FIGURE 9 — SOLAR HEAT RECEIVED AT BOISE, IDAHO

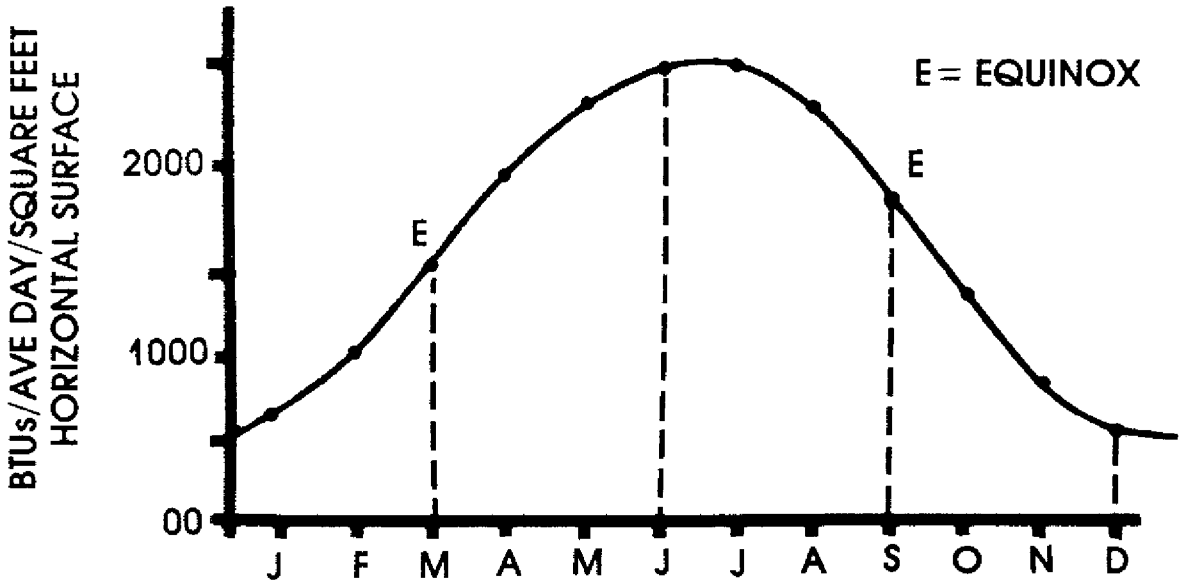
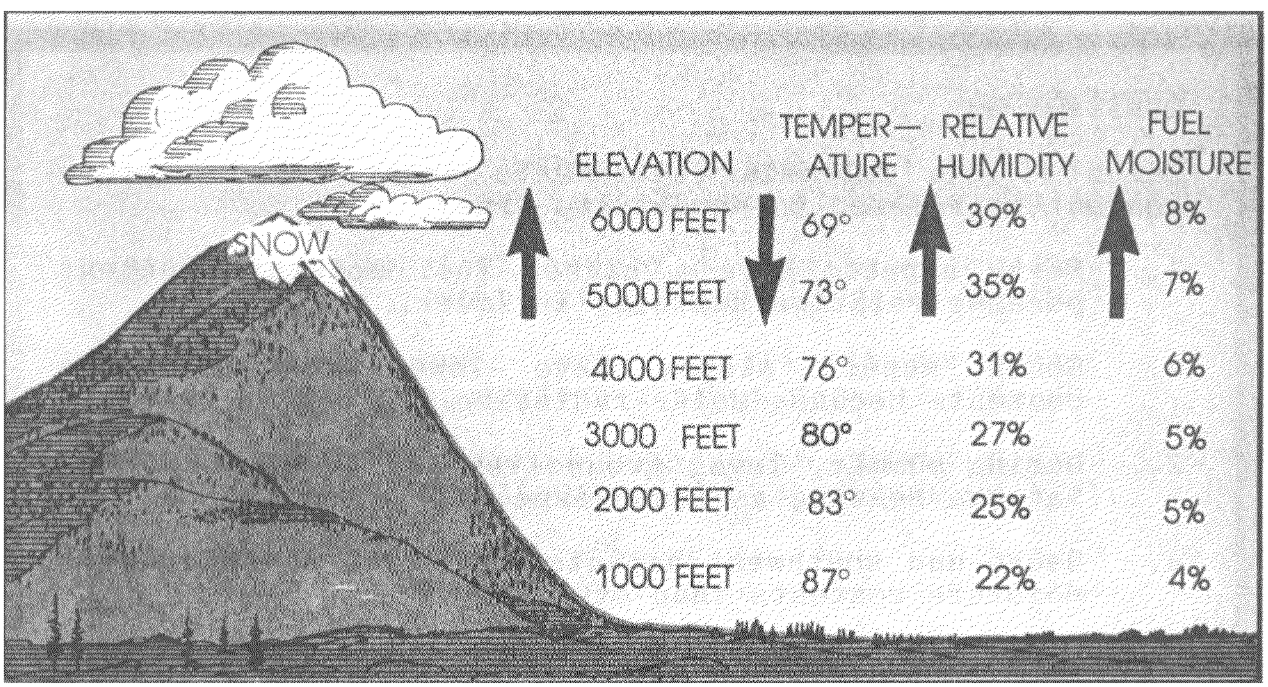


