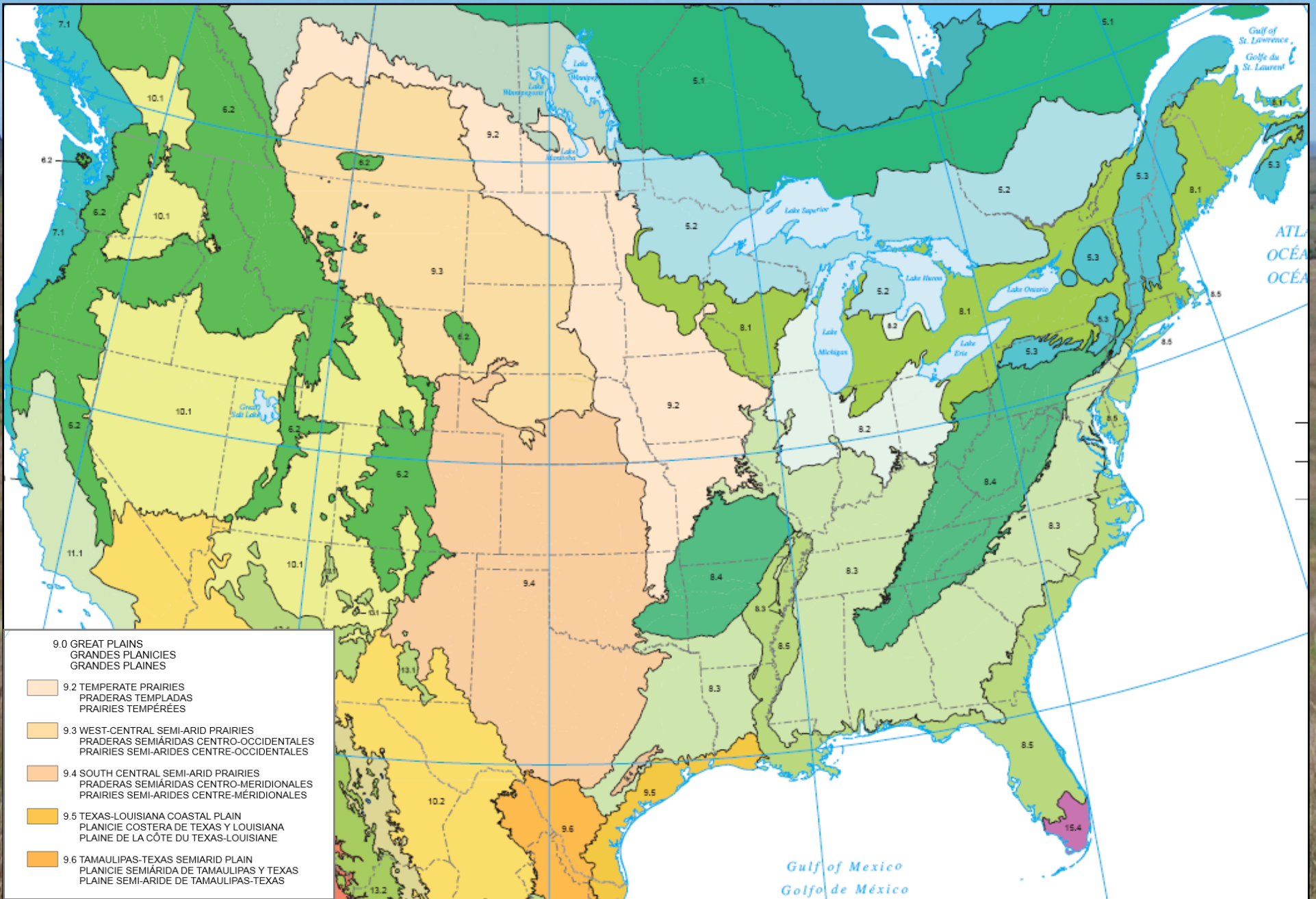


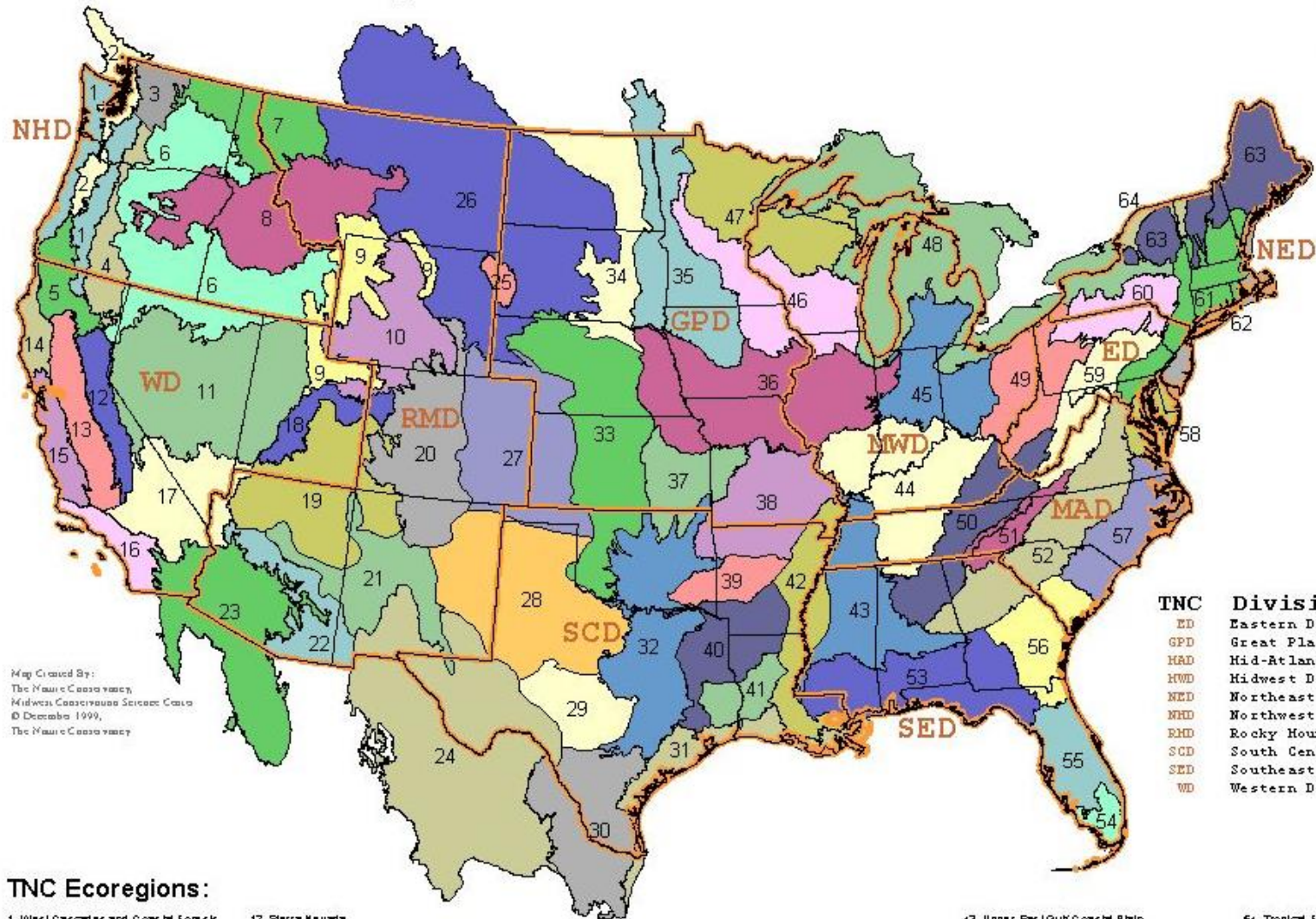
Weather and Soil Moisture Impacts on Large Oklahoma Wildfires from 2000 to 2012



