supplement to this handbook) to that within your plot area. Record the appropriate density-class number on your paper form.

### *Litter source (LS)*

Record the number from the following list that best describes the primary litter source on the plot. You may choose up to two “codes” in the event that you have mixed litter, AND the lesser type makes up about one-third of the total. Litter source influences litter bulk density, which can be an important variable in the prediction of fire behavior and fire effects.

1. Medium/long needle conifer – examples: ponderosa pine or lodgepole
2. Short needle conifer – example: Douglas-fir
3. Scale-leaf conifer – example: juniper
4. Broadleaf – examples: aspen, cottonwood
5. Graminoid
6. Other than above (such as cones, cone scales, seeds, dead lichen or moss.)

### *Litter compactness (LCo)*

Record the number from the following list that best describes the compactness of the litter within your plot. Hardwood litter, for instance, is most likely to be loose or fluffy when it first falls, but

compact after it has been on the ground for at least one winter. Compactness affects the bulk density of the litter.

1. Loose (freshly fallen or perched on grass)
2. Normal (been sitting a while; most is laying directly on top of the duff layer)
3. Compact (older obviously compressed litter – you can still distinguish the source, so it's not duff)

#### *Litter cover (LCv)*

Record the percentage litter cover for the entire plot. Select from the canopy cover codes in table 1.

#### *Woody debris depth (WDD)*

Estimate the vertical distance (to the nearest half foot) from the bottom of the litter layer to average maximum height of woody debris on the plot. To do so, envision a plastic sheet draped only over the woody debris (all sizes) in the sampling area (figure 18). Imagine a line corresponding to the average height of the sheet and another line at the average depth of the litter layer. The difference between these two lines would be the woody debris depth.



Figure 18. Calculate woody debris depth as the difference between the average height of woody debris and the average litter depth.

#### *Woody debris cover (WDC)*

Record the percentage cover of all woody debris in the plot. Select from the canopy cover codes in table 1.

#### *Foliage retention (or Proportion of Foliage Attached – PFA)*

Select the number from the following list that best describes the proportion of the total length of all DWD branches that still has foliage (brown, red, green, etc.) attached to it. Include all woody debris that could have supported foliage in the “denominator” of your estimate (in other words, do not include a large log that was probably a tree trunk).

1. None or almost none
2. Approximately a quarter
3. Approximately one-third
4. Approximately one-half
5. Approximately two-thirds
6. Approximately three-quarters
7. All or almost all

*Moss and lichen cover (MLC)*

Estimate the percentage cover of all moss and lichen in the plot. Select from the canopy cover codes in table 1.

**Precision Standards**

Use the standards in table 6 when collecting data according to the FL methods.

Table 6. Precision guidelines for FL sampling.

Component	Standard
Slope	±5 percent
FWD	±3 percent
CWD diameter	±0.5 inch
CWD decay class	±1 class
Duff/litter depth	±0.1 inch
Percentage litter	±10 percent
Vegetation cover	±1 class
Vegetation height	±0.5 foot

# LANDFIRE Field Methods

## Species Composition



Species Composition (SC) methods are used to describe the plant community found on the LANDFIRE plot. Canopy cover and height are recorded for the dominant trees, shrubs, and herbaceous plants on the plot.

### Sampling Procedure

Refer to the previous section on *Positioning and Defining Boundaries of Field Plots* for guidance on setting up your sampling unit.

#### **Plant Species ID Level** (*Field 5 in the FIREMON SCMacro Table*)

Enter an “X,” which indicates that a criterion other than a threshold cover level is the basis for inclusion of plants in your species list. For LANDFIRE, you will collect data for 10 species per life-form, with the total number of species represented no less than 15 but no greater than 30. There may be a few special exceptions to these numbers and they are described below.

For the SC data collection, you need only categorize the plants into three different life-forms (as opposed to the four life-form categories used for Plot Description):

1. Tree – woody and generally single stemmed near the ground
2. Shrub – woody and generally multi-stemmed near the ground
3. Herbaceous – non-woody (grasses plus forbs)

For each of these life-forms you will record the names, covers, and heights of the 10 most common species on the plot (regardless of their status – that is, whether they’re live or dead – or size class – that is, whether they’re seedlings or mature individuals). If you find you have less than 10 different species in a particular life-form, record data for as many as you have. Determine the most common species based on your initial plot survey described below. Remember the purpose of the plant sampling is to describe the plant community found on the plot. If you are unsure about whether or not to include a species (for example, is it a different plant? Or is it the same as an Unknown you already have data for?), go ahead and include it. But be careful not to get too enthusiastic about recording every species you are unsure of or find interesting because it may seriously impact your schedule. If you’re constantly hung up on unknowns and unsure whether you’re adequately sampling your plots, get in touch with a local expert (for example, spend a few days in a local herbarium) and get a better handle on the plant diversity of the area so that you can work more efficiently in the field. Especially at the

beginning of the season, time spent with local botanists honing your plant ID skills is sure to translate into time saved in the field!

As you work a plot, keep a running tally of the total number of species for which you have recorded data, with the target of at least 15 but no more than 30 on your plot list. If you've only a single life-form (for example, only herbs) on your plot, keep adding to the list with species from that life-form, again shooting for 15-30 on the final list. If the total number of all species on the plot is less than 15, you should leave the plot with data for all of them.

Here are two possible SC-list scenarios with notes on how to proceed in each:

Tree = 5 species  
Shrub = 10 species  
Herbaceous = 10 species  
Total = 25 species  
*How to Proceed:* No need to collect more SC data on that plot. You're done!

Tree = 0 species (none on plot)  
Shrub = 3 species (no more on plot)  
Herbaceous = 10 species  
Total = 13 species  
*How to Proceed:* Continue sampling on that plot. Since you've no trees and found only 3 shrubs, you need to collect data for 2 more herbaceous species to total 15.

Later in the season, you may also be asked to search for certain "indicator" species on the plots and add them to your species lists in the event that they're present but not common enough to note otherwise. These indicators are species that should aid identification of the Ecological Systems and Vegetation Alliances to be mapped in LANDFIRE.

### **Initial Plot Survey**

To begin, lay measuring tapes crosswise through plot center to divide the plot into four quarters. The subdivision method allows you to tally species and estimate cover within more tenably sized portions of the 0.1-acre field plot. Place pin flags at plot center and at each of the four points at which the tapes cross the plot perimeter. While marking these points, make mental notes of species (and amount in a general sense: rare, common, highly abundant) particularly those less obvious (incidental) species. If someone can record, take note of these.

Return to plot center and begin listing species and their Natural Resource Conservation Service (NRCS) Species Codes on the SC Data Form (and ultimately *Field 5* in the FIREMON SCCover Table) as you identify them. You will likely proceed most efficiently by organizing your list form by life-form, starting with trees, then shrubs, then herbaceous plants.

Plant names and codes from the NRCS Plants database are included in a supplement to this Handbook and in the FIREMON database. In the rare event that a species is not listed in the supplement or the FIREMON database, the species may still be entered into the SCCover Table. See the *Data Management* section of the Handbook for more details.

If a plant cannot be identified quickly and confidently, refer to the section called *Unknown Plants and Voucher Specimen Collection* below for instructions on how to assign an unknown code and how to collect a sample for later identification. As a rule of thumb: *if you have any doubt, collect a sample.*

### Status

For each item you record, enter “X” (not assessed) in *Field 6* of the FIREMON SCCover Table, which indicates that you are not distinguishing between live and dead (or dormant) plants.

### Size Class

For each item you record, enter “TO” in *Field 7* of the FIREMON SCCover Table, which indicates that you are reporting total cover values for each species (versus making separate entries by size class).

Once you’ve generated the species list (including any unknowns), return to plot center and begin recording canopy cover and height for each plant (or item) in your list according to the following instructions.

### Estimating Canopy Cover

Canopy cover is one of the most commonly gauged indices of the influence of individual plant species on plant community structure and composition. For LANDFIRE, canopy cover is defined as the area of ground covered by the vertical projection of the outermost perimeter of vegetation canopy onto the ground (figure 19). By this definition, the sum of canopy coverages recorded for the various species or life-forms on a plot will often exceed 100 percent due to overlap. Refer to *Appendix B: Estimating Canopy Cover* for thorough instruction in cover estimation. Enter the appropriate cover class code (table 1) that represents canopy cover for each species on the SC Data Form (and ultimately in *Field 8* of the FIREMON SCCover Table).

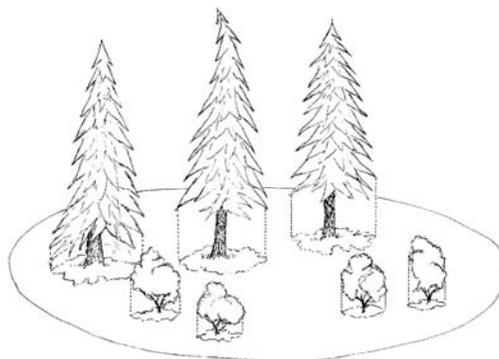


Figure 19. Canopy cover is estimated as the vertical projection of canopy cover onto the ground.

Note: When estimating total canopy cover for a species, do not “double count” any overlap between canopy layers of different plants of the same species (figure 20).

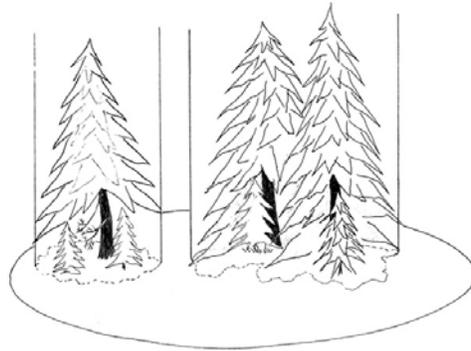


Figure 20. Estimating total canopy cover for plant species with overlapping canopies. In this figure the small trees underneath the canopy of the larger trees are the same plant species. Canopy cover is estimated as the projection of the large tree canopy onto the ground, which overlaps the canopy of the smaller trees.

## Measuring Height

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\*height) and to estimate biomass using the appropriate biomass equations based on cover and height. Plant height can be measured with a straight tape for small plants (<10 ft) and with a clinometer for larger plants (>10 ft). Refer to *Appendix F: Measuring Plant Height* for detailed instruction.

Enter the typical height (in feet) of the individuals that represent each plant species into the appropriate cell in the SC Data Form (and ultimately *Field 9* of the FIREMON SCCover Table).

## Sampling Hints and Techniques

Ocular cover estimates should be “calibrated” at the outset of a field campaign and repeatedly throughout a season (every 5 to 10 plots). Samplers can calibrate their eyes for estimating canopy cover by delineating (with pin flags) circular subplots known to be certain percentages of the field plot (table 7). Samplers should also become familiar with all the subplot sizes and the percentage of the entire field plot that each circular subplot represents. Samplers can then mentally group species into a subplot and use the subplot size to estimate percentage of canopy cover. This method and other cover estimation aids are reviewed in *Appendix B: Estimating Canopy Cover*.

Table 7. Percentage of a LANDFIRE field plot included within circles of different radii.

Radius (ft)	Percentage of total LANDFIRE plot
37.2	100
26.3	50
18.6	25
11.8	10
8.3	5
3.7	1

The average height of a plant species can be difficult to assess. Try selecting a single individual of that best represents the “typical” height of the plants of that species within the plot and record that value as the height of the species.

