Fuel Load (FL)

Sampling Method

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SUMMARY

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

INTRODUCTION

The Fuel Load (FL) methods are used to quantify three general components of the fuel complex: dead and down woody debris (DWD), duff and litter, and understory vegetation. Biomass estimates of dead and down woody debris are collected for the size classes that fire scientists have found important for predicting fire behavior and effects—1-hour, 10-hour, 100-hour, and 1,000-hour and greater. DWD measurements are based on the planar intercept methods published by Brown (1974). The sampling area is an imaginary plane extending from the ground, vertically from horizontal (not perpendicular to the slope) to a height 6 ft (2 m) above the ground. Pieces that intercept the sampling plane are measured and recorded. Frequently the term "line transect sampling" is used when discussing the planar intercept method. As far as the FL methodology is concerned the two terms can be interchanged as long as samplers recognize that the "line" is really the measuring tape laid on the litter layer while the "plane" extends above and below the tape, from the top of the duff layer to a height of 6 ft (2 m). Duff and litter are assessed by measuring the depth of the duff/litter profile down to mineral soil, and estimating the percent of the total duff/litter depth that is litter. The biomass of live and dead, woody and nonwoody understory vegetation is estimated using cover and average height estimations. The data collected using the FL methods are used to model fire behavior or to indicate potential fire effects. Forest managers often prescribe fuel treatments, at least partially, on the data collected using the FL methodology. The load of DWD can also be used to estimate the total carbon pool that is stored in the dead material, or DWD data can be used as an indicator of habitat for wildlife. Standing dead trees (snags) are sampled using the FIREMON Tree Data (TD) methods.

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

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

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

Two specific components of dead woody fuel are measured using the FL methods: fine woody debris (FWD) and coarse woody debris (CWD). Ecologists often refer to FWD and CWD independently because they function differently in forest ecosystems. FWD are pieces less than 3 inches (8 cm) diameter, and include 1-hour, 10-hour, and 100-hour fuels. CWD includes pieces 3 inches (8 cm) or greater in diameter and at least 3 ft (1 m) in length, also called 1,000-hour and greater fire fuels (table FL-1).

Pieces of DWD are sampled if they pass through the 6-ft (2-meter) high sampling plane. Fine woody pieces are recorded as simple counts. Diameter and decay class are recorded for each piece of CWD. DWD

Table FL-1—Ecologists and fire managers often use different terms to define the same dead woody debris. Typically 1-, 10- and 100-hour fuels are grouped together by ecologists and called “fine woody debris.“ They term 1,000-hour fuels and larger, “coarse woody debris.”

Dead woody class			Piece diameter	Piece diameter
			inches	*cm*
DWD				
	FWD	1-hr	0–0.25	0–0.6
		10-hr	0.25–1.0	0.6–2.5
		100-hr	1.0–3.0	2.5–8.0
	CWD	1,000-hr and greater	3.0 and greater	8.0 and greater

biomass estimation is made using equations published in Brown (1974). FIREMON provides six optional assessments for CWD: 1) diameter of the large end of the log, 2) log length, 3) distance along the tape where the piece intercepts the plane, 4) the percent of diameter lost to decay in hollow logs, 5) the percent of log length lost to decay in hollow logs, and 6) percent of the surface of CWD that is charred.

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

The planar intercept sampling methodology used in the FL protocol was originally developed by Warren and Olsen (1964) for sampling slash. Brown (1974) revised the original sampling theory to allow for more rapid fuel measurement while still capturing the intrinsic variability of forest fuels. Brown's method was developed strictly to provide estimates of fuel load in the size classes important to fire behavior. He determined the length of the sampling plane needed for each size class and, for FWD, determined quadratic mean diameter for several species. Planar sampling has been reduced to its most fundamental and efficient level while still providing good estimates of DWD.

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

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

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

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

SAMPLING PROCEDURE

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

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

Preliminary Sampling Tasks

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

Preparations need to be made before proceeding into the field for FL sampling. First, all equipment and supplies in the **FL Equipment List** must be purchased and packed for transport into the field. Since travel to FIREMON plots is usually by foot, it is important that supplies and equipment be placed in a comfortable daypack or backpack. Be sure you pack spare equipment so that an entire day of sampling is not lost if something breaks. Spare equipment can be stored in the vehicle rather than the backpack. Be sure all equipment is well maintained and there are plenty of extra supplies such as data forms, map cases, and pencils.

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

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

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

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

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

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

Determining Piece Size

An important task when sampling fuels is to properly determine whether each piece is in the 1-hour, 10-hour, 100-hour, or 1,000-hour and greater size class. Often it will be clear by examining which size class the pieces belong in. This is especially true as field crews gain experience sampling fuels. However, while samplers are calibrating their eyes or when pieces are clearly on the boundary between two size classes, samplers need to take the extra effort to measure pieces and assign them to the proper class. Each sampling crew should have at least one set of sampling dowels for this task. The set is made up of two dowels. One measures 0.25 inch (0.6 cm) in diameter and 3 inches (8 cm) long. Use this dowel to determine whether pieces are in the 1-hour or 10-hour class. The second dowel is 1 inch (2.5 cm) in diameter and 3 inches (8 cm) long. Use this dowel to separate the 10-hour from the 100-hour fuels. Cutting the dowels into 3 inch (8 cm) lengths makes them useful to discern 100-hour and 1,000-hour fuels. The go/no-go gauge is a tool that can speed up the sampling process (fig. FL-1). The gaps in the tool correspond to the 1-hour and 10-hour fuel sizes, and they allow quick assessment of fuel size. Make it out of sheet aluminum (about 0.06 inch thick) so that it is lightweight and durable. Or make one out of an old plastic card (such as the ones you get at grocery stores); while it won't be as durable as an aluminum one, it is easier to make because you can cut the openings using scissors.