J. D. Carlson, Erik S. Krueger, and Tyson E. Ochsner
Oklahoma State University, Stillwater, Oklahoma



TNC Ecoregions and Divisions of the Lower 48 United States

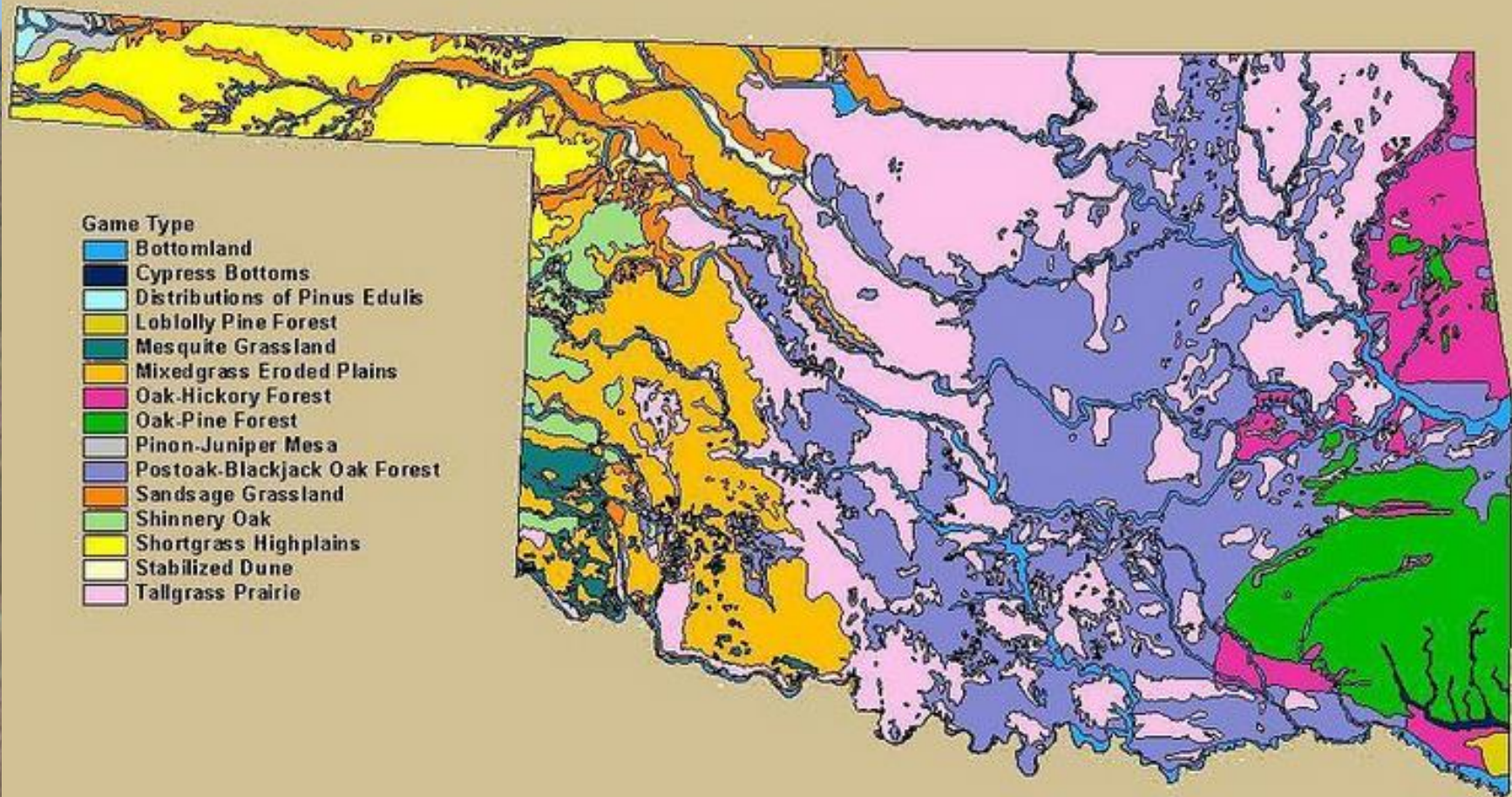


Map Created By:
The Nature Conservancy,
Midwest Conservation Service Center
© December 1999,
The Nature Conservancy

- TNC Divisions:**
- ED Eastern Division
 - GPD Great Plains Division
 - MAD Mid-Atlantic Division
 - MWD Midwest Division
 - NED Northeast Division
 - NHD Northwest & Hawaii Division
 - RMD Rocky Mountain Division
 - SCD South Central Division
 - SED Southeast Division
 - WD Western Division

TNC Ecoregions:

- | | | | | | |
|---------------------------------------|---------------------------------|---|-------------------------------------|---|--|
| 1 West Cascades and Coastal Forests | 12 Sierra Nevada | 23 Sonoran Desert | 33 Central Mixed-Grass Prairie | 43 Upper East Gulf Coastal Plain | 54 Tropical Florida |
| 2 Puget Trough and Willamette Valley | 13 Great Central Valley | 24 Chihuahuan Desert | 34 Northern Mixed-Grass Prairie | 44 Interior Low Plateau | 55 Florida Peninsula |
| 3 North Cascades | 14 California North Coast | 25 Black Hills | 35 Northern Tallgrass Prairie | 45 North Central Tillplain | 56 South Atlantic Coastal Plain |
| 4 Modoc Plateau and East Cascades | 15 California Central Coast I | 26 Northern Great Plains Steppe | 36 Central Tallgrass Prairie | 46 Prairie-Forest Border | 57 Mid-Atlantic Coastal Plain |
| 5 Klamath Mountains | 16 California South Coast | 27 Central Shortgrass Prairie | 37 Central Shortgrass Prairie | 47 Superior Mixed Forest | 58 Chesapeake Bay Lowlands |
| 6 Columbia Plateau | 17 Mojave Desert | 28 Southern Shortgrass Prairie | 38 Ozarks | 48 Great Lakes | 59 Central Appalachian Forest |
| 7 Canadian Rocky Mountains | 18 Utah High Plateaus | 29 Edwards Plateau | 39 Ouachita Mountains | 49 Western Allegheny Plateau | 60 High Allegheny Plateau |
| 8 Middle Rocky Mountain-Blue Mountain | 19 Colorado Plateau | 30 Tamaulipan Thorn Scrub | 40 Upper West Gulf Coastal Plain | 50 Cumberland and Southern Ridge and Valley | 61 Lower New England/Northern Piedmont |
| 9 Utah-Wyoming Rocky Mountains | 20 Colorado Rocky Mountains | 31 Gulf Coast Prairies and Marshes | 41 West Gulf Coastal Plain | 51 Southern Blue Ridge | 62 North Atlantic Coast |
| 10 Wyoming Basins | 21 Arizona-New Mexico Mountains | 32 Cross Timbers and Southern Tallgrass Prairie | 42 Mississippi River Alluvial Plain | 52 Piedmont | 63 Northern Appalachian/Boreal Forest |
| 11 Great Basin | 22 Apache Highlands | | | 53 East Gulf Coastal Plain | 64 St. Lawrence/Champlain Valley |



Map courtesy of Oklahoma Biological Survey

A landscape photograph showing a field of tall, golden-brown grasses in the foreground, with several small, dark shrubs scattered throughout. The background consists of a flat horizon line under a clear, light blue sky. The overall scene is bright and clear, suggesting a sunny day.

Oklahoma Fuels: Dormant Season







Oklahoma Fuels: Growing Season





10:02 84°



KOTV - DT

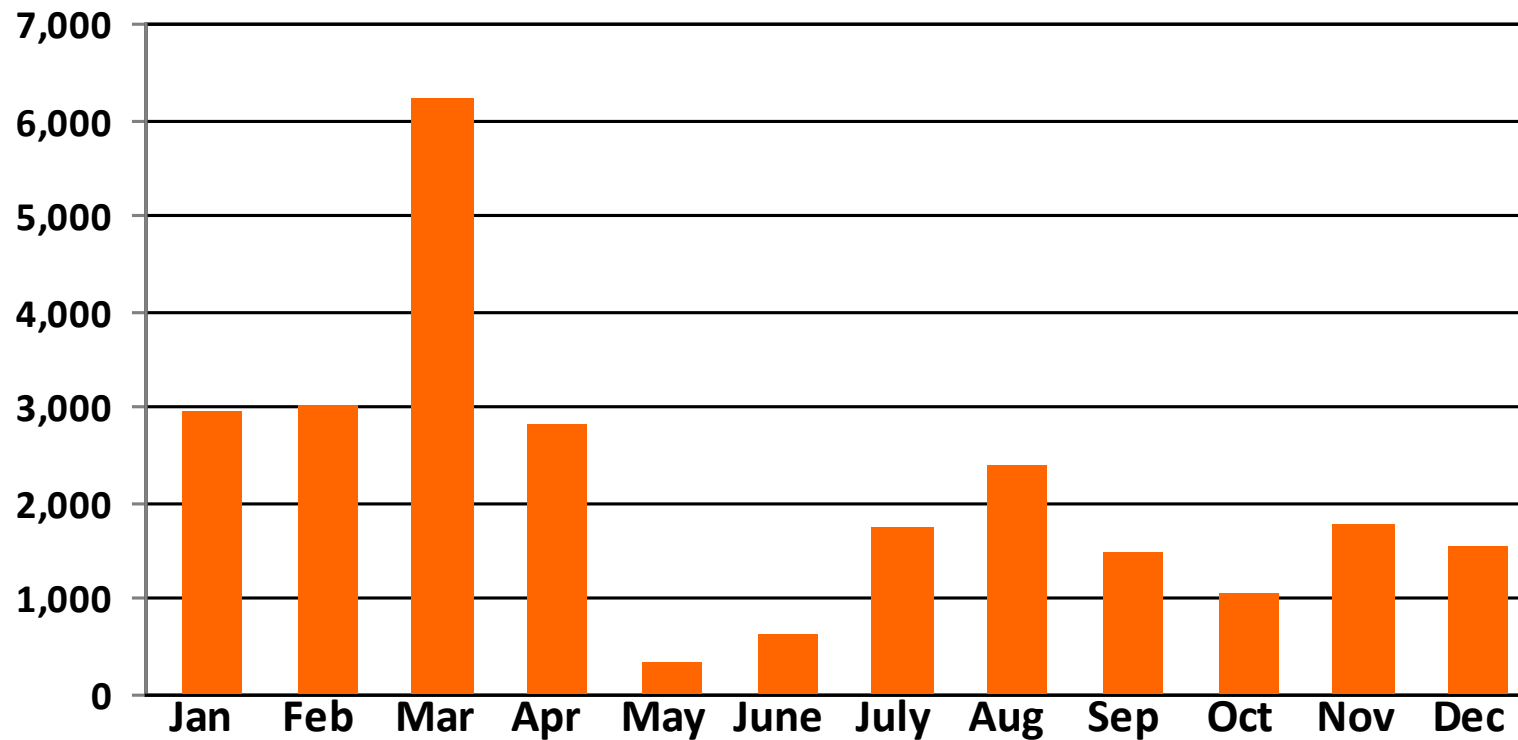


Oklahoma Wildfire Database (25,829 wildfires from 2000-2012)