### **Unknown Plants and Voucher Specimen Collection**

When you encounter a plant you do not recognize and you cannot identify it quickly and confidently using field guides, follow these basic steps:

#### **Assign an “Unknown Code”**

Assign your specimen one of the Unknown Codes listed in the supplement provided with this document. There are 99 Unknown Codes for each life-form: codes “UNKFO01” through “UNKFO99” are available for forbs, codes “UNKGR01” through “UNKGR99” are available for grasses, codes “UNKSH01” through “UNKSH99” are available for shrubs, and codes “UNKTR01” through “UNKTR99” are available for trees. Each distinct unknown must be assigned a unique code. Once you have assigned an Unknown Code to a collected specimen, you can enter that code as the plant’s “name” each time you encounter it. Be sure, however, to convince yourself that you have indeed found another example of your unknown plant before giving it the same “name.” When in doubt, always collect a sample and assign the new specimen its own Unknown Code.

#### **Create a Specimen Label**

Each team will be issued a set of pre-printed labels for unknown specimens. An example of a pre-printed label is provided in figure 21:

Label Number: 1	Temp ID: UNKFO01
Registration Code: SC01	Project Code: LFZ15
Plot Number: 223503	Sampling Event: T
Collection Date: 8/06/03	Collected by: John Doe
State: MN	County: Hubbard
Cover Type: Spruce-Fir	
Description: opposite leaves, square stem, purple flowers, minty fragrance, possibly peppermint	
Other Notes: (e.g., growth habit, height, dbh)	
Scientific Name:	

Figure 21. Example of label for unknown specimen.

All labels should be completed in the field to the extent possible and must remain with the specimen. A specimen without a label is useless.

Be sure to note the color of flower petals and other plant parts, as these attributes are seldom fully evident once the specimen has dried. Also note features of the plant that cannot be gleaned from a pressed specimen, including growth habit, height, dbh, fragrance, and other whole-plant attributes.

Keep a running list of your unknowns in a field notebook for quick reference. In this format you can list your own synonym for each formally identified specimen. For example, you might note the more descriptive alias, “peppermint,” for UNKFO01.

### **Collect a Specimen**

Select a specimen that best represents the “population” you encounter. Use a trowel or other tool to extract the entire plant, including the underground parts of herbaceous plants and leaves, flowers, and fruits whenever available. If the plant is abundant, you could collect two samples to increase the likelihood of taking a good specimen. All specimens must be labeled, pressed, and dried for shipping and subsequent identification by the vegetation specialist, cooperating herbarium, or specialist.

#### *Pressing plants*

Press your specimen(s) as soon as possible for best results. To do so, place it and its label inside a single layer of folded newsprint. Then write the plant’s Unknown Code on the outside of the folded newspaper.

Large plant specimens may be folded in a “v”, “z”, or “w” arrangement to fit on a single newsprint page. Arrange the specimen so that at least one upper and one lower leaf surface is exposed. Soil should be removed, and plants may be trimmed to reduce bulk, so long as all diagnostic parts are included. Diagnostic portions include stem sections, petioles, leaves, roots,

flowers, and fruits. Bulky fruits or nuts may be stored separately in a paper envelope that is taped to the newsprint and is accompanied by an identical copy of the specimen's label.

Once tucked into its newsprint sleeve, sandwich each specimen between two pieces of blotter paper inside two pieces of cardboard (12 x 18 inches, corrugated along the shorter dimension). Stack and bind the plant-newspaper-blotter-cardboard sandwiches together with sash cord or webbing wrapped around the length and width of the cardboard bundle. To dry the plants, place your press in a sunny spot, with the corrugations facing into the wind for ventilation.

### *Collecting in plastic bags*

If a field press is unavailable, place the plant material with its label in a large zip-lock bag. Never place more than one species and label in a single bag. Use a 3-hole-punch to punch holes in the bottom of your bags prior to traveling in the field. Place the punched bags into a 2-inch 3-ring binder with the zip-lock portion facing outward. Plants can then be placed with labels into the bag directly in the binder. This method prevents crumpling, tearing, and destroying the specimen during transportation.

### **Record Cover and Height Estimates for the Collected Specimen**

Enter cover and height estimates for each collected specimen as described above. Be sure to record the correct Unknown Code for the specimen on your Data Form and in *Field 5* in the FIREMON SCCover Table.

# LANDFIRE Data Management



At the end of each day in the field, all new plot data must be transferred from your Data Forms (including PDAs) into the FIREMON database on your personal computer (PC). Instructions for the transfer of electronic data are provided in supplements to this Handbook.

In this section we explain how to archive electronic LANDFIRE data in a FIREMON database on your PC and how to supply copies of those data to the appropriate LANDFIRE staff. Specifically, we explain (1) how to archive plot photos, (2) how to use the FIREMON database to view, edit, and enter plot data, and (3) where and how often to send copies of your data to the next tier of LANDFIRE data administrators.

## **Plot Photo Management**

Plot photos taken in the field must be downloaded from the digital camera to the photos subdirectory under firemon (c:\firemon\photos). After these photos are copied from the camera to the laptop computer, they must be renamed according to the photo naming convention described in the PD sampling method. For example, a north photo taken by crew SC01 in zone 18 sampling the first plot in PSU 25 would be renamed to SC01LFZ182501\_N.jpg. This identifier should be clearly visible on the dry-erase board in each photo. Once loaded onto your PC, view and rename each photo accordingly.

## **The FIREMON Database Software**

The FIREMON database software allows users to view and, if necessary, edit, or enter LANDFIRE data. The FIREMON data entry forms are particularly useful in this regard. For example, the forms can be used to view the complete species lists and all fuel transect data plot-by-plot and to edit these and other data as necessary. These data entry forms are also useful for ensuring that all data on paper forms are fully and accurately represented in electronic form before the database is shared with LANDFIRE staff.

The FIREMON database consists of a Java application and a Microsoft Access™ database. The Java application, also known as the Java “front end,” allows users to explore the data through a series of data-entry forms, data summary forms and reports, and other data management tools. In the Microsoft Access™ database, on the other hand, users can work directly with the raw data in FIREMON tables and find definitions of fields in the FIREMON tables and any codes (including NRCS plant codes) in the database.

## *The FIREMON software*

The FIREMON database software should be loaded onto your field computers prior to the start of any given field campaign. The FIREMON directory consists of the FIREMON Java application, the FIREMON database, the FIREMON data analysis software, and subdirectories for plot photos, and metadata documents (figure 22). The FIREMON Java application (JFiremon.exe) is the Java executable program containing all the FIREMON data entry forms, data summary forms and reports, and data management tools. The C program (sum.exe) is used by the JFiremon program to summarize FIREMON data for the data summary reports. The FIREMON database (landfire.mdb) is an empty database containing all the FIREMON data tables and lookup code tables (for example, NRCS species codes) used for the LANDFIRE implementation of FIREMON. The FIREMON Analysis Tools include the data analysis program (fmat.exe) and associated help files (firemon.hlp, roboex32.dll). The photo and documents subdirectories are used to store photos and documents and contain a few sample photos and a document used with the training data set. All digital photos taken by the LANDFIRE field crews should be stored in the photos subdirectory.

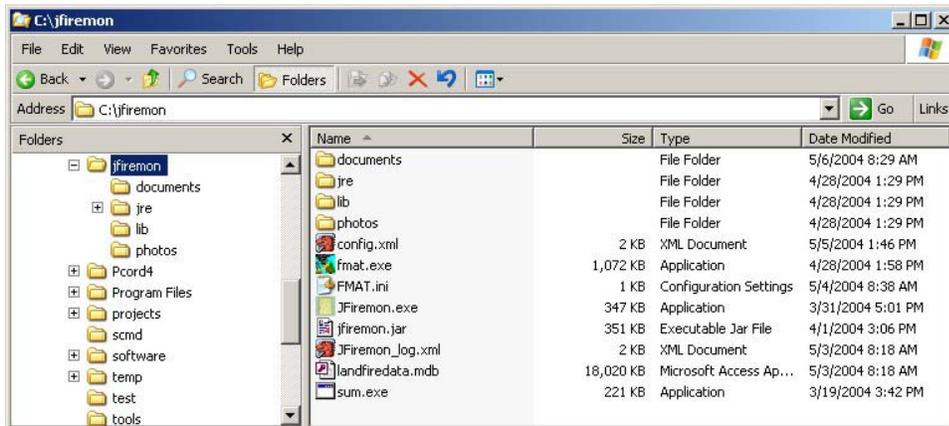


Figure 22. Files contained in FIREMON directory.

The JFiremon program is the application through which users interact with the FIREMON database (landfire.mdb). The data in the landfire.mdb database are viewed or edited through the data entry forms in the JFiremon application. Once data are transferred to the landfire.mdb database, field crews can view and edit these data.

### *Configuring the FIREMON database application*

Open the FIREMON application (JFiremon.exe) in Windows Explorer or from the desktop icon. After the FIREMON splash screen disappears, the main FIREMON Form appears on the screen along with the plot data entry forms (figure 23).

Figure 23. Main form for the FIREMON application database with plot data entry forms window open.

Next, close the plot data entry forms window and select *File > Settings...* from the FIREMON toolbar. This will display the FIREMON Configuration and Settings Form (figure 24).

The *Configuration and Settings* Form allows users to set the default directories for plot photos and documents, the FIREMON analysis software, and the FIREMON database. The *Photos Base Directory* and *Documents Base Directory* settings establish the hyperlinks for the plot photos and metadata documents and the directories storing the photos and documents, respectively. Once these directories are set, the FIREMON application uses these settings until they are changed again. Click on the *Save Settings* button to save the current settings. The default settings for FIREMON on the LANDFIRE field laptops connect to the landfire.mdb database and use the photos subdirectory as the plot photo hyperlink base.

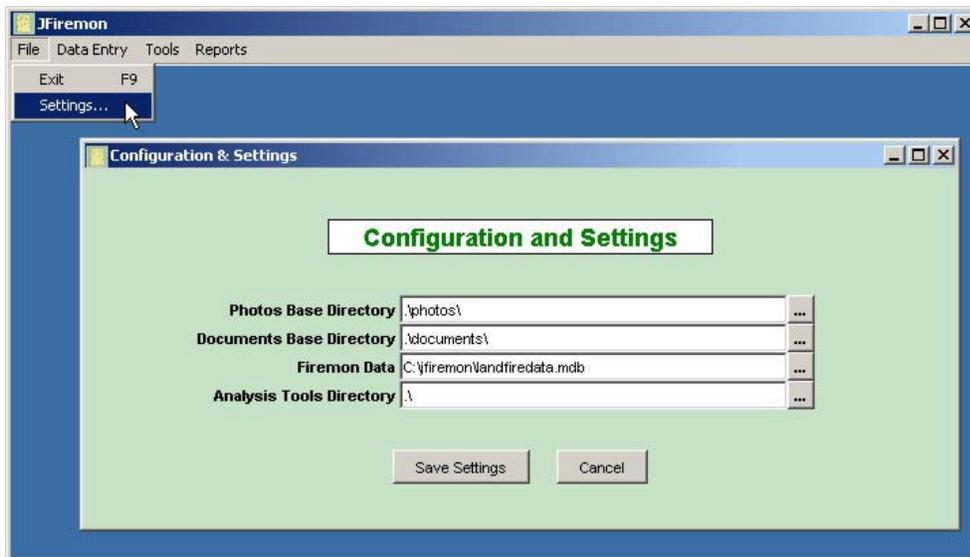


Figure 24. FIREMON configuration settings.