FIGURE 10 — ELEVATION AFFECTS FUEL MOISTURE (DAYTIME)

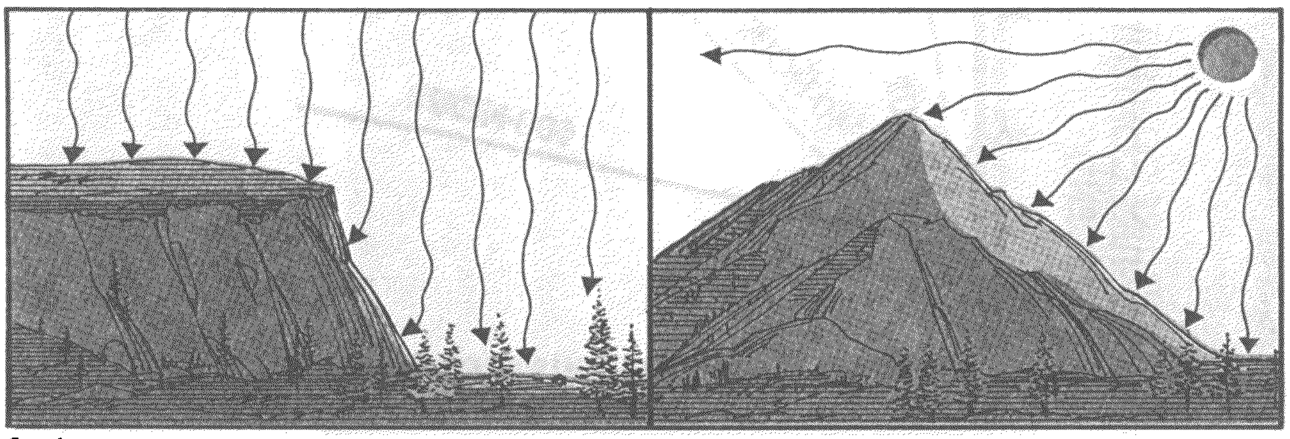


QUESTION 4

The elevation in mountainous country affects fuel moisture content because:

1. Thermal belt zones can have lower fuel moistures.
2. Snow melt dates are earlier at higher elevations.
3. Curing dates are later at higher elevations.
4. Higher elevations usually receive more precipitation.

FIGURE 11 — SLOPE PERCENT AFFECTS SOLAR HEATING



Surfaces perpendicular to incoming radiation receive considerably more heating than slopes that are almost parallel to these heat rays. The angle at which solar radiation hits various surfaces changes throughout the day and with the time of year.

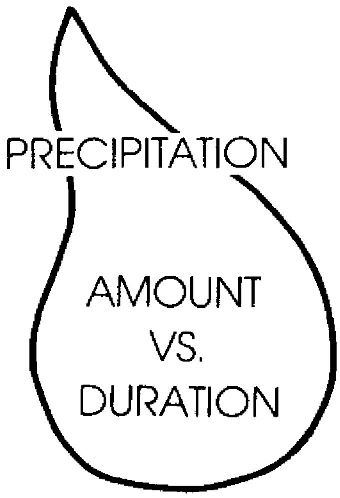
WIND SPEEDS UP BOTH THE DRYING AND WETTING PROCESSES IN FUELS.

- Wind speeds up the evaporation process.

  During calm air conditions, the air near the fuels tends to become saturated with water vapor, decreasing the evaporation rate of moisture from the fuel. Wind removes this saturated air, continually replaces it with drier air, and thus speeds up the evaporation process.

- Wind can speed up the absorption process.

  Moist air blowing over dry fuels provides a continuous supply of moisture for fuel moisture increase.



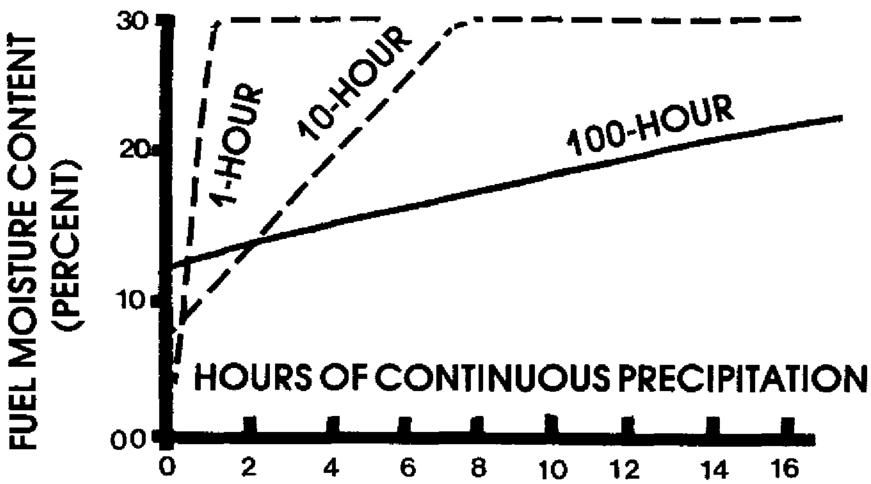
FINE, DEAD FUELS

React very rapidly to precipitation and reach their saturation points quickly. Additional rainfall has little effect on the fuels.