- **Karen Short database (Oklahoma fires) for 2000-2012**
- **111 wildfires \geq 1000 acres reported to Oklahoma Fire Marshal were added (flagged as likely viable by Karen and not in her database)**

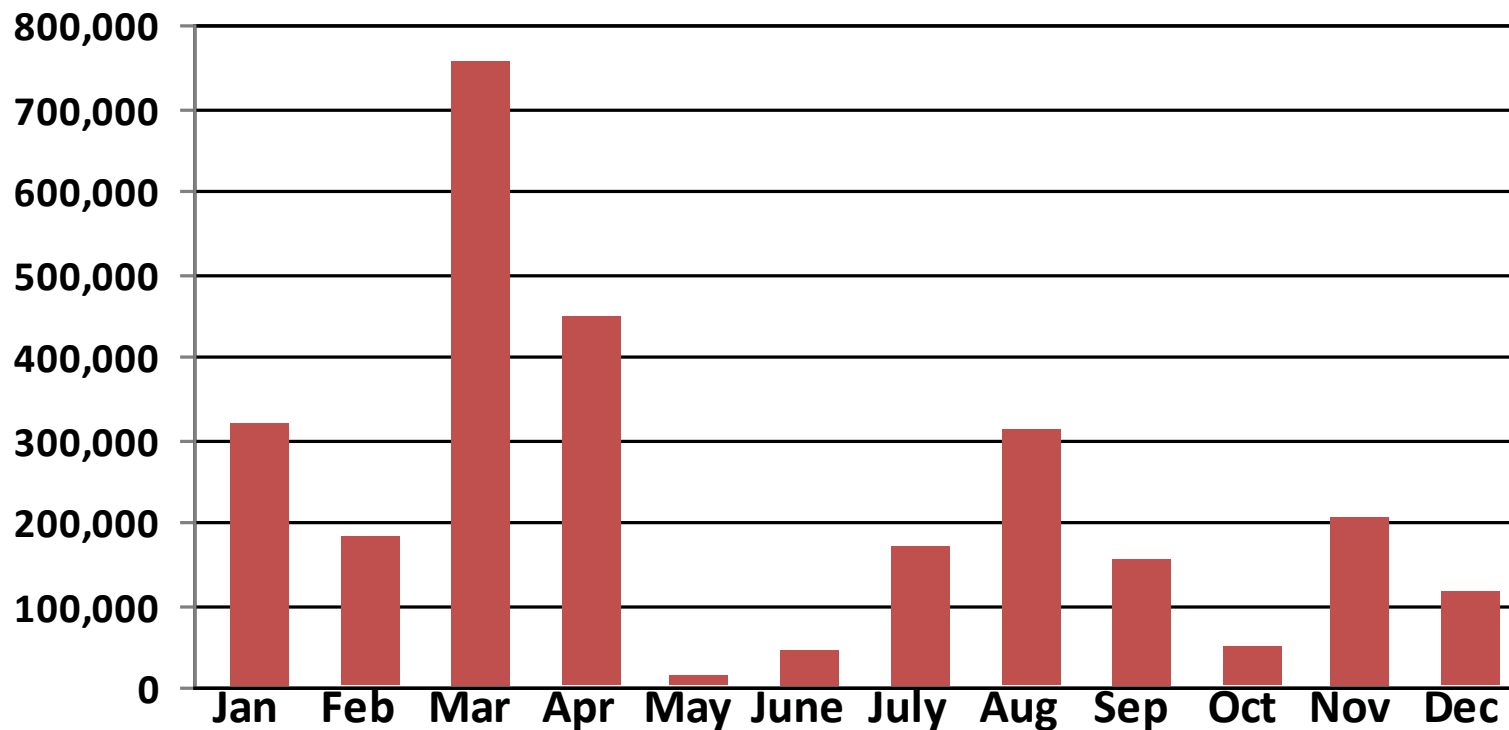
Oklahoma Wildfire Monthly Climatology (25,829 wildfires from 2000-2012)

Total Number of Wildfires by Month

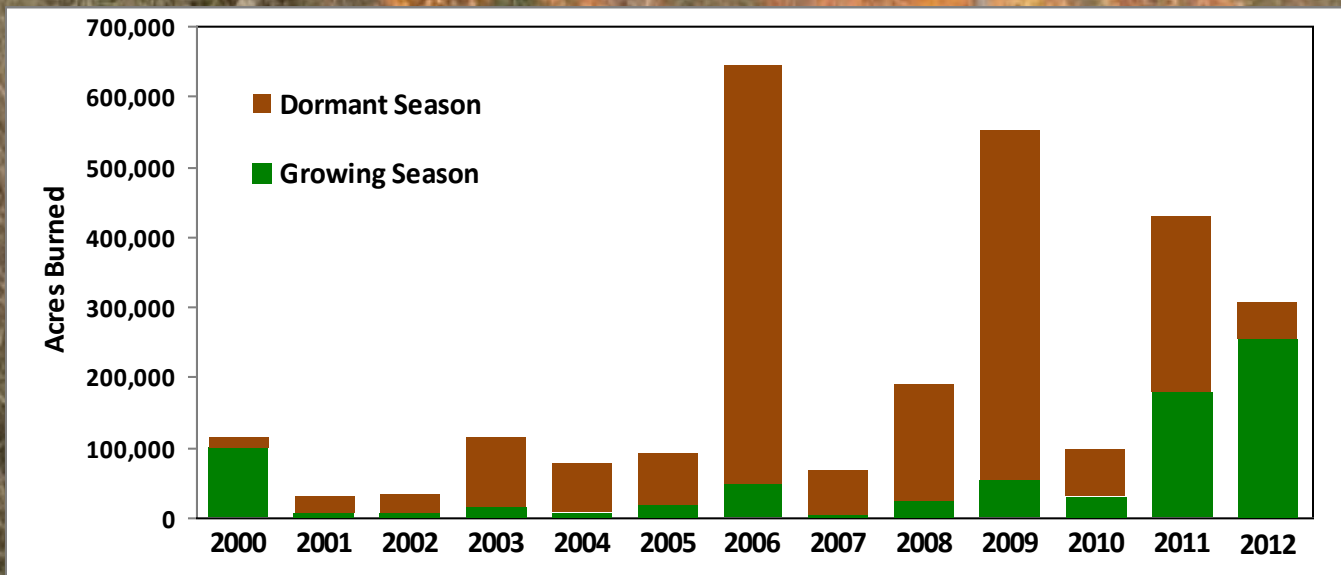
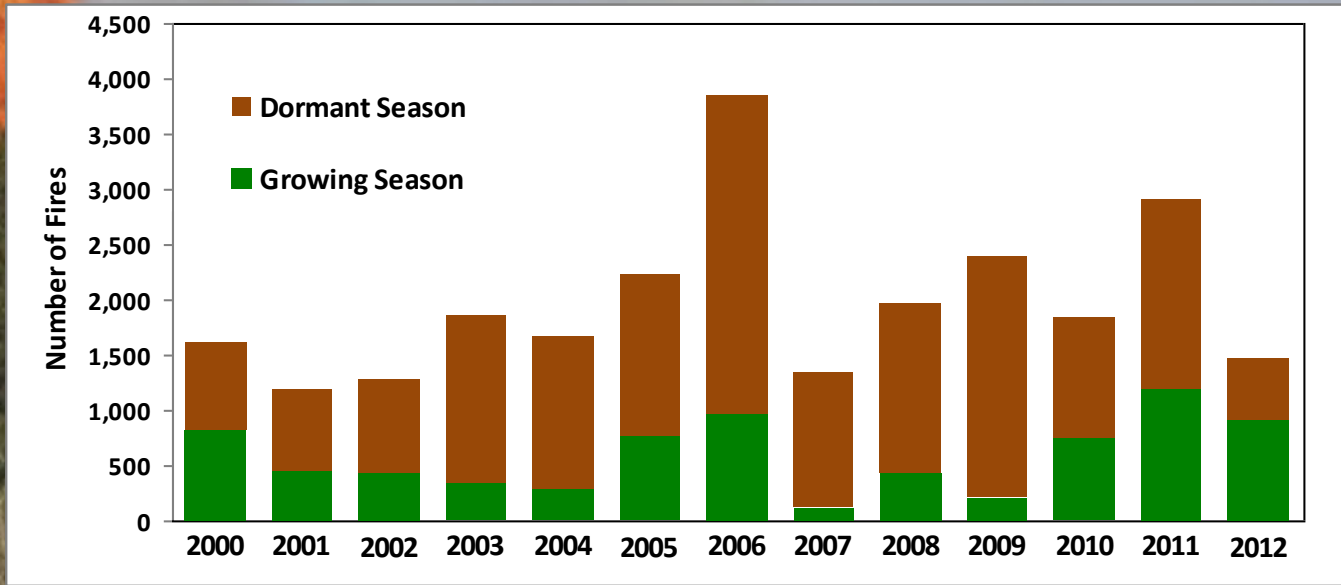


Oklahoma Wildfire Monthly Climatology (25,829 wildfires from 2000-2012)