#### *Populating the plant species codes lookup table*

FIREMON uses the NRCS Plants Database codes as the default plant species codes; however, local codes may be used with FIREMON. If any plant species data are collected using the FIREMON sampling methods, users must populate the plant species code table with a list of plant species for their project area. Although FIREMON provides the entire list of species from the NRCS Plants Database, this list is much too large to effectively display in a drop-down list for data entry. The LANDFIRE database plant species pull-down lists are already populated. If for some reason a plant species is not included in the pull-down list, it may be added using the FIREMON Plant Species Codes form.

Select *Data Entry > Plant Species Codes* from the FIREMON toolbar to display the NRCS Plants Database Form (figure 25).

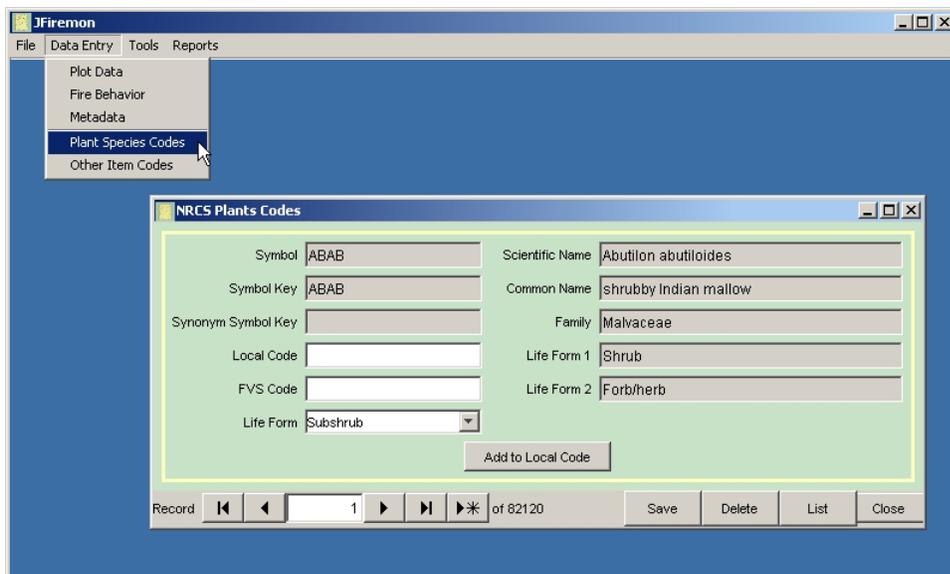


Figure 25. NRCS Plants database form.

This form allows users to search for a plant species by the NRCS Plants Code, scientific name, or common name. Users must find each plant species for their project area and populate the *Local Code* field on the form. If you are using the NRCS plant codes, click on the *Add to Local Code* button and the plant's code will automatically populate the *Local Code* field. If you are using other plant species codes, enter the local code in this field.

### *Data Entry and Editing*

Field data collected by the LANDFIRE field crews should always be entered on paper forms and then loaded into the LANDFIRE database. The FIREMON data entry screens allow field crews an easy way to view all the data and ensure all plot data was copied from the paper forms to the LANDFIRE database.

Users may enter plot data for each of the FIREMON sampling methods. Select *Data Entry > Plot Data* on the form from the FIREMON toolbar to display the Plot Data Entry Forms (figure 26). Click on the *New Record* button at the far right of the Access record navigation bar. This advances beyond the last record in the database and allows users to enter new records. When editing existing records, use the *List* button to find and edit the desired record (figure 27).

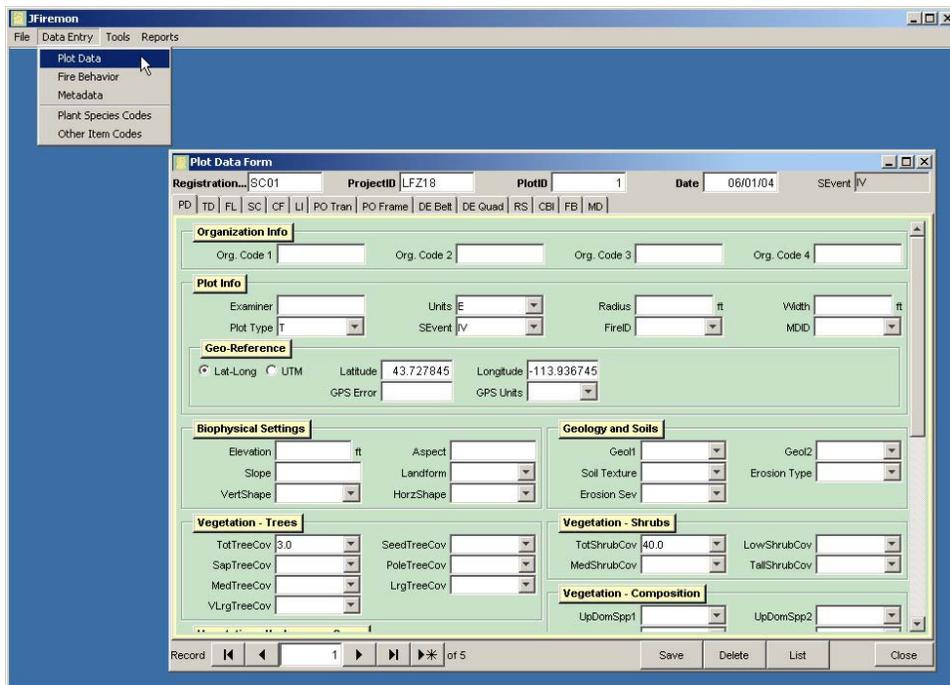


Figure 26. Plot Data Form.

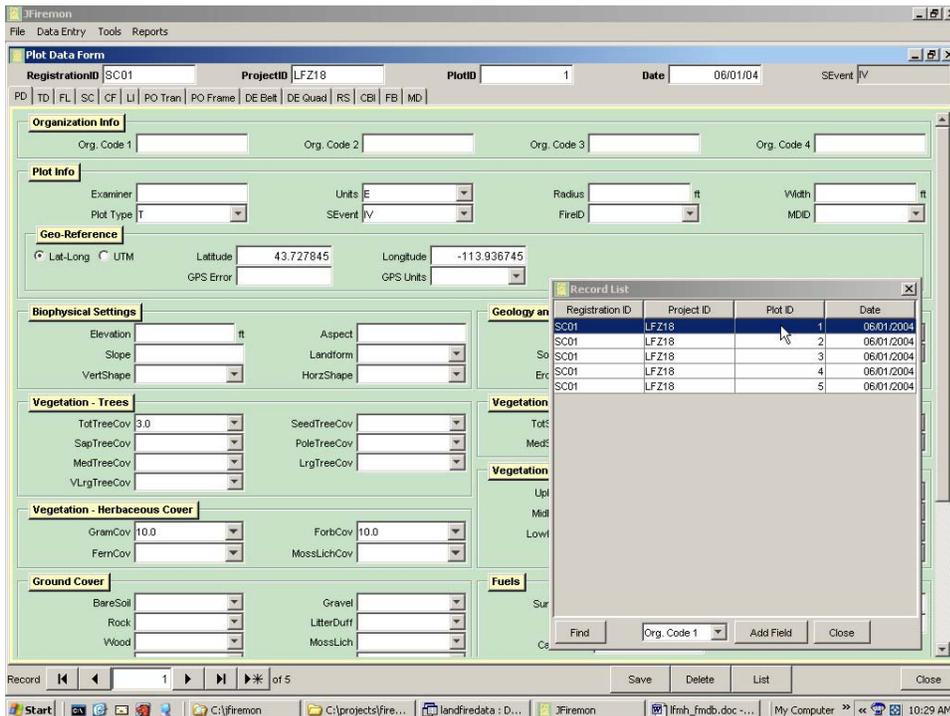


Figure 27. Editing an existing record in the FIREMON database.

If you attempt to enter a new record before you have entered valid data in all the plot key fields (RegID, ProjID, PlotID, and Date), FIREMON returns an error message stating there are missing

fields (figure 28). You must either delete the current record or fill in the required key fields. The current record may be deleted by right-clicking on the record and pressing the *Delete This Record* button (figure 29).

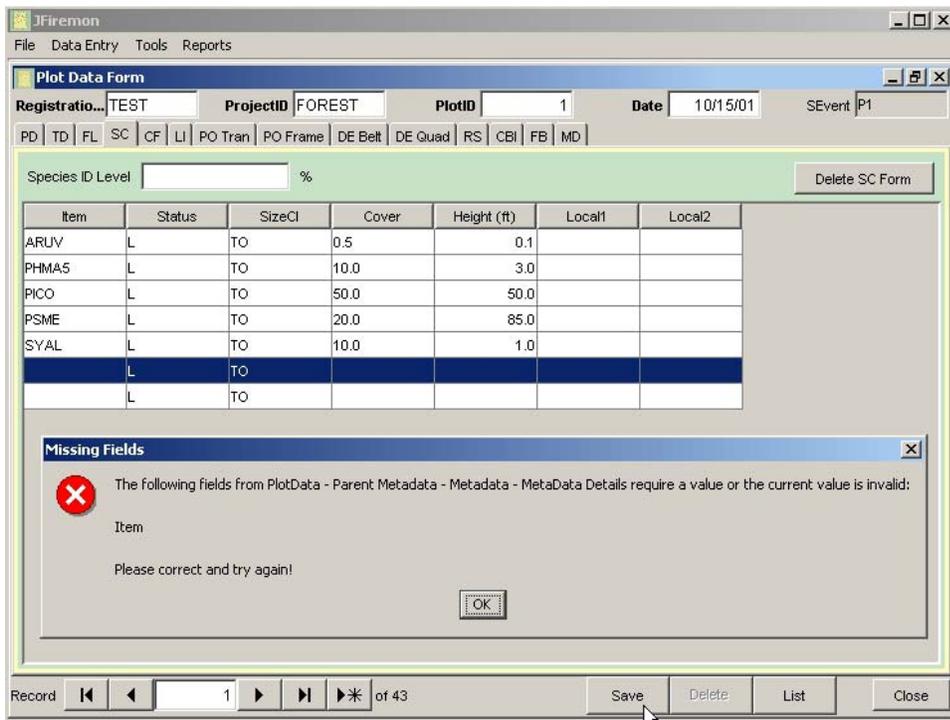


Figure 28. Example of the error message generated when trying to save a null record (a record missing one or more key fields).

