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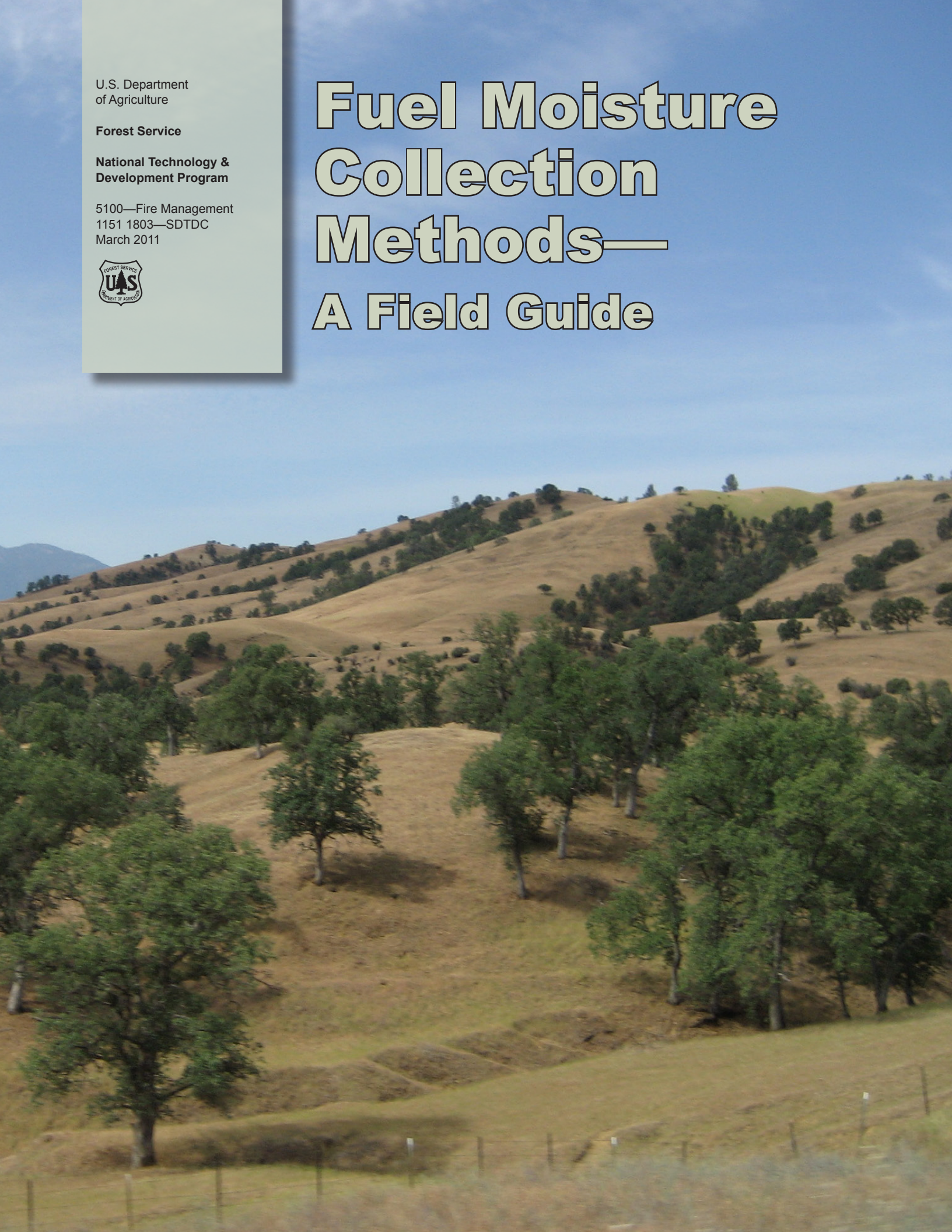
Fuel Moisture Collection Methods—

A Field Guide



Fuel Moisture Collection Methods—A Field Guide

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Prior to Leaving for the Field

- Read and become familiar with "A Synthesis of Fuel Moisture Collection Methods and Equipment: A Desk Guide."
- Become familiar with the species and material that you will collect.
- Ensure that the processing area is completely set up to receive the samples.
- Make sure all containers are clean and undamaged.
- Mark all containers and lids with a matching number or other identifier and weigh together.
- Record the weights of each container on the fuel moisture content form.

