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A Synthesis of Fuel Moisture Collection Methods and Equipment—A Desk Guide

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Abstract

This desk guide is a synthesis of accepted methods, practices, and equipment currently used by many agencies across the United States to collect and process fuel moisture samples. This synthesis fulfills four primary goals:

1. Provide a fuel moisture sampling desk guide that serves as a single source for available methodologies and procedures for fuel moisture collection.
2. Develop a field guide to help field-going personnel with the process of collecting fuel samples.
3. Make recommendations for equipment used to process fuel moistures.
4. Highlight areas where there is a need for additional research.

Introduction

In 1979, Clive Countryman and William Dean developed the first published fuel moisture collection guide, "Measuring Moisture Content in Living Chaparral: A Field User's Manual," which focused on measuring fuel moistures in live chaparral. Since that time, others have used a variation of Countryman and Dean's guide to develop methods and protocols useful for sampling other fuel types, including:

- "Measuring Fuel Moisture Content in Alaska: Standard Methods and Procedures" (Norum and Miller 1984).
- "Fuel Moisture Sampling Guide" (Pollet and Brown 2007).
- "Southwest Area Fuel Moisture Monitoring Program: Standard Methods and Procedures" (Stonex et al. 2004).
- "Measuring Live Fuel Moistures in Florida: Standard Methods and Procedures" (Brenner 2002).

These guides provide guidance to field personnel and researchers in sampling fuels, including:

- Duff.
- Litter.
- Timber foliage.
- Shrubs.
- Grasses.
- Moss.
- Lichens.
- Dead fuels.

There are no nationally standardized scientific methodologies and/or protocols for the collecting, processing, and monitoring of live and dead fuel moistures. The intent of this desk guide is not to give direction or provide national fuel moisture collection standards, but to provide one source for accepted methodologies and procedures to sample fuel moistures that are currently used by agencies and units throughout the United States.

This desk guide also provides recommendations for additional research needed in the area of fuel moisture sampling. One example is determining the appropriate oven temperatures for drying fuel samples. Our research found that temperatures used by various individuals or units across the country varied widely with no explanation or supporting documentation as to why they chose the temperatures they did.

If changes occur to your fuel moisture sampling techniques, we recommend that you document these changes since consistent adherence to methods and protocols is even more important now that the National Fuel Moisture Database (NFMD) simplifies sharing and cross utilization of the data. These data are no longer local use only.

It is hoped that through this guide, many who are starting a new fuel collection program—or are in need of a simple review—will find the information useful and will have opportunities to test a variety of theories and methodologies to support essential fuel collecting and reporting.

Table of Contents

Why Collect Fuel Samples?

Wildland fire managers, researchers, and fire modelers have long recognized the strong influence that live and dead fuel moisture contents have on wildland fire behavior. The amount of moisture in fuel determines whether the fuel is available to burn or not. Fuels with higher fuel moisture values have a slower combustion process since much of the heat needed for combustion is lost in drying out fuels; as fuels dry, the rate of combustion increases.

Live and dead fuel moisture values are used for various management purposes, including determining drought or drying trends, formulating fire danger ratings, providing a basis for severity funding, gathering input for fire behavior modeling, determining prescription parameters for prescribed burns, and determining the effects of fire in an ecosystem.

Who Should Sample?

To achieve greater consistency in the results, we (the authors) recommend that only individuals trained and experienced in collecting and processing fuel samples do so. It is preferable that the same person, or small crew, collect samples throughout the sampling period and that they cross-train replacements or subsequent individuals to use the same methods.

Data Quality

Inconsistent and inaccurate data occurs when care is not taken in collecting and processing fuel samples. The following are some of the common errors that occur in fuel moisture sampling.

Field Errors

- Failing to know exactly what part of the plant to collect (i.e., leaf, needle, stem).
- Changing fuel collection methods and protocols without documenting this change on the fuel moisture collection form.
- Failing to be consistent with the amount of material collected, such as not collecting enough or collecting too much plant material in one container.
- Contaminating samples with rain or heavy fog, high dew levels, or other free water.
- Sampling duff, soil, or litter that contains small rocks, animal droppings, and other extraneous material.
- Collecting the wrong plant samples (i.e., samples do not meet collection objectives, such as representing the primary carrier of fire or the one best representing all of the species in a fuel complex).
- Failing to remove flowers, seedpods, nuts, berries, attached branches, and unwanted living or dead materials from the sample.
- Failing to collect material from different sections of the same plant or different aspects around the plant.
- Failing to collect material from different plants on a collection site.
- Mixing different plant material in one container (i.e., sphagnum moss is included in the sample of lichens and feather mosses, or stems, roots, and leaves of forbs or shrubs are included in the moss and lichen sample).
- Failing to be consistent with numbering. The number listed on the fuel moisture content form is different from the one on the container.
- Failing to document or record changes in methodology in collecting fuel samples.
- Using an incorrect lid on a container.
- Heating a sample prematurely with excessive exposure to the sun or leaving it in a vehicle. This is detectable by condensation on the inside of the container lid.
- Leaving the container open or not keeping the lid tight.
- Using damaged or dirty containers, or containers beyond their performance reliability (i.e., dented or rusty metal cans).

Processing or Laboratory Errors

- Failing to check the container numbers against the sample contents as recorded on the fuel moisture content form.
- Failing to document or record changes in processing fuel samples.
- Allowing material to fall out of the container while drying.
- Failing to set the scale to zero before weighing.
- Misreading the scale.
- Changing processing or laboratory methods and protocols without documenting the change on the fuel moisture collection form.
- Making errors while entering values into the calculator or while doing the calculations (this is possibly the greatest single source of error—doublecheck everything!). *Note: Use the fuel moisture content form in appendix B or online at the National Fuel Moisture Database (NFMD) <http://72.32.186.224/nfmd/public/index.php>.*
- Opening sample container with untested or unmeasured material inside.
- Failing to remove the lid after the initial weighing and before it goes into the oven.
- Not calibrating the scale or placing the container in the middle of the scale platform.
- Leaning on the table or counter that the scale is resting on.
- Having a dirty container, scale, or sticky rocker arm of balance scale.
- Failing to allow the sealed samples to cool to room temperature.
- Failing to read balance correctly.
- Placing additional samples in the oven while already drying another set of samples.

Equipment Needed

The authors recommend the following equipment for collecting fuel samples:

Weather kit: Use a belt weather kit or a calibrated handheld weather meter to collect weather data if a remote automated weather station (RAWS) is not in close proximity (i.e., it represents weather affecting the sample site).

Clippers: Choose good-quality pruning shears with two curved sharp blades. Keep two pairs of clippers available onsite. Sharpening may be necessary during the field season.

Garden trowel: Use a trowel with a heavy shank and a sharp blade to sample duff moisture.