HEAVY, DEAD FUELS

React slower to precipitation as much of the rain may run off the fuel. Fuels continue to absorb moisture throughout the duration, thus duration is more important than the amount.

FIGURE 12 — DURATION OF PRECIPITATION AND FUEL MOISTURE



QUESTION 5

The amount of precipitation is much less important than the duration of that precipitation to changing fuel moisture of large fuels because:

1. Excessive amounts of rainfall runs off the fuels.

2. The rate of absorption of moisture into fuels is mostly fixed.

3. Heavy rains soak into the fuels much better than light rains.

4. The longer the duration of liquid water on the fuels the greater the fuel moisture increase.

EXERCISE 1:

ENVIRONMENTAL FACTORS AFFECTING DRYING OF DEAD FUELS

IF FUELS ARE SATURATED DURING A HEAVY RAINFALL, THE RATE AT WHICH THEY LOSE THEIR MOISTURE CONTENT DEPENDS ON SEVERAL ENVIRONMENTAL FACTORS. HOW DO EACH OF THESE FACTORS DETERMINE THE RATE OF DRYING IN FUELS (MATCH)?

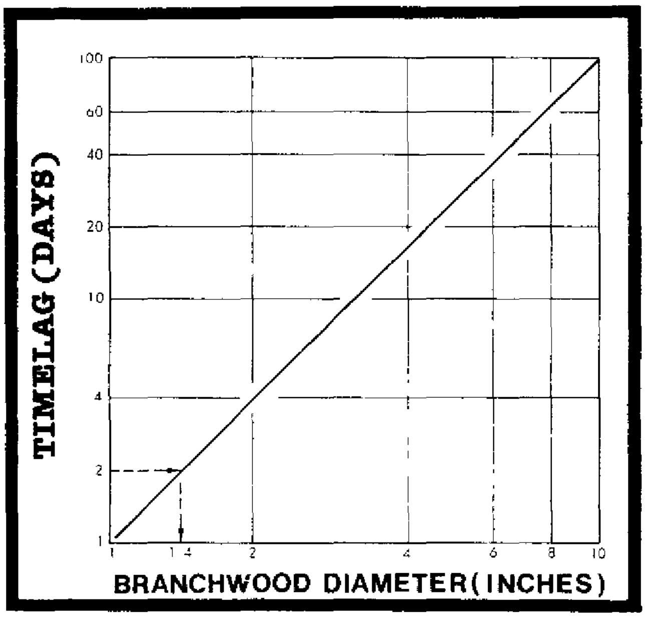
_____	Relative humidity	A.	Air and fuel temperatures are raised, thus reducing relative humidity of the air and increasing the evaporation rate.
_____	Wind	B.	Air temperatures at or near the surface can be considerable higher than at 10 feet above due to air circulation and vegetative cover.
_____	Compactness	C.	Equilibrium moisture content can be reached faster by air circulating and carrying off moisture from the fuels.
_____	Exposure to sun	D.	The greater the surface area to volume ratio, the faster the exchange of moisture between air and fuels.
_____	Size and shape	E.	The lower the water vapor pressure of the air, the faster the drying process.
_____	Height above ground	F.	Air circulation around the fuels dries them more rapidly when the fuel particles are loosely arranged.

CHECK YOUR ANSWERS WITH THOSE ON PAGE 29, THEN RESTART THE TAPE.

FUEL MOISTURE TIMELAG

TIMELAG: AN INDICATION OF THE RATE A FUEL GAINS OR LOSES MOISTURE DUE TO CHANGES IN ITS ENVIRONMENT, OR ———THE TIME NECESSARY FOR A FUEL PARTICLE TO GAIN OR LOSE APPROXIMATELY 63 PERCENT OF THE DIFFERENCE BETWEEN ITS INITIAL MOISTURE CONTENT AND ITS EQUILIBRIUM MOISTURE CONTENT.