Equipment Needed

- Weather kit (if a remote automated weather station (RAWS) is not available).
- Clippers.
- Garden trowel.
- Fuel gauge.
- Ruler.
- Clipboard.
- Chainsaw.
- Containers.
- Paint can opener.
- Pole saw.
- 12-inch compass saw or keyhole saw.
- Carrying case large enough to carry all sample containers.
- Gloves. Always use gloves to protect hands and to prevent hand oils from touching the fuel samples.

Sampling Time of Day

- Take fuel samples at the same time each day.
- Collect fuel moisture 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.
- Collect samples during the time that local National Fire Danger Rating System (NFDRS) weather observations are collected.
- Do not collect samples when they are wet from rain, dew, or fog.

Figure 1—Morning moisture on vegetation.

Arriving On Site

- Place the sample case in a shady spot upon arrival at the sampling site.
- Fill out the fuel moisture content form.

Figure 2—Fuel moisture content form.

- Record the weather observations, site number, date, time, sampler name, and the container number for each fuel sample to be collected on the fuel moisture content form.

  Note: If a RAWS is used, document that fact and make sure to record the weather data for the same time the samples are taken on the fuel moisture content form.
- Take one container with lid, clippers, gloves, and any other equipment needed to sample.

Material To Collect

Live Fuels

Plant Phenology

The following plant descriptions are based on average conditions. Record one or more of the description titles listed below on the fuel moisture content form to capture the general life stage of the species that you will sample.

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 ½ inch of new growth on most growing stems; or most flowers are developing seeds. Circle both starting and continuing.

Figure 3—Continuing or peaking of new growth.

- Complete—New growth and flowering ARE complete. Old growth is no longer distinguishable from new growth.

Figure 4—Starting new growth.

- None—Any new growth was complete at the previous sampling. No new growth or very little growth is occurring.

Flowering

- Starting—First appearance of flowers; only occasional flowers are in view. One may observe this stage on more than one sampling date.
- Peaking—Flowers are present on most flowering stems. Starting and peaking can occur on the same sampling data and can be observed more than one time.
- 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. Declining and drying may occur together in some seasons.
- 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.

Collecting Live Fuel Samples

- Do not collect live fuels if water drops are present on leaves or stems.
- Randomly select material from multiple individual trees/shrubs/plants that are located at least several paces away from each other.
- Collect samples throughout the sampling site following appropriate local protocol.
- Replace the lid on the container to cover materials already collected as you move about the site and collect material.
- Cut material into pieces 2 to 3 inches long so the material will fit easily into containers. Never compress the fuels to get additional material into the container.
- Arrange the material loosely in the containers.
- Collect the desired amount of material (see the desk guide for additional information); 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.

- Arrange the containers in numerical order in the carrying case, with the fuel moisture content forms.
- Keep the samples cool and dry until weighed (see storage section of the desk guide).

Herbaceous—Live Grasses and Forbs

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.

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. Later in the season, when entire blades have 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 collecting a large volume of sample material, take the entire stem of a large plant. Remove and discard all flowers and fruits in any stage of development from all forbs, but 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) into the sampling container. Many shrubs tend to produce most of their growth on upper branches so focus in those areas.

Figure 5—Cutting and collection of fuel samples.

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 in the same container.

Figure 6—Examples of old growth (left) and new growth.

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 or 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 locally designed protocols in determining the most appropriate collection method. 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 the same way that one samples sagebrush.

There are two methods to collect sagebrush.

- Method 1—For shrubs on which leaves appear on relatively nonwoody stems but the current year's growth is not easily distinguishable from the previous year's, collect by clipping both leaves and stems only to the point of stem transition from pliable and green to 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 7—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 collection method on the fuel moisture content form. Continue using that method throughout the season and in subsequent years.