Fuel gauge: Use a fuel gauge to check the diameter (size class) of dead woody fuel.

Ruler: Use a ruler that resists breakage, repels water, and is long enough to measure duff depths.

Clipboard: Use a covered clipboard to hold the fuel moisture content form, field notes, pens or pencils, paper clips, and the fuel moisture sampling field guide.

Chainsaw: Use a chainsaw to collect 100-hour and larger samples (Zahn and Haase 2006). *Note: Ensure that the chainsaw operator adheres to all agency safety regulations for operation and use.*

Containers: Use one of three types of fuel sampling containers: (1) high-temperature polypropylene bottles, (2) aluminum soil sample cans, and (3) specially designed zipper-lock or self-sealing bags. Based on studies completed by the San Dimas Technology and Development

Center (SDTDC) of the Forest Service, U.S. Department of Agriculture, and the Forest Service's Pacific Southwest Research Station's Riverside Fire Lab, the high-temperature polypropylene bottles are recommended for use; glass bottles and zipper-lock or self-sealing bags are not recommended (Haase and Zahn 2007).

Use sampling containers that will hold the largest anticipated sample size, have tight-fitting or sealed lids, are rustproof, are able to withstand high heat, and have permanent sequential numbering. Mark all containers and lids using permanent markers; in addition to permanent markers, you also can use etching or stamping tools to number metal containers and lids. Mark each lid and each container pair with the same number; container and lid weights may vary.

Ensure that all containers are rust-free, clean, and in good shape. Replace any damaged bottle, can, or lid, or a lid that does not seal. If lids are switched between containers, remove the old numbers and weight markings. Then, renumber and reweigh.

Remove all fuel particles from the containers. If needed, wipe the containers with a damp cloth. Ensure that no foliage adheres to the sides or bottom of a container, especially with live growth samples. It may be necessary to soak the containers in soapy water to remove material. Thoroughly dry the containers.

Paint can opener/standard screwdriver: Use to open aluminum sample containers.

Pole saw: Use to collect sample material up high in the trees.

Compass saw or keyhole saw (12 inch): Use handsaws with narrow blades for cutting circles and curves in wood. Use the compass saws for slightly heavier work; they have longer, coarser blades than keyhole saws.

Carrying case: Use an insulated hard or soft plastic cooler large enough to carry all sample containers. If using aluminum cans for collecting, transport them in an insulated hard plastic cooler so not to damage the cans in transit.

Gloves or hot pad: Use heat-resistant gloves with a fair amount of flexibility or hot pads to remove heated samples from the convection oven. Also, while in the field, always use gloves to protect hands and to prevent hand oils from touching the fuel samples.

Ovens: Use a standard convection oven for fuel moisture sampling (Hasse et al. 2007). Convection ovens come in many sizes with a wide range of drying temperatures. The convection oven must be able to maintain a regulated temperature and have adequate volume to allow air to circulate freely around all samples. Convection drying ovens often have large temperature variations within them, particularly older and low-cost ovens. Check the oven temperature at the beginning of each field season. Use a thermometer designed for oven use to verify the actual temperature within the oven.

Figure 1—Various types of drying ovens.

Note: Over the last few years, rapid-response ovens for drying fuel moisture samples have become available. The primary selling point for these rapid-response ovens is that they can analyze fuel moisture samples in a fraction of the time of a standard convection oven. The rapid-response ovens are self-contained so that the user does not need a balance or conventional drying oven to obtain moisture content of organic material or soils. When compared to the convection oven, the rapid-response oven uses a smaller sample and often has a higher drying temperature. Research is underway by the Riverside Forest Fire Laboratory and SDTDC to compare the convection and rapid-response ovens. We anticipate publishing the results.

Scales: Use an accurate scale for weighing the samples. Use the same scale for weighing containers prior to going to the field and weighing the samples when you return to the processing site, both before and after drying. Calibrate the scale each day it is used and/or each time it moves to a new location.

There are two types of scales:

- ***Electronic***: A top-loading electronic scale capable of accurately measuring to the nearest 0.1 gram is adequate. Some scales are battery operated, which make them suitable for field use, but beware that movement (i.e., a breeze) may make the scale produce an erroneous reading. Check your electronic scale's operation manual to see if the scale can self-calibrate or if you must return it to the manufacturer for adjustment.

- ***Balance Scale***: A top-loading beam or torsion balance scale is capable of accurately measuring to the nearest 0.1 gram. These scales are adequate for weighing most fuel samples. Calibrate the beam or torsion balances according to the manufacturer's directions using the calibration weights provided.

Place either scale type on a firm, level surface, such as a heavy table or countertop. The area must be free from drafts or vibration that can cause movement of the scale mechanism and cause inaccurate readings. Ensure that the scale pan is clean. Check scales for accuracy before the field season so that new parts or the replacement of a damaged scale does not interfere with field-season sampling.

Site Selection

Climate—and the physiological responses of live fuels to climate—are the primary influences on fuel moisture. Sampling sites may be permanent or project specific (i.e., prescribed burn project), so ensure that the samples are taken from the same site. The sample site should be representative of the fuel complex of interest. Sample sites should include a range of conditions, such as microclimate, aspect, slope, soil quality, elevation, topographic features, and settings that might influence the fuel within the fuel complex. Choose a site that is located away from heavily used roads or trails but is easily accessible.

Use line transects. Transects allow for repeatable results since individuals follow the same path each time samples are taken. Transects capture the elevation differences, slopes, and aspects across fuel moisture sampling sites. The number of transects needed depends on the amount of variation within and outside a project area. Generally, the number of transects increases with the size of the project. You can sample a project area with one aspect, similar slope, and a single species with one transect running from the bottom to the top of the slope or project boundary. Use additional transects if there are significant differences in species, aspect, slope, or other characteristics. The time spent to collect the samples varies based on species, plant material and amount collected, and the sampler's experience collecting samples. One rule of thumb is to allow yourself approximately 2 hours per transect.

Establish collection routes to provide access to all parts of the sampling area before collection begins. These routes may weave through the area or may follow more or less straight lines, following the changes in topography. Some pruning and slashing may be necessary in dense vegetation.

Choose reasonably undisturbed sites; however, areas with heavy browsing, fuel treatments, or other disturbances may be the representative fuel that you have selected.

Try to locate the site near a RAWS or in an area with a manual weather station that represents the sampling site well. Location of the site near a weather station allows you to study the long-term correlation of fuel moisture cycles to weather. If neither weather station is available, then you will need to take the weather manually when collecting fuel samples.

Figure 2—Remote Automatic Weather Station (RAWS).