FIGURE 13 — TIMELAG AND FUEL SIZE RELATIONSHIP

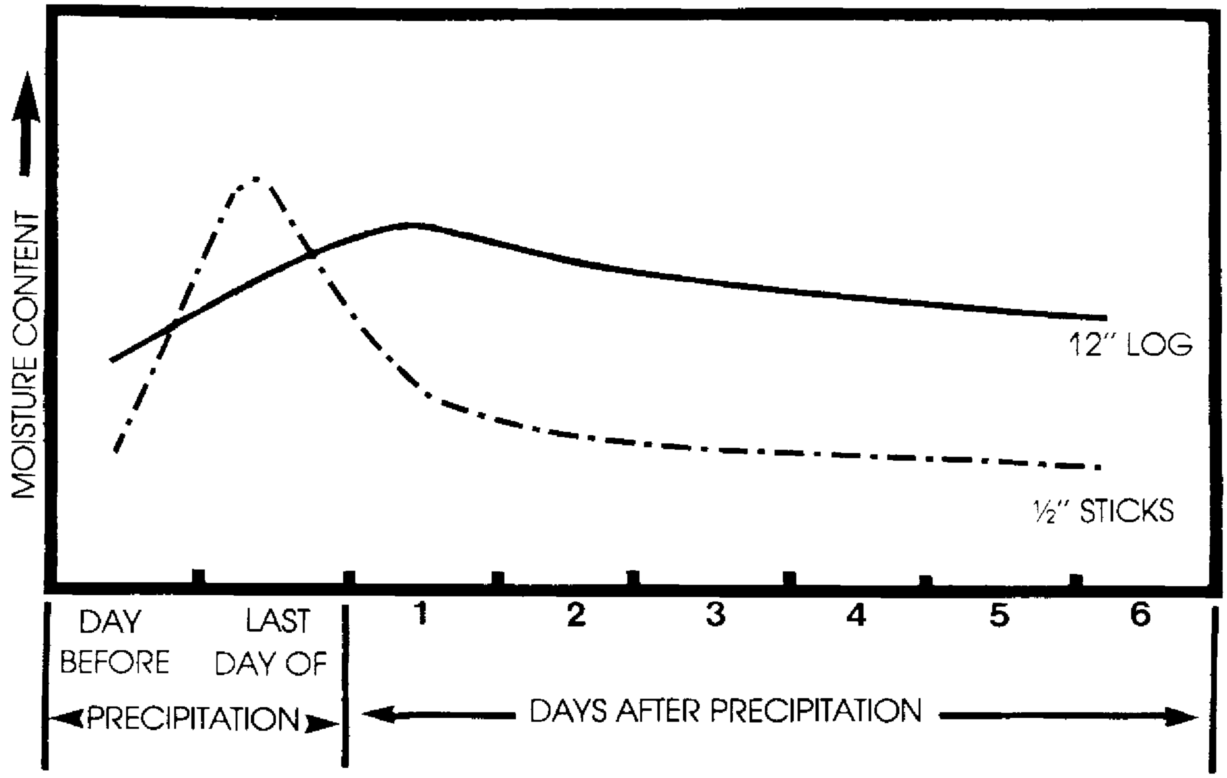


QUESTION 6

Using the chart in Figure 13, what is the approximate timelag for eight-inch diameter branchwood?

1. 4 days
2. 20 days
3. 60 days
4. 100 days

FIGURE 14 — REACTION TIME OF FUELS TO WETTING AND DRYING



QUESTION 7

Why does the fuel moisture content of the sticks (Figure 14) react faster to changes in humidity in the atmosphere than the fuel moisture content of the 12-inch log?

1. The reaction time for drying is less in the sticks.

2. The reaction time for drying is less in the large fuels.

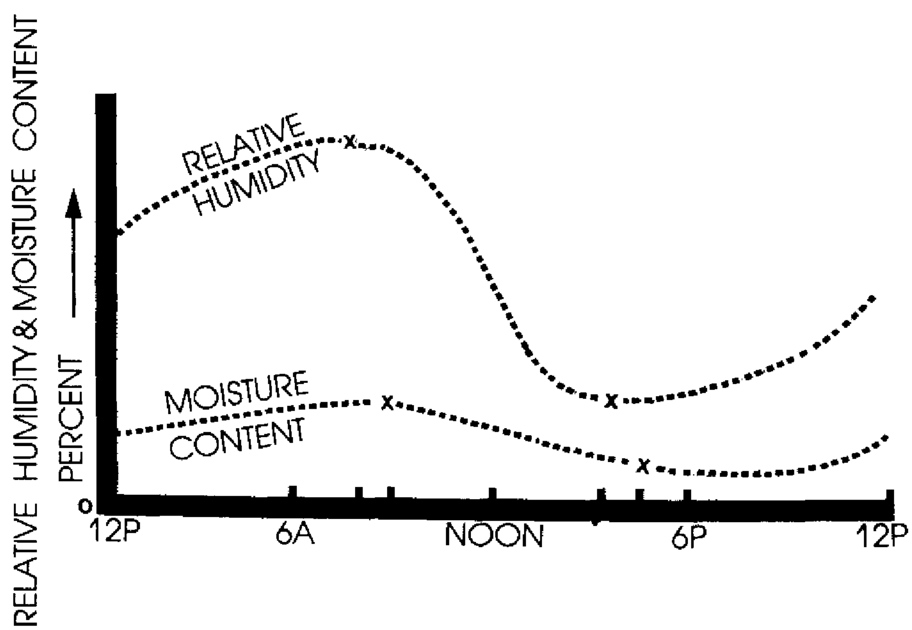
3. The surface area to volume ratio is greater in the log.