Trees

Evergreen Needle Trees – examples: fir, pine, spruce, juniper

Collect needles from all sides of the tree and at various reachable heights. Use a pole saw to reach upper portions of the trees. Several trees of the same species can be sampled 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.

Figure 8—Evergreen needles.

Broadleaved Evergreen Trees – Oak (coastal live oak, scrub oak), madrone, hickory, American holly

Collect leaves from all sides of the tree and at various reachable heights. Use a pole saw to reach upper portions of the trees. Several trees of the same species can be sampled 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 brown and woody. Do not collect any stem material larger than ¼-inch diameter.

If new growth is identifiable, begin collecting new foliage samples once the bud scale covering is lost. Place the new foliage and the previous years mature growth in separate containers. Do not include dead or diseased foliage.

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. Use a pole saw to reach upper portions of the tree. Several trees of the same species can be sampled using one container, take equal amounts from each tree. Begin collecting new foliage once the leaves have begun to form on trees and continue collecting until the leaves drop or the trees become dormant. Collect only foliage. Do not include twigs, branches, or dead or diseased foliage.

Mosses and Lichens

Collect separate samples of living mosses and lichens in the upper part of the moss/lichen 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.

Figure 9—Collected moss sample.

Do not mix different species since individual species can retain different amounts of free water, which can affect fuel moisture calculations. For large quantities or deep layers of lichen, trim off dead roots or dead parts from the live or dormant parts before putting the samples in containers.

Collect more than one moss or lichen species per container instead of separating the species, depending upon how they exist 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 15- to 20-centimeter-square plugs of mineral soil or permafrost with a keyhole saw. Remove plugs intact by hand or with a long-bladed shovel. Once extracted, record the thickness of the upright plug and place the plug on its side. Mark the plug in 5-centimeter increments from the surface downward on all four faces. Take care to maintain the thickness measurement of the upright plug when the plug is on its side. Carefully cut away each 5-centimeter segment using the markers as a guide. Determine fuel layers visually by degree of decomposition. Place material from the desired levels into containers. Record the fuel layer, the tare weight, and the sample depth to the nearest 0.5 centimeter while in the field.

Dead Fuels

Collect material from several sites within the entire sampling area each time that samples are collected. To obtain good site representation, collect samples throughout the site from different down and dead material and not 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. Each sample must be detached 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.

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 collected does not have to be completely solid and unbreakable (sound), but should not be decayed to the point of easily crumbling to powder or splinters when rubbed between your fingers (rotten). 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 one follows the rule stated above. Make a note on the fuel moisture content form whether the material is sound or rotten.

Collecting Dead and Down Fuels

Collect samples from both 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 other free water (i.e., dew, heavy marine layer, or fog) are present on the material. 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 as many twigs sizes as possible within the size class. Place in the sampling container and tighten the lid.

Note: One-hour fuel moistures also can be estimated from environmental factors using tables found in the 1992 Fire Behavior Field Reference Guide or by using the Fine Dead Fuel Tool in BehavePlus. Ten-hour fuel sticks are standard at all National Fire Danger Rating System (NFDRS) sampling stations and provide a relative measure of drying.

10-Hour Fuel Samples

Larger Twigs and Small Branches–Cut one piece about 1 to 1½ inches long from each dead branch sampled. 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 an NFDRS RAWS, use the 10-hour fuel stick output from the RAWS to estimate 10-hour fuel moistures rather than actual field sampling. However, field sampling is the recommended process since it provides greater accuracy.

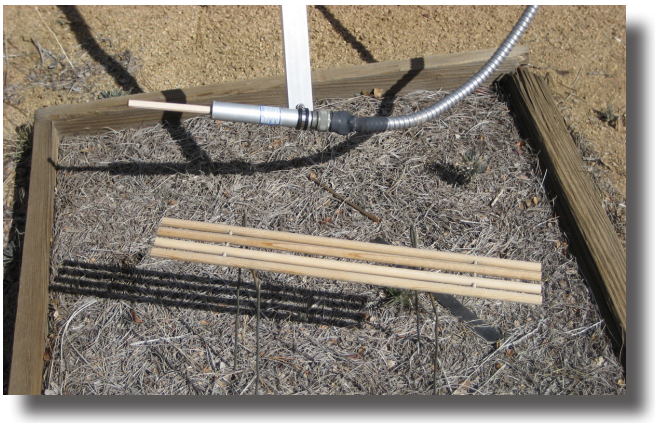

Figure 10—Fuel stick at a RAWS station.