Sites for Establishing and Monitoring Seasonal Trends

A permanent fuel moisture sampling site for establishing and monitoring seasonal trends, such as those used in the NFDRS, should range from 5 to 10 acres in size depending on the amount of fuel available for sampling. Areas with sparse vegetation and greater spacing between plants and dead down material may need a larger sample area than a site with heavier concentrations of fuels with tighter spacing.

Year-to-year comparison of fuel moisture levels and trends is an important function of permanent sampling sites, so these sites should be located in areas that are not likely to be disturbed over a period of years.

To ensure that significantly different fuels and/or geographic variations are included to prevent duplication of efforts, interagency partners should work closely with agency personnel when establishing new sites.

Sites for Use in Management-Ignited Prescribed Fires or Wildland Fires

If fuels surrounding the project area are distinctly different from those within the project area, then include the surrounding fuels in the sampling effort. This helps in planning contingencies in the event that the prescribed fire escapes or in assessing trigger points for wildland fires managed for multiple resource values.

The size of the sampling site may vary; however, it should be about 5 acres and relatively homogeneous in terms of species composition and canopy cover. Areas with sparse vegetation and greater spacing between plants and dead down material may need a larger sample area than a site with heavier concentrations of fuels with tighter spacing.

Mark transects for prescribed burns with stakes or flagging so that you take fuel samples from the same area each time.

Site Selection Documentation

Include basic site information on a site description sheet (see appendix A) or on an electronic version of this form on the National Fuel Moisture Database at <http://72.32.186.224/nfmd/public/index.php>.

Include the following information for either permanent or temporary sites:

- Latitude and longitude.
- Elevation.
- Aspect.
- Position on terrain (low, midslope, or ridgeline, and so forth).
- Percent canopy cover of dominant species.
- Average ratio of live to dead material in the collected species.
- Percent coverage of surface vegetation type in the fuel complex.
- Percent cover of bare mineral soil.
- Nearest RAWS or manual weather station.
- Aerial photo covering the fuel complex.

To establish a permanent site, the site documentation also should describe vegetation the first year immediately following full green up after the plants have finished maturing.

Plot transects for prescribed burns on a project map; this helps in the evaluation of fire results and fire behavior.

Site documentation should include digital photographs taken at established photopoints on the sites looking at the four cardinal directions. Take the photos during site selection, preferably in the middle of a day while the sun is directly above to minimize shadows. A brightly colored, vertically placed meter stick or other visible object aids as a size reference for the vegetation. Use a whiteboard or a white paper with large text in the photograph that contains the plot name, date of the photos, and the compass direction. More photos looking downward toward the fuels will be useful for characterizing surface vegetation, duff, litter, and the amount of exposed soil. Take site photos annually, or after a major disturbance, such as frost kill, branch breakage, or postprescribed burn.

Sampling Time of Day, Periods, and Frequency

How often you take samples depends on why you are sampling and what material you are sampling.

Sampling Time of Day

Take fuel samples at the same time each day. Collect the samples during the hottest part of the day, usually between 1100 and 1500 in the spring and summer and between 1100 and 1400 in the fall. If correlating your sample outputs with NFDRS weather observations, it would be ideal to collect samples during the time that local NFDRS weather observations are collected. Do not collect samples when they are wet from rain, dew, or fog.

Figure 3—Morning moisture on vegetation.

Sampling Periods

Periods for Monitoring Seasonal Trends

Sample live fuel moistures throughout the year; however, in some areas, year-round sampling may not be necessary or sites may not be accessible. If this is the case, weekly sampling may be necessary through that portion of the season when live fuel moistures are changing rapidly. Establish starting and ending dates for each State or geographic area. To identify trends in species, start live fuel moisture sampling in the early spring, well before the fire season begins, and end well into the fall. Try to sample throughout the entire growing season, recognizing that some evergreen-leaved shrubs will not begin to show new growth until well after deciduous vegetation and grasses have begun to green up. Once you establish fuel moisture levels and trends for key indicator species, shorten the sampling period.

Frequency for Monitoring Seasonal Trends

Usually, live fuel moisture changes slowly. Therefore, sampling periods about 10 to 14 days apart normally are sufficient to indicate moisture trends; however, additional sampling may be desirable during prolonged heat waves or foehn wind periods, such as Santa Ana or Chinook winds. If conducting year-round sampling, the sampling interval may drop to once a month until new growth starts. Then, transition to 10 to 14 days apart.

Moisture content of soil and 1,000-hour dead fuels changes slowly. Therefore, sampling periods about 10 to 15 days apart normally are sufficient to indicate moisture trends; however, additional sampling during prolonged heat waves or following precipitation may be desirable.

Typically, herbaceous and deciduous vegetation has the most moisture in late spring and becomes drier through the summer and into the fall. However, moisture levels of conifer needles are lowest in the spring. Surges in live fuel moisture may occur in some species or in some areas in late summer or early fall when significant precipitation occurs.

Sampling Period for Management-Ignited Prescribed Fire

Sampling live fuel moistures for a year or more prior to a prescribed fire may provide valuable information on the best time of year to implement a prescribed burn project to meet project objectives. This can be particularly important if the seasonal pattern and range of values of foliar moisture for key species are unknown.

Sampling Frequency for Management-Ignited Prescribed Fire

Sample fuels during the weeks before and during planned prescribed fire ignition to determine when required fuel moisture conditions are met. However, sample small down and dead woody fuels, litter, and mosses and lichens daily because of their quick response to changes in weather.

If the prescribed fire is planned for a certain time of the day, such as late afternoon, collect fuel moisture samples daily during that time before the planned ignition. Sample these fuels at intervals throughout the day to determine when conditions are nearest to those called for in the prescription. Temperatures and humidity often can change rapidly in the late afternoon and evening hours in midsummer and late summer, which can be critical for the success of the project.

Sampling Methods to Evaluate the Effect of Rain on Seasonal Trends

We recommend taking additional samples if ½ inch (1.26 centimeter) or more of rain occurs within the normal 2-week sampling period. Take these collections daily during the 5 days following the rain. If sampling on the first day after a rain is not possible due to the presence of water on the leaves, use four sampling days. Use the same sample plots and techniques used to establish trends and comparisons of moisture contents between species (Rice 1989).

Number of Samples and Sample Size

The number of samples and sample size may vary based on the collecting objectives and the species or fuels sampled. Most units and researchers have adopted Countryman and Dean (1979) or have developed their own variation of the number of samples and sample size. We recommend additional research to determine the appropriate number of samples and sample size based on species and objectives.

Table 1 lists literature sources and their recommended number of samples as well as the sample size.

Prior to Leaving for the Field

Set up the processing area to receive your samples prior to going to the field. Make sure all containers are clean and undamaged.

You will need to know the empty (tare) weight of each container. Make sure to set the scale to zero before weighing each empty container. Minor vibrations and movement of the scale can affect the calibration adjustment; this includes air-conditioning vents or room drafts.