FL sampling requires 12 tasks for each sampling plane:

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

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

Modifying FL Sampling

In the FL method we suggest sampling over a 60-ft (20-m) distance with an addition 15 ft (5 m) of buffer provided to keep from disturbing fuels around the plot center (fig. FL-2). The 60-ft (20-m) plane is the shortest recommended for sampling CWD. However, there are instances of high fuel loads, in slash for instance, where shorter planes for DWD may be justified. If the FIREMON architect wants to use shorter (or longer) sampling planes based on research or expert knowledge, the database can accommodate that data. This write-up assumes that the FIREMON crew is using the suggested FL method.

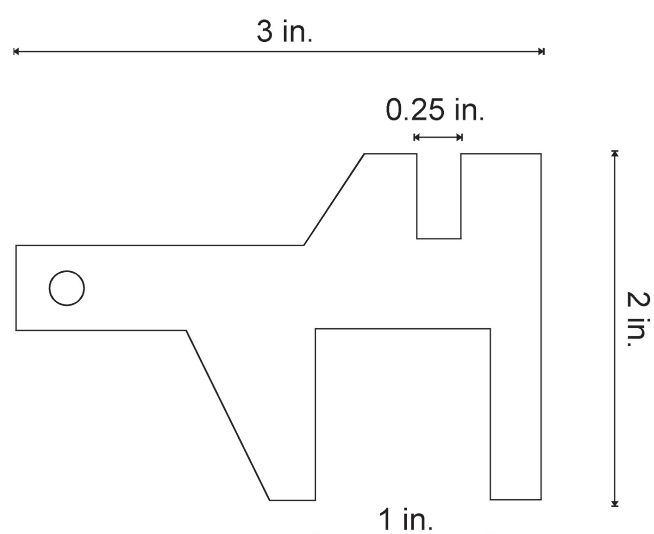


Figure FL-1—A go/no-go gauge helps samplers tally 1-hour, 10-hour, and 100-hour fuels quickly and accurately.

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

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

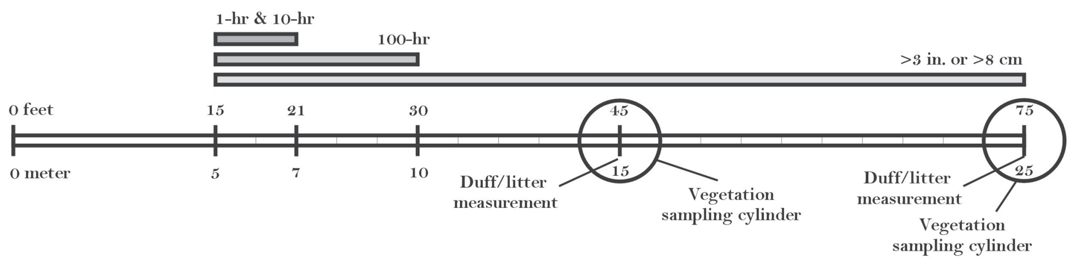


Figure FL-2—Dead fuels, duff/litter, and vegetation data are recorded at specific locations on or along each sampling plane. The 1-hour and 10-hour fuels are sampled from the 15-ft (5-m) to the 21-ft (7-m) marks along the plane, the 100-hr fuels are sampled from the 15-ft (5-m) to the 30-ft (10-m) marks,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

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

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 6 ft (2 m). When laying out the tape, crew members need to step carefully to minimize trampling and compacting fuels—DWD, duff/litter and vegetation—especially along the sampling plane. While the data recorder is arranging field forms and so forth, the other two crew members can lay out the measuring tape for the first sampling plane. Have one crew member stand at plot center (see **How to Locate a FIREMON Plot** in the **How-To Guide** chapter) holding the zero end of the tape, then, using a compass, he or she will guide second crew member (see **How to Use a Compass—Sighting and Setting Declination** in the **How-To Guide** chapter) 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-ft (25-m) 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 (fig. FL-3). It pays to sight carefully with the compass and identify potential obstructions before rolling out the tape.

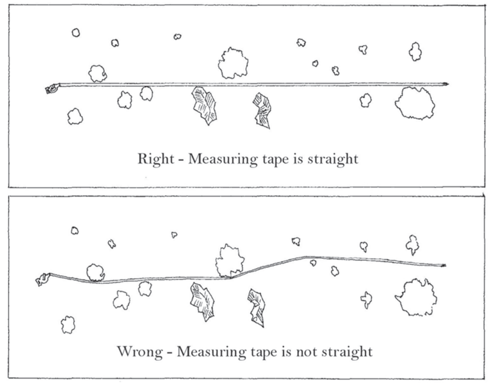


Figure FL-3—The measuring tape, which represents the lower portion of the sampling plane, should be as straight as possible. If the tape is not straight it needs to be offset left or right until it can be established without kinks or bends.

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

Once established, anchor the tape and do not move its position until all sampling is finished for the sampling plane. Most tapes have a loop on the zero end that a spike can be placed through to keep it anchored, and a spike or stick though the handle on the other end of the tape will hold it in place. Roll-up tapes (fig. FL-4) usually have a winding crank that can be flipped so that the knob points toward the reel. In this position the knob will lock the reel so the tape won't unwind when it is pulled tight.

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

Determining the Slope of the Measuring Tape

Once the tape has been secured, use a clinometer to measure the percent slope of the line. Aim the clinometer at the eye level of sampler at the other end of the line (fig. FL-5). If there is a height difference of the samplers, adjust the height where you are aiming so that the slope reading is accurate. Carefully, read the percent slope from the proper scale in the instrument and report to the data recorder who will enter it in Field 7 on the FL Field Form.

What Are "Woody," "Dead," and "Down" Debris?