4. The surface area to volume ratio is greater in the small fuels.

GROUPED TIMELAG CATEGORIES

- 1-Hour — up to ¼ inch diameter
- 10-Hour — ¼ to 1 inch diameter
- 100-Hour — 1 to 3 inches diameter
- 1000-Hour — 3 to 6 inches diameter

FIGURE 15 — DAILY RELATIONSHIP OF RELATIVE HUMIDITY TO FINE DEAD FUEL MOISTURE



QUESTION 8

Dead fuels lying directly on the ground (litter) will usually exhibit a slower moisture exchange rate in response to changing weather factors because:

1. Air circulation in compacted fuels is less.

2. Air temperatures at the surface are lower.

3. Moisture in the soil can be exchanging with the fuels.

4. The effects of precipitation are longer lasting in litter.

DETERMINING DEAD FUEL MOISTURE CONTENTS

C. FUEL MOISTURE CONTENTS CAN BE DETERMINED FOR EACH OF THE TIMELAG CATEGORIES BY THESE MEANS:

1. 1-hour timelag fuels.

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. 10-hour timelag fuels.

   a. ______________________________

   b. ______________________________

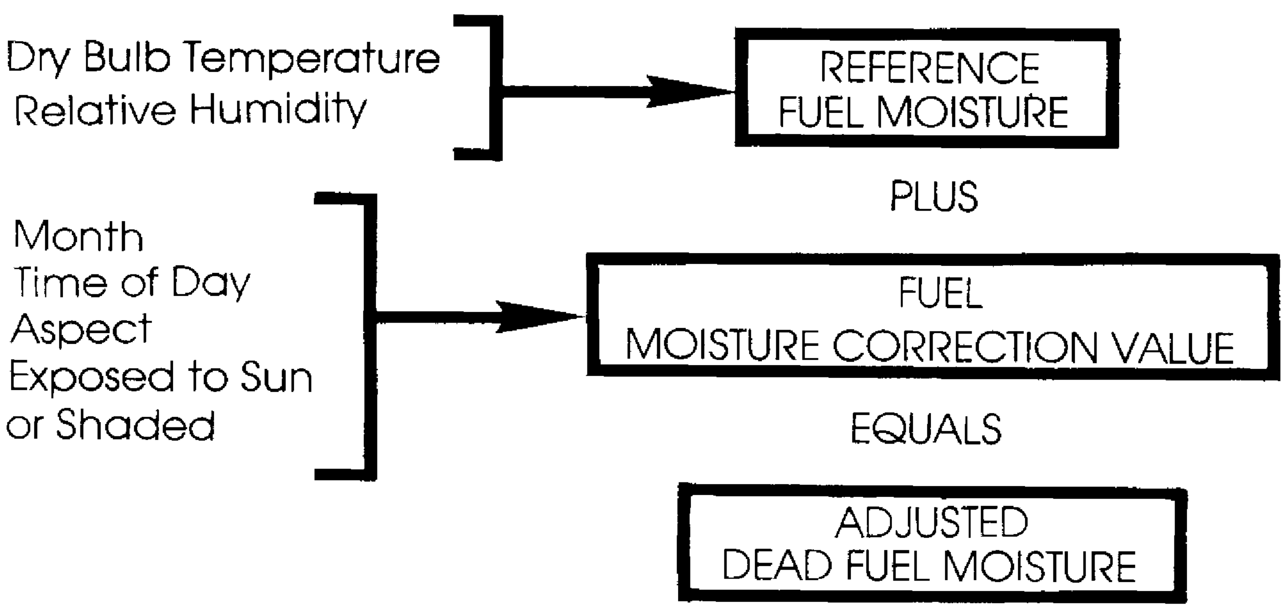
   c. ______________________________

3. 100-hour timelag fuels.

   a. ______________________________

4. 1000-hour timelag fuels.

   a. ______________________________



USING DEAD FUEL MOISTURE TABLES (1-HOUR TIMELAG)

STEP 1 - Obtain the following site data for determining dead fuel moisture:

Time of day

Month

Dry bulb temperature

Relative humidity

Aspect (N, S, E, W, Level)

Exposure of fine dead fuels to sun or not

GO TO STEP 2

STEP 2 - Consider location/elevations for predictions:

a. Predictions for same site as data gathered.

GO TO STEP 3

b. Predictions for site above or below the data site (daytime only with no inversions).

GO TO STEP 7

STEP 3 - Consider day or night conditions:

a. Daylight hours (0800 - 1959).

GO TO STEP 4

b. Nighttime hours (2000 - 0759).

GO TO STEP 9

STEP 4 - Determine reference fuel moisture from dry bulb temperature and relative humidity using table 1 on page 20.

GO TO STEP 5

STEP 5 - Consider exposed or shaded fuel conditions:

a. At least 50% of fine dead fuels are exposed to sun. Use "clear and/or no canopy" portions on tables 2 - 4.

b. At least 50% of fine dead fuels are shaded by clouds or canopy.

GO TO STEP 6

STEP 6 - Determine fuel moisture correction value considering month, time of day, and aspect:

a. May, June, July--use table 2, page 20.

b. February, March, April/August, September, October--use table 3, page 21.

c. November, December, January--use table 4, page 21.

GO TO STEP 8

STEP 7 - Determine dead fuel moisture content for prediction sites above or below data site on same slope (daytime only with no inversions). Follow these substeps:

(1) Determine elevation difference between data site and prediction site.