Total Acres Burned by Month

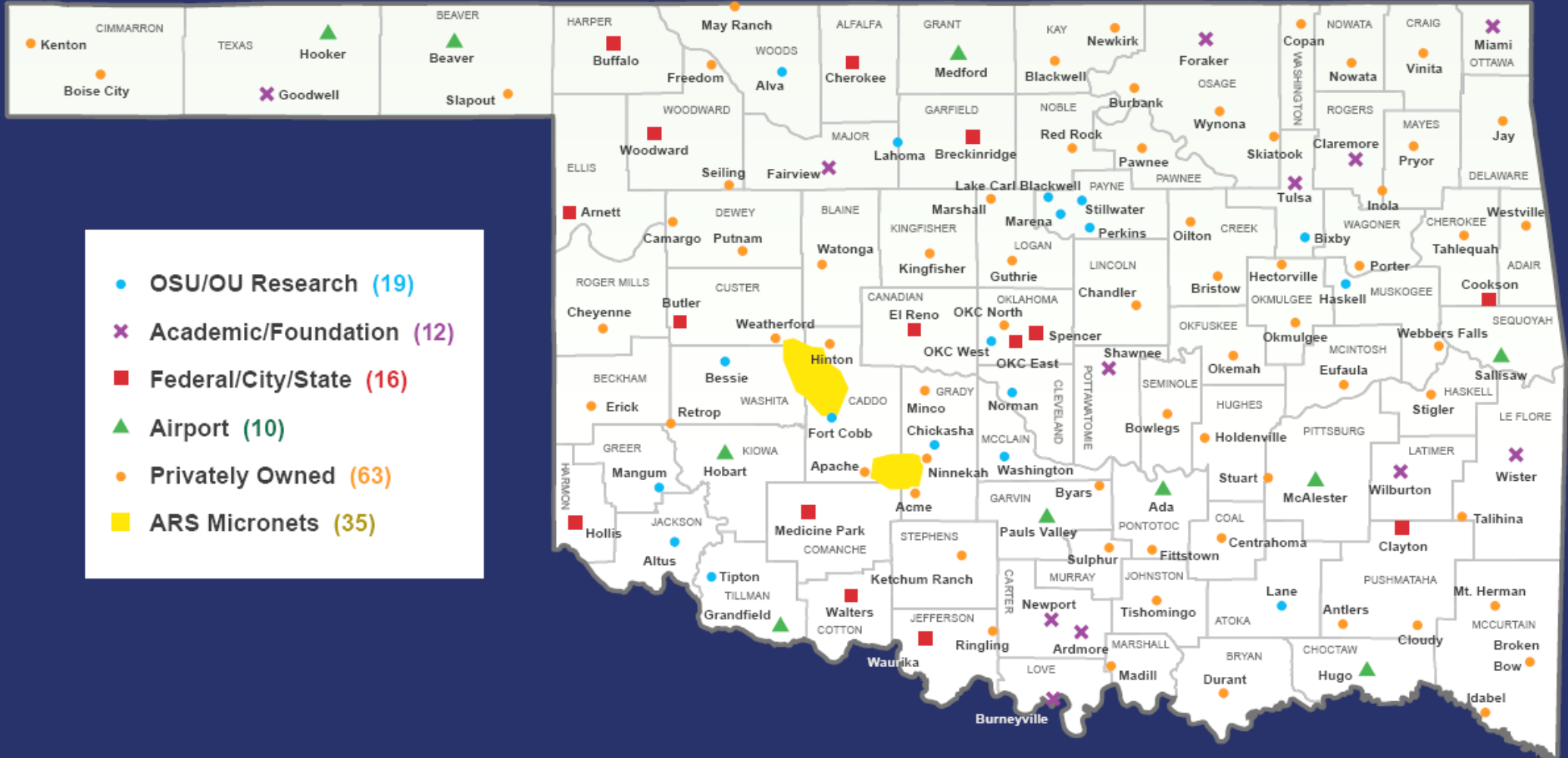


Oklahoma Wildfires by Year (2000-2012)



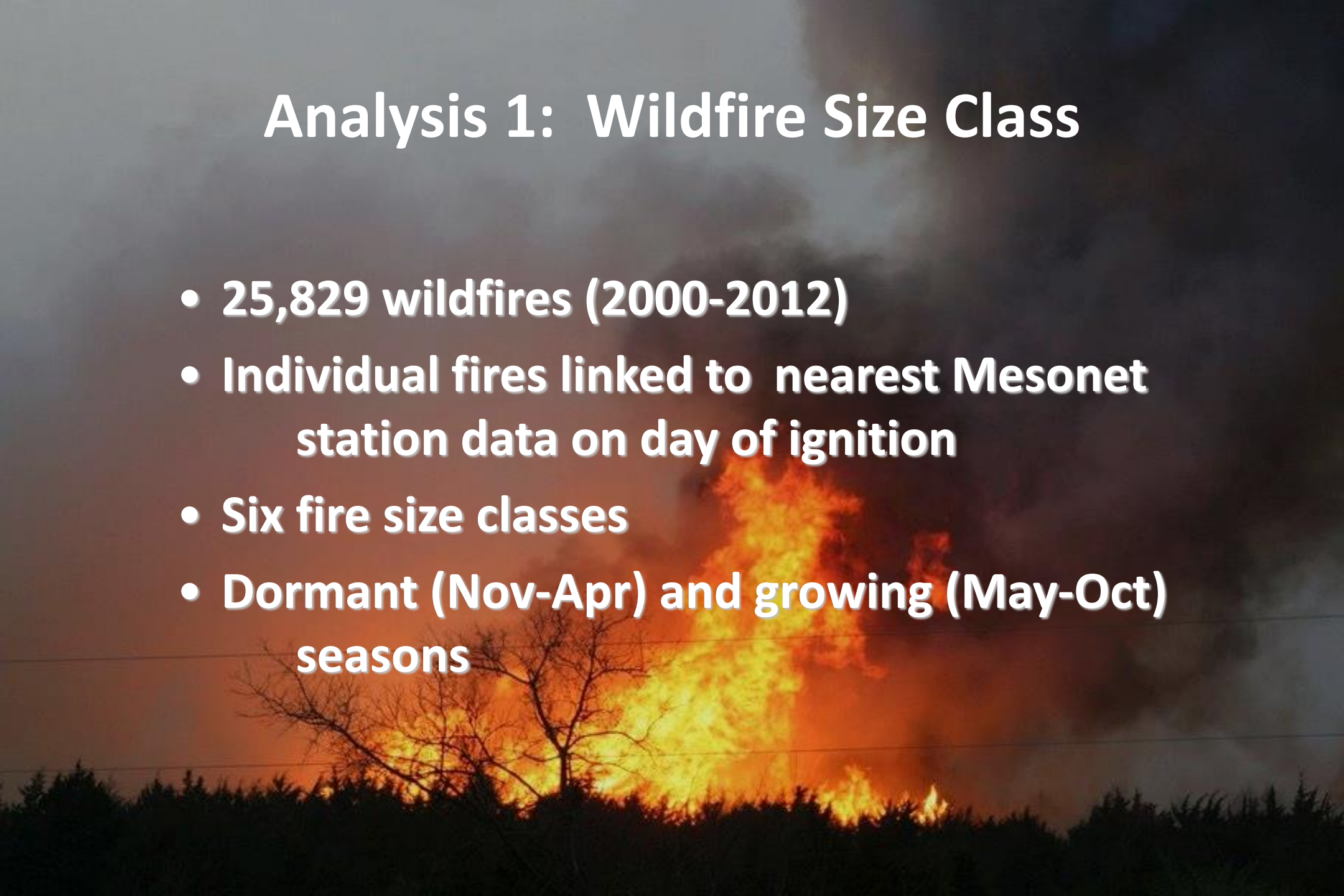
The Oklahoma Mesonet





Analysis 1: Wildfire Size Class

- **25,829 wildfires (2000-2012)**
- **Individual fires linked to nearest Mesonet station data on day of ignition**
- **Six fire size classes**
- **Dormant (Nov-Apr) and growing (May-Oct) seasons**