Before sampling any DWD the terms "woody," "dead," and" "down" need to be understood so data gathered with the FL methods are consistent between field crews. "Woody" refers to a plant with stems,

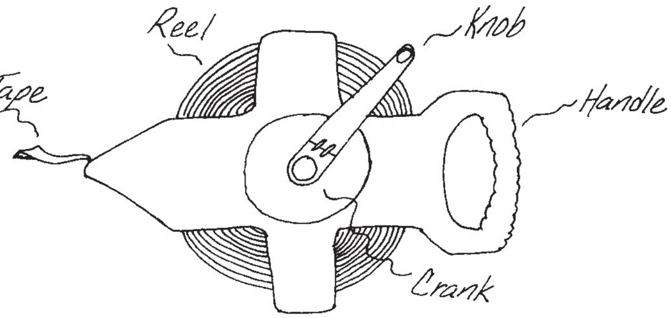


Figure FL-4—Parts of a roll-up measuring tape. The crank can usually be flipped in the opposite direction allowing the knob to lock the reel. This will keep more tape from being pulled off.

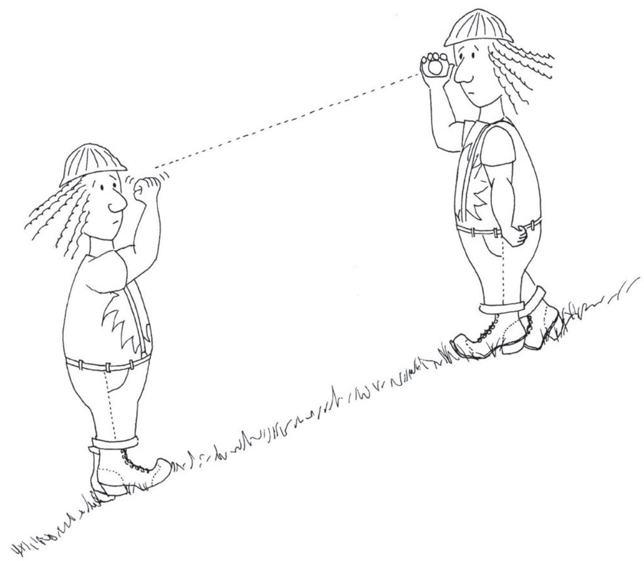


Figure FL-5—Measure the slope of each line by aiming the clinometer at eye level on the sampler at the opposite end of the measuring tape, then reading and recording the percent slope seen on the scale in the instrument.

branches, or twigs that persist from year to year. The structural parts support leaves, needles, cones, and so forth, and it is these structural components that are tallied along the sampling plane.

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

CWD

CWD includes pieces 3 inches (8 cm) or greater in diameter. Some authors suggest CWD must also be at least 3 ft (1 m) in length. Because this may lkead to unrealistic CWD biomass values—especially in logging slash where many pieces may not meet the length criteria—we do not suggest defining CWD using a length component. CWD at an angle of greater than 45 degrees above horizontal where it passes through the sampling plane should only be considered "down" if it is the broken bole of a dead tree where at least one end of the bole is touching the ground (not supported by its own branches, or other live or dead vegetation). If CWD is at an angle of 45 degrees or less above horizontal where it passes through the sampling plane, then it is "down" regardless of whether or not it is broken, uprooted, or supported in that position (fig. FL-6 and FL-7).

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 (fig. FL-8). These pieces burn more like duff, and the duff/litter methodology will allow field crews to collect a representative sample of this material.

FWD

FWD are pieces less than 3 inches (8 cm) diameter. Pieces of FWD that are "woody," "dead," and" "down" fall into three general categories: 1) pieces that are not attached to the plant stems or tree boles where

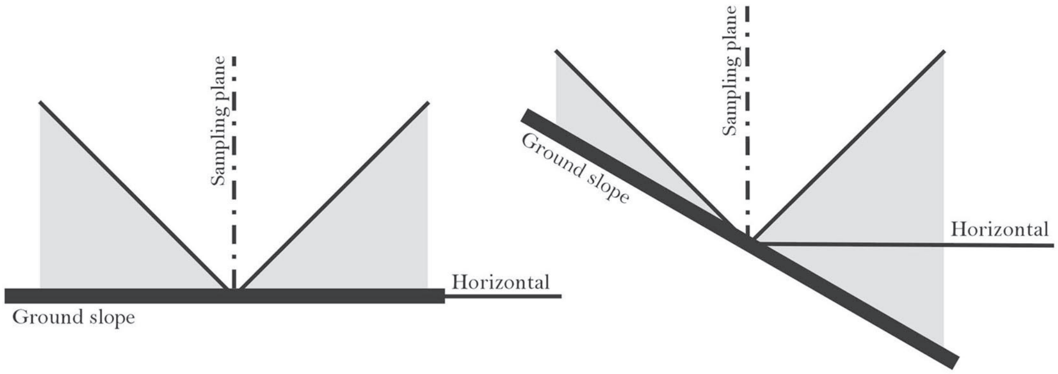


Figure FL-6—CWD pieces crossing through the sampling plane at an angle less than 45 degrees from horizontal (represented by the shaded areas in the figure) are always considered to be “down.” Some CWD leaning greater than 45 degrees may be considered “down.” See the text for details.

