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# A PROBE FOR MEASURING MOISTURE CONTENT IN DEAD ROUNDWOOD





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ABSTRACT.—This paper reports field test results of a wood moisture probe's accuracy in measuring fuel moisture content of dead roundwood. Probe measurements, corrected for temperature, correlated well with observed fuel moistures of 1-inch dead jack pine branchwood.

KEY WORDS: Wood moisture gauge, fire danger, jack pine, prescribed burning, ovendrying.

Fire managers need to know the moisture content of forest fuels to predict the behavior and effect of wildfires and prescribed burns. A fast, accurate, easy-to-use method to measure dead roundwood moisture in the field has long been needed.

There are many existing methods to obtain fuel moistures: conventional ovendrying (Countryman and Dean 1979), microwave ovendrying (Palmer and Pace 1974, Norum and Fischer 1980, McCreight 1981, Schuman and Rauzi 1981) xylene distillation (Collins)[1], and measurement with a small moisture analyzer (Sackett 1980). These methods can require relatively expensive equipment, special training, a power source, up to 48 hours to complete the measurement, and special precautions in their safe use.

Because of these difficulties, fuel moisture analogs and mathematical models are often used to indirectly estimate fuel moisture in the field. Field tests have indicated, however, that these models may not be as accurate as is needed for many fire management applications (Loomis and Main 1980).

For many years, fuel moisture probes, which use electrical resistance to measure moisture content, have been applied to lumber. Although these probes have proven accurate in measuring lumber moisture (James 1975), no one had verified their accuracy with respect to roundwood. We established a study to determine if wood moisture probes could be used to accurately measure roundwood in the field.

## THE WOOD MOISTURE PROBE

The *Triton 100 Wood Moisture Gauge*[2] used in this study is manufactured by Valley Products and Design, Inc. (fig. 1). The unit, costing approximately $200, weighs less than 1 pound and uses rechargeable batteries. Both audio and visual indicators are available with the probe. It has a measurement range of 7 to 80 percent divided into 1-percent increments from 7 to 24 percent, 2-percent increments from 24 to 30 percent, and progressively larger increments from 30 to 80 percent.

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[1]*Collins, Robert D. Obtaining fuel moisture with portable xylene distillation. Unpublished manuscript on file at the USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Riverside, CA.*

[2]*Use of trade names does not constitute official endorsement of the product by the USDA Forest Service.*

Figure 1.—*Obtaining fuel moisture with the probe.*

The probe is activated by pressing its two electrodes firmly into a sample. Then the moisture selection switch is rotated clockwise, starting at the 80-percent mark, until the indicator light and buzzer come on. The reading shown at this point is the moisture content (uncorrected for temperature) of the sample.

# PILOT STUDY

A pilot study was conducted to determine whether the probe's measurements correlated well with ovendry measurements. We collected 39 samples of 1- to 2 year-old jack pine slash on two separate occasions in Roscommon County, Michigan. Each sample was approximately 1 inch in diameter and 18 inches long. We took probe readings on the shady side of each sample and then placed the sample in a plastic bag for later ovendrying. To ensure a representative measurement, we averaged five probe readings per sample. The multiple correlation coefficient between probe readings and ovendried fuel moisture content was 0.79. Because of this high correlation, we conducted the following field test.

# FIELD EVALUATION

We exposed eight samples of 1- by 18-inch jack pine roundwood (2 to 4 years old) under field conditions in Lower Michigan. The ends of each stick were sealed with polyurethane to prevent rapid moisture escape. One-inch samples were chosen because Lake States fire managers generally consider the complete combustion of fuels in this size class a good criterion for a successful prescribed burn. We placed two samples with bark and two without bark on wire racks 10 inches above the litter layer. In addition, we placed two samples with bark and two without bark on the surface of the litter. We took daily (1300 hrs. EDT) moisture probe readings in the center of the shady side of each sample, midway between the top and the bottom.