Wildfire Size Classes

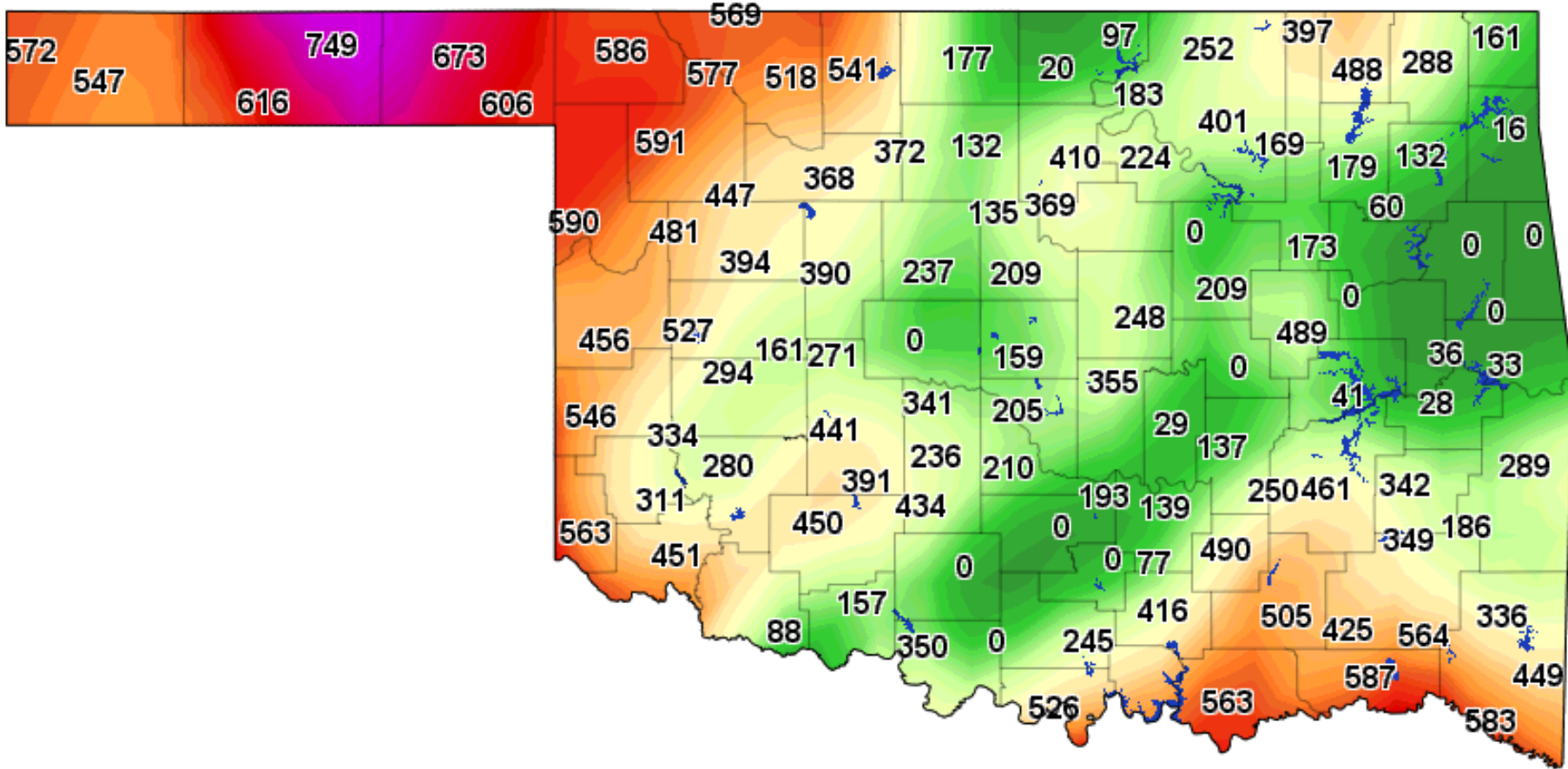
- **Class 1** < 1 acre (0.40 ha)
- **Class 2** 1-10 acres
- **Class 3** 10-100 acres
- **Class 4** 100-1000 acres
- **Class 5** 1000-10,000 acres
- **Class 6** \geq 10,000 acres (4047 ha)

Variables Inspected

- Max Air Temperature
- Min Relative Humidity
- Average and Max Wind Speed
- Daily Solar Radiation
- Daily Precipitation
- KBDI
- 1-hr, 10-hr, 100-hr, and 1000-hr Dead Fuel Moisture
- Soil Moisture (Fractional Available Water)

Keetch-Byram Drought Index (KBDI)

Function of daily max temp and precipitation



09-Nov-2011 01:00 PM CST

Dead Fuels

(Dead Fuel Moisture = % moisture content by weight)



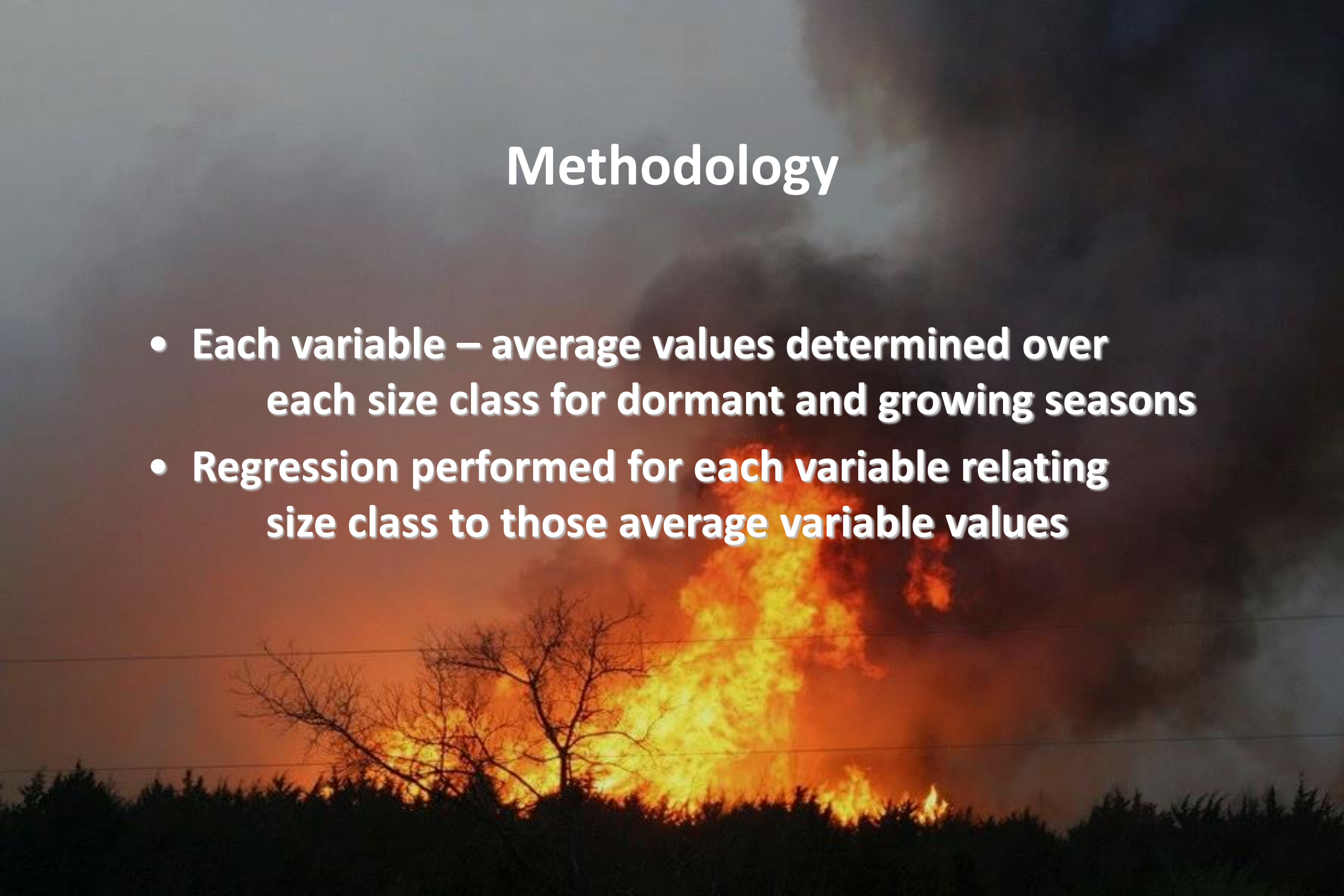
Soil Moisture (FAW)

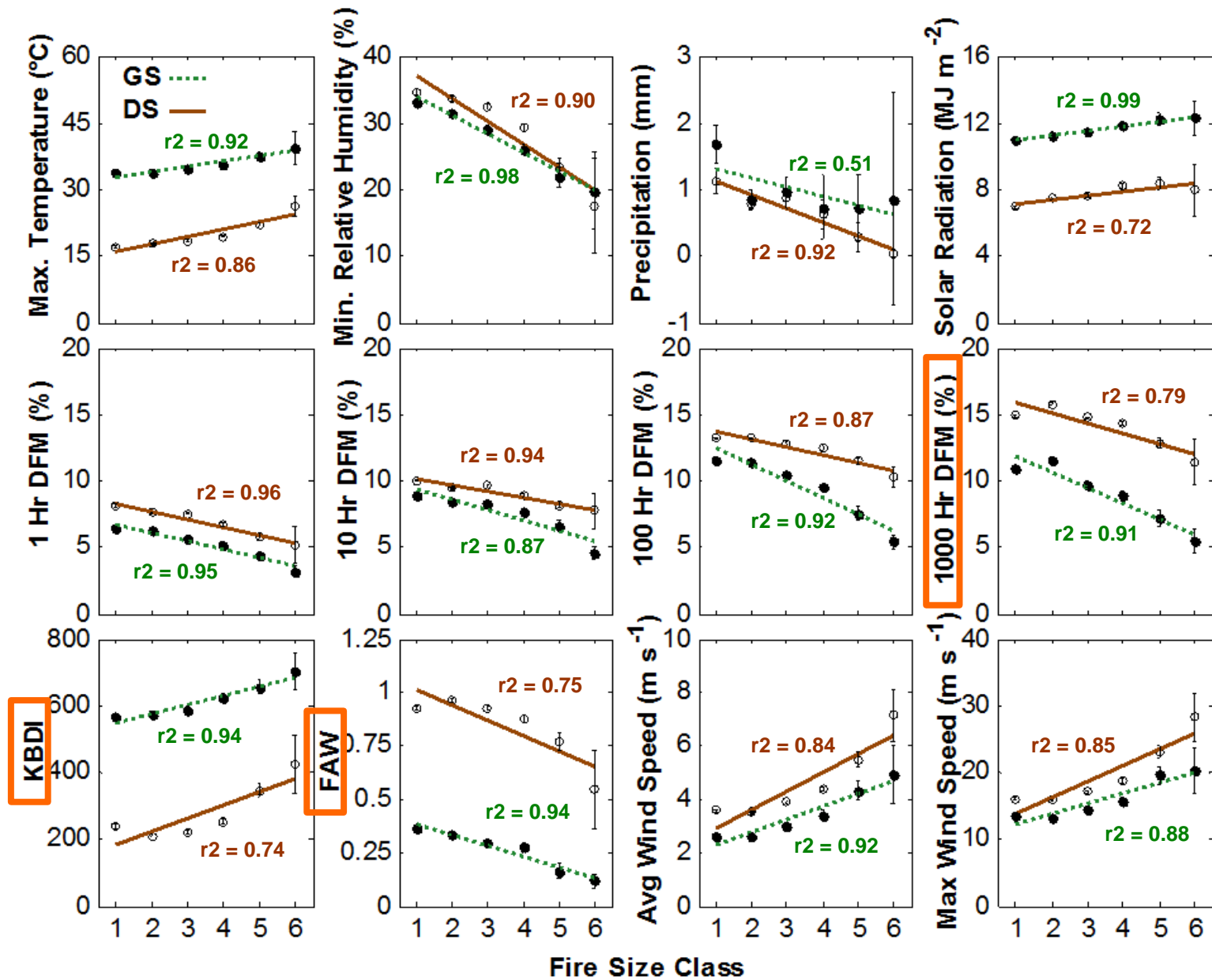
- Mesonet soil moisture sensors at 5, 25, 60, 75 cm
- Integrated water content: 0-40 cm soil layer
- Volumetric Water Content (VWC)
- Fractional Available Water (FAW)
- Normally, $0 \leq \text{FAW} \leq 1$