All containers and lids should be marked with a matching number or other identifier and weighed together. Record the tare weight on the fuel moisture content form.

Make sure that you have all field equipment and it is clean and operable before going to the field.

Figure 4—Fuel moisture sample container.

Arriving on Site

When you arrive at the sampling site, place the sample case in a shady spot and prepare the fuel moisture content form. Record the weather if a RAWS is not in close proximity.

Note: If a RAWS is used, document the RAWS utilized and make sure to record the weather data for the same time the samples were taken on the fuel moisture content form.

Take one container with lid, clippers, gloves, and any other equipment needed to sample.

Table 1—Literature sources, number of samples, and sample size

Literature Source (see references)	The Number of Samples	Each Sample Size
U.S. Fish and Wildlife Service (2004) http://www.fws.gov/fire/downloads/monitor.pdf	20	40-80 (wet weight)
Countryman and Dean (1979)	3	25-35 g (dry weight)
Norum and Miller (1984)	Based on presampling	Amount that fits in a 2½-inch diameter soil can
Pollet and Brown (2007)	5-15	Container ¾ full.
Brenner (2002)	15-20 plants. In evergreen plants, for which the current year's growth is obviously different from past years', collect 6-7 samples of new and 6-7 samples of the previous year's growth from each plant; continue with separate samples until there is a difference equal to or less than 5 percent fuel moisture.	40-80 g (wet weight)
Cohen et al. (1995)	20 plants 20 species	40-80 g (wet weight) 20-35 g (dry weight)
Stonex et al. (2004)	Based on presampling	20 g (wet weight)
Rice (1989)	3 per species or fuel size	At least 0.35 oz or 10 g
Sequoia Kings Canyon National Park	3	Container ¾ full
Region 2 Live Fuel Sampling Procedures	20 samples from 20 plants	40-80 g (wet weight)
Loomis and Blank (1981)	10 per plant group	5 g

Material To Collect

The fuels you collect and process may include live and dead fuels; each has its own specific collection method.

Figure 5—Cutting and collection of fuel samples.

Live Fuels

Depending on your reasons for sampling, the species collected should be one with the greatest potential to carry a fire or the one that you feel best represents all of the species in a fuel complex. Become familiar with the species that you are sampling. If you are concerned about more than one species in the fuels complex, then sample all species of concern.

Ensure that the moisture content derived from fuel samples best represents the average moisture for the sampling area. Fuel moisture content can vary within the same plant so, depending on species and location, collect samples from all sides of the plant and from different heights above the ground. Do not sample deep within the interior of the plant because that material may represent senescent (aging) or ephemeral (short-lived) foliage. Do not collect diseased or damaged stems or leaves. Collect the material from as many plants as possible; collect this material from the entire sampling area each time that samples are collected.

Variation in moisture content of 20 percent is common even if you sample perfectly. Minimize sample variation by collecting several samples at the same location and collect the same proportion of material from the same parts of the plant. Management decisions, such as those concerning the start of fire season and management-ignited prescribed fire, can tolerate a variation of approximately 15 percent; however, when the moisture content of plants decreases below 100 percent, the accuracy of the information becomes more critical.

Plant Phenology

Phenology is the study of the annual cycles of plants and how the plants respond to seasonal changes in their environment. Phenology refers to the timing of flower emergence, sequence of bloom, fruiting, and leaf drop. It is important for you to understand the plant phenology of your particular species of interest to ensure that you sample properly.

Noting the occurrence of the plant's physiological changes each time live fuel samples are collected provides useful information for describing potential flammability and for comparing physiological responses from site to site or from year to year.

The following descriptions are based on average conditions. Record these descriptions on the fuel moisture content form.

New growth:

Figure 6—Starting new growth.

- Starting: First appearance of new leaves or flower buds. Depending on the species, flowering may be the first indication of the beginning of growth.
- Continuing: New growth or flowering has progressed enough to provide more than a ½-inch new growth on most growing stems, or most flowers are developing seeds. Circle both starting and continuing on the fuel moisture content form.
- Complete: New growth and flowering is complete. Old growth is no longer distinguishable from new growth.
- None: Any new growth was complete at the previous sampling. No new growth or very little growth or change is occurring.

Flowering:

Figure 7—Continuing or peaking of new growth.

- Starting: First appearance of flowers, only occasional flowers are in view. You may observe this stage on more than one sampling date.

- Peaking: Flowers are on most flowering stems. You may observe starting and peaking on the same sampling data.
- Declining: Few new flowers are in view, and some flowers are turning color, dropping petals, or dropping intact. In a few instances, both peaking and declining may occur.
- Drying: New flowers are absent or rare. Nearly all flowers are turning color or dropping. In some seasons declining and drying may occur together.
- None: Flowers are absent or isolated on a few plants. If a few plants have some flowers, make a note under remarks.

Fruit:

- Presenting: Seeds, berries, or nuts are in view but are green and/or soft.
- Ripe: Seeds, berries, or nuts appear to be mostly ripe and are beginning to fall.
- Fallen: Most seeds, berries, or nuts are gone.
- None: Fruit is gone or is rare and isolated to a few plants.

To access information on plant phenology, visit the fire effects information system database at <http://www.fs.fed.us/database/feis>.

Collecting Live Fuels

Do not collect live fuels if water drops are present on leaves or stems. Shaking the leaves to remove excess water is not adequate because there is enough free water to bias the sample.

The intent of live fuel moisture sampling is to characterize the fuel moisture for the area. Randomly select material (not recently sampled) that is located at least several paces away from other collection points. The samples should cover a range of conditions, including elevation changes from the lowest to the highest, all aspects within the project area, moister or drier areas, shaded to more exposed areas, higher and lower concentrations of fuels, younger and older stands, and any other variation that may influence fuel moistures. Collect samples throughout the sampling site following appropriate local protocol.

As you move about the site and collect material, replace the lid on the container to cover materials already collected. Do this because sample material can become rigid as it dries, and some material may be lost from containers while in the drying oven. If using metal containers, the lids may be difficult to replace and some of the sample may fall out. Cut material into pieces 2 to 3 inches long so the material fits easily into containers. Never compress the fuels to get additional material into the container. Loosely arrange the material in the containers. It is better to fill several containers than to force too much into one container.

When the desired amount of material is collected, immediately replace the lid tightly and seal. Be sure no dirt or debris clings to the outside of the sample container. Record any comments or observations about plant phenology or other concerns on the fuel moisture content form.

Secure the containers and the fuel moisture content forms in the carrying case. Keep the samples cool and dry until you weigh them (see storage section). If the collected samples receive even moderate heat, some moisture evaporates, yielding an error. Furthermore, decomposition could begin, causing a loss in sample weight and calculation errors.

