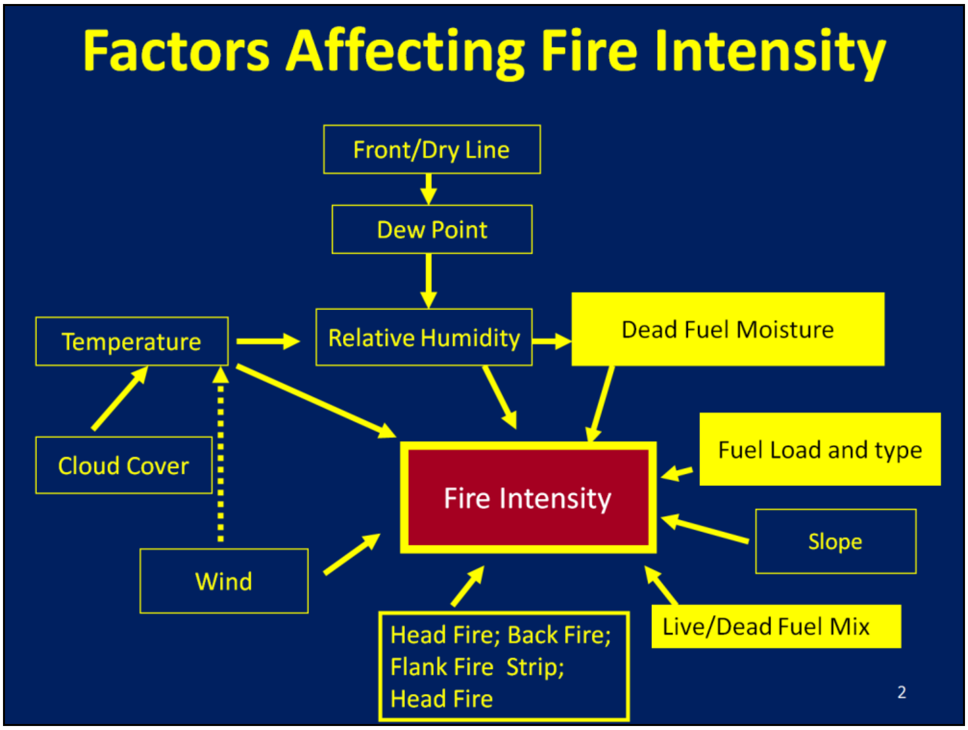
Fuels and Fuel Moisture



Factors Affecting Fire Intensity

Front/Dry Line

Dew Point

Temperature

Relative Humidity

Dead Fuel Moisture

Cloud Cover

Fire Intensity

Fuel Load and type

Slope

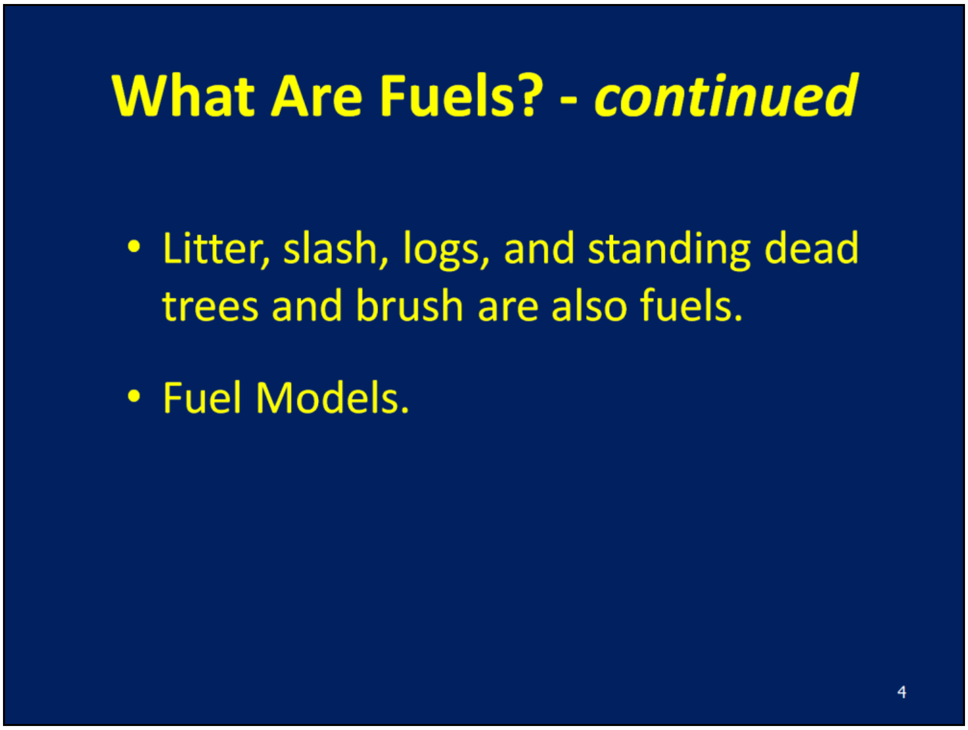
Wind

Head Fire; Back Fire;
Flank Fire Strip;
Head Fire

Live/Dead Fuel Mix

What Are Fuels?

- Dry, dormant, grass is the primary fuel determining fire behavior in Rx burns.



What Are Fuels? - *continued*

- Litter, slash, logs, and standing dead trees and brush are also fuels.
- Fuel Models.

Different vegetation types can be further described by categorizing them into fuel models. Each fuel model has different characteristics and potential for fire intensity.

What Are Fuels? - *continued*

- Green grass can burn, however it is much harder to predict fire behavior from green or green/dead mix.