$$\text{FAW} = (\text{VWC} - \text{VWC}_{\text{wp}}) / (\text{VWC}_{\text{fc}} - \text{VWC}_{\text{wp}})$$

Methodology

- **Each variable – average values determined over each size class for dormant and growing seasons**
- **Regression performed for each variable relating size class to those average variable values**







Toward a Statewide Predictive System
(large wildfires \geq 1000 acres)

Analysis 2: Wildfire Frequency and Area Burned

- Large wildfires \geq 1000 acres (400 ha)
- 501 wildfires (2000-2012)
- Analyses by month for dormant and growing season fires
- Average statewide weather/soil conditions during month, as well as prior month



Variables Inspected

- Max Air Temperature
- Min Relative Humidity
- Average and Max Wind Speed
- Daily Precipitation
- KBDI
- 1-hr, 10-hr, 100-hr, and 1000-hr Dead Fuel Moisture
- Soil Moisture (Fractional Available Water)



A landscape photograph featuring a utility pole with power lines stretching across the frame. A large, fluffy white cumulus cloud is the central focus, set against a clear blue sky with scattered smaller clouds. The foreground is filled with tall, dry grass, and a dense line of green trees is visible on the left side. The text 'Monthly Correlations' is overlaid in a blue, italicized font on the white cloud.

Monthly Correlations

Correlations with Monthly Wildfires (Growing Season)

Variable	Correlation (r) §	
	Prior Month	Fire Month
<u>Number of Monthly Fires (GS)</u>		
Maximum Temperature	0.48	0.46
Minimum RH	-0.52	-0.69
Average Wind Speed	-0.02	0.03
Maximum Wind Speed	-0.05	0.03
Precipitation	-0.37	-0.37
KBDI	0.38	0.64
FAW ₄₀	-0.42	-0.64
1-hr DFM	-0.32	-0.40
10-hr DFM	-0.25	-0.32
100-hr DFM	-0.56	-0.62
1000-hr DFM	-0.50	-0.63
<u>Monthly Acres Burned (GS)</u>		
Maximum Temperature	0.41	0.44
Minimum RH	-0.42	-0.65
Average Wind Speed	0.01	0.07
Maximum Wind Speed	0.00	0.05
Precipitation	-0.29	-0.34
KBDI	0.28	0.55
FAW ₄₀	-0.32	-0.59
1-hr DFM	-0.27	-0.36
10-hr DFM	-0.19	-0.29
100-hr DFM	-0.45	-0.59
1000-hr DFM	-0.41	-0.59

§ Correlations in bold font are statistically significant at the 95% confidence level.

Correlations with Monthly Wildfires (Dormant Season)

Variable	Correlation (r) §	
	Prior Month	Fire Month
<u>Number of Monthly Fires (DS)</u>		
Maximum Temperature	-0.09	0.33
Minimum RH	-0.18	-0.39
Average Wind Speed	0.28	0.43
Maximum Wind Speed	0.26	0.41
Precipitation	-0.33	0.01
KBDI	0.10	0.25
FAW ₄₀	-0.01	-0.16
1-hr DFM	0.02	-0.18
10-hr DFM	-0.12	-0.19
100-hr DFM	-0.12	-0.23
1000-hr DFM	-0.17	-0.22
<u>Monthly Acres Burned (DS)</u>		
Maximum Temperature	-0.10	0.31
Minimum RH	-0.14	-0.25
Average Wind Speed	0.31	0.37
Maximum Wind Speed	0.30	0.36
Precipitation	-0.26	0.03
KBDI	-0.04	0.10
FAW ₄₀	0.11	-0.04
1-hr DFM	0.06	-0.06
10-hr DFM	-0.07	-0.05
100-hr DFM	-0.09	-0.08
1000-hr DFM	-0.11	-0.12

§ Correlations in bold font are statistically significant at the 95% confidence level.

Monthly Comparisons: Growing vs Dormant Season

Variable	Correlation (r) §	
	Prior Month	Fire Month
<u>Number of Monthly Fires (GS)</u>		
Maximum Temperature	0.48	0.46
Minimum RH	-0.52	-0.69
Average Wind Speed	-0.02	0.03
Maximum Wind Speed	-0.05	0.03
Precipitation	-0.37	-0.37
KBDI	0.38	0.64
FAW ₄₀	-0.42	-0.64
1-hr DFM	-0.32	-0.40
10-hr DFM	-0.25	-0.32
100-hr DFM	-0.56	-0.62
1000-hr DFM	-0.50	-0.63
<u>Monthly Acres Burned (GS)</u>		
Maximum Temperature	0.41	0.44
Minimum RH	-0.42	-0.65
Average Wind Speed	0.01	0.07
Maximum Wind Speed	0.00	0.05
Precipitation	-0.29	-0.34
KBDI	0.28	0.55
FAW ₄₀	-0.32	-0.59
1-hr DFM	-0.27	-0.36
10-hr DFM	-0.19	-0.29
100-hr DFM	-0.45	-0.59
1000-hr DFM	-0.41	-0.59

§ Correlations in bold font are statistically significant at the 95% confidence level.

Variable	Correlation (r) §	
	Prior Month	Fire Month
<u>Number of Monthly Fires (DS)</u>		
Maximum Temperature	-0.09	0.33
Minimum RH	-0.18	-0.39
Average Wind Speed	0.28	0.43
Maximum Wind Speed	0.26	0.41
Precipitation	-0.33	0.01
KBDI	0.10	0.25
FAW ₄₀	-0.01	-0.16
1-hr DFM	0.02	-0.18
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100-hr DFM	-0.12	-0.23
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<u>Monthly Acres Burned (DS)</u>		
Maximum Temperature	-0.10	0.31
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1-hr DFM	0.06	-0.06
10-hr DFM	-0.07	-0.05
100-hr DFM	-0.09	-0.08
1000-hr DFM	-0.11	-0.12

§ Correlations in bold font are statistically significant at the 95% confidence level.

A wide-angle photograph of a lush green field of tall grasses. In the background, there is a dense line of trees under a clear sky. The text is overlaid in the center of the image.