Herbaceous—Live Grasses and Forbs

Some herbaceous plants sprout from roots, rhizomes, or overwintering basal leaves several weeks after the herbs have leaves. Therefore, the mix of species of herbaceous plants collected may change markedly the first few weeks of the growing season.

Grasses

Collect only the leaves of grasses and sedges. Some live blades may have gray, shriveled material that died the previous year at their tips. This is because leaves form continuously from the same growth point for several seasons. Clip these portions and discard the gray tips. Do not collect stems, seed heads, or succulent white or pale-green leaf bases.

For tall grasses, clip the leaves from all vertical portions of the plants, cutting the blades near their point of attachment to the stem. This is particularly important late in the season because the lower blades begin to dry and cure earlier than those near the top of the plant.

For low-growing bunchgrasses, clip blades of different lengths from each clump; include only the leafy material and not the base of the leaves. Clip several blades from each clump.

In some species, individual blades die back during the summer starting at the tip. Do not remove this reddish brown part of the leaf because it is part of the seasonal growth. *Note: The current year's dieback color is usually distinguishable from the previous year's dieback color, described above as gray.*

Later in the season, when entire blades are cured, include them in the sample in proportion to their presence on the site.

Forbs

Collect the entire plant of small, single-stemmed forbs by clipping the stem at ground level. If a species has multiple stems, cut one stem with leaves from each plant.

If you are collecting a large volume of sample material, take the entire stem of a large plant instead of small parts from multiple stems. Remove and discard all flowers and fruits in any stage of development from all forbs; keep the stems and leaves.

Shrubs

Collect only the new, small-diameter stems and their associated leaves or needles. Use clippers and clip foliage and/or pliable small-stem material (up to ¼-inch diameter) and put into the sampling container. Many shrubs tend to produce most of their new growth on upper branches, so focus in those areas.

Figure 8—Examples of old growth (left) and new growth.

Collect samples of new growth and old growth (mature foliage/stems) in separate containers until new growth is not distinguishable from old growth in the field or until new and old growth fuel moistures are within 5 percent of each other. Later in the season, when fuel moistures are within 5 percent of each other, you can combine foliage/stems for new growth and old growth into the same container.

Figure 9—Fuel sample in container.

Collect samples from both exposed sunny locations and shaded locations. Collect samples from approximately 10 to 20 individual plants at different areas or compass points around each plant. Eliminate all dead twigs and twigs with diseased or insect-infested needles and leaves. Do not include flower buds, flowers, seedpods, or berries at any stage of development.

Due to the differences in species from one area to another, use a locally designed protocol in determining specific collection methods that are most appropriate. For example, bitterbrush (Purshia tridentata) is technically a deciduous leaved shrub, but its growth form is most like sagebrush, a broadleaf evergreen shrub with tiny leaves. The Rocky Mountain Region (Region 2) of the Forest Service, U.S. Department of Agriculture, determined that it is most appropriate to sample bitterbrush and sagebrush the same way.

There are two methods used to collect sagebrush.

- Method 1: For shrubs with leaves that appear on relatively nonwoody stems but with current year's growth that is not easily distinguishable from the previous year's, clip both leaves and stems only to the point where the stem transitions from pliable and green to becoming brown and woody. Do not collect any stem material larger than ¼-inch diameter. This generally includes only the current year and the previous year's growth.

Figure 10—Sagebrush.

- Method 2: Collect foliage by hand-stripping leaves from stems. Collect from the outer portion of the plant, avoiding reproductive (flower/seed) stalks and leaves on old growth material.

Regardless of the method selected, describe the method used on the fuel moisture content form and use that method throughout the season and in subsequent years. The sample material you collect and the method you choose influences results from one sampling period to the next and from one year to the next. Consistency, documented on forms year after year, makes data comparisons stronger and more reliable; less assumptions occur.

Trees

Figure 11—Pine needles.

Evergreen Needle Trees: Fir, pine, spruce, juniper
Collect needles from all sides and at various reachable heights of the tree. Use a pole saw to reach upper portions of the tree. You can sample several trees of the same species using one container; take equal amounts from each tree. A bud scar located on twigs at the end of each year's growth separates needles formed each year. Collect the foliage by clipping the twig at the bud scar between the 1- and 2-year-old needles. The needles attached just below the scar are inclined at a sharper angle to the branch than are the other needles. In addition, the stem of 1-year-old growth is lighter brown than the dark and slightly woody stem segment that grew the previous year. Do not include twigs, stems, dead or diseased foliage, buds, cones, or berries in any stage of development.

Broadleaved Evergreen Trees: Oak (coastal live oak, scrub oak) madrone, hickory, American holly
Collect leaves from all sides and at several reachable heights of the tree. You can sample several trees of the same species using one container; take equal amounts from each tree. If you cannot identify the new growth, collect the sample by clipping both leaves and stems only to the point of stem transition from pliable and green to becoming brown and woody. Do not collect any stem material larger than ¼-inch diameter.

If new growth is identifiable from old growth, collect new foliage samples once the bud scale covering is lost. Place the new foliage and the previous year's mature growth in separate containers. Do not include dead or diseased foliage.

Figure 12—Oak trees.

Deciduous Trees: Oak (Oregon oak, valley oak), maple, beech, aspen, cottonwood, alder
Collect leaves from all sides and at various reachable heights of the tree. You can sample several trees of the same species using one container; take equal amounts from each tree. Collect new foliage once the leaves have begun to form on trees and continue to collect until the leaves drop or the trees become dormant. Collect only foliage. For deciduous trees, do not include twigs larger than ¼-inch diameter, branches, or dead or diseased foliage.

Mosses and Lichens

Collect separate samples of living mosses and lichens in the upper part of the layer and the dead mosses and lichens beneath them. Grasp a few moss and/or lichen stems and gently pull them from the moss and lichen layer. Clip off the highly decomposed dark brown moss and the dark or obviously decomposed lichens at the base of the layer. Pinch off the plants at the boundary between the upper and lower layer. Then, separate the living plants from the dead ones by pulling or clipping them apart. Remove all twigs, undecomposed leaves, plant stems, and rhizomes. Repeat this process at several locations until you have collected the amount desired in each container.

Do not mix different species. Individual species can retain different amounts of free water, which can affect fuel moisture calculations. For large quantities of lichen or deep layers, it may be necessary to trim off dead roots or dead parts from the live or dormant parts before putting the samples in containers (Norum and Miller 1984).

It may be necessary to collect more than one moss or lichen species per container instead of separating the species, depending upon their arrangement and proximity in the environment. In a matted area of many species, collect a composite sample of multiple species that has the same proportion of each species in the container as the amount of that species at the collection site.