100-Hour Fuel Samples

Small to Moderate Branches–Samples should consist of 1- to 1½-inch-thick cross sections, known as cookies or wafers. The sample should be laying in contact with the litter surface, but not have more than one-half of its diameter below the litter surface. Take branch wood at least 6 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 forms. The samples with bark will probably have higher moisture contents and should be collected and tested separately. Take the samples from logs that represent the common overstory trees and can be cut with a chainsaw (see chainsaw study in the desk guide). 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 with a chisel and hammer and placed in the container immediately.

Figure 11—Sampling of 1,000 hour fuels.

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 laying in contact with the litter surface, but not have more than one-half of its diameter below the litter surface. Take cross sections and wafers at least 3 feet from the ends of the log. The sample should not have bark when possible. If any samples include bark, note that fact on the fuel moisture content forms. Treat samples with bark separately because of the higher moisture content. Use a chainsaw to take the samples from logs representing the common overstory trees (see the chainsaw study in the desk guide). 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 with a chisel and hammer and placed in the container immediately.

Note: You can also collect 100- and 1,000-hour samples 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. Just as in collecting wafers, bore the holes at least 6 inches from the ends of the log or any other holes previously drilled. Place material into a container for drying and tighten the lid.

Other methods that will work for measuring 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 on a site to measure increases in fuel moisture. This is similar to how the 10-hour fuels sticks are used to measure moisture content.

Note the sampling method used in the remarks section on the fuel moisture content form. Continue using that method throughout the season and in subsequent years.

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 by clipping the stem at ground level. If species have multiple stems, cut one stem with leaves from each plant. Clip them into short pieces as you place it into the sample container and tighten the lid.

Litter and Duff

Litter

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

Figure 12—Preparing to collect litter and duff samples.

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. Put into a container. Do not overstuff.

Duff

Duff lies below the litter layer and above the mineral soil. It includes 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 more aggregated because of the fine plant roots growing in the duff material.

Cut standardized squares (approximately 4-inch-square on top) of duff 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. Gently use the blade of a trowel or knife to scrape the litter layer to one side. Then, return the blade to the point where the litter scrape starts, 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 layers until mineral soil shows at the bottom of the profile. Mineral soil is usually lighter in color than the duff and coarser in composition, often sandy or gravelly. The depth of duff samples is important. Measure them using the base of the moss and lichen or litter layer as a reference point.

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.

Additionally, 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 will be decomposed so that the original plant species is not readily recognizable.
- The 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 rubbed between your fingers, and will fill the indentations in your fingertips.

Sometimes deciphering between 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 guide is based on if 50 percent or more is the desired material then collect it, but when 50 percent or more is not the desired material do not collect it. For example, if the duff has 50 percent or more soil particles, then you have collected too deep a duff sample and it is more of a soil sample.

Number of Samples and Sample Size

The number of samples and sample size may vary based on the objectives for collecting fuel moisture samples and species or fuels sampled. Agencies and units should already have identified the appropriate number of samples and sample size prior to field collection.

Storing Samples

It is best to weigh the samples in the field to ensure accurate measurement and avoid false higher moisture values. Record the weight in the gross wet weight column of the fuel moisture content form. (See example fuel moisture content form in the desk guide.). If weighing in the field is not possible:

- Keep the samples cool and dry until they are processed.
- 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 insulated container, as it will cause condensation. Weigh the samples immediately upon arrival at location where processing (weighing, drying, and recording data) will occur.
- When back at the laboratory or processing area, please refer to the desk guide for further instructions.

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