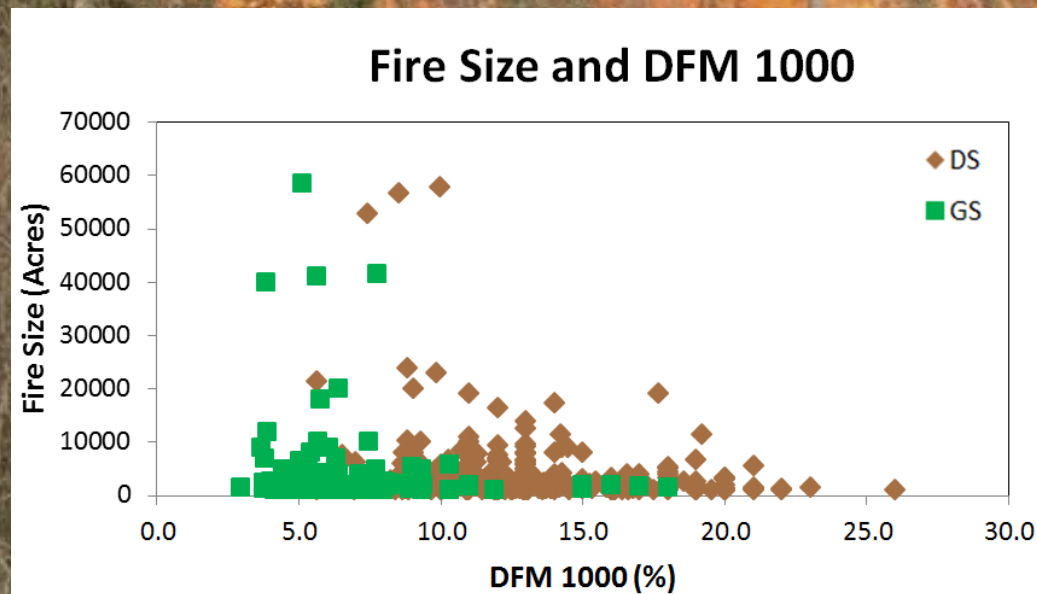
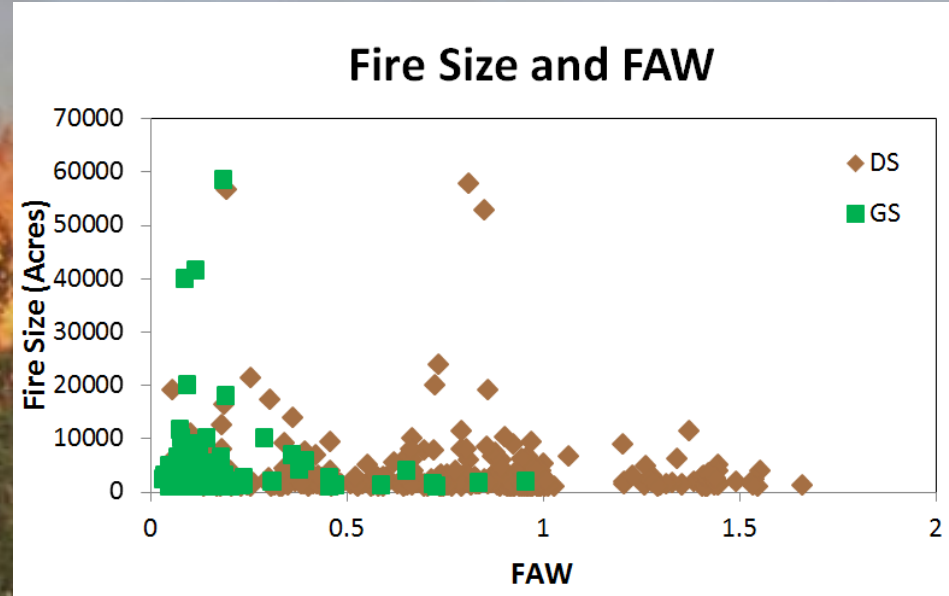
**A Closer Look at Fractional Available Water (FAW)
and 1000-hr Dead Fuel Moisture**

Analysis 3: Acres Burned

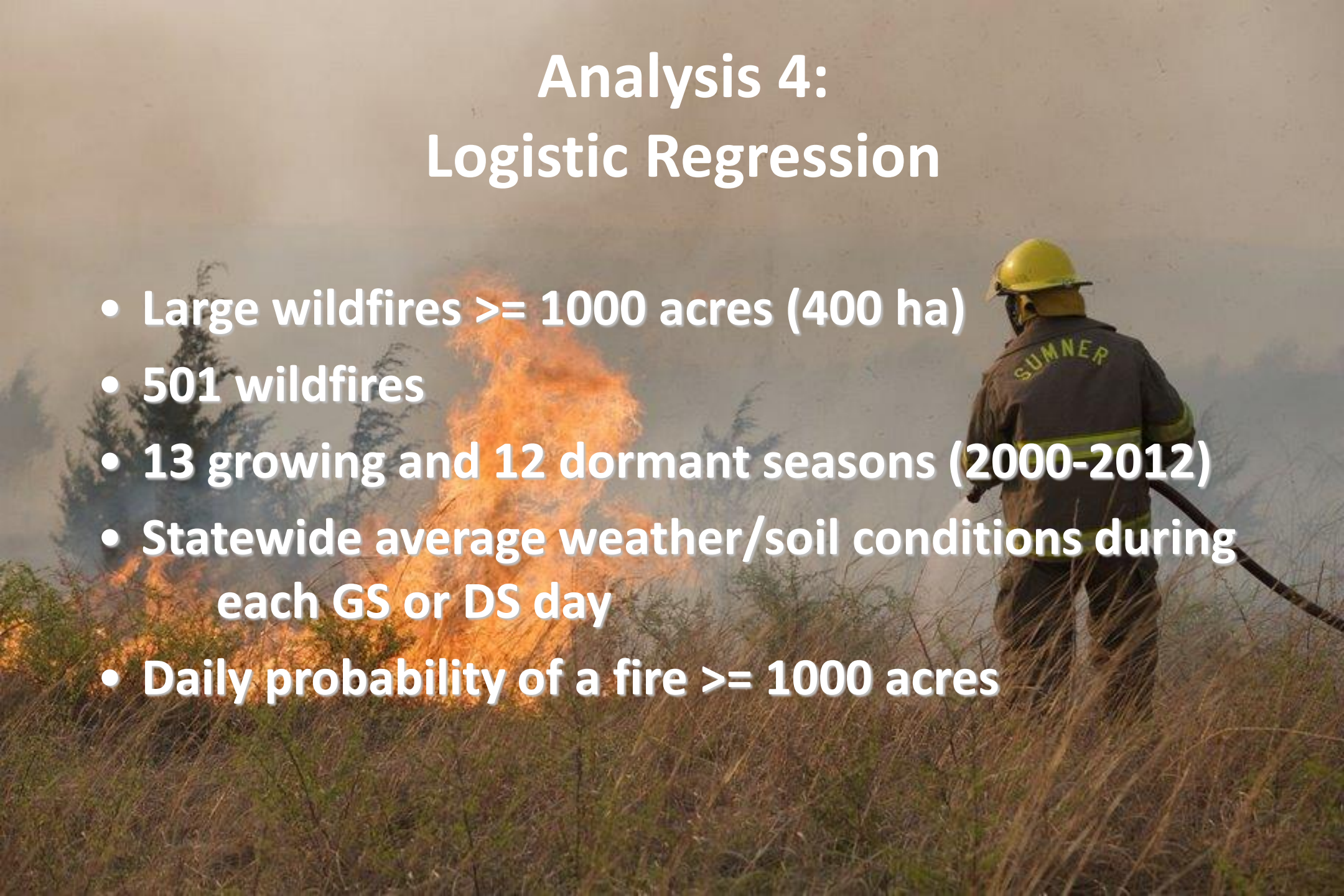
- Large wildfires \geq 1000 acres (400 ha)
- 501 wildfires
- 13 growing and 12 dormant seasons (2000-2012)
- Acres burned from each fire
- FAW and 1000-hr DFM values taken from nearest Mesonet station to each fire