Another method is to cut a 15- to 20-square centimeter plug to mineral soil or permafrost with a keyhole saw. Remove the plug intact by hand or with a long-bladed shovel. Record the thickness of the upright plug. Lay the plug on its side and mark 5-centimeter increments, beginning at the surface–downward on all four faces. Maintain the thickness measurement of the upright plug when you lay the plug on its side. Carefully cut away each 5-centimeter segment using the markers as a guide. Determine fuel layers visually by degree of decomposition (Norum and Miller 1984). Place material from the desired levels into containers. While in the field, record the sample depth to the nearest 0.5 centimeters, the fuel layer, and the tare weight.

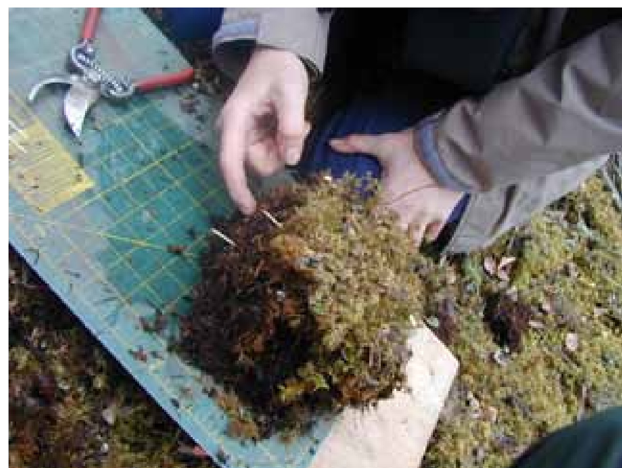

Figure 13—Collected moss sample.

Dead Fuels

Ensure that the moisture content derived from the fuel samples best represents the average moisture for the sampling area. Collect the material from several sites within the entire sampling area each time you sample.

In order to obtain good site representation, collect samples throughout the site from different down and dead material and not just from one location or from one single branch. Take samples from material resting on the ground but do not collect material buried in litter, duff, or soil. Detach each sample from its growth point, such as the base of trees, green branches, or shrubs.

Dead fuels consist of small- to large-diameter woody fuels (woody refers to a plant with stems, branches or twigs that remain from year to year and support leaves, needles, and cones) found on the ground.

These fuels consist of all dead material on the forest floor. They can be natural fuels, which are the result of natural plant growth and death, or activity fuels, which are the result of human activity, such as logging and thinning.

Figure 14—1-hour dead fuel sample.

Dead Fuels	Timelag	Fuel Size
Small twigs	1-hour	0-¼ inch
Larger twigs	10-hour	¼-1 inch
Small to moderate branches	100-hour	1-3 inches
Large branches, small trees	1,000-hour	3-8 inches

The wood you collect does not have to be completely solid or hard (sound), but it should not be decayed to the point of crumbling to powder or splinters when rubbed between your fingers. Some splitting caused by drying is acceptable. Wood, in various stages of decay, should be collected in proportion to its presence on the site as long as you follow the previously stated rule. Make a note on the fuel moisture content form whether the material is sound or rotten.

Collecting Dead and Down Fuels

Collect samples from a combination of shaded and unshaded areas. Remove all lichen or other debris and very loose pieces of bark from the samples prior to placing them in the sample container.

Delay the collection of fuel samples until the next day if water drops from rain or dew are present on the material because the presence of this added moisture will cause large errors in calculating moisture content. Shaking the sample to remove excess water or attempting to dry the sample in any way is ineffective.

1-Hour Fuel Samples

Small Twigs: Collect twigs of as many sizes as possible within the size class. All samples must be collected from dead wood that is detached from its growth point. Do not collect parts buried in the litter, duff, or soil and do not collect dead branches attached to the base of live trees or shrubs. Place the material in the sampling container and tighten the lid.

Note: You can estimate 1-hour fuel moistures from environmental factors using tables found in the "Fire Behavior Field Reference Guide 1992" or using the Fine Dead Fuel Tool in BehavePlus. BehavePlus is a Windows software application to predict wildland fire behavior for fire management purposes. BehavePlus is designed for use by trained, professional wildland fire planners and managers familiar with fuels, weather, topography, wildfire situations, and the associated concepts and terminology. Ten-hour fuel sticks are standard at all NFDRS sampling stations and provide a relative measure of drying.

Figure 15—Fuel stick at RAWS station.

10-Hour Fuel Samples

Larger Twigs and Small Branches: Take samples of ¼- to 1-inch-diameter down and dead woody fuels from several branches resting on the ground. Collect all samples from dead wood that is detached from its growth point. Do not collect parts buried in the litter, duff, or soil and do not collect dead branches attached to the base of live trees or shrubs. Cut the pieces with good quality pruning shears. Place the material in the sampling container and tighten the lid.

Note: If 10-hour fuel sticks are available at a NFDRS RAWS, the 10-hour fuel stick output from the RAWS may be used to estimate 10-hour fuel moistures rather than actual field sampling, but field sampling is recommended since it provides greater accuracy and comparisons to the RAWS estimates.

100-Hour Fuel Samples

Small to Moderate Branches: Samples should consist of 1- to 1½-inch-thick cross sections or wafers. The sample should be lying in contact with the litter surface, but not have more than one-half its diameter below the litter surface. Take branch wood at least 3 inches from the end of the branch. The sample should not have any bark when possible. If any samples include bark, note that fact on the fuel moisture content form. The samples with bark will probably have higher moisture contents and you should collect and test them separately. Take the samples from logs that represent the common overstory trees that you can cut with a chainsaw (Zahn and Haase 2006). Each wafer represents one sample. Place the wafer in the sampling container and tighten the lid.

1,000-Hour Fuel Samples
Large Branches to Small Trees: Samples should consist of 1- to 1½-inch-thick cross sections or wafers. The sample should be lying in contact with the litter surface, but not have more than one-half its diameter below the litter surface. We recommend taking the cross sections or wafers approximately 3 feet from the ends of the log or at a distance where the moisture likely represents the average moisture of that log as compared to the ends, where decay and/or small cut or broken splinters may dry or absorb moisture differently than the main part of the log. The sample should not have bark when possible. If any samples include bark, note that fact on the fuel moisture content form. The samples with bark will probably have higher moisture contents, so note this sample characteristic to account for differences in moisture percentages. Take the samples from logs representing the common overstory trees that you can cut with a chainsaw (Zahn and Haase 2006). Each wafer represents one sample. Place the wafer in the sampling container and close. If the sample is too large for the container, it can be broken using a chisel and hammer and placed in the container immediately.

Figure 16—Sampling of 1,000 hour fuels.

Note: You can also collect 100- and 1,000-hour samples by using a brace and large wood bit. To do this, bore at least two cross-section holes completely through the material at 45-degree angles to each other. Use the wafer-collection method and bore the holes at least 6 inches from the ends of the log or any other previously drilled holes. Place the material in a container and tighten the lid.