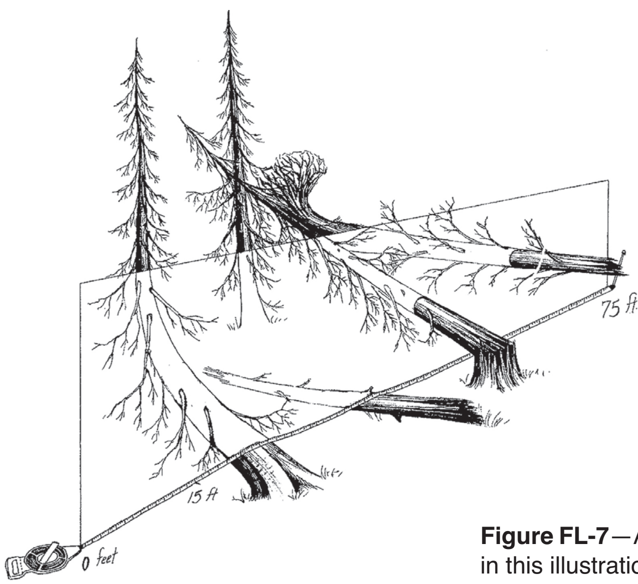


Figure FL-7—All of the pieces crossing through the sampling plane in this illustration would be considered “down.”

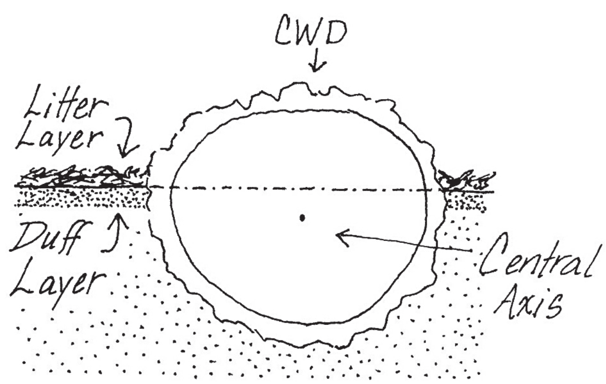


Figure FL-8—Do not sample CWD when the central axis of the piece lies in or below the duff layer.

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

DWD Sampling Distances

DWD is sampled along a certain portion of the sampling plane based on the size of the piece (fig. FL-2). The 1-hour and 10-hour fuels are sampled from the 15-ft (5-m) to the 21-ft (7-m) marks along the plane, the 100-hr fuels are sampled from the 15-ft (5-m) to the 30-ft (10-m) marks, and pieces 3 inches (8 cm) and larger are sampled between the 15-ft (5-m) and 75-ft (25-m) marks along the plane. The distances for sampling FWD are shorter than for CWD because pieces of FWD are more numerous, so a representative sample can be obtained with a shorter sampling distance. DWD is not measured along the first 15 ft (5 m) of the tape because fuels are usually disturbed around plot center by the activity of the sampling crew as they get organized to lay out the tape. The Analysis Tools program will accept different sampling plane lengths from the ones suggested here. If you use different lengths, record the reason for changing them in the Metadata (MD) table. Enter the sampling plane length for 1-, 10-, 100-, and 1,000-hour fuels in Fields 1 through 4 of the FL field form. If you are using a predetermined number of sampling planes per plot, enter that value in Field 5, otherwise the field will be filled in at the end of the plot sampling. This issue is more completely covered in later sections.

Sampling FWD

The crew member at the zero end of the tape should sample FWD to maximize sampling efficiency. Count the 1-hour and 10-hour fuels that pass through the sampling plane from the 15-ft (5-m) to the 21-ft (7-m) marks on the measuring tape. Remember the plane extends from the top of the duff layer vertically to a height of 6 ft (2 m). The best way to identify the pieces intercepting the plane is to lean over the tape so that your eye is positioned vertically a few feet over the measuring tape at the 15-ft (5-m) 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-ft mark while making separate counts for the 1-hour and 10-hour fuels that cross under or above the edge of the tape. Each piece needs to be classified as 1-hour or 10-hour fuel by the diameter where it intercepts the sampling plane, defined by one edge of the measuring tape. Samplers should use the dowels or the go/no-go gauge discussed earlier to classify fuels that are close to the size class bounds. Often pieces above will cover pieces below. It is important to locate all the pieces that intercept the plane in order to get accurate fuel load data (fig. FL-9). When finished tallying the 1-hour and 10-hour fuels, report the counts to the data recorder who will enter them in Fields 8 and 9 on the data sheet.

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

Sampling CWD

The CWD sampling plane is 6 ft (2 m) high and extends from the 15-ft (5-m) mark to the 75-ft (25-m) mark along the measuring tape. Sample CWD that intercepts the sampling plane and meets the dead, down, and woody requirements discussed above. In general, at least two fields are recorded for each piece of CWD: diameter and decay class. Percent char, log length, diameter of the large end, point of intersect, and

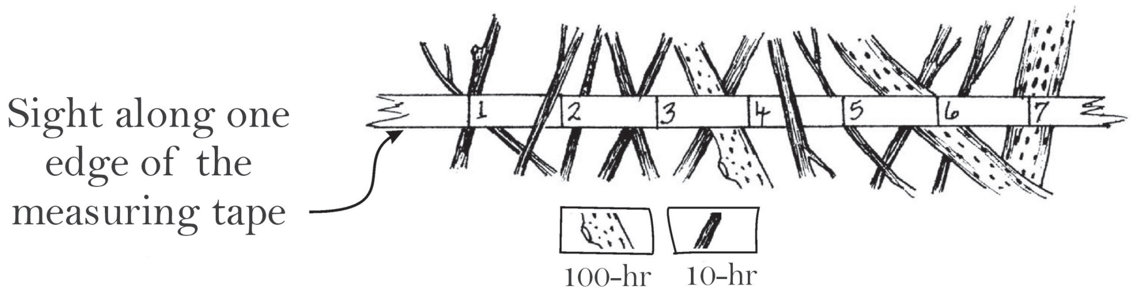


Figure FL-9—Tally pieces that intercept the sampling plane both above and below the measuring tape. Focus on one edge of the tape to make counting easier. Be sure to note any lower fuels that are hidden by pieces above. In this illustration there are 11 1-hour and 3 10-hour fuels.

estimations of volume lost to decay are additional data that may be collected for each piece of CWD. See the **Sampling Design Customization** section at the end of this document for more information. CWD sampling should be done by the crew member who is standing at the 75-ft (25-m) end of the tape while moving toward the zero end. This will keep him or her out of the way of the other sampler and will reduce the chances of the FWD being inadvertently disturbed before being sampled.