(2) Calculate new temperature for prediction site using usual lapse rate of 3.5° Fahrenheit per 1000 feet. See unit IV, page 8.

(3) Determine relative humidity for prediction site by following procedures (using dew point) as given in unit IV, page 18.

(4) Calculate dead fuel moisture content by using new dry bulb temperature and relative humidity for prediction site.

RETURN TO STEP 4

STEP 8 - Determine dead fuel moisture content (daytime) by adding correction value (step 6) to reference fuel moisture (step 4).

END

STEP 9 - Determine dead fuel moisture content (nighttime) from dry bulb temperature and relative humidity using table 5 on page 22.

END

TABLE 1 — REFERENCE FUEL MOISTURE (DAYTIME 0800 - 1959)

Dry Bulb Temp. (°F)	Relative Humidity (Percent) 0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100
10-29	1	2	2	3	4	5	5	6	7	8	8	8	9	9	10	11	12	12	13	13	14
30-49	1	2	2	3	4	5	5	6	7	7	7	8	9	9	10	10	11	12	13	13	13
50-69	1	2	2	3	4	5	5	6	6	7	7	8	8	9	9	10	11	12	12	12	13
70-89	1	1	2	2	3	4	5	5	6	7	7	8	8	8	9	10	10	11	12	12	13
90-109	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	13
109+	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	12

GO TO TABLES 2 - 4 FOR CORRECTION VALUES

TABLE 2 — DEAD FUEL MOISTURE CONTENT CORRECTION VALUES

DAYTIME 0800 - 1959 (MAY, JUNE, JULY)

Aspect/Time	0800 →	1000 →	1200 →	1400 →	1600 →	1800 →
CLEAR AND/OR NO CANOPY (LESS THAN 50% SHADED)						
North	3	1	0	0	1	3
East	2	0	0	0	2	4
South	3	1	0	0	1	3
West	4	2	0	0	0	2
CLOUDY AND/OR CANOPY (MORE THAN 50% SHADED)						
North	5	4	3	3	4	5
East	4	4	3	4	4	5
South	4	4	3	3	4	5
West	5	4	3	3	4	4

TABLE 3 — DEAD FUEL MOISTURE CONTENT CORRECTION VALUES

DAYTIME 0800 - 1959 FEBRUARY, MARCH, APRIL, AUGUST, SEPTEMBER, OCTOBER

Aspect/Time	0800 →	1000 →	1200 →	1400 →	1600 →	1800 →
CLEAR AND/OR NO CANOPY (LESS THAN 50% SHADED)						
North	4	2	2	2	2	4
East	3	1	1	1	3	4
South	4	2	1	1	2	4
West	4	3	1	1	1	3
CLOUDY AND/OR CANOPY (MORE THAN 50% SHADED)						
North	5	5	4	4	5	5
East	5	4	4	4	5	5
South	5	4	4	4	4	5
West	5	5	4	4	4	5

TABLE 4 — DEAD FUEL MOISTURE CONTENT CORRECTION VALUES

DAYTIME 0800 - 1959 (NOVEMBER, DECEMBER, JANUARY)

Aspect/Time	0800 →	1000 →	1200 →	1400 →	1600 →	1800 →
CLEAR AND/OR NO CANOPY (LESS THAN 50% SHADED)						
North	5	4	4	4	4	5
East	5	3	2	3	4	5
South	5	3	2	1	3	5
West	5	4	3	2	3	5
CLOUDY AND/OR CANOPY (MORE THAN 50% SHADED)						
North	5	5	5	5	5	5
East	5	5	5	5	5	5
South	5	5	5	5	5	5
West	5	5	5	5	5	5

TABLE 5 — DEAD FUEL MOISTURE CONTENT (NIGHTTIME 2000 - 0759)

No corrections are needed during this time period.

Dry Bulb Temp. (°F)	Relative Humidity (Percent)																			
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90-94	95-99	100
10-29	1	2	4	5	5	6	7	8	9	10	11	12	12	14	15	17	19	22	25	25+	25+
30-49	1	2	3	4	5	6	7	8	9	9	11	11	12	13	14	16	18	21	24	25+	25+
50-69	1	2	3	4	5	6	6	8	8	9	10	11	11	12	14	16	17	20	23	25+	25+
70-89	1	2	3	4	4	5	6	7	8	9	10	10	11	12	13	15	17	20	23	25+	25+
90-109	1	2	3	3	4	5	6	7	8	9	9	10	10	11	13	14	16	19	22	25	25+
109+	1	2	2	3	4	5	6	6	8	8	9	9	10	11	12	14	16	19	21	24	25+

EXERCISE 2:
DETERMINING DEAD (1-HOUR) FUEL MOISTURE CONTENT

USING THE STEPS AND TABLES 1-5 ON THE PRECEDING PAGES, COMPLETE THE ITEMS BELOW:

1. What is the reference fuel moisture (RFM) for the following daytime situations?

   a. Temperature 85°, relative humidity 22% RFM ______

   b. Temperature 60°, relative humidity 62% RFM ______

2. What are the fuel moisture correction (FMC) values for the following situations?

   a. August 20, 1200 hours, midslope location, east aspect, and cloudy sky.
   FMC ______

   b. May 10, 1400 hours, south aspect, clear with exposed fuels.
   FMC ______

3. What is the fuel (1-hour) moisture (FM) content for the following situations?

   a. It is November 19, 1500 hours. Fuels are exposed to sun on a west aspect. Readings from a belt weather kit give dry bulb temperature 92°, relative humidity 16%, wind SW 7 mph.