Fuel

- Any combustible material

Fuel - *continued*

- Fuels carry the fire across the landscape.
- Fuel quantity (lbs/acre).
- Fuel continuity.

Fuel - *continued*

- Ground Level Fuels
  - at or below ground fuels - duff, organic matter, and roots.
- Surface Fuels
  - litter, twigs, needles, and other vegetation.

Fuel - *continued*

- Ladder Fuels
  - tall grass and bushes capable of taking the fire to the canopy
- Aerial Fuels
  - standing vegetation, canopies, hanging moss, branches, vines, leaves
  - fire brands can carry aerial fuels great distances and catch other fuels on fire

Fuel Moisture

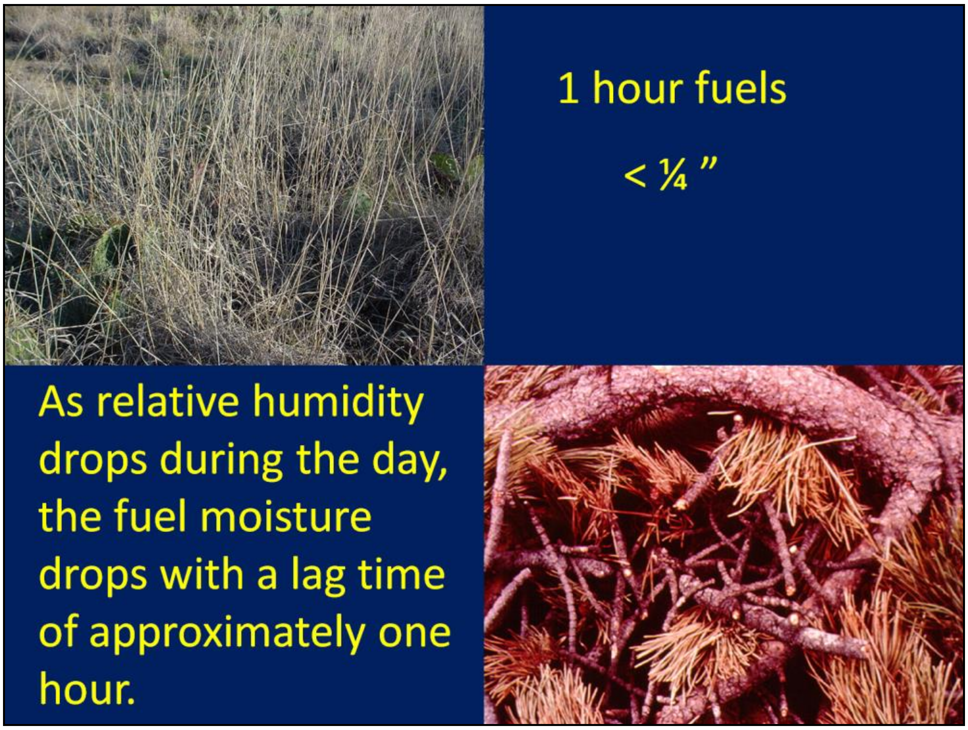
- The drier the fuel, the quicker it will ignite, the faster it will burn and more complete will be the combustion.
- The greater the moisture content, the higher the heat temperatures required to dry the fuel.

Fuel Moisture - *continued*

- Dormant or dead fuels moisture content is directly related to fire behavior.
- Dormant or dead fuels react to ambient moisture (rh - relative humidity) dependent on the size of the fuels.
- The time it takes for fuel to react to ambient moisture is called **time lag**.

Time Lag

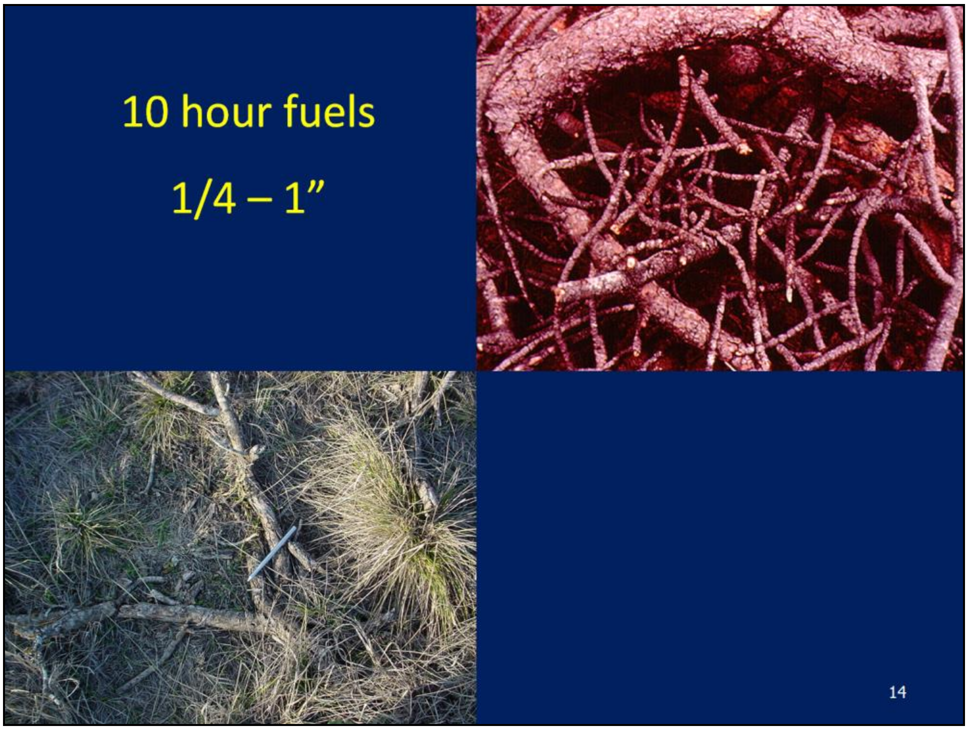
- Measure of the rate of a specified size of dead fuel gains or loses moisture.
- Fuels initially respond quickly to changes in moisture content, but change is slower as the fuel moisture gets closer to the equilibrium moisture content.
- Fine fuels (1-hr) can respond quickly to changes.