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

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

What Are, "Duff," "Litter," and the "Duff/Litter Profile"?

Duff and litter are two components of the fuel complex made up of small, woody, and nonwoody pieces of debris that have fallen to the forest floor. Technically, packing ratio, moisture content, and mineral content are used to discriminate the litter and duff layers. Samplers will find it easier to identify each layer by using the following, more general, criteria. "Litter" is the loose layer made up of twigs, dead

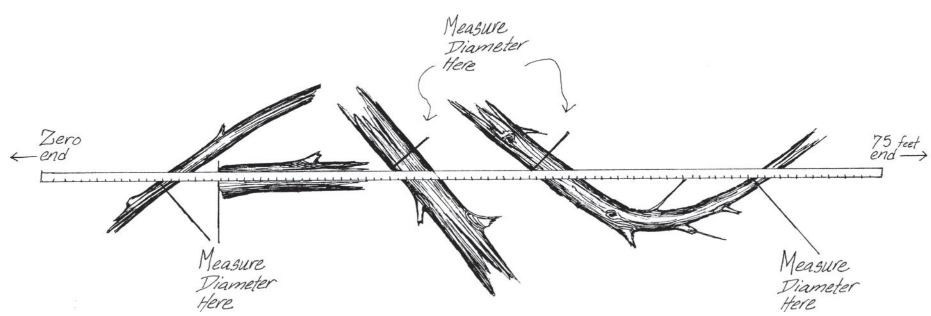


Figure FL-10—Measure the diameter of CWD crossing through the sampling plane perpendicular to the central axis of the piece. If a curved piece passes through the plane more than once measure its diameter at each intersection.

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

Decay class	Description
1	All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked.
2	Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked.
3	Most of the bark is missing, and most of the branches less than 1 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 then it should not be included in the CWD sampling, as these pieces act more like duff than wood when burned.

grasses, recently fallen leaves, needles, and so forth, where the individual pieces are still identifiable and little altered by decomposition. The "duff" layer lies below the litter layer and above the mineral soil. It is made up of litter material that has decomposed to the point that the individual pieces are no longer identifiable. The duff layer is generally darker than the litter layer and is more aggregated because of the fine plant roots growing in the duff material.

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

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

Sampling Duff and Litter

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

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

Use a plastic ruler to measure total depth of the duff/litter profile to the nearest 0.1 inch (0.2 cm). Place the zero end at the point where the mineral soil meets the duff layer, then move either your index finger or thumb down the ruler until it is level with or just touches the top of the litter (fig. FL-12). While keeping your finger in the same position on the ruler, lift the ruler out of the profile and note the duff/litter depth, indicated by your finger. If your ruler is not long enough to measure the duff/litter depth use the ruler to make marks on a stick, and measure the profile with the stick. If you use the stick measurement method often, get a longer ruler. Next examine the duff/litter profile and estimate the

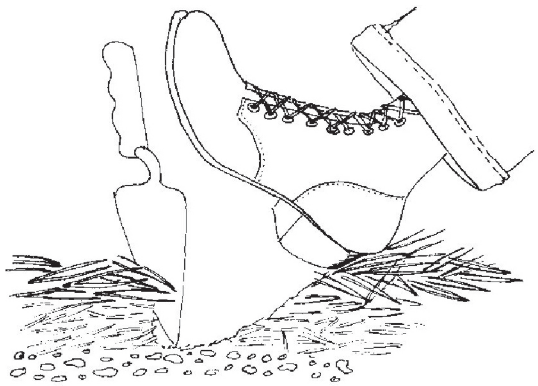


Figure FL-11—Use your boot to carefully pull the litter and duff layers away, until you are down to mineral soil.

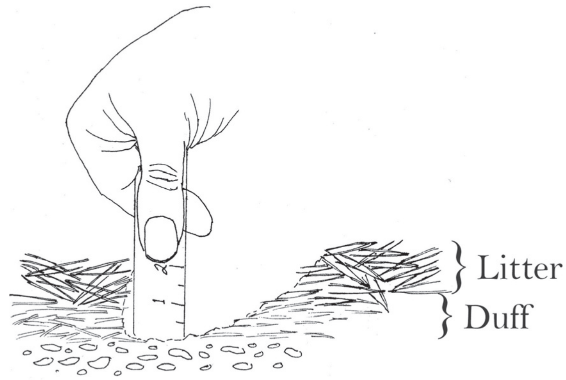


Figure FL-12—Use a plastic ruler to estimate duff and litter depth. Place the zero end at the intersection of the mineral soil and duff layer, then mark top of the litter layer using your thumb or finger. In this illustration the duff/litter depth is 2 inches (5 cm), and the proportion of that depth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

percent of the total depth that is made up of litter, to the nearest 10 percent. Finally, report the duff/litter depth measurement and litter percent estimate to the data recorder who, depending on measurement point, will enter the data in Fields 11 and 12 or Fields 13 and 14 on the FL field form.

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

What Is "Woody" and "Nonwoody" Vegetation?