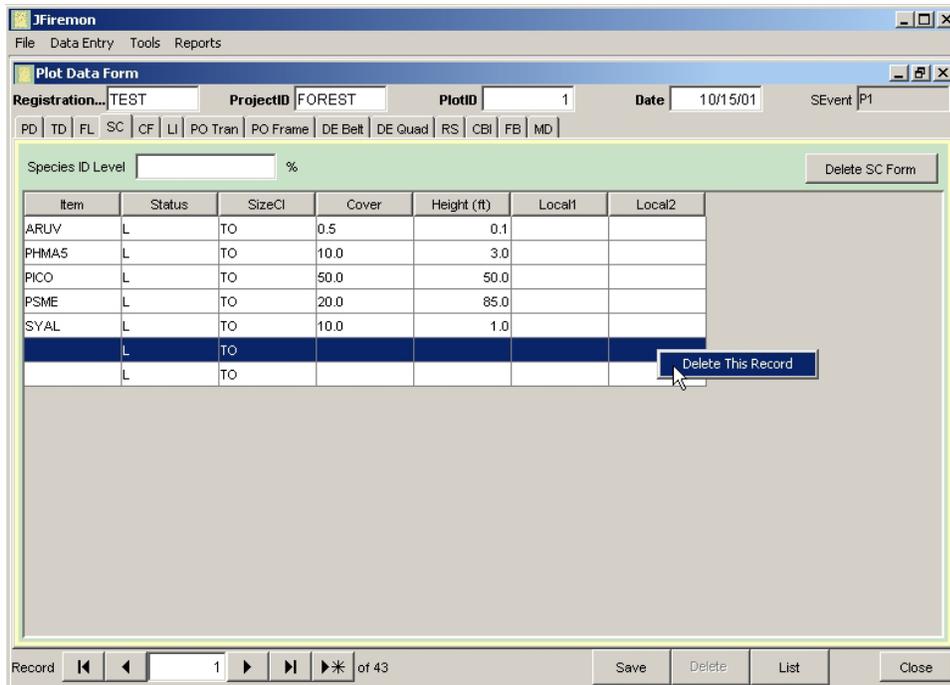


Figure 29. Delete a record by right-clicking on the current record and pressing the *Delete This Record* button.

### *Plot Description (PD) Data Entry Form*

The first data entry form is used in conjunction with the PD sampling method (figures 26 and 27). Users are required to enter data in this form first for each plot. The FIREMON key fields (*RegID*, *ProjID*, *PlotID*, and *Date*) are required and are automatically filled-in in the other sampling method data entry forms. Users must also enter the units in which the FIREMON data are collected (E = English), the plot type (T = Training, A = Accuracy Assessment), and the sampling event (IV = inventory). Other required codes are provided in the appropriate drop-down lists and are compatible with the field sampling methods previously described in this manual.

The *Delete* button deletes the current PD record and any records linked to this record. Since all tables are linked to the PD table, this button deletes any records in the database for the current plot.

### *Fuel Loading (FL) Data Entry Form*

The FL Data Entry Form (figure 30) is used to enter fuel counts for fine fuels and coarse fuels, duff and litter depths, and vegetation cover and height. Users must enter the correct transect lengths, slope values, fuel counts, duff/litter depths, litter percentage, and log diameters, and decay classes in order for the fuel loading calculations to provide the correct values.

The *Transect* field is a key field in the *Fine Woody Debris* table and is required for each record. Enter the slope of the transect, fuel counts, duff-and-litter depths, and litter percentage for each

transect. Zero values should be entered when a fuel class is not counted on a transect, although the fuel loading calculations assume a zero value if these fields are left blank. The *Transect* and *LogNum* fields are key fields in the *Coarse Woody Debris* table and are required for data entry. Enter the diameter and decay class for each log. The *Transect* field is a key field in the *Vegetation* table and is required for each record. Enter shrub and/or herbaceous cover and height for each transect. If vegetation cover and height are collected at only one point along the transect, the data summary calculations include only this one point when averaging these values across the transect. If two points were sampled and there is no vegetation cover at one of the points, a zero must be entered in the *Transect* field. It is important that the units for all fields entered be consistent with the units on the data entry form.

The *Delete FL Form* button deletes the current FL record and any records linked to this record. This button deletes any records in the fuel data tables for the current plot including the transect length data, fine fuels data, coarse fuels data, and vegetation cover data. Users may delete records specific to the individual fuel tables (small debris, large debris, vegetation) by highlighting the records in the desired table and pressing the delete key.

**Length and Number of Transects**

1-hr	6 ft	10-hr	6 ft	100-hr	15 ft	1000-hr	50 ft
Num. Transects	2						

**Fine Woody Debris**

Transect	Slope	1hr	10hr	100hr	D/LDep1 (in)	LitterPct1	D/LDep2 (in)	LitterPct2	Local1
1	26.0	38	20	3	2.5	30	2.0	20	300
2	6.0	51	27	4	2.0	25	3.0	50	28

**Coarse Woody Debris**

Transect	LogNum	Dia (in)	DecayCl	Local1
1	1	7.1	2	
1	2	5.5	3	
2	3	4.5	3	
2	4	6.1	4	

**Vegetation** All heights are in feet.

Transect	LiShC1	DdShC1	ShHt1	LiHeC1	DdHeC1	HeHt1	LiShC2	DdShC2	ShHt2	LiHeC2	DdHeC2	HeHt2
1	30.0	10.0	3.0	50.0	20.0	0.5						
2	20.0	30.0	2.0	40.0	20.0	1.0						

Record 1 of 43 | Save | Delete | List | Close

Figure 30. Fuel Loading Data Entry Form.

### *Species Composition (SC) Data Entry Form*

The SC Data Entry Form (figure 31) is used to enter ocular estimates of plant species cover and height. The *Item* (NRCS plant species code), *Cover* (a percent code from table 1), and *Height* fields must be populated by LANDFIRE field crews.

The *Delete SC Form* button deletes the current SC record and any records linked to this record.

This button deletes any records in the species composition tables for the current plot including the species ID level and all species on the plot. Users may delete individual species records by highlighting these records and pressing the delete key.

The screenshot shows the 'Plot Data Form' window in Jfiremon. At the top, there are fields for RegistrationID (TEST), ProjectID (FOREST), PlotID (1), and Date (10/15/01). Below these are several tabs: PD, TD, FL, SC, CF, LI, PO Tran, PO Frame, DE Belt, DE Quad, RS, CBI, FB, MD. The 'Species ID Level' is set to 0%. A 'Delete SC Form' button is visible. The main area contains a table with the following data:

Item	Status	SizeCl	Cover	Height (ft)	Local1	Local2
ARUV	L	TO	0.5	0.1		
PHMA5	L	TO	10.0	3.0		
PICO	L	TO	50.0	50.0		
PSME	L	TO	20.0	85.0		
SYAL	L	TO	10.0	1.0		
	L	TO				

At the bottom, there are navigation buttons: Record, Save, Delete, List, Close. The status bar shows 'Record 1 of 43'.

Figure 31. Plant Species Composition Data Entry Form.

### Data Transfer

At the end of each work week, the LANDFIRE database (landfire.mdb), the NEWMDL database, and the plot photo directory should be copied to a CD and sent via Fed-Ex to:

Ben Butler  
 SCA-LANDFIRE Program Coordinator  
 315 S. 4<sup>th</sup> E.  
 Missoula, MT 59801

All field crews will be provided with the necessary Fed Ex envelopes. Alternatively, you may be instructed to transfer the data electronically (for example, directed to an FTP site).

# References



Anderson, H. E. 1982. Aids to Determining Fuel Models for Estimating Fire Behavior. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-122.

Burgan, R. E., and R. C. Rothermel. 1984. BEHAVE: Fire Behavior Prediction and Fuel Modeling System – FUEL Subsystem. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-167.

Lutes, D. C., R. E. Keane, J. F. Caratti, K. H. Key, N. C. Benson, S. Sutherland, and L. J. Gangi. *In press*. FIREMON: Fire Effects Monitoring and Inventory System. USDA Forest Service, Rocky Mountain research Station, General Technical Report RMRS-GTR-XXXX.

United States Department of Agriculture, Natural Resources Conservation Service. The PLANTS Database, Versions 3.1-3.5 (<http://plants.usda.gov>). National Plant Data Center, Baton Rouge, LA 70874-4490 USA, 2001-2002.

# Appendix A

## Random Number Tables



Select random numbers (starting at the first entry and continuing down each column) from the appropriate table. Be sure to cross through the numbers as you use them.

### Random numbers (1 to 1500) for positioning your first transect

837	718	241	618	1280	639	559	881	993	1156	585	139
1265	429	50	911	857	762	1005	127	627	858	1032	838
205	1118	108	176	35	404	195	367	1067	1278	375	581
1261	335	1275	531	74	488	1	635	492	742	1056	1427
1485	1028	944	38	753	528	1257	677	809	1376	281	226
194	1233	1424	1302	294	588	32	549	918	444	1210	614
354	1345	1338	1243	999	7	713	1074	758	1066	280	244
769	483	392	662	1364	74	1148	131	371	1017	532	1203
473	1236	1092	161	135	460	903	128	613	1454	1500	615
373	708	998	1330	1121	1225	251	323	292	1482	1143	1264
545	441	256	154	876	347	21	377	1098	550	75	1408
415	1213	599	1060	344	448	1323	346	26	1418	854	1227
315	1054	1500	1040	997	784	1309	1139	570	735	298	1349
1022	1083	1280	1142	200	722	612	907	1439	1250	992	745
494	1102	1423	32	129	1388	1130	677	261	506	842	120

### Random numbers (1 to 3000) for locating your first field plot along a transect

1473	2427	557	2387	1503	628	2111	1603	2468	2593	380	1339
1610	958	735	1650	2558	2621	30	1583	2513	2789	1208	1047
275	184	2333	1876	1676	1973	2185	1832	390	1127	1914	2988
1649	1257	1947	1825	725	1852	1722	1853	812	2099	1183	925
2623	579	2326	1431	368	399	2345	2103	1405	2711	2288	86
146	151	1780	2123	663	2751	2637	1076	1120	733	2652	2967
2772	1249	2272	1316	1050	2744	2773	1642	1476	1745	107	2266
2963	443	2869	2230	2931	1996	1527	1237	1217	401	2062	1216
966	1359	242	1852	2396	2927	321	491	1176	102	581	1525
686	461	1639	306	180	845	2193	1922	561	1805	1470	1376
2964	1559	2169	1949	505	2753	823	2470	2828	1404	486	2763
2784	1736	1265	259	797	789	380	1157	1346	2230	2459	377
382	1337	2672	2290	1694	1875	1777	922	296	778	2593	2083
1570	1391	1223	1297	1524	811	2765	2124	1092	291	1441	1946
1207	2241	1669	1332	1323	1998	1353	1569	1110	619	1221	2776

## Appendix B

### Estimating Canopy Cover



For LANDFIRE, “cover” is defined as the vertically projected cover of the component being sampled. Vertically projected cover is best described as the cover of the sampling entity if it were compressed to the ground. In order to make good estimations of cover, field samplers will need to visualize this compression for each component. Compressed cover of logs, lichen, or some other low entity may not be difficult to visualize; however, as the vegetation gets taller and occupies more layers, the task becomes increasingly difficult. With experience comes confidence in estimating cover.

The cover classes used in LANDFIRE are relatively broad, typically spanning 10 percent (table A1). We recommend a process of elimination for discriminating between the cover classes for each estimate you must make. For example, imagine you are looking at a sampling area, and you know for certain that the cover is between 15 and 55 percent (cover classes 20 and 60). You should then ask yourself, “Does the true percentage of cover fall within the range of 15 to 35 or within the range of 35 to 55 percent?” If you conclude that the cover is lower than 35 percent, then ask yourself, “Is it in the range of 15 to 25 percent or is it in the range of 25 to 35 percent?” The cover class you record would be 20 if you answered “Yes” to the former but 30 if you answered “Yes” to the latter.

Table A1. Cover classes used in LANDFIRE.