1 hour fuels

< ¼ ”

As relative humidity drops during the day, the fuel moisture drops with a lag time of approximately one hour.

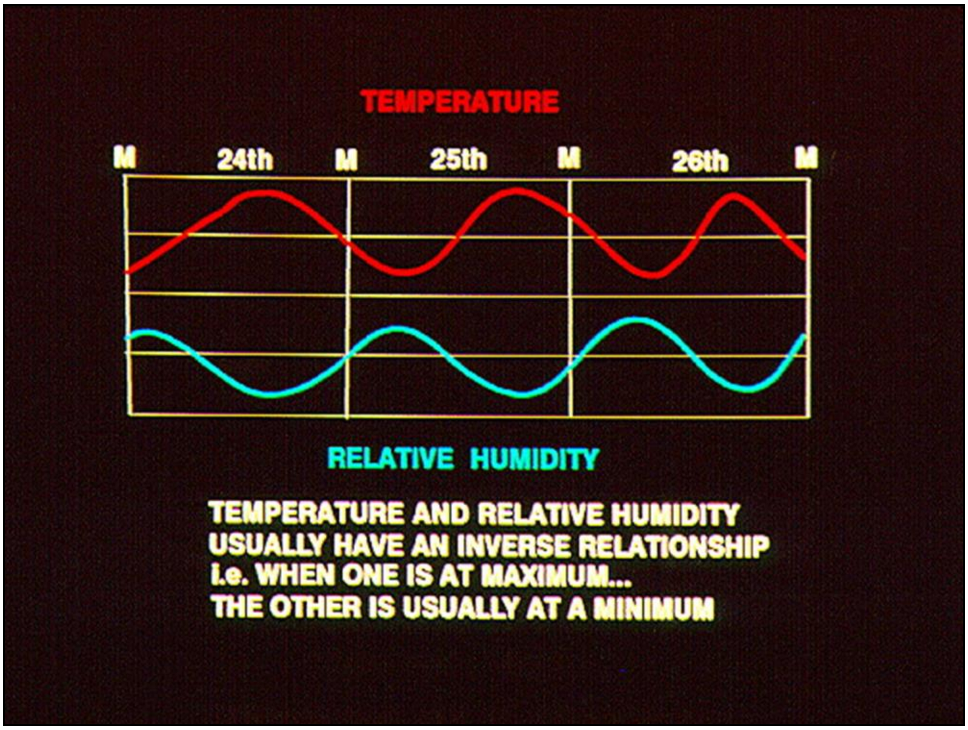


10 hour fuels

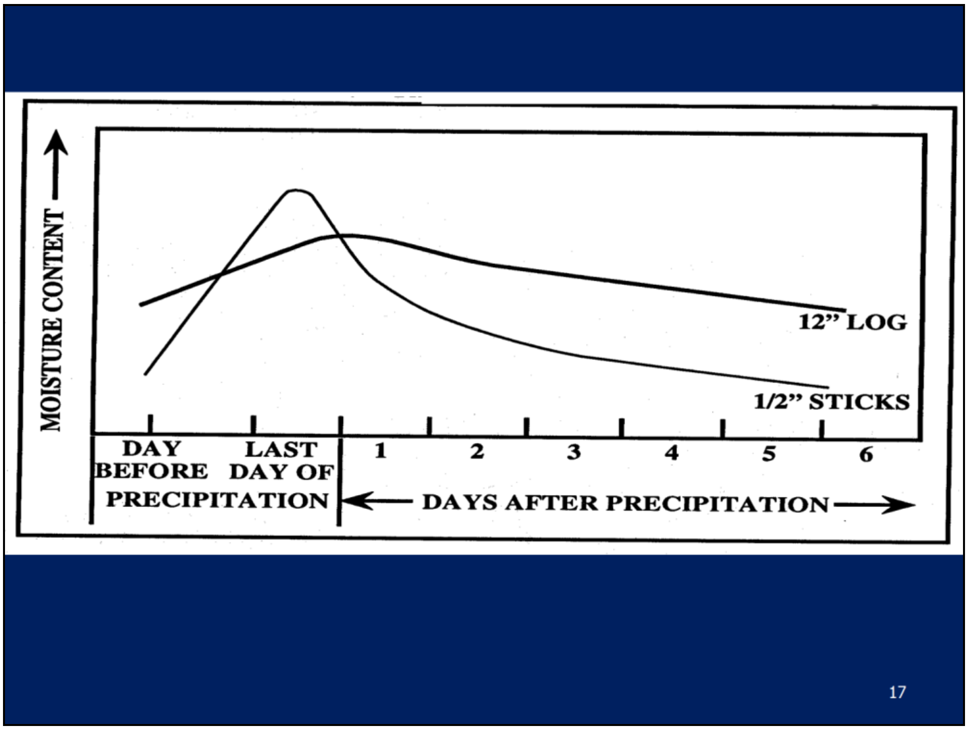
1/4 – 1”

100-hour fuels – 1-3” in diameter

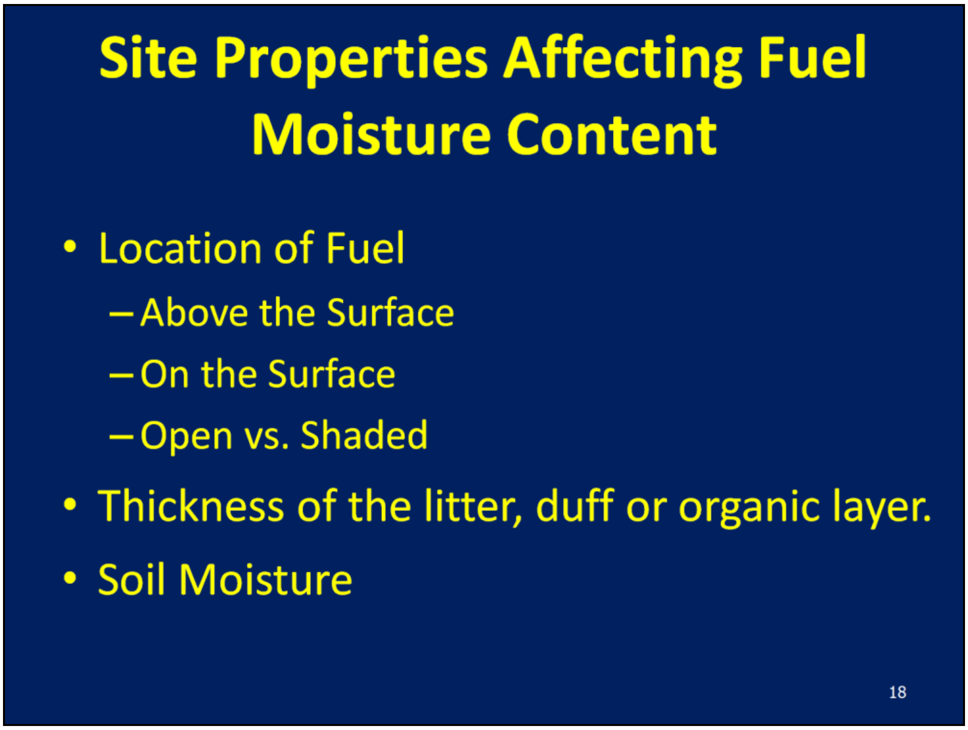
1000-hour fuels – 3-8” in diameter



TEMPERATURE AND RELATIVE HUMIDITY
USUALLY HAVE AN INVERSE RELATIONSHIP
i.e. WHEN ONE IS AT MAXIMUM...
THE OTHER IS USUALLY AT A MINIMUM

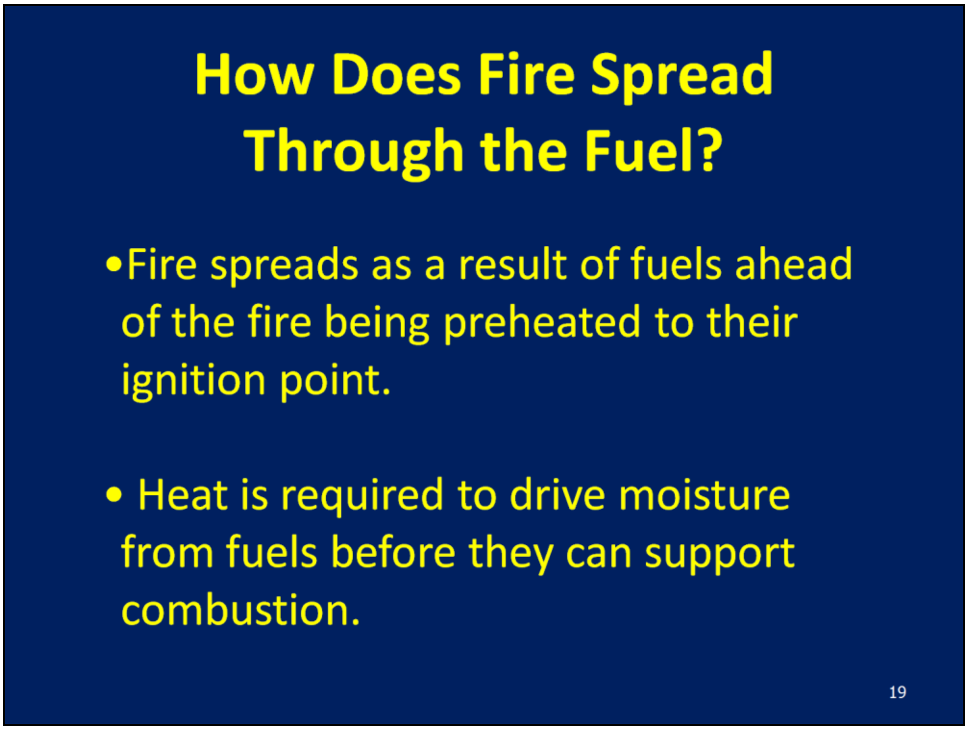


1 hr. fuels react within an hour to the atmospheric environment. Larger fuels, and especially those that are lying on the ground take on moisture quickly with precipitation, but may take days to dry.



Site Properties Affecting Fuel Moisture Content

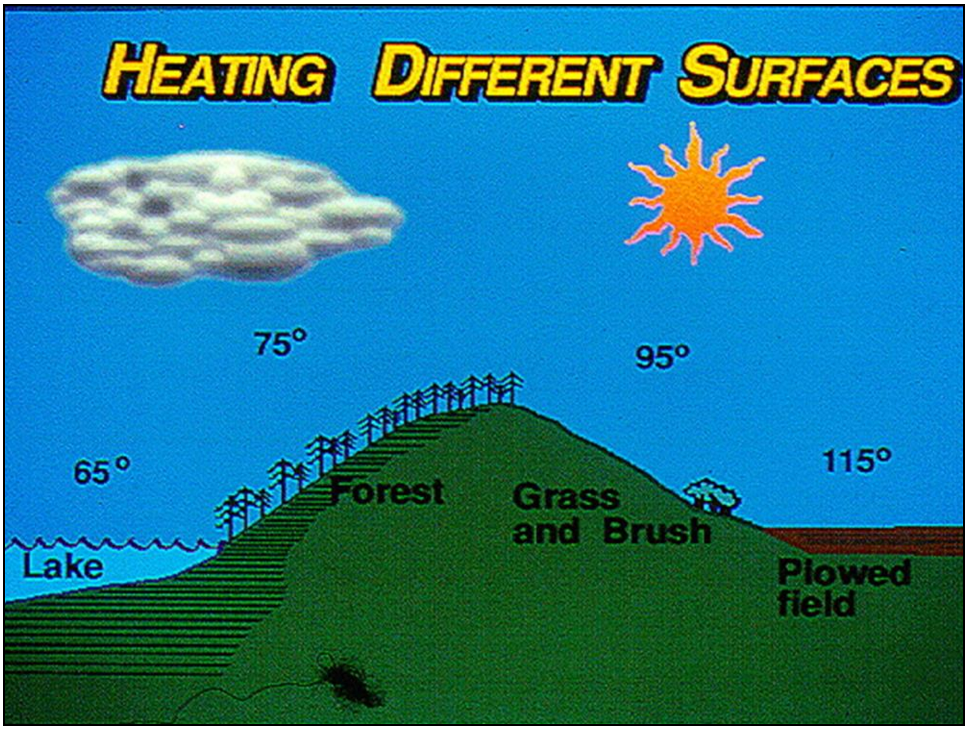
- Location of Fuel
  - Above the Surface
  - On the Surface
  - Open vs. Shaded
- Thickness of the litter, duff or organic layer.
- Soil Moisture



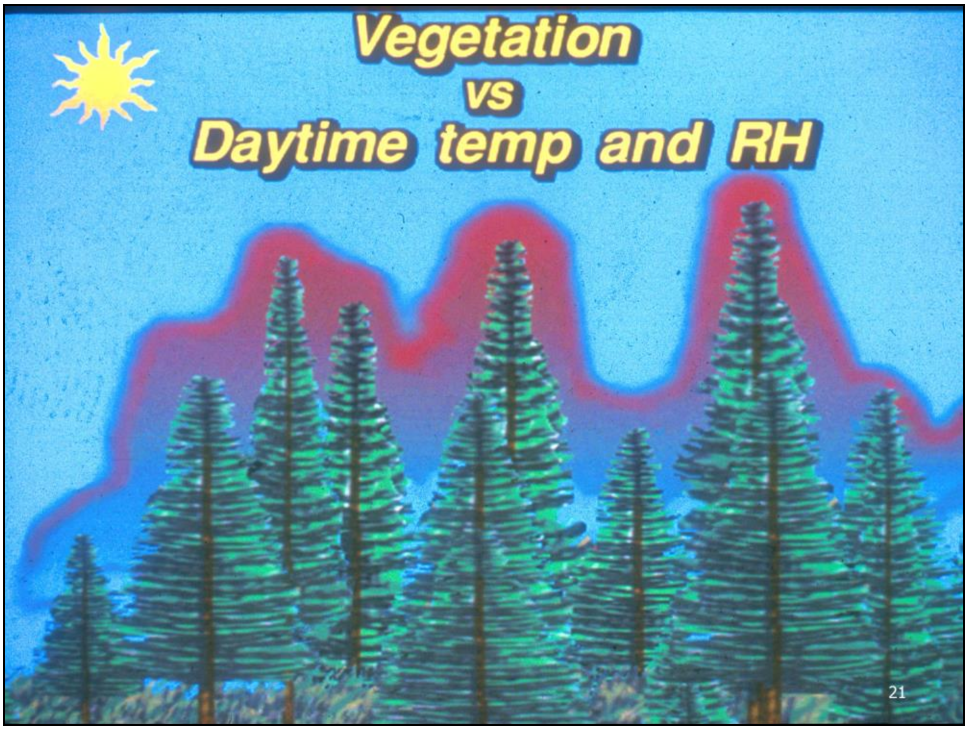
How Does Fire Spread Through the Fuel?

- 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.



Note how different environmental and habitat conditions can affect the temperature at the surface.



Vegetation vs Daytime temp and RH

During the daytime, the trees buffer the hot sun and keep the surface much cooler.

Vegetation vs Nighttime temp and RH

The inverse can occur during the night and the vegetation can buffer the cool air and actually keep the surface warmer.

Poor Burning Potential

There is little grass available as fuel for a burn.

Moderate Potential

This area is has approximately 50% shaded area which will cool the area and raise the relative humidity thereby reducing fire intensity.

Good Potential

Estimating Fuel Load and Fuel Moisture

- Build a ¼-meter square plot frame out of rebar or pvc tubing (50-cm on each side).
- Place plot frame at several locations in the pasture and clip grass close of ground level.
- Weigh the bag and sample as soon as possible (nearest gram).

Estimating Fuel Load and Fuel Moisture

- Sample can be dried in a microwave oven at 30-second intervals until the weight does not change. (wet weight-Dry Weight/Dry weight) x 100=% moisture.
- Calculate lbs/acre by subtracting the bag weight from each sample weight then multiplying the weight in grams x 40 to the weight in kg/ha. Lbs/ac=kg/ha x .89.

What is that Point Where Fine Dead Fuel Moisture Discourages Combustion and Fire Spread?

- We call it the moisture of extinction, and it is defined as the fuel moisture content at which a fire will not spread, or spreads only sporadically and in a non-predictable manner.

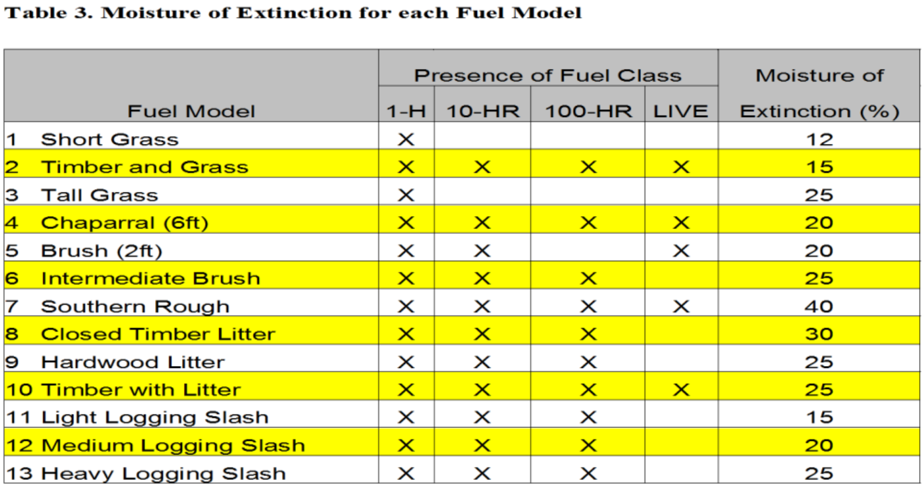
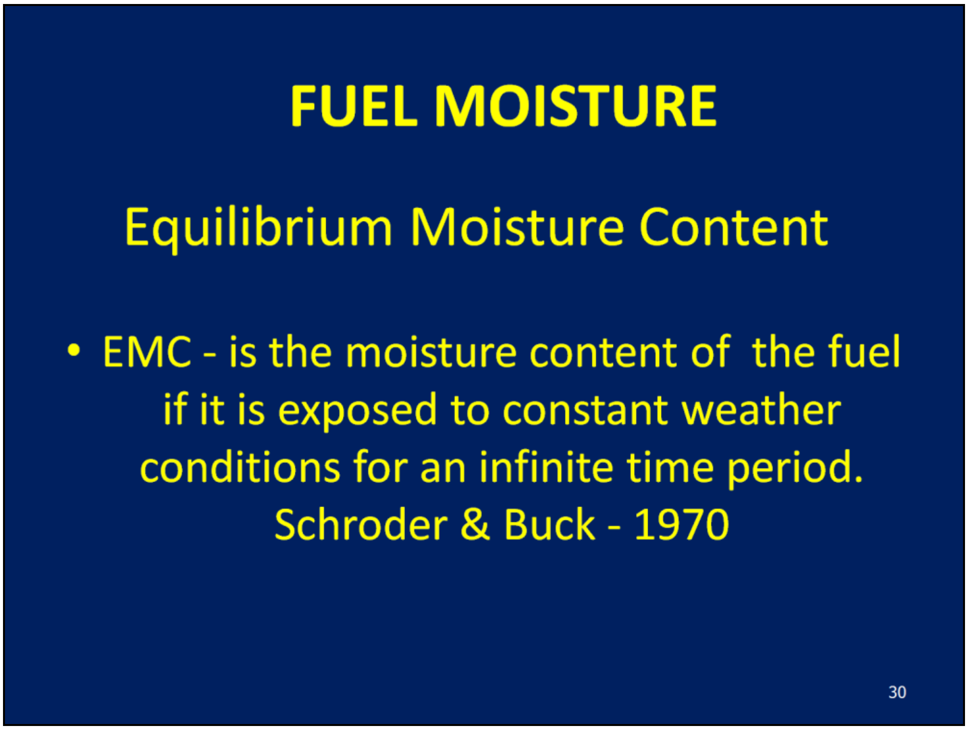


Table 3. Moisture of Extinction for each Fuel Model

	Presence of Fuel Class				Moisture of
Fuel Model	1-H	10-HR	100-HR	LIVE	Extinction (%)
1 Short Grass	X				12
2 Timber and Grass	X	X	X	X	15
3 Tall Grass	X				25
4 Chaparral (6ft)	X	X	X	X	20
5 Brush (2ft)	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