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

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

Sampling Vegetation Cover and Height

Estimate vegetation cover and height at the 45-ft (15-m) and 75-ft (25-m) marks on the measuring tape. Field crews will estimate the vertically projected cover of vegetation within a 6-ft (2-m) tall by 6-ft (2-

m) diameter imaginary sampling cylinder. Use the marks on the measuring tape to help visualize the 6-ft (2-m) diameter. For instance, when standing at the 45-ft (15-m) mark, the 42-ft (14-m) and 48-ft (16-m) marks will identify the boundary of the cylinder along the tape. Use that measurement to get a good idea of the distance needed on each side, perpendicular to the tape, required to form the imaginary base of the cylinder. Many people have an arm's width spread that is about 6 ft (2 m). Each sampler should measure his or her arm span and use that measurement to help them visualize the sampling cylinder.

The extent of plant cover (foliage and supporting parts) is a function of phenological stage. Early in the season many plants may not have completely leaved out, in mid-season plant cover and height reaches a maximum, and then in late season plant material, especially herbaceous vegetation, moves from the live to dead class. So the question is: when should vegetation be sampled? Should you sample at the same time every year regardless of the growth stage of the vegetation, or should you sample at the peak of growth, or should you sample during the burning season…? Often an examination of the project objectives will help determine the best time for sampling. However, the reality is that sampling will typically occur when field crews have the time, and that may have little to do with the objectives or the plants' phenological stage during previous sampling visits.

In the FIREMON FL vegetation sampling we suggest *estimating* the peak cover and height regardless of the seasonal timing of the sampling visit. This adds a certain amount of error in the cover and height estimates, so it may not be advisable in some monitoring programs. For instance, if project objectives are specifically interested in monitoring fuel characteristics during the burning season, it will be better to actually sample during the burning season. The benefit of estimating peak cover is twofold. First, it allows some sort of standardization between vegetation assessments by partially eliminating the variation due to seasonal changes in vegetation characteristics. Second, it gives the manager some idea of the maximum biomass, maximum vertical distribution of the fuel complex, and maximum live component. Then he or she can use that information to estimate vegetation characteristics during other times of the season, say, when considering an end of the season prescribed fire. For example, if cover in a grassland is estimated at peak to be 70 percent cover, 3 ft tall, with 20 percent dead material you can figure that at the end of the growing season biomass will be the same, or nearly so, but with a majority closer to the ground and with a much higher dead component. (The biomass equations in FIREMON are based on oven-dry weight, so when cover and height are equal there is no difference in biomass between live and dead plants.) Given the same weather conditions, the resulting fire behavior and, possibly, fire effects will be more extreme at the end of the season than during the peak because of denser packing and lower fuel moistures.

Herbaceous species such as some grasses fall over when they become dormant. In order to get good biomass estimates, when sampling dormant material you need to estimate cover and height as if plants were erect. For height, simply lift the tops of a few plants up from the ground and measure the height. Cover can be a bit more challenging as the flattened grass makes cover look greater than it is. Usually lifting the grass and examining the basal distribution of the stems will lead to sufficient estimates. Sometimes cover estimation can be accurately made simply by recalling what was seen at the peak of the growing season in similar areas. Because of the woody component, shrub height does not change much between growing and dormant season. However, during the dormant season, shrub cover must be estimated by imagining the plants with their foliage. Getting accurate estimates this way may be difficult, but reasonable cover assessments are possible with practice.

Again, estimating cover and height at the peak of the growing season is a *suggested* sampling scheme for the vegetation component. You should sample vegetation using the methods you feel the most comfortable with and that meet the needs of the project. Be sure to record in the Metadata table the how, when, and why of your FL vegetation sampling.

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

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

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

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

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

Code	Cover
	percent
0	No cover
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	>95–100

Finishing Tasks

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

Successive Sampling Planes

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

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

It is not necessary for one sampling plane to start at the exact 75-ft (25-m) mark of the previous one. In fact it is better if the start of the new line is 5 ft or so away from the end of the last so that the activity around the new start does not adversely impact the fuel characteristics at the end of the last one. The duff/litter layer and woody and nonwoody vegetation at the 75-ft (25-m) mark, in particular, could be disturbed by field crew traffic, which can bias the data when the plot is resampled. Make sure that no portion of the new sampling plane will be crossing fuels that were sampled on the previous plane. Once the start of the new sampling plane has been determined, collect the data as you did on the first plane. Look ahead and see which starting point will guarantee a straight line before you start laying out the next sampling plane. If the sample sampling planes are going to be remeasured be sure to carefully mark 0-ft and 75-ft end of each sampling plane.

Determining the Number of Sampling Planes

After the crew has finished sampling three planes, the data recorder will sum up the counts of all the DWD pieces (1-hour, 10-hour, 100-hour, and 1,000-hour pieces), and if that number is greater than 100 then the crew is finished sampling DWD for the plot. If the count is less than 100 then the crew needs

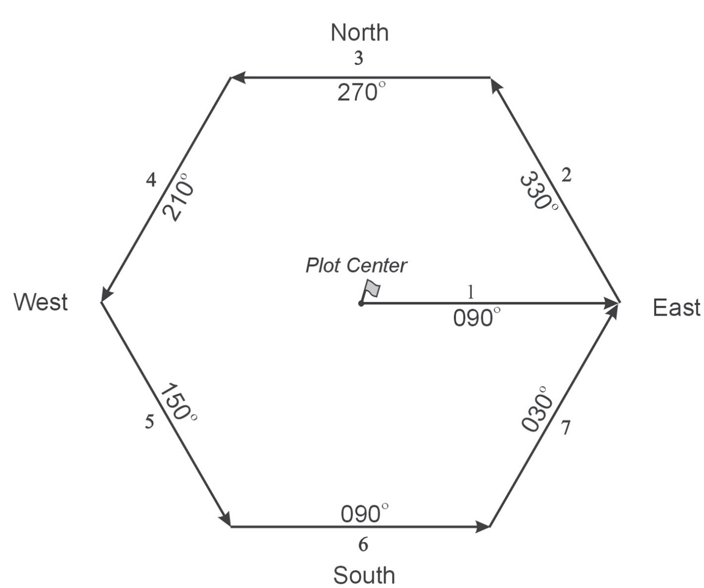


Figure FL-13—The FL plot design allows a representative sample of DWD to be obtained while reducing or eliminating the bias introduced by nonrandomly oriented pieces. Data are collected on and along three to seven sampling planes.