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

Experienced field samplers usually use one of two methods to estimate cover: grouping or subdividing. On smaller plots, many samplers mentally group the plants into one corner of the sampling area and then estimate the cover. Cover estimates are easier when you group using a marked quadrant. The subdivision method uses our natural ability to estimate cover more accurately for small rather than large areas and is typically used for large plots, such as the LANDFIRE plot. Also, because samplers may not be able to see the entire plot from one location, subdivision is required in order to achieve accurate estimates.

When using the subdivision method, divide the sampling area into quadrants (or some other easily determined area) and estimate the cover in each part. It may be useful to also use the grouping technique for each individual quadrant. In figure A1, “A” illustrates plants, represented by the circles, distributed across a plot. “B” shows the plot divided into quadrants and plants being mentally grouped within the quadrant. The combined cover is shown in “C” as circles or as squares in “D”. The areas of all the circles in “A” make up 10 percent cover. In C, cover percentage for quadrants 1, 2, 3, and 4 is 12, 4, 16, and 8 percent, respectively. Cover percentage for “C”, then, is  $(12 + 4 + 16 + 8) / 4$ , which also equals 10 percent. While estimating cover, you will usually also be developing a species list for the plot; so, as you walk around the perimeter looking at the cover within each quadrant, you can record the species at the same time.

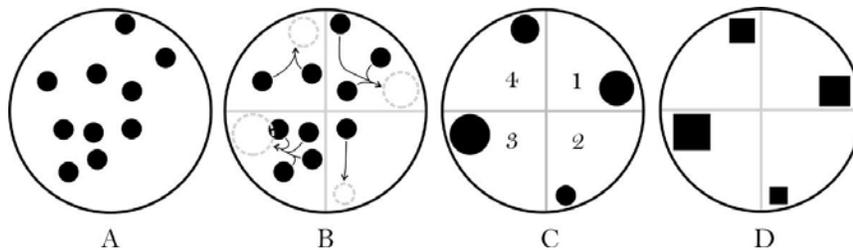


Figure A1. The subdivision and grouping technique for estimating cover. Take the average of cover estimates for all quadrants as your cover estimate for the whole plot.

The dimensions of the imaginary item groups can also be used by the field sampler to estimate cover for the entire plot. For example, if you visually group all of the herbaceous cover on the 0.10 acre macroplot and find that it would fit in a circle approximately 24 feet in diameter (12-foot radius), that group would constitute a cover of about 10 percent (table A2). This method can be used at the individual species level for estimating cover in layers or for a composite estimation of cover.

Table A2. Cover percentage for different radius areas on a 0.1-acre LANDFIRE field plot.

Radius (ft)	Percentage of total LANDFIRE plot
37.2	100
26.3	50
18.6	25
11.8	10
8.3	5
3.7	1

Regardless of the technique used for estimating cover, samplers will need to calibrate their eyes in order to make accurate assessments of cover. Field crews should develop a plan so that samplers can calibrate their eyes periodically throughout the field season. The best way to do this is by visually estimating cover on a LANDFIRE-plot-sized area in which the “true” value has been verified. Below are some illustrations that are designed to help samplers calibrate their eyes.

The illustrations in figure A2 represent a circular plot of any size. Before reading the figure caption, try to estimate the area inside each large circle that is covered by the smaller circles. Hint: people tend to overestimate.

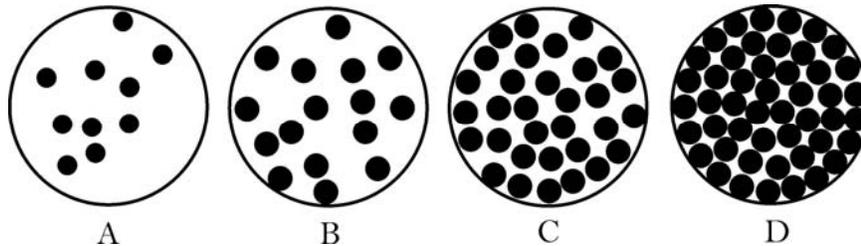


Figure A2. Illustrations showing different levels of cover. Cover in A, B, C and D is 10, 25, 50, and 75 percent, respectively.

The illustrations in figure A3 represent a 6-foot diameter sampling area with 1-inch and 0.25-inch diameter pieces scattered inside. Try to estimate the cover percentage before reading the caption.

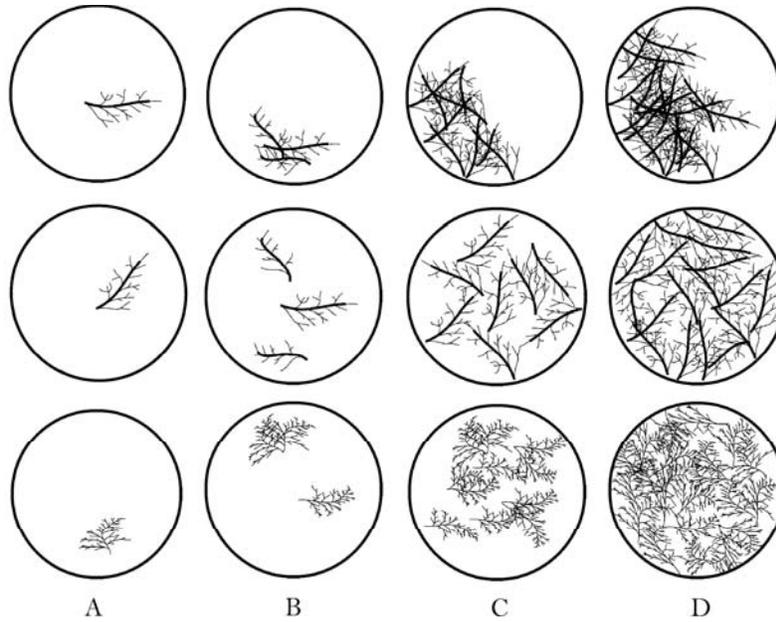


Figure A3. Illustrations showing cover percentage of dead vegetation. Each circle represents a 6-foot diameter sampling area. Thick lines represent pieces 1-inch in diameter and thin lines 0.25-inch in diameter. The cover percentages depicted in columns A, B, C, and D are 1, 3, 10, and 20 percent, respectively.

Notice that in figure A3 the illustrations of branches are two-dimensional representations of three-dimensional entities - that is, each illustration shows how much ground the dead branches would cover if they were compressed to the ground. In the field, samplers will need to become comfortable imagining all of the suspended pieces moved to the ground in order to accurately estimate vertically projected cover.

The illustrations in figure A4 represent live cover within a 6-foot diameter sample plot. This cover estimate includes both the branches and leaves together. What percentage cover would you guess is in each of the illustrations below? Remember, some of the vegetation in the sampling area might be rooted outside the sampling area; however, it is included in your cover estimate.

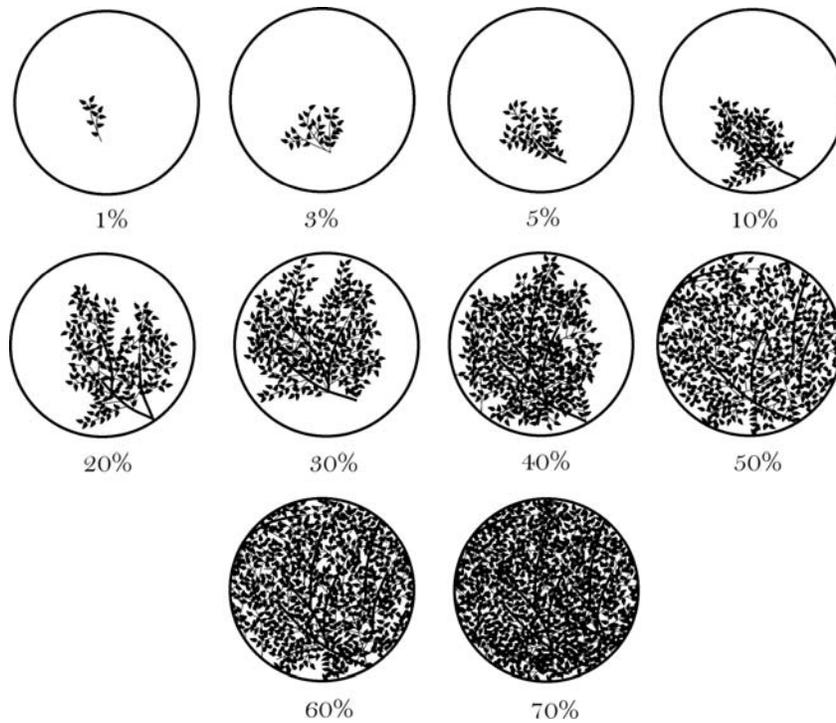


Figure A4. Cover of live vegetation within a 6-foot diameter sampling area. The percentage cover is indicated under each illustration.

Estimating the cover of multiple entities (such as woody vs. non-woody plants; trees vs. shrubs vs. grasses vs. forbs) makes the task more difficult because you have to mentally separate each entity. It is easiest to first estimate the cover percentage of the total vertically projected cover on the sampling area and then estimate cover percentages of the individual entities from greatest cover to least cover. Figure A5 shows two entities, woody and non-woody vegetation, being sampled on the same sampling area. First, the total cover (A) would be estimated, then non-woody cover (B), and finally the woody cover (C). Because of overlap between entities, the sum total of the entities may be greater than the total cover and may be greater than 100 percent.

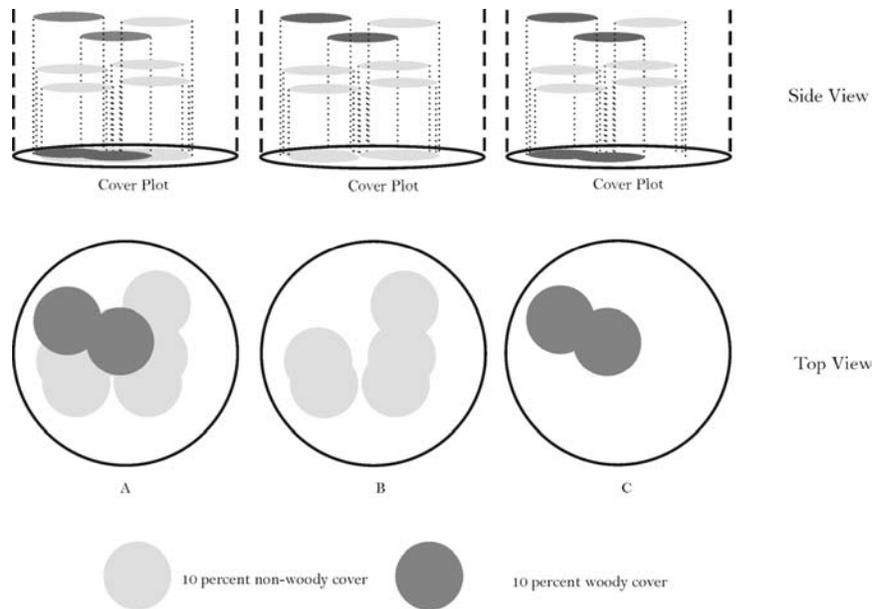


Figure A5. In these illustrations, each individual circle represents 10 percent cover. A) Total cover within the sampling area is approximately 40 percent; B) Cover of non-woody vegetation is approximately 30 percent; C) Cover of woody vegetation is approximately 15 percent. As cover classes, the values for A, B, and C would be recorded as 40, 30, and 20, respectively.