   RFM ____________ + FMC ____________ = FM ____________

   b. It is October 12, 1700 hours. Fuels are shaded on a north aspect, but under clear skies. Weather forecast data for the site is: dry bulb temperature 75°, relative humidity 28%, wind W 8 mph.

   RFM ____________ + FMC ____________ = FM ____________

   c. It is June 29, 2300 hours. Fuels are under a canopy on an east aspect. Weather observations at that time are: dry bulb temperature 72°, relative humidity 33%, wind E 3 mph.

   RFM ____________ + FMC ____________ = FM ____________

CHECK YOUR ANSWERS WITH THOSE ON PAGE 29, THEN RESTART THE TAPE

EXERCISE 3:
RELATIVE HUMIDITY, PRECIPITATION, AND FUEL MOISTURE

FUEL MOISTURE CONTENT CHANGES WITH CHANGES IN HUMIDITY AND PRECIPITATION. RANK ORDER THE THREE TYPES OF FUELS AS TO HIGHEST FUEL MOISTURE CONTENT FOR THE HOURS GIVEN BELOW. PLACE A 1 FOR THE HIGHEST, A 2 FOR THE NEXT HIGHEST, AND A 3 FOR THE LOWEST IN EACH COLUMN. ALL ARE NEAR THE GROUND SURFACE.

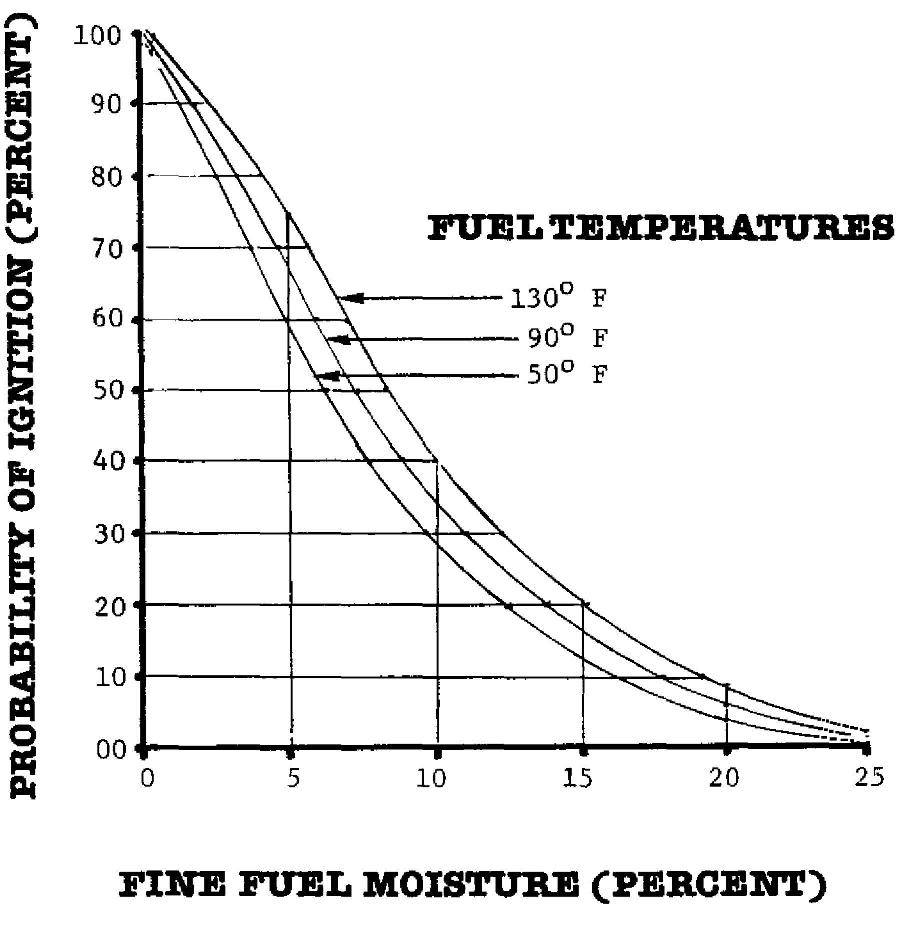
SITUATION: A forest area has experienced hot, dry weather for several weeks. Fuel moisture percents for the afternoon of August 1, at a nearby Fire Danger Rating Station were recorded as follows: 1-hour timelag fuels 3%, 10-hour timelag fuels 5%, and 100-hour timelag fuels 20%. Relative humidity is ranging between 22% during the day and 62% at night. The morning of August 2, the area received a .2-inch rainfall within a 2-hour period beginning at 0800. At approximately 1000 the clouds passed on and the remainder of the day was warm and dry.