Other methods you can use to measure 100- and 1,000-hour fuels are:

- Insert a moisture probe into branches or logs and note the readings.
- Place a piece of branch or log that has been oven dried to a known dry weight at the fuel moisture collection site. Then, measure the increase in fuel moisture. This procedure is similar to how we use 10-hour fuels sticks to measure moisture content.

If consistently followed, these methods may all be acceptable. Note which sampling method you used in the remarks section on the fuel moisture content form.

Herbaceous—Dead Grasses and Forbs
Herbaceous: Remove and discard all dead flowers and fruits from all herbaceous plants. Clip the material into pieces and fill the container with the desired amount.

Grasses: Clip dead blades from all vertical portions of tall grasses. Collect blades that are brown or tan, not gray or decomposed. Collect the entire sample and then clip it into short pieces as you place it into the sample can and tighten the lid.

Forbs: Collect the entire dead plant of small, single-stemmed forbs; clip the stem at ground level. If species have multiple stems, cut one stem with leaves from each plant. Clip the plant into short pieces as you place it into the sample container, then tighten the lid.

Litter and Duff

The moisture content of litter and duff is an important factor of the effects that a wildfire or prescribed burn has on vegetation on the forest floor. Moist litter and duff minimizes consumption of the litter or duff layer. The Keetch-Byram Drought Index is a number that represents the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in the deep duff or upper soil layers. Therefore, monitoring these layers is important for following fire-danger trends.

To differentiate between the litter, duff, and soil layer use these rules of thumb:

- Material in the litter layer is generally not compacted, but organized enough for slight compaction to begin.
- Material in the duff layer decomposes so that the original plant species is not readily recognizable.
- Duff layer often contains a very dense network of very fine hair-like strands, called fungal hyphae.
- Soil particles are generally easy to feel when you rub them between your fingers. The particles fill the indentations in your fingertips.

Sometimes deciphering where the litter turns to duff and the duff to soil is difficult. You can use the 50-percent rule to help. The 50-percent rule is based on if 50 percent or more is the desired material, then collect it. Conversely, if 50 percent or more of your sample is not the desired material, leave it alone. For example, if the duff has more than 50 percent soil particles, then you have collected too deep a duff sample and it is more of a soil sample

Litter

Litter includes the loose surface layer of dead grasses, recently fallen leaves, needles, and so forth where the individual pieces are still easily identifiable and little altered by decomposition.

Gather litter (pine needles, cone debris, and so forth) from both sunny and shady spots within a stand, burn unit, or area of interest. If the canopy is uniform, visit only a few locations. Collect only uncompacted dry leaves. Usually the upper ½ inch of leaf litter has whole, undecomposed leaves suitable for collection. Place in the container. Do not overstuff.

Figure 17—Preparing to collect litter and duff samples.

Duff

Duff lies below the litter layer and above the mineral soil. It consists of litter material that has decomposed to the point that the individual pieces are no longer easily identifiable. The duff layer is generally darker than the litter layer and is cohesive because of the fine plant roots and fungi growing in the duff material.

Choose duff samples carefully and selectively. Cut standardized squares of duff (approximately 4-inch-square on top) and separate the litter and duff layers. Cut duff plugs with a 12-inch compass saw from the live moss or litter at the surface down to mineral soil. Using the blade of a trowel or knife, carefully scrape the litter layer to one side. Then, return the blade to the point where the litter scrape 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 you see mineral soil at the bottom of the profile. Mineral soil is usually lighter in color than the duff and coarser in composition, and it is often sandy or gravelly. The depth of duff sample is important and is measured using the base of the moss/lichen/litter layer as a reference point. Note the duff depth on the fuel moisture collection form.

The upper layers of duff become wet and dry at a faster rate than deeper, more compact duff layers and may have significantly different moisture content. Select spots that are representative of the area, including shaded and nonshaded areas. Do not take duff samples from elevated mounds of moss or thick patches of lichens unless they are representative of the area.

Remove all live plant stems, roots, rhizomes, other parts of living plants, and animal droppings from the sample. Do not include mineral soil or rocks in the sample. Soil particles are usually easy to feel when rubbed between fingers, and soil particles will fill the indentations in fingertips.

Weighing and Storing Samples

To ensure accurate measurements and avoid false higher moisture values, weigh fuel moisture samples in the field immediately after you collect the samples (Brown et al. 2009). Record the weight in the gross wet weight column of the fuel moisture content form, appendix B.

Keep the samples cool and dry until you weigh them. If the collected samples receive even moderate heat, some moisture will evaporate, possibly escaping the container, or else it will remain as vapor and be lost when the container is opened, yielding an error. Further, decomposition could begin again, causing a loss in sample weight and subsequent errors.

If it is not possible to weigh the samples in the field, place the samples in an insulated storage container and transport. Do not place ice in the container; it will cause condensation. On hot days, you may want to precool the sample container with cold packs, but be sure to remove them and ensure that there is no condensation in the container. Weigh the samples immediately upon arrival at the location where you will process (weigh, dry, and record weights) the samples.

If it is not possible to process material right away, store the samples for a short period as follows:

On collection day, weigh the sealed containers and record the weight. Then, open the sample containers. Samples in the open containers can be stored for up to 48 hours at room temperature and up to 5 days in a refrigerator. Do not reweigh the samples when they are placed in the oven for drying; weight loss during storage will appear as part of the weight loss in the oven. Discard samples not processed within 5 days after collection.

Note: This method is not desirable. Note this extended drying and weighing process on the fuel moisture content form to account for any discrepancies in moisture data.

Drying

Internal oven temperatures vary depending on the oven manufacturer. Therefore, times required for drying fuel moisture samples vary. We found no scientific research on comparisons of different oven temperatures. We recommend further research into selecting oven temperatures and drying times for use in fuel moisture sampling. Table 2 lists available information on drying temperatures and drying times.

Select the desired temperature and turn on the oven before placing the samples inside.

Table 2—Drying guidelines

Literature Source (full citation in References)	Drying Temperature	Drying Time
U.S. Fish & Wildlife Service (2004) http://www.fws.gov/fire/downloads/monitor.pdf	80 ºC	24 hours
Clive M. Countryman and William A. Dean (1979)	103 to 105 ºC	15 hours
Rodney A. Norum and Melanie Miller (1984)	100 ºC	18 to 24 hours. Large samples of wet duff 48 hours
J. Pollet and A. Brown (2007)	100 ºC	24 to 48 hours, or until no loss in weight
Jim Brenner (2002)	80 ºC	24 hours
Jack Cohen et al. (1995)	80 ºC	24 hours
Scott Stonex et al. (2004)	60 ºC minimum	24 to 48 hours and no loss in weight for large fuels.
Carol Rice (1989)	93 ºC	24 hours
Sequoia Kings Canyon NP	103 to 105 ºC	15 to 24 hours
Richard M. Loomis and Richard W Blank (1981)	105 ºC	16 hours

After you collect the fuel moisture samples, weigh them as soon as possible (see sample storage section). Ensure that the scale is set to zero. Record wet weights on the fuel moisture sample content form.