## Appendix C

### Using a Compass



Compass headings can be used to navigate to plots, determine plot aspect, and orient sampling transects. We call the compass heading the *azimuth*. You must know how to use a compass to walk a course with a known azimuth and define the azimuth of a course in the event that the azimuth is unknown. (A compass is used differently when following versus determining a course.) We recommend that you use a compass with a sighting mirror and a declination adjustment. The parts of a compass are shown in figure A6.

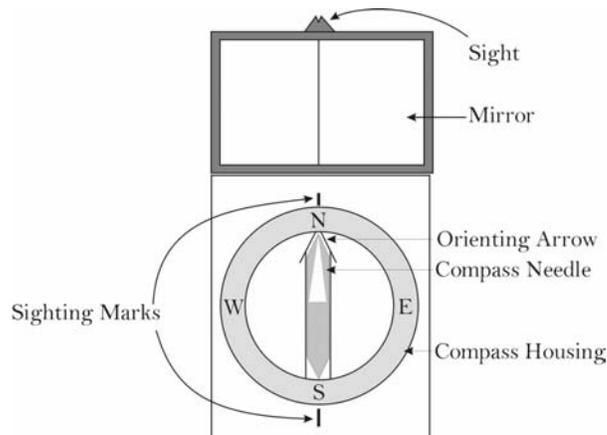


Figure A6. The parts of a compass. Azimuth numbers have been omitted for readability.

Let's say you wish to determine a course between two points: a flagged tree and plot center, for example. To do so, you stand at the tree and set up your compass so that you can see the compass face in the mirror with the sighting line in the mirror and the sight on the compass aligned. Now, with the compass level, hold it out in front of you at eye-level so that you can see the plot center in the sight on top of the compass. If the compass is not held level, the compass needle will not rotate freely and the azimuth will be wrong. Sometimes there is a bubble in the compass, and you can use the bubble's reflection in the mirror to tell you whether the compass is level. With the plot center in the sight and the scribed line on the mirror aligned with the sighting marks on the compass face, hold the compass still. While looking at the compass needle in the mirror, use your free hand to turn the compass housing until the compass needle is parallel to the orienting arrow. Make sure that the north end of the compass needle (usually marked red) is pointing the same direction as the orienting arrow, or your azimuth will be off by 180 degrees. Now you can lower the compass and record the azimuth from the sighting mark closest to the mirror. If the

declination is set to zero, you will be recording the azimuth in magnetic degrees. If the declination is set to the declination for the sampling area, you will be recording the azimuth in degrees true north.

If the bearing between two points is known and you want to follow that course, set the known azimuth at the sighting mark closest to the mirror. Hold the compass in front of you, level and at eye-level. Keep the compass in the same position relative to your eye and rotate your body until you see in the mirror that the compass needle is parallel with the orienting needle. Make sure the scribed line on the mirror is aligned with the sights marks, or you will be going the wrong direction. With the needles parallel, use the sight on the mirror to pick an obvious object (such as a rock or tree) that falls in line with the direction you want to go. Choose something that you will be able to see for the entire distance you are walking and make sure it is distinct enough that you remember which object you are headed toward. For example, don't choose just any tree, because many look alike. Instead, choose a tree with a forked crown or other distinctive feature. Once you get to the object, repeat the procedure. For long distances or in dense vegetation, you may have to repeat this sight and walk procedure many times before you get to your destination. When laying out the sampling planes for the FL method, use this technique to guide the sampler pulling the tape.

Magnetic declination is the difference between true north (pointing to the North Pole) and magnetic north (the direction the needle of your compass points). We suggest always using true north degrees, and this requires that you set the declination on your compass. The declination for the area you are sampling should be set the same on all the compasses in the project and recorded in the Comments field of the PD Form/Table. Declination can change substantially as you move from place to place, especially in the northern U.S. and Canada, so be sure that you look up the declination at each of your sampling sites. The best declination values are available from aircraft sectional charts; however, these maps may not be immediately available. Ask a pilot friend to give you an out-dated sectional chart (they're updated yearly) and keep it on hand for reference. Declination changes over time, so do not use sectional charts older than 10 years for the declination value. Other sources are the people you work with that are familiar with the sampling area or the Internet. The USGS, for example, has a coarse-scale map of declination on their website (<http://geomag.usgs.gov/usimages.html>).

Different compasses have different mechanisms for changing the declination, but most use a small screw on the compass housing. Use a screwdriver (usually supplied with a new compass) to turn the declination screw left or right until the mark in the orienting arrow lines up with the proper declination. Be sure that you use the correct declination direction, east or west. In figure A7, declination is set to 6 degrees east.

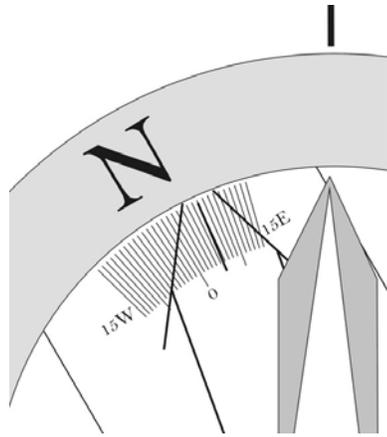


Figure A7. The mark in the orienting arrow indicates the compass is set to 6 degrees east declination.

# Appendix E

## Measuring and Adjusting for Slope



### How to Measure Slope

Use a clinometer to determine the percentage slope of a field plot or fuel transect. To do so, aim the clinometer at the eye-level of the sampler at the other end of the line (figure A8). Be sure to read the slope from the percentage scale in the clinometer. If there is a height difference between the samplers, adjust your aim either upward or downward so that the slope reading is accurate.

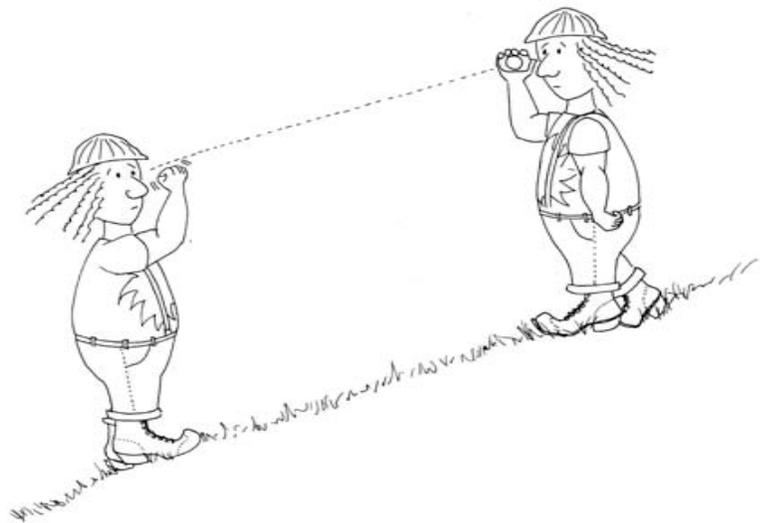


Figure A8. Measure the slope of each line by aiming the clinometer at eye-level of the sampler at the opposite end of the measuring tape, then read and record the percentage of slope seen on the scale in the instrument.

If you do not have a clinometer, many compasses will have a slope indicator that can be used to measure slope. SCA Field Crews will need to use their Brunton Nexus 26DNL compass for slope measurements. To measure slope with this compass, open compass and rotate Graduated Dial until East ( $90^\circ$ ) is at the index line located between the two travel arrows. Hold the compass at eye-level on its side until the green clinometer needle moves freely. Let one long side of the compass line up with the slope of the terrain to measure the angle. Read the clinometer needle

against the percentage scale and record percent of inclination. The compass clinometer can also be used to measure height: hold the compass on its side and partially close the mirror so that you can read the reflected clinometer scale in the mirror. Sight along the base plate edge to the top of the object being measured and record the percentage of the angle.

### How to Adjust the Size of a Field Plot on an Incline

To install a circular plot with a radius of 37.2 *horizontal* feet on a slope of 30 degrees or more, you must pull your tapes out to a distance greater than 37.2 feet from plot center. Table A3 lists the correction factors you must use to determine this adjusted distance for particular slopes by percentage class. Note that the correction factor on slopes less than 30 percent is negligible. To determine the adjusted distance you must travel, multiply 37.2 feet by the appropriate correction factor. For example, to install an appropriately sized LANDFIRE plot on ground that slopes 50 percent, you would actually have to lay out 41.67 feet (37.2 feet x 1.12 correction factor) from plot center.

Table A3. Correct for slope by multiplying the horizontal distance you need to travel by the appropriate correction factor listed

Slope (%)	Correction factor
10	1.00
20	1.02
30	1.04
40	1.08
50	1.12
60	1.17
70	1.22
80	1.28
90	1.35
100	1.41
110	1.49
120	1.56
130	1.64
140	1.72
150	1.80
160	1.89
170	1.97
180	2.06

## Appendix E

### Measuring Diameter with a Straight Tape



Using a straight tape (or ruler) to measure tree or log diameter can be easier and quicker than with a diameter tape; however, straight-tape measurements can give biased estimates of diameter if done incorrectly. To measure diameter correctly using a straight-tape, first hold the end of the tape so that it is aligned with one edge of the tree (at breast height) or log. Then, while keeping the tape in the same position, move your head to the other side of the tree or log at a perpendicular angle to the tape (figure A9). Estimate the diameter to the appropriate precision.

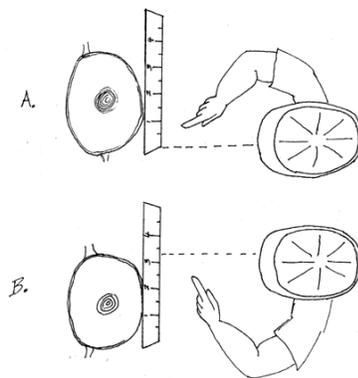


Figure A9. To accurately measure tree diameter using a straight tape, A) align the end of the tape with the left side of the tree, then B) without moving the tape, move your head so that it is aligned with the right side of the tree. The same method can be used for logs.

# Appendix F

## Measuring Plant Height



### Plants Taller than 20 Feet

First, attach a cloth or logger's tape to the tree or plant at breast height and walk away from the tree a distance slightly farther than you think the tree is tall. For example, if you think a tree is about 30 feet tall, walk out about 40 feet. Once you are in position, read the angle to the top of the tree from the percentage scale in the clinometer. Next, take the percentage reading from your position to bottom of the tree (where it enters the ground). This angle usually will be negative (figure A10).

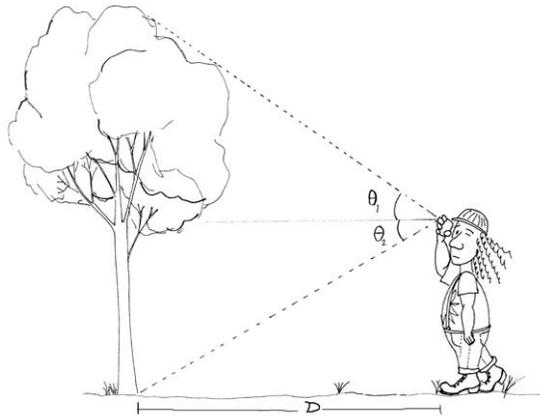


Figure A10. Measure the height of tall trees by moving away from the tree a measured distance on the slope contour and measure the slope percentage to the top and the bottom of the tree. Use equation A1 to calculate height. Units of tree height (HT) are the same as the units on the distance (D) measurement.