After each probe measurement, we weighed the samples. At the end of the study, we ovendried and weighed all samples to obtain ovendry weights. Moisture content of each sample was calculated daily by:

$$\frac{\text{Wet weight} - \text{dry weight}}{\text{dry weight}} \times 100$$
$$= \text{percent moisture content}$$

Probe measurements should be corrected for temperature (James 1975, Cech and Pfaff 1975). To determine where the temperature should be taken, we took daily (1300 hrs. EDT) temperature readings at three locations: on the ground, exposed to direct sunlight; 10 inches above the ground, exposed to direct sunlight; and in a standard instrument shelter. We then calculated a fourth temperature by correcting the temperature in the instrument shelter for the state of the weather. The correction was based on the average difference between the shelter and ground thermometer readings for each state-of-the-weather class.

# FINDINGS

Because all probe readings over 20 percent were associated with precipitation during the preceding 24 hours, only those readings less than or equal to 20 percent were included in the study. Using regression analysis, we correlated the probe and various temperature readings with the moisture content of the samples.

We found that probe readings—with temperature corrections applied—correlated more closely with the actual moisture content of the samples than those readings without temperature corrections (table 1). Little difference was shown between the four temperature correction possibilities (temperature 10 inches above ground, instrument shelter temperature, instrument shelter temperature corrected for state of the weather, and ground temperature). The

Table 1.—*Multiple correlation coefficients for regression equations using probe reading and temperature at various thermometer positions to estimate the ovendry moisture content*

| Thermometer location | n[1] | $\bar{t}$[2] | [3]$R^2$ |
|---|---|---|---|
| 10 in. above ground | 136 | 80.6 | 0.70 |
| On ground | 136 | 101.3 | .69 |
| Instrument shelter corrected for state of weather | 177 | 97.3 | .67 |
| Instrument shelter | 177 | 74.9 | .66 |
| Without thermometer | 177 | — | .57 |

[1]Sample size
[2]$\bar{t}$ = average temperature (°F).
[3]Multiple correlation coefficient

Table 2.—*Multiple correlation coefficients and coefficients for regression equations using moisture probe reading and ground-level temperature to estimate fuel moisture obtained by ovendrying*

| Position of sample | N | $\bar{M}$[1] | $R^2$ | Standard error | Equation coefficients a | b | c |
|---|---|---|---|---|---|---|---|
| | Without bark | | | | | | |
| 10 in. above ground | 51 | 19.7 | 0.54 | 4.3 | 28.0 | 0.53 | 0.16 |
| On ground | 41 | 17.2 | .93 | 2.0 | 10.7 | 1.37 | .10 |
| | With bark | | | | | | |
| 10 in. above ground | 21 | 19.4 | .61 | 1.1 | 19.8 | .34 | .05 |
| On ground | 23 | 18.8 | .62 | 2.0 | 17.4 | .66 | .07 |

[1]$\bar{M}$ = average moisture content (%)

correction for ground temperature was chosen for ease of use during field operations.

Probe measurements correlated better with actual moisture content of samples on the ground than for samples 10 inches above the ground (table 2). Samples without bark had better correlation with the probe than those with bark. The highest correlation ($R^2 = 0.93$) was with the ground samples without bark.

Because the moisture contents of each type of sample differed, a regression equation was obtained with different coefficients for each category.[3] The general equation used is:

M = a + b (probe)−c (temperature) where coefficients a, b, and c can be found in table 2.

This equation may not be applicable for species other than jack pine (Cech and Pfaff 1973).

# PROBE USER GUIDELINES

1. A modest degree of force is needed to press the probe pins, which are quite sharp, into the wood. Caution should be used when inserting the pins in order to avoid personal injuries.

2. Probe readings should be made with the pins in line with the wood grain.

3. Probe measurements on rainy or foggy days may be in error due to the excess moisture on the outer portion of the sample.

4. Probe measurements should be repeated and then averaged—especially on samples with loose bark.

5. We recommend a wood moisture probe with both visual and audio indicators because the indicator light is difficult to see on sunny days.

# CONCLUSION

Our findings indicate that the wood moisture probe can be applied in field sampling the moisture content of jack pine branchwood. At moisture contents of 20 percent or less, the temperature-corrected probe reading is generally within 2 percent of actual fuel moisture. The probe is a fast, reasonably accurate, easy-to-use, and inexpensive method of measuring fuel moisture in the field.

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[3]*These equations have been programmed on a TI-59 calculator. A copy of the program is on file at the USDA Forest Service, North Central Forest Experiment Station, Steven S. Nisbet Building, 1407 South Harrison Road, East Lansing, MI 48823.*

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