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

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

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

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

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

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

Resampling FL Plots

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

What If…

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

Precision Standards

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

SAMPLING DESIGN CUSTOMIZATION

Alternative FL Sampling Design

Number of sampling planes: Minimum 3, maximum 7. Continue sampling until count of pieces, across all sizes, is greater than 100. If you are resampling an existing plot, use the same number of planes as were used in the initial survey.

Duff/Litter depth measurements per plane: 2.

Vegetation assessments per plane: 2.

Large debris piece measurements: Diameter and decay class.

Table FL-5— Precision guidelines for FL sampling.

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

Streamlined FL Sampling Design

Number of line sampling planes: 3. If you are resampling an existing plot use the same number of planes as were used in the initial survey.

Duff/Litter depth measurements per plane: 2.

Vegetation assessments per plane: 2.

Large debris piece measurements: Diameter and decay class.

Comprehensive FL Sampling Design

Number of sampling planes: 7. If you are resampling an existing plot use the same number of planes as were used in the initial survey.

Duff/Litter depth measurements per plane: 2.

Vegetation assessments per plane: 2.

Large debris piece measurements: Diameter and decay class.

Optional Data

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

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

Log length—Important for wildlife concerns and useful for rough determination of piece density. Record length of CWD to the nearest 0.5 ft (0.1 m). If a piece is broken but the two parts are still touching then record the length end-to-end or sum the lengths for broken pieces not lying in a straight line (fig. FL-14). If piece is broken and the two parts are not touching, then measure only the length of the piece that intercepts the sampling plane.

Distance from beginning of line to log—This measurement makes relocation of specific logs easier, which is especially important when calculating fuel consumption on a log-by-log basis. Frequently, logs that were included in prefire sampling roll away from the sampling plane during a fire, while other logs

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

Class	Char
	percent
0	No char
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	>95–100

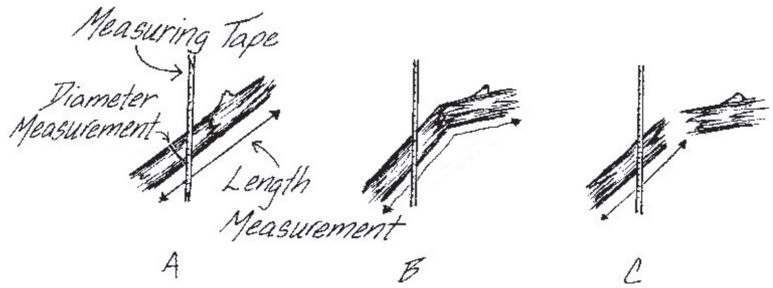


Figure FL-14—Log length and diameter measurement for optional CWD data. In each case the diameter measurement is made at the same point. In A and B the broken pieces are touching so length includes both pieces. In C, only the piece crossed by the measuring tape is measured for length.

not originally sampled will roll into the plane. Recording the distance from the start of the line, in addition to permanently marking the logs with tags, will make postfire sampling easier. Record the distance from the start of the measuring tape to the point where the diameter was measured.

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

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

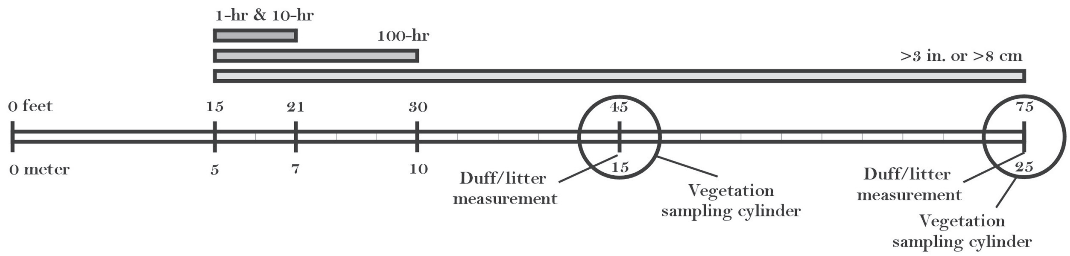
Class	Lost to decay
	percent
0	No Loss
0.5	>0–1
3	>1–5
10	>5–15
20	>15–25
30	>25–35
40	>35–45
50	>45–55
60	>55–65
70	>65–75
80	>75–85
90	>85–95
98	>95–100