Remove the lids from the containers and place the open containers in the drying oven. If the lid fits under the base of the container, place the lid beneath the container in the drying oven. Alternatively, place all lids in sequential order in a convenient place so you can quickly and easily replace the matching lid when you remove the dried samples from the oven. Space the containers evenly in the oven so that air can circulate freely around them. If you are drying only a small number of samples, group them near the center of the oven. Record the date and time that you place the samples into the oven.

Figure 18—Fuels samples drying in oven (autoclave nalgene bottles).

Do not put additional samples into the oven while drying a set of samples. If you do, the original samples will absorb moisture from the new samples and you may need to dry the entire set for an additional 24 hours depending on which drying guidelines you follow.

When you are ready to remove the samples from the oven, take only a few samples from the oven at a time and quickly replace the lids. If you are drying material not enclosed in a container (i.e., wafers or cookies from 1,000-hour dead fuels), ensure that you close the oven after removing each sample to maintain a constant temperature and not allow outside humidity to enter. Do not leave the oven door open for a long period, particularly if the humidity is high, because the samples can quickly absorb moisture from the air. If any sample material falls from a container as you remove it from the oven, throw that sample away, unless you are sure exactly what fell and can replace all of it in the container.

Allow the container to cool to the touch or to room temperature, then weigh the sample with the lid on as soon as possible. Hot air in the container may cause buoyancy, which may result in a weighing error, particularly if the samples are very light. Be sure to set the scale to zero before you weigh each sample. Record the dry weight to the nearest 0.1 gram. Check the container number and its contents before you record the weight on the fuel moisture content form. After you weigh and check each dried sample, replace the lid tightly on the container and save the sample until you calculate the fuel moisture content. If an obvious error appears in the calculation, reweigh the sample or double-check the container contents to find the cause of the problem.

Larger Fuels

For 100-hour or 1,000-hour fuel samples, remove the wafer from its container and weigh it. Place the wafer directly on the rack in the oven and dry for the desired length of time. Pull the wafer from the oven and weigh immediately. If the sample was very wet or heavy, you may want to return it to the oven for a longer drying time to reduce the moisture content. Continue this process until the sample reaches its lowest weight.

Calculating Moisture Content

After the sample has been collected, weighed, dried, and reweighed, it is time to calculate the fuel moisture content.

The formula for calculating percent moisture content is:

$$\frac{\text{(weight of water in sample)}}{\text{(dry weight of sample)}}(100) = \text{percent moisture content}$$

Use this formula for a simpler method:

$$\frac{\text{wet weight of sample - dry weight of sample}}{\text{dry sample weight - container tare weight}}(100) = \text{percent moisture content}$$

Here is an example:

Wet sample weight = 48.2 grams.
Dry sample weight = 46.9 grams.
Container tare weight = 38.1 grams.

Using the simpler method:

$$\frac{(48.2 - 46.9)}{(46.9 - 38.1)}(100) = \frac{1.3}{8.8}(100) = 0.1477\ (100) = 14.77 \text{ percent}$$

If you need to calculate the averages of many similar samples, keep to one decimal place to maintain precision, rather than rounding to the nearest whole number.

Use the fuel moisture content form found on the NFMD Web site to increase the speed and accuracy of the calculations. Whether you complete the computations by hand, calculator, or computer program, consider repeating the calculations to be sure they are correct.

Remember: One of the most common sources of error while processing samples involves these calculations.

National Fuel Moisture Database (NFMD)

The NFMD is a Web-based query system that enables users to view sampled and measured live- and dead-fuel moisture information. It provides a storage area for sampled live- and dead-fuel moisture, is a resource available to anyone with a need for fuel moisture data, and provides easy viewing of fuel moisture data in formats that are consistent with other applications used in the land management arenas.

NFMD is available to anyone with an Internet connection. The Web site—as well as user instructions—is located at <http://72.32.186.224/nfmd/public/index.php>. You will need a password to input data, which you can obtain through an administrator at your local geographic area coordination center.

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USDA Forest Service and U.S. Department of the Interior, Bureau of Land Management employees also can view videos, CDs, and National Technology and Development Center's individual project pages on their internal computer network at: <http://fsweb.sdtdc.wo.fs.fed.us/>.

For additional information on the national fire program, contact Ralph Gonzales, program leader, at SDTDC. Phone: 909–599–1267 ext 212. Email: <rhgonzales@fs.fed.us>.

Appendix A

Fuel Moisture Site Description Form

1. Date ______________________________
2. Observer ________________________
3. Unit ______________________________
4. Site Name or # __________________
5. Latitude ____________________________
6. Longitude ______________________
7. UTM Coordinates ____

8. Major Vegetation:

Tree species 1 ______________________________ percent cover____________
Tree species 2 ______________________________ percent cover____________
Tree species 3 ______________________________ percient cover ____________
All other trees ______________________________ percent cover____________

Shrub species 1 ____________________________ percent cover____________
Shrub species 2 ____________________________ percent cover____________
Shrub species 3 ____________________________ percent cover____________
All other shrubs____________________________ percent cover____________

Grass/forb species 1_________________________ percent cover____________
Grass/forb species 2_________________________ percent cover____________
Grass/forb species 3_________________________ percent cover____________
All other grasses/forbs ______________________ percent cover____________

9. Predominent aspect ________________
10. Predominant % slope ___________

11. Elevation (feet) ____________________
12. NFDRS fuel model _____________

13. Associated NFDRS or RAWS weather station number ________________________

14. Vegetation condition description of layer chosen for moisture sampling:

Average height (ft) _________________ Percent dead _____________________
Continuity of layer__________________

15. Photo numbers and descriptions ____
____
____
____
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Appendix B

Fuel Moisture Content Form

Agency	State	Field Office	Site Name/Number

Collection Record			Moisture Determination Record		
Observer	Date	Time	Observer	Date in oven	Time put in oven

Container Number	Species (Live) Size Class (Dead)	A Gross Weight Wet	B Gross Weight Dry	C Tare Weight	D Water Weight	E Dry Weight	F Percent Moisture

Sample Material Collected	Calculation Summary
Live Fuels ( ) Dead Fuels ( )	A - B = D B - C = E (D / E) * 100 = F Average of Samples

Weather (Optional)

Dry Bulb __________ RH __________ % Wet Bulb _____________ Cloud Cover ______________

Remarks