Calculate height using the equation:

Equation A1. 
$$HT = \theta_1 \left( \frac{D}{100} \right) - \theta_2 \left( \frac{D}{100} \right)$$

Where

$\theta_1$  is the angle from the sampling position to the top of the tree, measured in percentage slope.

$\theta_2$  is the angle from the sampling position to the bottom of the tree, measured in percentage slope.

D is the horizontal distance from the tree in feet or meters.

Note that when the  $\theta_2$  is negative, you actually add the two angles. If either  $\theta_1$  or  $\theta_2$  are greater than 100 percent, go out another 20 feet and recheck the angles. Measuring at high angles can cause great error. It may be helpful to make a table of tree height as a function of tree angles (total angle from top to bottom of the tree) and distances to reduce the time spent making height calculations in the field.

Sometimes it is difficult to see the top of the tree because of obstructions or other tree tops. In these cases, have someone shake the tree at breast height which will cause the top to move and perhaps make it more visible. The sampler may also have to move uphill or downhill one or two paces, making sure the distance from the tree is kept constant, to get a better view of the tree top. If you need to move up or down slope, correct for slope using the correction factors in *Appendix D: Measuring and Adjusting for Slope*.

Note: The highest foliage might not be directly above the tree bole, so the sampler must be sure to check all lateral branches to make sure the highest foliage is being measured.

### **Plants between 10 and 20 Feet Tall**

These plants can be measured using a clinometer (described above) for higher accuracy, or their heights may be estimated. The clinometer method is described in the previous section. Faster, less precise measurements can be made by looking at a tree and moving your eyes up in increments. If, for example, you are six feet tall, start at the ground level and simply move your eyes up six feet at a time, keeping a mental tally. At first, you should check your estimate using a clinometer, but with a little practice you will be able to consistently estimate heights of these plants to within 1 to 2 feet.

### **Plants Less than 10 Feet Tall**

Measure the heights of these plants with a straight tape. Alternatively, you can relate plant height to the known heights of the top of your boots, knees, hips, head, and raised hand to aid estimation.

### **Other Height Measuring Tips**

Often you will be able to estimate the height of tall trees based on the measured height of another tree that is close by. This can substantially reduce the sampling time because you only need to make four or five height measurements per plot.

When measuring the height of herbaceous plants, measure only to the point that includes approximately 80 percent of the plant's biomass, not necessarily to the top. For example, the taller flowers of grasses are not typically measured; measure only to the tops of the leaves.

# Appendix G

## Fire Behavior Fuel Model Key



Use the following key to assign a fuel model pictured and described in Anderson's 1982 publication, *Aids for Determining Fuel Models for Estimating Fire Behavior* to a LANDFIRE plot.

1. Primary carrier of fire is grass; expected rate of spread is moderate-to-high, with low to moderate fireline intensity (flame length).
  - a. Grass is fine-structured, generally below knee level, cured and primarily dead. Fires are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present, generally less than one-third of the area..... **See Fire Behavior Model 1**
  - b. Grass is coarse-structured, above knee level (averaging about 3 feet), and is difficult to walk through ..... **See Fire Behavior Model 3**
  - c. Grass is usually under an open timber or brush overstory. Litter from the overstory is involved, but grass carries the fire. Expected spread rate is lower than Fuel Model 1 and intensity is less than Fuel Model 3 . **See Fire Behavior Model 2**
2. Primary carrier of the fire is brush or litter beneath the brush. Expected rates of spread and fireline intensities (flame length) are moderate to high.
  - a. Live fuels are absent or sparse. Brush averages 2 to 4 feet in height and requires moderate winds to carry fire ..... **Fire Behavior Model 6**
  - b. Live fuel moisture can have a significant effect on fire behavior.
    - i. Brush is about 2 feet with light loading of brush litter underneath. Litter may carry the fire, especially at low windspeeds ..... **See Fire Behavior Model 5**
    - ii. Brush is head high (6 feet) with heavy loadings of dead woody fuel. Very intense fire with high spread rates expected .... **See Fire Behavior Model 4**
3. Primary carrier of fire is litter beneath a timber stand. Spread rates are low-to-moderate and fireline intensity (flame length) may be low-to-high.

- a. Surface fuels are mostly foliage litter. Large fuels are scattered and lie on the foliage litter and are not supported above the litter by their branches. Green fuels are scattered enough to be insignificant to fire behavior.
    - i. Dead foliage is tightly compacted, short needle (2 inches or less) conifer litter or hardwood litter ..... **See Fire Behavior Model 8**
    - ii. Dead foliage litter is loosely compacted long needle pine hardwood litter. .... **See Fire Behavior Model 9**
  - b. There is a significant amount of larger fuel. Larger fuel has attached branches and twigs or has rotted enough that it is splintered and broken. The larger fuels are fairly well distributed over the area. Some green fuel may be present. The overall depth of the fuel is mostly below the knees, but some fuel may be higher. .... **See Fire Behavior Model 10**
4. Primary carrier of the fire is logging slash. Spread rates are low and fireline intensities (flame length) are low to very high.
- a. Slash is from hardwood litter and is cured and dried out; leaves have fallen and cured..... **See Fire Behavior Model 6**
  - b. Slash is from conifers; needles have fallen and vegetation has grown in..... **See Fire Behavior Model 10**
  - c. Slash is fresh (approximately 0-3 years) and not overly compacted.
    - i. Slash is not continuous. Needle litter is present; live fuels are absent. .... **See Fire Behavior Model 11**
    - ii. Slash generally covers the ground (heavier loadings than Fuel Model 11); slash depth is about 2 feet and not overly compacted. About half the needles still on branches but are not red; live fuels are absent ..... **See Fire Behavior Model 12**
    - iii. Slash is continuous and not overly compacted with an average depth of 3 feet. About half the needles are still on the branches and are red or all needles are still on the branches and are green. .... **See Fire Behavior Model 13**

# Appendix H

## NEWMDL



In addition to the variables you have been asked to collect on the Fuel Load Form, you have been asked to collect a few more fuel variables. These variables will be used as input to the NEWMDL software program developed by Burgan and others.

In the Plot Description Form, you were asked to determine a Fire Behavior Fuel Model (FBFM) using the FBFM key and Anderson's 1982 publication, *Aids for Determining Fuel Models for Estimating Fire Behavior*. An alternate way to describe the fuel complex and develop your own fuel model is to use the NEWMDL software approach.

The following has been excerpted from the 1984 Burgan and Rothermel publication, *BEHAVE: Fire Behavior Prediction and Fuel Modeling System – FUEL Subsystem*.

### Field Procedures

When building a fuel model, the task is more one of describing vegetation as a fuel complex rather than precisely measuring its biomass, although the two are related.

When considering how a particular vegetation type might burn, remember the following limitations of the fire behavior model that will use the fuels data.

1. The fire is assumed to be a line fire burning steadily in surface fuels.
2. The fire model is intended to predict fire behavior produced by fine fuels [FWD] at the perimeter of the fire, usually the fire front.
3. The fire model works best in uniform, continuous fuels such as grass, long-needed pine litter, uniform brush fields, and continuous logging slash.

These limitations have important implications regarding how to view vegetation as a forest or range fuel. For example, because a surface fire is assumed, it is wrong to include vegetation that is in a separate and distinctly higher canopy level than that near the ground. Consider only vegetation that influences fires (< 6 feet tall) before erratic behavior such as crowning or spotting begins.

The fire model predicts behavior on the fire perimeter, normally at the fire front. [The fine fuel that propagates the fire is often] much less than the total fuel load per acre. [It] ignore[s] fuels that burn long after the fire front has passed. These

include duff, stumps, large logs, and so on. (Note: These large fuels influence fire effects, such as smoke production and soil heating.)

The assumption of uniform and continuous fuel means that the fire model will calculate fire behavior as though the fuel components in the model were mixed and distributed uniformly throughout the specified depth.

The fact that the assumptions and limitations do not always match reality accounts in part for differences between predicted and observed fire behavior. Nevertheless, a fuel model that is properly developed and tested can be used with a fire model to produce surprisingly accurate fire potential estimates.

Perhaps the greatest difficulty in constructing a site-specific fuel model is clearly defining the fuel complex it represents. The infinite variability produced by changes in fuel composition, quantity, depth, continuity, and so on, make it imperative that even site specific fuel models must represent a rather broad range of conditions.

### **Specific Field Procedures**

The first step is to conduct a field reconnaissance to obtain a general impression of the fuels to be modeled. A fire that covers a significant area will often be influenced by considerable fuel variability. Try to develop an impression of the “typical” situation by looking at the vegetation in broad terms. During your reconnaissance, consider the following questions about the fuel:

1. Which fuel components – litter, grass, shrubs and slash – are present in significant quantity?
2. How continuous are the various fuel components?
3. What fuel stratum is most likely to carry the fire?
4. Are there large variations in the amount of one or more fuel components?
5. What proportion of the fuel is in the 1-hr, 10-hr, 100-hr, live herbaceous and live woody categories?
6. How many grass and shrub types must be dealt with?
7. Which bulk density photos best represent the bulk densities of the important grasses and shrubs in the area?

### **Grass and Shrub Fuel Types and Bulk Density Classes**

The photos (provided in a supplement to this handbook) are meant to illustrate the general morphology for widely different types of grasses and shrubs. That is, any set of grass or shrub photos represents a large variety of grass or shrub species. One must select the photo that best fits the actual conditions.

The species photographed are listed below:

<u>Photo Page</u>	<u>Species Photographed</u>	<u>Morphology Represented</u>
Grass Type 1	cheatgrass	fine grasses
Grass Type 2	rough fescue	medium grasses
Grass Type 3	fountaingrass	coarse grasses
Grass Type 4	sawgrass	very coarse greases

<u>Photo Page</u>	<u>Species Photographed</u>	<u>Morphology Represented</u>
Shrub Type 1	huckleberry	fine stems, thin leaves
Shrub Type 2	ninebark	medium stems, thin leaves
Shrub Type 3	ceanothus	medium stems, thick leaves
Shrub Type 4	chamise	densely packed fine stems and leaves
Shrub Type 5	manzanita	thick stems and leaves

# Appendix I

## Glossary



This glossary includes terms associated with LANDFIRE and FIREMON that may be unfamiliar to some readers. The source of each definition is provided in parentheses at the end of each definition.

**1000-Hour Fuel:** Dead fuels consisting of roundwood 3.0 to 8.0 inches in diameter, estimated to reach 63 percent equilibrium moisture content in one thousand hours. (Fire Effects Guide)

**100-Hour Fuel:** Dead fuels consisting of roundwood in the size range from 1.0 to 3.0 inches in diameter, estimated to reach 63 percent of equilibrium in one hundred hours. (Fire Effects Guide)

**10-Hour Fuel:** Dead fuels consisting of roundwood 0.25 to 1.0 inches in diameter, estimated to reach 63 percent of equilibrium moisture in ten hours. (Fire Effects Guide)

**1-Hour Fuel:** Dead fuels consisting of dead herbaceous plant material and roundwood less than 0.25 inches in diameter, estimated to reach 63 percent of equilibrium moisture content in one hour or less. (Fire Effects Guide)

**Annual:** Plant species that complete their life-cycle within a single growing season. (FGDC-STD-005)

**Azimuth:** A horizontal angular measure from true north to an object of interest. (FSVeg)

**Biennial:** Plant species that complete their life-cycles within two growing seasons. (FGDC-STD-005)

**Canopy Cover:** The proportion of ground, usually expressed as a percentage, that is occupied by the perpendicular projection down onto it of the aerial parts of the vegetation or the species under consideration. The additive cover of multiple strata or species may exceed 100 percent. (FGDC-STD-005) See also Foliar Cover.