	August 1 1500	August 2 0630	August 2 1000	August 2 1700
Small log (3-inch diameter)	20%	______	______	______
Dead branch (1/2-inch diameter)	5%	______	______	______
Clump of cured grass	3%	______	______	______

CHECK YOUR ANSWERS WITH THOSE ON PAGE 29, THEN RESTART THE TAPE.

PROBABILITY OF IGNITION: A RATING OF PROBABILITY THAT A FIREBRAND (GLOWING) WILL CAUSE A FIRE PROVIDING IT LANDS ON RECEPTIVE FUELS.

FIGURE 16 — PROBABILITY OF IGNITION AS A FUNCTION OF FUEL TEMPERATURE AND MOISTURE CONTENT.



FUEL MOISTURE EFFECTS ON FIRE SPREAD:

- Fire spreads as a result of fuels ahead of the fire being preheated to their ignition point.
- Heat is required to drive moisture from fuels before they can support combustion.
- At some point fuel moisture content can slow combustion and the preheating of new fuels, and ignition temperature in new fuels is not reached.
- The intensity of the fire, then, determines whether moist fuels can be dried and preheated to their ignition temperatures.

NATURAL FUEL COMPLEXES GENERALLY CONTAIN A COMBINATION OF LIVE AND DEAD FUELS. A FIRE PASSING THROUGH A FUELS COMPLEX MAY OR MAY NOT BURN THE LIVE FUELS.

- When live fuels are not consumed, there must be enough dead, dry fuels to support the fire.
- Some live fuels will burn although their moisture contents are 100% or higher, i.e., pine needles that have volatile substances.

MOISTURE OF EXTINCTION THE FUEL MOISTURE CONTENT AT WHICH A FIRE WILL NOT SPREAD OR SPREADS ONLY SPOPRADICALLY AND IN A NONPREDICTABLE MANNER.

THE MOISTURE OF EXTINCTION VARIES BY FUEL SITUATIONS.

- Moisture of extinction is dependent on various fuels characteristics, such as, fuel loading, fuel size, arrangement, and chemical content.
- Moisture of extinction may be as low as 12% in certain fuel situations, but rarely higher than 30% in dead fuels.

FIGURE 17 — MOISTURE OF EXTINCTION FOR EACH FUEL MODEL

Fuel Model	Presence of Fuel Class				Moisture of Extinction (Percent)
	1-H	10-H	100-H	Live	
1 Short Grass	X				12
2 Timber and Grass	X	X	X	X	15
3 Tall Grass	X				25
4 Chaparral (6 feet)	X	X	X	X	20
5 Brush (2 feet)	X	X		X	20
6 Intermediate Brush	X	X	X		25
7 Southern Rough	X	X	X	X	40
8 Closed Timber Litter	X	X	X		30
9 Hardwood Litter	X	X	X		25
10 Timber with Litter	X	X	X	X	25
11 Light Logging Slash	X	X	X		15
12 Medium Logging Slash	X	X	X		20
13 Heavy Logging Slash	X	X	X		25

EXERCISE 4:
PROBABILITY OF IGNITION AND MOISTURE OF EXTINCTION

USING FIGURE 16 ON PAGE 25 AND ANY OTHER MATERIALS PRESENTED IN THIS UNIT, COMPLETE THE FOLLOWING ITEMS:

1. What is the probability of ignition of fine fuels for these conditions?

Fuel Moisture	Fuel Temperature	Probability of Ignition
5%	100°	________
10%	50°	________
20%	90°	________

2. A change in which variable, fuel moisture or fuel temperature, will cause the greatest change in probability of ignition?

3. Can a fire continue to spread in short grass (fuel model I) when the dead fuel moisture content reaches 15%?

   _____ Explain. ______________________________

   ____

4. If live fuels are present within a fuel complex, describe the conditions under which they will be consumed by fire.

   ____

   ____

   ____

   ____

ANSWERS TO EXERCISES

EXERCISE 1

E	Relative humidity	F	Compactness	D	Size and shape
C	Wind	A	Exposure to sun	B	Height above ground

EXERCISE 2

1. a. RFM 3% (Table 1)

   b. RFM 8% (Table 1)

2. a. FMC 4% (Table 3)

   b. FMC 0% (Table 2)

3. a. RFM 2% + FMC 2 = 4% (Tables 1 and 2)

   b. RFM 4% + FMC 5 = 9% (Tables 1 and 3)

   c. RFM 6% + FMC 0 = 6% (Table 5)

EXERCISE 3

	August 1 1500	August 2 0630	August 2 1000	August 2 1700
Small log	20%	1 (20%)	2 (23%)	1 (22%)
Dead branch	5%	3 (8%)	3 (15%)	2 (12%)
Cured grass	3%	2 (11%)	1 (30%)	3 (4%)

( ) Probable fuel moisture percents for clarification only.

EXERCISE 4

1. Probability of ignition 75%, 29%, 5%
2. Fuel moisture
3. No. The moisture of extinction of short grass is about 12%.
4. There must be enough dead, dry fuels mixed with the live fuels to bring down the average fuel moisture and carry fire. Volatile substances in some live vegetation may aid combustion.