FUEL LOAD (FL) FIELD DESCRIPTIONS

Field 1: **1-Hr.** Sampling plane length for the 1-hour fuels (ft/m).
Field 2: **10-Hr.** Sampling plane length for the 10-hour fuels (ft/m).
Field 3: **100-Hr.** Sampling plane length for the 100-hour fuels (ft/m).
Field 4: **1,000-Hr.** Sampling plane length for the 1,000-hour fuels (ft/m).
Field 5: **Number of Planes.** Number of sampling planes/transects that the data were recorded along. (One "plane" includes data for the 1-hour through 1,000-hour fuels.)
Table 1. FWD, litter and duff.
Field 6: **Plane/Transect Number.** Sampling plane/transect number for data recorded in Fields 7 to 15.
Field 7: **Slope** (percent). Slope of the sampling plane. Precision: ±5 percent.
Field 8: **1-hour Count.** Count of pieces in the 1-hour size class (0–0.25 inch). Precision: ±3 percent total count.
Field 9: **10-hour Count.** Count of pieces in the 10-hour size class (0.25–1.0 inch). Precision: ±3 percent total count.
Field 10: **100-hour Count.** Count of pieces in the 100-hour size class (1.0–3.0 inches). Precision: ±3 percent total count.
Field 11: **D/L Depth 1** (inch/cm). Duff/litter depth measured at the first location. Precision: ±0.1 inch/0.2 cm.
Field 12: **Litter Percent 1.** Percent of the total duff/litter depth that is litter at the first location. Precision: ±10 percent.
Field 13: **D/L Depth 2** (inch/cm) Duff/litter depth measured at the second location. Precision: ±0.1 inch/0.2 cm.
Field 14: **Litter Percent 2.** Percent of the total duff/litter depth that is litter, at the second location. Precision: ±10 percent.
Field 15: **Local Code.** Optional data field.
Table 2. CWD
Field 16: **Plane/Transect Number.** Sampling plane/transect number for CWD data recorded in Fields 17 to 20.
Field 17: **Log Number.** Log number, numbered sequentially by transect.
Field 18: **Diameter** (inch/cm). Diameter of the piece measured perpendicular to the longitudinal axis. Precision: ±0.5 inch/1 cm.
Field 19: **Decay Class.** Decay class of the log where it crosses the plane. Valid classes are in table FL-3 of the sampling method. Precision: ±1 class
Field 20: **Local Code.** Optional data field.
Table 3. Vegetation.
Field 21: **Plane/Transect.** Sampling plane/transect number for vegetation measurements recorded in Fields 22 to 33.
Field 22: **Live Tree/Shrub Cover 1.** Cover class of live trees and shrubs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 23: **Dead Tree/Shrub Cover Class 1.** Cover class of dead trees and shrubs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 24: **Average Tree/Shrub Height 1** (ft/m). Average height of live and dead tree/shrub component at the first sampling location. Precision: ±0.5 ft/0.2 m.
Field 25: **Live Herb Cover 1.** Cover class of live herbs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 26: **Dead Herb Cover 1.** Cover class of dead herbs at the first sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 27: **Average Herb Height 1** (ft/m). Average height of live and dead herb component at the first sampling location. Precision: ±0.5 ft/0.2 m.
Field 28: **Live Tree/Shrub Cover 2.** Cover class of live trees and shrubs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 29: **Dead Tree/Shrub Cover 2.** Cover class of dead trees and shrubs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 30: **Average Tree/Shrub Height 2** (ft/m). Average height of live and dead tree/shrub component at the second sampling location. Precision: ±0.5 ft/0.2 m.
Field 31: **Live Herb Cover 2.** Cover class of live herbs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 32: **Dead Herb Cover 2.** Cover class of dead herbs at the second sampling location. Precision: ±1 class. Valid classes are in table FL-4 of the sampling method.
Field 33: **Average Herb Height 2** (ft/m). Average height of live and dead herb component at the second sampling location. Precision: ±0.5 ft/0.2 m.

FIREMON FL Cheat Sheet

Sampling plane layout



Task list

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

Precision

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

CWD decay class

Decay class	Description
1	All bark is intact. All but the smallest twigs are present. Old needles probably still present. Hard when kicked.
2	Some bark is missing, as are many of the smaller branches. No old needles still on branches. Hard when kicked.
3	Most of the bark is missing and most of the branches less than 1 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 then it should not be included in the CWD sampling, as these pieces act more like duff than wood when burned.

Fuel load (FL) equipment list

0.25 inch diameter by 3 inch long dowel	Field notebook
1.0 inch diameter by 3 inch long dowel	FL cheatsheet
75-foot tape	FL data forms
Bridge spikes	Hard hat
Clipboard	Pencils/pens
Compass	Sharp trowel or small shovel
Clear plastic 6-inch ruler (w/0.1 inch gradations)	Small stakes or rebar
Clinometer (with percent scale)	Survey flags
Diameter tape, caliper, yardstick, or similar (w/0.1 inch gradations) for measuring large log diameter	

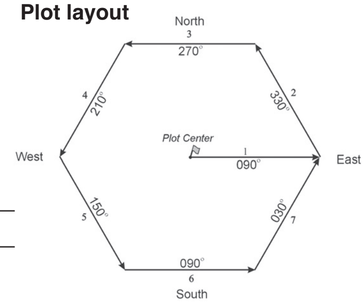
Optional

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

Piece sizes

Dead woody class			Piece diameter
			inches (cm)
DWD	FWD	1-hr	0–0.25 (0–0.6)
		10-hr	0.25–1.0 (0.6–2.5)
		100-hr	1.0–3.0 (2.5–8.0)
	CWD	1,000-hr and greater	3.0 and greater (8.0 and greater)

Plot layout



Cover class

Code	Canopy cover
	Percent
0	Zero
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	>95–100

Fuel Load (FL) Form

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

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _

PlotID: _ _ _

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

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

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

Notes/Dot Tally Space:

Crew:

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

Field 16	Field 17	Field 18	Field 19	Field 20	Field 16	Field 17	Field 18	Field 19	Field 20
Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code	Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code

Fuel Load (FL) Form

FL Page _ _ of _ _

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _

PlotID: _ _ _

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

Notes

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

Field 16	Field 17	Field 18	Field 19	Field 20
Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code

Field 16	Field 17	Field 18	Field 19	Field 20
Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code

Field 16	Field 17	Field 18	Field 19	Field 20
Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code

Field 16	Field 17	Field 18	Field 19	Field 20
Transect Number	Log Number	Diameter (in/cm)	Decay Class	Local Code

Fuel Load (FL) Form

Plot Key

RegistrationID: _ _ _ _

ProjectID: _ _ _ _ _ _ _ _ _

PlotID: _ _ _

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

FL Page _ _ of _ _

FL Table 3 - Vegetation Data

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

Notes: