FIRE DANGER
Questions You Should Be Able to Answer by the End of this Module

- What are the three major physical determinants of fire danger?
- What are the differences between dead and live fuels?
- How do 1-h and 10-h dead fuels respond differently to weather conditions than 100-h and 1000-h fuels?
- What is a fuel model and how can I change it on OK-FIRE?
- Why is relative greenness (RG) important to fire danger?
- What fire danger variables do fuel model and RG influence?
Fire Danger

FUEL LOADINGS + FUEL MOISTURE + WEATHER
FUEL MODEL + GREENNESS LEVEL + WEATHER

FIRE DANGER MODEL

FIRE BEHAVIOR
Wildland Fuels

- Dead Fuels
- Live Fuels
Dead Fuels
Dead Fuels

(moisture content controlled exclusively by weather conditions)

- Dead roundwood
- Cured/dead vegetation
- Litter/Duff
Classification of Dead Fuels

- 1-hour (dia < 1/4”; depth < 1/4”)
- 10-hour (dia = 1/4 - 1”; depth = 1/4 - 1”)
- 100-hour (dia = 1 - 3”; depth = 1 - 4”)
- 1000-hour (dia = 3 - 8”; depth = 4 - 12”)

Dead Fuel Moisture
(the “Nelson model”)

- 1-hour
  - 1-85%

- 10-hour
  - 1-60%

- 100-hour
  - 1-40%

- 1000-hour
  - 1-32%
1-h and 10-h Dead Fuel Moisture
Typical Daily Pattern when No Rain

Firegram for Buffalo
## 1 and 10-h Dead Fuel Moisture

<table>
<thead>
<tr>
<th>1-hr fuels</th>
<th>10-hr fuels</th>
<th>Fire Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 20%</td>
<td>&gt; 15%</td>
<td>Fuels too moist for fire spread; heavy smoke possible</td>
</tr>
<tr>
<td>7-20%</td>
<td>6-15%</td>
<td>Normal range for prescribed burning</td>
</tr>
<tr>
<td>5-7%</td>
<td>5-6%</td>
<td>Containment difficult; quick ignition; spot fires increase</td>
</tr>
<tr>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>Extreme fire behavior; spot fires frequent; burn with extreme caution</td>
</tr>
</tbody>
</table>
10-hr Dead Fuel Moisture

10-hr Dead Fuel Moisture (%)
100-h and 1000-h Dead Fuel Moisture
100-hr Dead Fuel Moisture

- 36-40: 7
- 31-35: 6
- 26-30: 5
- 21-25: 4
- 16-20: 3
- 11-15: 2
- 8-10: 0-1

Map of Oklahoma showing dead fuel moisture percentages for 100 hours.
1000-hr Dead Fuel Moisture

6:00 PM April 17, 2018 CDT
100-hr (blue) and 1000-hr (green) Dead Fuel Moisture (Oilton)

20,000 acre Keystone/Terlton fires
Fractional Available Water (FAW) (Oilton)
Ferguson Fire
September 1-10, 2011
39,907 acres
100-hr (blue) and 1000-hr (green) Dead Fuel Moisture (Medicine Park)

40,000 acre Ferguson fire
16” Fraction of Plant Available Water
*(Medicine Park)*

![Graph showing the fraction of plant available water over time.](image)

- **40,000 acre Ferguson fire**

The graph illustrates the fluctuation of the fraction of plant available water (FAW) from January 1, 2011, to January 1, 2013. The water levels are measured in inches (0-40 cm) and show significant changes, particularly corresponding to the 40,000 acre Ferguson fire.
Live Fuels
(moisture content based on plant physiology and soil moisture)

- Herbaceous (grasses/forbs)
- Woody (leaves/twigs)
Live Fuel Moisture

- **Herbaceous (grasses/forbs)**
  - up to 200%

- **Woody (leaves/twigs)**
  - up to 160%
Napa County, California – October 2017 Fires
Web Site Demo:
Fuel Moisture Products in OK-FIRE
Fuel Models
1988 NFDRS Fuel Models (20 Models)

- Loading of Dead Fuels (tons/acre)
  - 1-hr
  - 10-hr
  - 100-hr
  - 1000-hr
  - drought

- Loading of Live Fuels (tons/acre)
  - herbaceous
  - woody
### 1988 NFDRS Fuel Model Descriptions

<table>
<thead>
<tr>
<th>Fuel model parameters</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q*</th>
<th>R</th>
<th>S</th>
<th>T</th>
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<tr>
<td><strong>Load (tons/acre)</strong></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>1-hour dead</td>
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<td>3.5</td>
<td>0.4</td>
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<td>1.0</td>
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<td>2.5</td>
<td>1.5</td>
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<td>7.0</td>
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<td>0.25</td>
<td>1.5</td>
<td>2.0</td>
<td>1.0</td>
<td>2.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
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<tr>
<td>10-hour dead</td>
<td>--</td>
<td>4.0</td>
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<td>1.0</td>
<td>0.5</td>
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<td>2.0</td>
<td>1.0</td>
<td>12.0</td>
<td>7.0</td>
<td>2.5</td>
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<td>1.5</td>
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<td>5.4</td>
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<td>0.25</td>
<td>1.5</td>
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<td>2.0</td>
<td>10.0</td>
<td>6.0</td>
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<td>--</td>
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<td>1000-hour dead</td>
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<td>1.0</td>
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<td>0.5</td>
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<td>Woody</td>
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<td>11.5</td>
<td>0.8</td>
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<td>7.0</td>
<td>0.5</td>
<td>0.5</td>
<td>--</td>
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<td>2.0</td>
<td>7.0</td>
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<td>Herbaceous</td>
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<td>0.8</td>
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<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
<td>--</td>
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<tr>
<td>Drought</td>
<td>0.2</td>
<td>3.5</td>
<td>1.8</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>5.0</td>
<td>2.0</td>
<td>12.0</td>
<td>7.0</td>
<td>2.5</td>
<td>0.25</td>
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<td>3.5</td>
<td>1.0</td>
<td>3.5</td>
<td>0.5</td>
<td>1.5</td>
<td>1.0</td>
<td>2.0</td>
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</table>
Oklahoma Default Fuel Models

- Grassy Models
  - Model A
  - Model L
  - Model T

- Brushy Models
  - Model B
  - Model F

- Forest Models
  - Model P
  - Model R
Oklahoma Default Fuel Models
Station Fuel Model Options

**Grassy Models**
- A - Western annual grasses / annual cropland / urban
- L - Western perennial grasses
- T - Tallgrass with open evergreen brush

**Brushy Models**
- B - Tall dense evergreen brush / eastern redcedar
- F - Intermediate evergreen brush

**Forest Models**
- G - Forest with heavy downed fuels
- P - Southern pine forest
- R - Hardwood forest

**Light Slash**
- K - Light slash
Grassy Fuel Models
Fuel Model A: Western Annual Grasses
(also used in OK-FIRE for annual cropland and urban areas)
Please note that a LOT of Mesonet stations are assigned Fuel Model A as their default fuel model. In “Station Fuel Model Options” you may wish to change the fuel model for these stations to one (e.g., Model L, Model T) with heavier fuel loads to represent your wildland fuels.
Fuel Model L: Western Perennial Grasses
Fuel Model T: Tallgrass with Open Evergreen Brush
Brushy Fuel Models
Fuel Model B: Tall Dense Evergreen Brush
(also can be used for eastern redcedar forests)
Fuel Model F: Intermediate Evergreen Brush
Fuel Model G: Forest with Heavy Downed Fuels
Fuel Model P: Southern Pine Forest
Fuel Model R: Hardwood Forest
Slash Model
Fuel Model K: Light Slash
Select Mesonet Station

Type in city name or zip code to find nearest Mesonet station

Display Mode:
- Charts
- Tables

Time Mode:
- Past
- Forecast

Selected Station:
Stillwater

Variable(s)
- Burning Index (BI)

Duration
Next 84 Hours
Interval
1 Hr

Default Fuel Model:
T - Tallgrass with open evergreen brush

Current Fuel Model:
T - Tallgrass with open evergreen brush

Add Second Fuel Model:
F - Intermediate evergreen brush

Get Data
Web Site Demo:
Fuel Models in OK-FIRE
FUEL MODEL + GREENNESS LEVEL + WEATHER

FIRE DANGER MODEL

FIRE BEHAVIOR
Satellite Assessment of Vegetation Greenness
NASA Aqua Satellite
Utilization of Satellite Data

- **Daily updates of NDVI 500-m pixel data from the MODIS sensor aboard Aqua**
  - Last 7-day NDVI composites updated daily

- **Visual Greenness (VG)**
  - Greenness (0-100%) as it would be perceived by the eye

- **Relative Greenness (RG)**
  - Greenness (0-100%) relative to 10-yr historical range (2003-2012) of NDVI values for that pixel
Relative Greenness Values Used to Model Live Fuel Moisture and the Live-to-Dead Fuel Ratio
Napa County, California – October 2017 Fires
Annual Relative Greenness Cycle: Foraker 2009
(Tallgrass Prairie)

Live Fuel / Dead Fuel = LOW
Green-up
Live Fuel / Dead Fuel = HIGH
Senescence
Forecast Burning Index with Different RG Values
(Same Fuel Model = T; Same Weather)

Lahoma (RG = 21%)

Blackwell (RG = 59%)
Satellite “sees” composite vegetation in each 500-m pixel; if you are in an agricultural or urban area, the nearest Mesonet station RG value may not properly represent the greenness of the wildland fuels in your area.
Accordingly, it’s important to know the current greenness conditions of your wildland fuels and to choose a nearby Mesonet station to use with the fire danger model whose RG value best reflects what you’re currently seeing on the ground.
Web Site Demo:
Relative Greenness Products in OK-FIRE
FUEL MODEL + GREENNESS LEVEL + WEATHER

FIRE DANGER MODEL

FIRE BEHAVIOR
The OKLAHOMA MESONET
*(current and past weather conditions)*
Forecast Meteogram Chart for Stillwater

84-h Output from the NAM Model
(forecast weather conditions)

- Relative Humidity
- 1-hr Precipitation

Wind Speed (mph)

- Wind Speed
- Wind Barbs
FUEL MODEL + GREENNESS LEVEL + WEATHER

FIRE DANGER MODEL

FIRE BEHAVIOR
National Fire Danger Rating System (NFDRS)
NFDRS Fire Danger Indices

- **Spread Component (SC)**
  - relates to forward speed of fire (ft/min)

- **Energy Release Component (ERC)**
  - relates to heat release per unit area in flaming zone

- **Burning Index (BI)**
  - based on both SC and ERC
  - relates to fireline intensity and flame length (BI/10 ft)
Spread Component (ft/min)

5:00 PM April 17, 2018 CDT

Created 6:14:06 PM April 17, 2018 CDT. © Copyright 2018
Energy Release Component

Energy Release Component (BTU/ft²)

Mesonet

5:00 PM April 17, 2018 CDT
Created 6:14:06 PM April 17, 2018 CDT. © Copyright 2018
# Burning Index Interpretation

## Fire Danger Level

<table>
<thead>
<tr>
<th>Fire Danger Level</th>
<th>Flame Length (ft)</th>
<th>Fireline Intensity (Btu/ft/s)</th>
<th>Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOW</strong> (0-20)</td>
<td>&lt;4 (Bl &lt; 40)</td>
<td>&lt;100</td>
<td>Fires can generally be attacked at the head or flanks by persons using handtools. Hand line should hold the fire.</td>
</tr>
<tr>
<td></td>
<td>4-8 (Bl=40-80)</td>
<td>100-500</td>
<td>Fires are too intense for direct attack on the head by persons using handtools. Hand line cannot be relied on to hold fire. Equipment such as dozers, pumpers, and retardant aircraft can be effective.</td>
</tr>
<tr>
<td></td>
<td>8-11 (Bl=80-110)</td>
<td>500-1,000</td>
<td>Fires may present serious control problems--torching out, crowning, and spotting. Control efforts at the fire head will probably be ineffective.</td>
</tr>
<tr>
<td></td>
<td>&gt; 11 (Bl &gt; 110)</td>
<td>&gt;1,000</td>
<td>Crowning, spotting, and major fire runs are probable. Control efforts at head of fire are ineffective.</td>
</tr>
<tr>
<td><strong>MODERATE</strong> (20-40)</td>
<td>(Bl &lt; 40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HIGH</strong> (40-80)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SEVERE</strong> (80-110)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>EXTREME</strong> (110+)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Current Relative Humidity and Wind Direction**

- **Station:** Stillwater, Oilton

- **Weather:**
  - **Relative Humidity:**
    - Stillwater: 83%
    - Oilton: 79%
  - **Past 1-hr RH Change:**
    - Stillwater: +4%
    - Oilton: +1%
  - **10-m Wind:**
    - Stillwater: NNW at 8 mph
    - Oilton: NNW at 7 mph
  - **Max Wind Gust:**
    - Stillwater: 10 mph
    - Oilton: 14 mph
  - **Temperature:**
    - Stillwater: 50°F
    - Oilton: 50°F
  - **24-hr Rainfall:**
    - Stillwater: 0.46 in
    - Oilton: 0.22 in
  - **Dispersion:**
    - Stillwater: Moderately Poor
    - Oilton: Moderately Poor
  - **Sunrise / Sunset:**
    - Stillwater: 6:34 am / 8:17 pm
    - Oilton: 6:31 am / 8:15 pm

- **Fire Danger:**
  - **Current Fire Danger:** LOW
  - **Burning Index:**
    - Stillwater: 1
    - Oilton: 3
  - **Spread Component:**
    - Stillwater: 0
    - Oilton: 0
  - **Ignition Component:**
    - Stillwater: 1%
    - Oilton: 2%
  - **NFDRS Fuel Model:**
    - Stillwater: T
    - Oilton: R
  - **1-hr Fuel Moisture:**
    - Stillwater: 14%
    - Oilton: 15%
  - **10-hr Fuel Moisture:**
    - Stillwater: 16%
    - Oilton: 17%
  - **Soil Moisture:**
    - Stillwater: 98%
    - Oilton: 98%
  - **KBDI:**
    - Stillwater: 0
    - Oilton: 16
  - **Relative Greenness:**
    - Stillwater: 87%
    - Oilton: 89%
Typical Daily Cycle (Burning Index)

Firegram for Arnett

- Burning Index (10°Ft) - Fuel Model L

Graph showing the typical daily cycle of the burning index.
Look for days with high BI values (> 40) and how they compare to others in the 84-h forecast period.
Look for high BI values as well as their duration
NFDRS Fire Danger Indices

- Ignition Component (IC)
  - relates to probability of reportable fire resulting from a firebrand; says nothing of intensity
Ignition Component

Ignition Component (%)
Keetch-Byram Drought Index

- Index (0-800) added to NFDRS in 1988 based on simple model to estimate water content in soil column

\[ 0 = \text{saturated (8” water)}; \ 800 = \text{no water} \]
Keetch-Byram Drought Index (KBDI)
Comparison of Soil Moisture and KBDI Maps
July 11, 2019

Map 1: Large Wildfire Potential (May - October)
- Low
- Moderate
- High
- Extreme

Map 2: 24-hr Avg 16-inch Plant Available Soil Moisture (%)

Map 3: Keetch-Byram Drought Index
- 750-800
- 700-749
- 600-699
- 500-599
- 400-499
- 300-399
- 200-299
- 100-199
- 0-99
The Oklahoma Fire Danger Model
Oklahoma Fire Danger Model

- Model is run every 15 minutes with Mesonet data
- Colored maps (500-m resolution) of BI, SC, ERC, and IC
- Colored maps of 1-h, 10-h, 100-h, 1000-h dead fuel moisture (every 15 minutes), live fuel moisture (daily), and KBDI (daily)
- Charts and tables for Mesonet sites
Questions You Should Be Able to Answer by the End of this Module

- What are the three major physical determinants of fire danger?
- What are the differences between dead and live fuels?
- How do 1-h and 10-h dead fuels respond differently to weather conditions than 100-h and 1000-h fuels?
- What is a fuel model and how can I change it on OK-FIRE?
- Why is relative greenness (RG) important to fire danger?
- What fire danger variables do fuel model and RG influence?
QUESTIONS ?
Web Site Demo:
Fire Danger Model Output