**Canopy Fuel Base Height:** A subjective assessment of the lowest live or dead fuels attached to the stem of a tree that are sufficient to move fire to the burnable material above. Used to assess crown fire potential. (FIREMON)

Clinometer: An instrument for measuring angles of slope or inclination. (Webster's New World Dictionary)

Cover: The area of ground covered by the vertical projection of the aerial parts of plants of one or more species. (FGDC-STD-005)

CWD (Coarse Woody Debris): Generally pieces greater than 10 cm or 3 inches in diameter and longer than 2 meters or 6 feet in length; however, definitions vary widely. In FIREMON, defined as dead woody debris larger or equal to 3 inches in diameter, also called 1000-hour and greater fuels. (Ecology of Coarse Woody Debris in Temperate Ecosystems, FIREMON)

Decay Class: A method used in FIREMON to determine the degree of decay present in Coarse Woody Debris. Compare snag class. (Ecology of Coarse Woody Debris in Temperate Ecosystems, FIREMON)

Deciduous: A woody plant that seasonally loses all of its leaves and becomes temporarily bare-stemmed. (FGDC-STD-005)

Declination: The angle between the magnetic and geographical meridians, expressed in degrees and minutes east or west, to indicate the direction of magnetic north from true north; also known as magnetic declination or variation. (McGraw-Hill Dictionary of Scientific and Technical Terms)

Duff: The partially decomposed organic material of the forest floor that lies beneath the freshly fallen needles, twigs, and leaves and above the mineral soil. This is the fermentation and humus layer where the vegetative material is broken down, and the individual pieces are no longer identifiable. (FSVeg, Fire Effects Guide)

Duff-and-Litter Profile: 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. (FIREMON)

DWD (Dead and Downed Woody Debris): Dead woody pieces of trees and shrubs that have been broken, uprooted, or severed from their root system, not self supporting, and are lying on the ground. (No longer supporting growth.) DWD are categorized in size classes of 1-hour, 10-hour, 100-hour and, 1000-hour. (FSVeg).

Evergreen - A plant that has green leaves all year round or a plant that in xeric habitats has green stems or trunks and never produces leaves. (FDGC-STD-005)

FARSITE (Fire Area Simulator): A fire growth model that uses fuels, topography, and weather to predict fire spread.

Fern: A nonflowering embryophyte having roots, stems, and fronds, and reproducing by spores instead of by seeds. (Webster's New World Dictionary)

**Fire Behavior:** The manner in which a fire burns in response to the variables of fuel, weather, and topography. A fire may be described as hot or cool, running or creeping, flaming or smoldering, or torching or crowning. Compare to Fire Effects. (Fire Effects Guide, Glossary of Wildland Fire Management Terms Used in the U.S.)

**Fire Behavior Fuel Model:** Mathematical descriptions of fuel properties (such as fuel load and fuel depth) that are used in conjunction with environmental conditions to predict certain aspects of fire behavior. (FSVeg, Intro. to Wildland Fire Behavior Glossary)

**Fire Effects:** Any consequence – neutral, detrimental, or beneficial – resulting from fire. Examples of first order fire effects are tree mortality, emissions, and fuel consumption. Examples of second order fire effects are trees damaged by fire that later succumb to insect infestations, sedimentation in streams from eroding soils, and plant succession. Compare to Fire Behavior. (Glossary of Landscape, Vegetation Ecology for Alaska)

**FL (Fuel Load):** Methods 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. Downed woody debris is sampled using the planar intercept technique. (Handbook for Inventorying Downed Woody Material, FIREMON)

**Foliar Cover:** The percentage of ground covered by the vertical projection of the aerial portion of the plants (foliage and supporting parts). Small openings in the canopy and intraspecific overlap are excluded. This is the cover assessment recommended in FIREMON. (Glossary of Terms Used in Range Management, FIREMON)

**Forb:** A broad-leaved herbaceous plant. (FGDC-STD-005)

**FWD (Fine Woody Debris):** Dead woody debris less than 3 inches in diameter, including 1-hour, 10-hour, and 100-hour fuels. (FIREMON)

**Go/no-go gauge:** A tool used to classify fuels into one of three classes; 1-hour, 10-hour, and 100-hour. (Handbook for Inventorying Downed Woody Debris)

**GPS (Geographic Positioning System):** A network of radio-emitting satellites from which your position can be triangulated in three dimensions (North, East, and Elevation) to within 3-50 meters of accuracy. (FSVeg, FIREMON)

**Graminoid:** Grasses and grass-like plants, including sedges and rushes. (FGDC-STD-005)

**Herb (or Herbaceous Plant):** A vascular plant without significant woody tissue above or at the ground; an annual, biennial, or perennial plant lacking significant thickening by secondary woody growth, with perennating buds borne at or below the ground surface. Herbs include non-woody vascular plants such as grasses, grass-like plants, and forbs. (FGDC-STD-005)

**Ladder Fuel:** Fuels that provide vertical continuity between strata, thereby allowing fire to carry from surface fuels into the crowns of trees and shrubs with relative ease. (Glossary of Wildland Fire Management Terms Used in the U.S.)

**Landscape:** All of the natural features, such as hills, forest, and water, which distinguish one part of the earth's surface from another. A landscape can be any size and shape but it spatially defines stands. Compare to stand. (Glossary of Landscape, Vegetation Ecology for Alaska, FIREMON)

**Lichen:** An organism generally recognized as a single plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association. (FGDC-STD-005)

**Life-form:** A classification of plants based upon their size, morphology, habit, life span, and woodiness. (FGDC-STD-005)

**Litter:** The top layer of the forest floor composed of loose debris such as branches, twigs, and recently fallen needles and leaves; little altered by decomposition and still identifiable. This layer may also include debris from shrubs, grasses, and forbs that have recently died. The litter layer is directly above the duff layer. (Fire Effects Guide, FIREMON)

**Loggers' Tape:** A spring wound tape measure which has one side in linear units which are converted to diameter and the other side in units for measuring feet and inches. Also, called a diameter tape or D-tape. (Measurements for Terrestrial Vegetation)

**Metadata:** Data about data. This describes the content, quality, condition, and other characteristics of data. Its purpose is to: (1) help organize and maintain an organization's internal investment in spatial data, (2) provide information about an organization's data holdings to data catalogues, clearinghouses, and brokerages, and (3) provide information to process and interpret data received through a transfer from an external source. (FGDC-STD-005)

**Mineral Soil:** Soil composed principally of mineral matter, the characteristics of which are determined more by the mineral than the organic content. This soil is often gravelly or sandy and lighter than the duff layer. (The Concise Oxford Dictionary of Ecology)

**Moss:** A non-vascular small, green bryophyte growing in velvety clusters on rocks, trees, and moist ground. (Webster's New World Dictionary)

**Non-Vascular Plant:** A plant without specialized water or fluid conductive tissue (xylem and phloem); includes bryophytes, lichens, and algae. (FGDC-STD-005)

**NRCS Plant Database:** The Natural Resources and Conservation Service supported plants database. It is used in FIREMON for consistent naming and coding of plant species. (<http://plants.usda.gov/>)

PD (Plot Description): Methods 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, and fuels and soils information. The PD method contains the only required fields in FIREMON. (FIREMON)

Perennial: Plant species with a life-cycle that characteristically lasts more than two growing seasons and persists for several years. (FGDC-STD-005)

Phenological Stage: A specific phase within the cycle (usually annual) of a plant's leafing, flowering, fruiting, etc. (The Concise Oxford Dictionary of Ecology)

Pixel: Literally, "picture element"; the smallest area for which data values are assigned. Pixels generally are all the same size and arranged in a contiguous rectangular grid of rows and columns. Spatial orientation of the grid can be registered to a map projection, so that individual pixels may be located on the ground. (Landscape Assessment Sampling Methods)

Planar-Intercept: A method in which the sampling area is an imaginary plane extending from the ground, vertically from horizontal (not perpendicular to the slope), to a height of six feet above the ground. Pieces of DWD (downed woody debris) that intercept the sampling plane are measured and recorded. Frequently the term "line transect sampling" is used when discussing the planar intercept method. (FIREMON) Compare to Line Intercept.

Plot: The basic sampling unit. This is an area of ground where FIREMON methods will be implemented. The plot is spatially defined by the macroplot. (FIREMON)

Rhizomatous Plants: A plant that has a stem, generally modified, that grows below the surface of the ground and produces roots, scale leaves, and suckers irregularly along its length. (Glossary of Landscape, Vegetation Ecology for Alaska)

Riparian: 1) Pertaining to streamside environment. 2) Vegetation growing in close proximity to a watercourse, lake, or spring and often dependent on its roots reaching the water table. (Glossary of Landscape & Vegetation Ecology for Alaska)

Sampling Plane: Used in the FIREMON FL sampling. The imaginary plane is defined by a measuring tape laid on or near the ground and extends from the top of the litter layer, duff layer or mineral soil - whichever is the highest layer - to a height of six feet. (Handbook for Inventorying Downed Woody Material, FIREMON)

SC (Species Composition): This is a method used to provide ocular estimates of canopy cover and height for plant species on a LANDFIRE plot. The SC sampling methods are suited for a wide variety of vegetation types and are especially useful in communities of tall shrubs or trees. (FIREMON)

**Shrub:** A woody plant that generally branches below or near the ground and exhibits several erect, spreading, or prostrate stems, thus having a bushy appearance (in other words, no clear trunk). Shrubs generally attain mature heights of greater than 0.5 m (~1.5 ft), but less than 5 m (~15 ft) in height. They may be deciduous or evergreen. (FDGC-STD-005, The Concise Oxford Dictionary of Ecology)

**Slope:** Defined in FIREMON as the inclination of the land surface, measured in degrees, from the horizontal. (Glossary of Landscape & Vegetation Ecology for Alaska, FIREMON)

**Stand:** A spatially continuous group of trees and associated vegetation having similar vertical and spatial structure and species composition (for example, pole, seedling, sapling, mature) usually growing under similar soil and climatic conditions. (FSVeg).

**Tree:** A woody plant that generally has a single main stem and a more or less definite crown. Trees generally attain heights greater than 5 m (~15 ft). (FDGC-STD-005)

**Vascular Plants:** Plant with water- and fluid-conducting tissue (xylem and phloem); includes seed plants, ferns, and fern allies. (FDGC-STD-005)

**Vegetation:** The collective plant cover over an area. (FDGC-STD-005)

**Vegetation Data:** The attributes of the vegetation that are used to classify and characterize the vegetation type and to map a vegetation stand. These data come from the interpretation of remotely sensed imagery, field work, and other thematic data sources. (FDGC-STD-005)

**Woody Plant:** Plant species life-form with woody tissue and buds on that woody tissue near or at the ground surface or above; plants with limited to extensive thickening by secondary woody growth and with perennating buds. (FDGC-STD-005)

**Woody:** Containing lignified plant tissue. (FDGC-STD-005)