KR Bluestem MOE is approximately 17%



FUEL MOISTURE

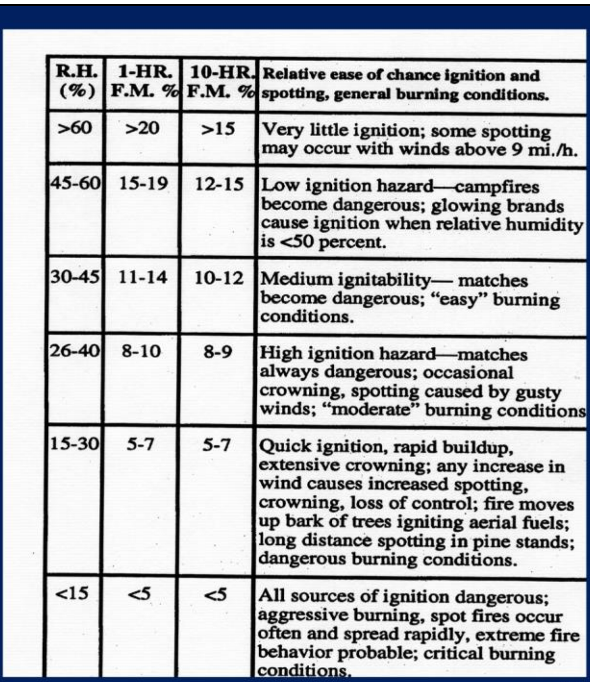
Equilibrium Moisture Content

- EMC - is the moisture content of the fuel if it is exposed to constant weather conditions for an infinite time period. Schroder & Buck - 1970

Fire Behavior

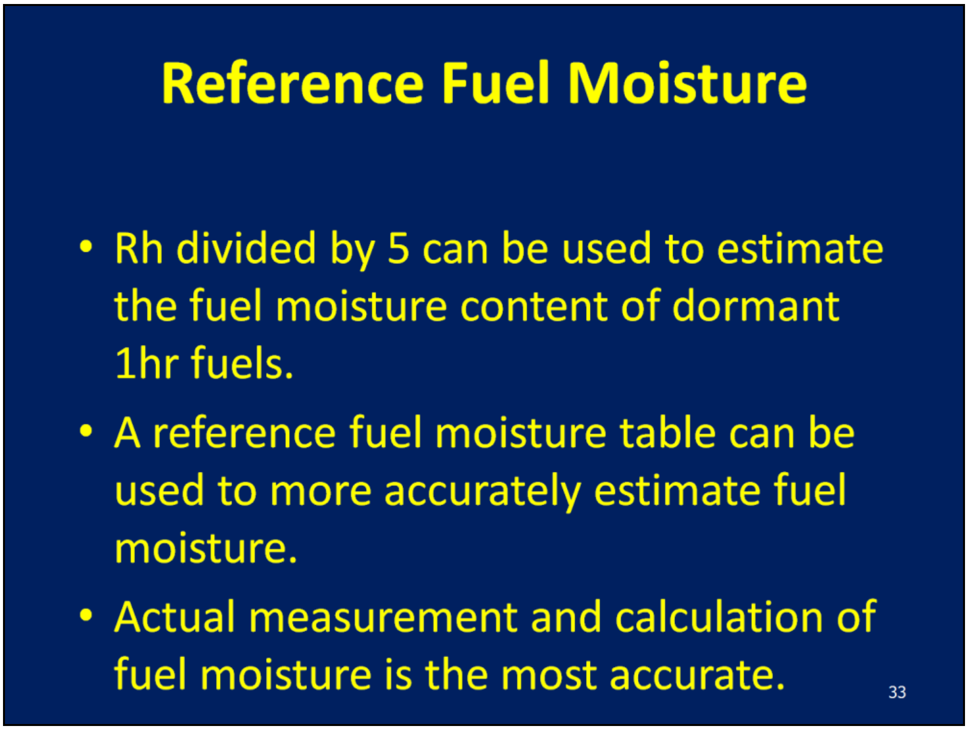
- Fire behavior is related directly to the fuel moisture content of the fuels.
- The drier the fuel, the quicker it will combust.

Relationship between probability of ignition and spot firing and fuel moisture.



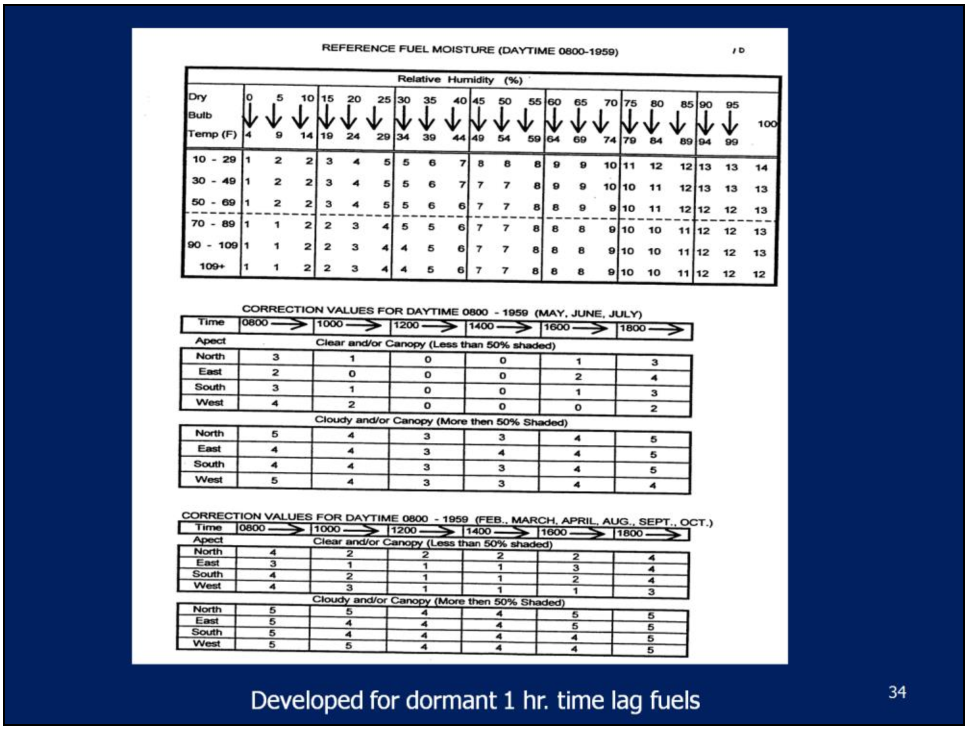
R.H. (%)	1-HR. F.M. %	10-HR. F.M. %	Relative ease of chance ignition and spotting, general burning conditions.
>60	>20	>15	Very little ignition; some spotting may occur with winds above 9 mi./h.
45-60	15-19	12-15	Low ignition hazard—campfires become dangerous; glowing brands cause ignition when relative humidity is <50 percent.
30-45	11-14	10-12	Medium ignitability— matches become dangerous; "easy" burning conditions.
26-40	8-10	8-9	High ignition hazard—matches always dangerous; occasional crowning, spotting caused by gusty winds; "moderate" burning conditions
15-30	5-7	5-7	Quick ignition, rapid buildup, extensive crowning; any increase in wind causes increased spotting, crowning, loss of control; fire moves up bark of trees igniting aerial fuels; long distance spotting in pine stands; dangerous burning conditions.
<15	<5	<5	All sources of ignition dangerous; aggressive burning, spot fires occur often and spread rapidly, extreme fire behavior probable; critical burning conditions.

Chart developed from fuel models of forest fuels



Reference Fuel Moisture

- Rh divided by 5 can be used to estimate the fuel moisture content of dormant 1hr fuels.
- A reference fuel moisture table can be used to more accurately estimate fuel moisture.
- Actual measurement and calculation of fuel moisture is the most accurate.



REFERENCE FUEL MOISTURE (DAYTIME 0800-1959) / D

Dry Bulb Temp (F)	Relative Humidity (%) 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

CORRECTION VALUES FOR DAYTIME 0800 - 1959 (MAY, JUNE, JULY)

Time	0800 →	1000 →	1200 →	1400 →	1600 →	1800 →
Apect	Clear and/or 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 then 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

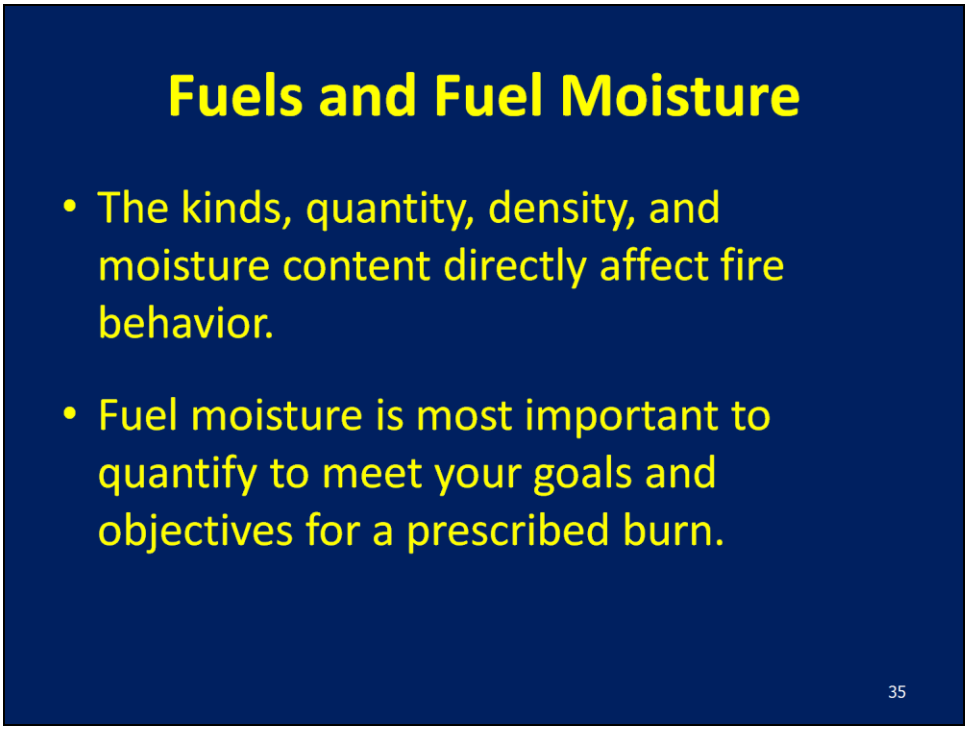
CORRECTION VALUES FOR DAYTIME 0800 - 1959 (FEB., MARCH, APRIL, AUG., SEPT., OCT.)

Time	0800 →	1000 →	1200 →	1400 →	1600 →	1800 →
Apect	Clear and/or 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 then 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

Developed for dormant 1 hr. time lag fuels

For example. You are planning a prescribed burn. The temperature is expected to be 88 degrees with a relative humidity predicted to be around 23. The month is March and you are planning to light the head fire at 2 pm. The pasture that you are burning has less than 50% canopy cover with a south slope. What is the calculated fuel moisture?

Based on the temperature and rh you should get a relative fuel moisture of 3%. To further refine the estimate, find the Month chart for March, and the south slope row and the 1400 (2pm) column and you will find the number 1. Add that number to the base fuel moisture number of 3 and you estimate of fuel moisture would be 4%.



Fuels and Fuel Moisture

- The kinds, quantity, density, and moisture content directly affect fire behavior.
- Fuel moisture is most important to quantify to meet your goals and objectives for a prescribed burn.