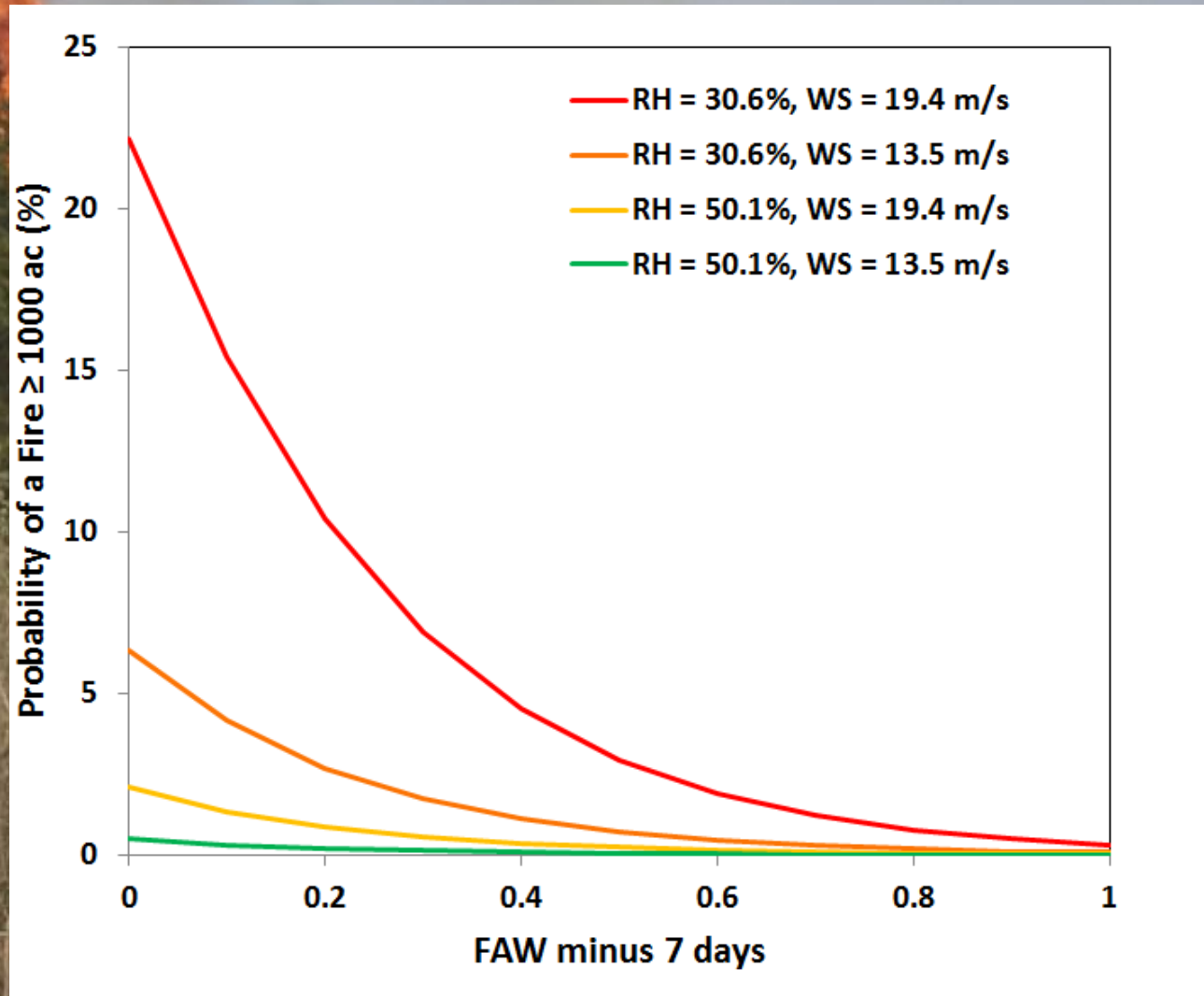
Acres Burned



Analysis 4: Logistic Regression

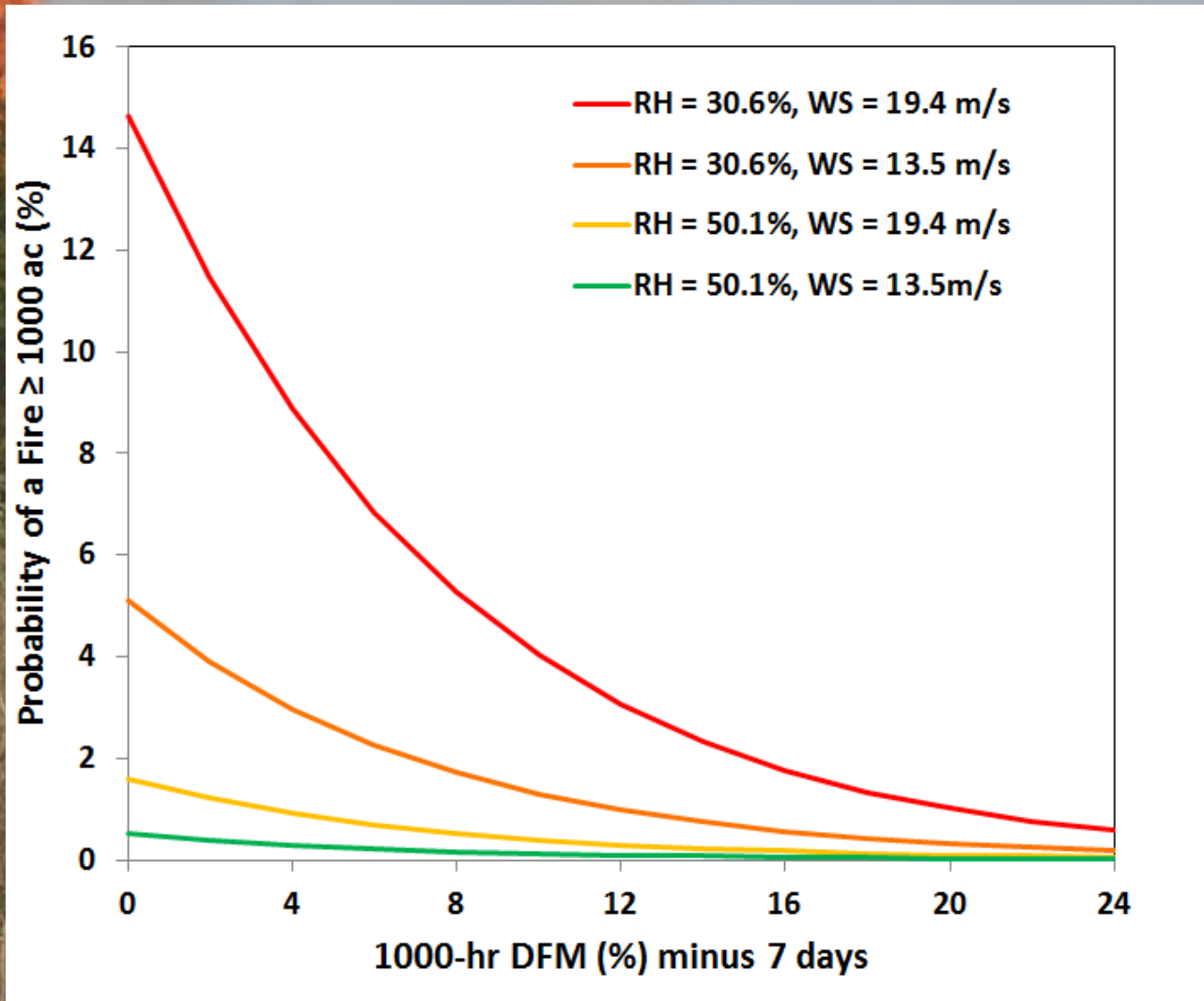
- Large wildfires ≥ 1000 acres (400 ha)
 - 501 wildfires
 - 13 growing and 12 dormant seasons (2000-2012)
 - Statewide average weather/soil conditions during each GS or DS day
 - Daily probability of a fire ≥ 1000 acres
- 

Fractional Available Water



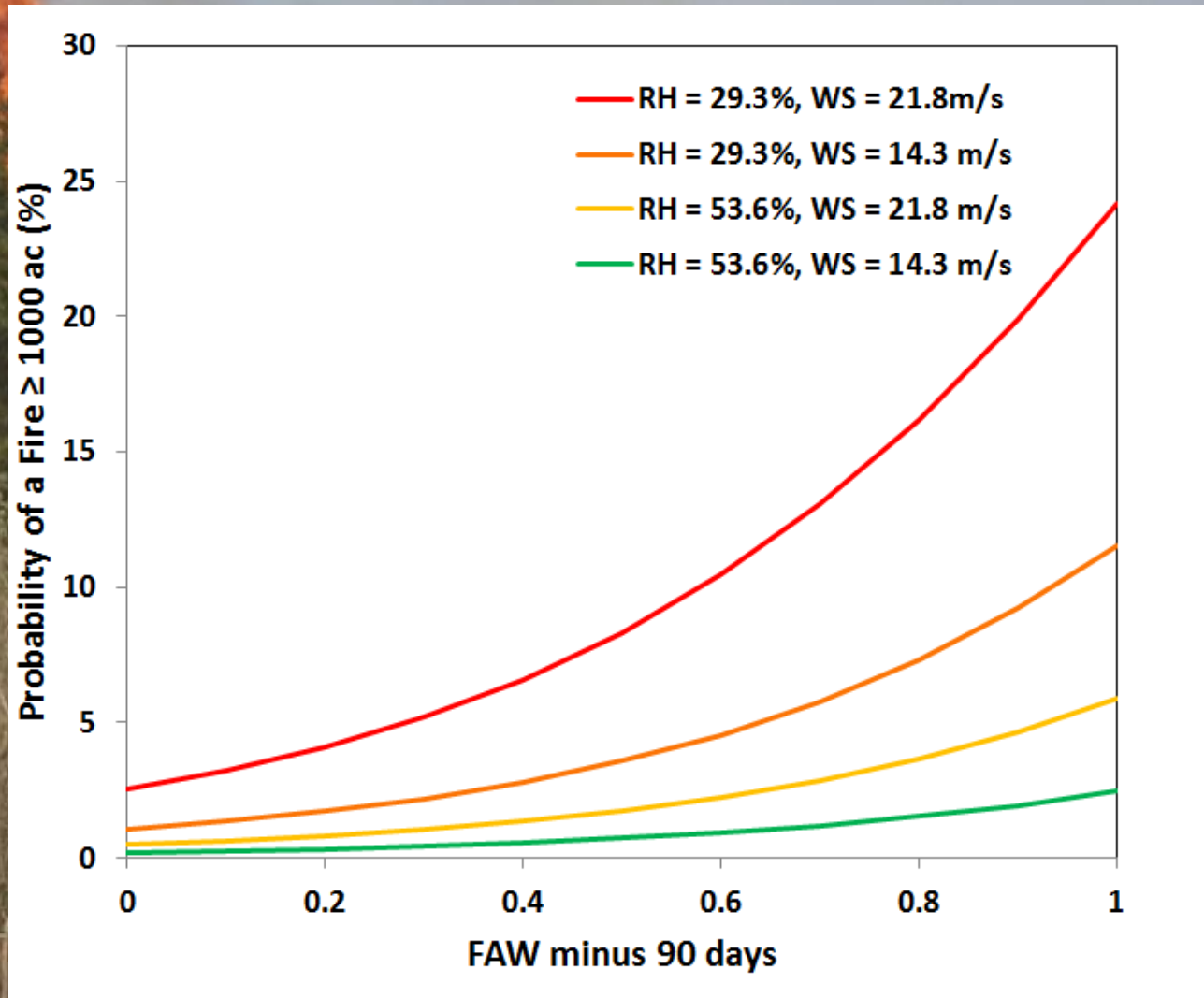
Growing Season

1000-hr Dead Fuel Moisture



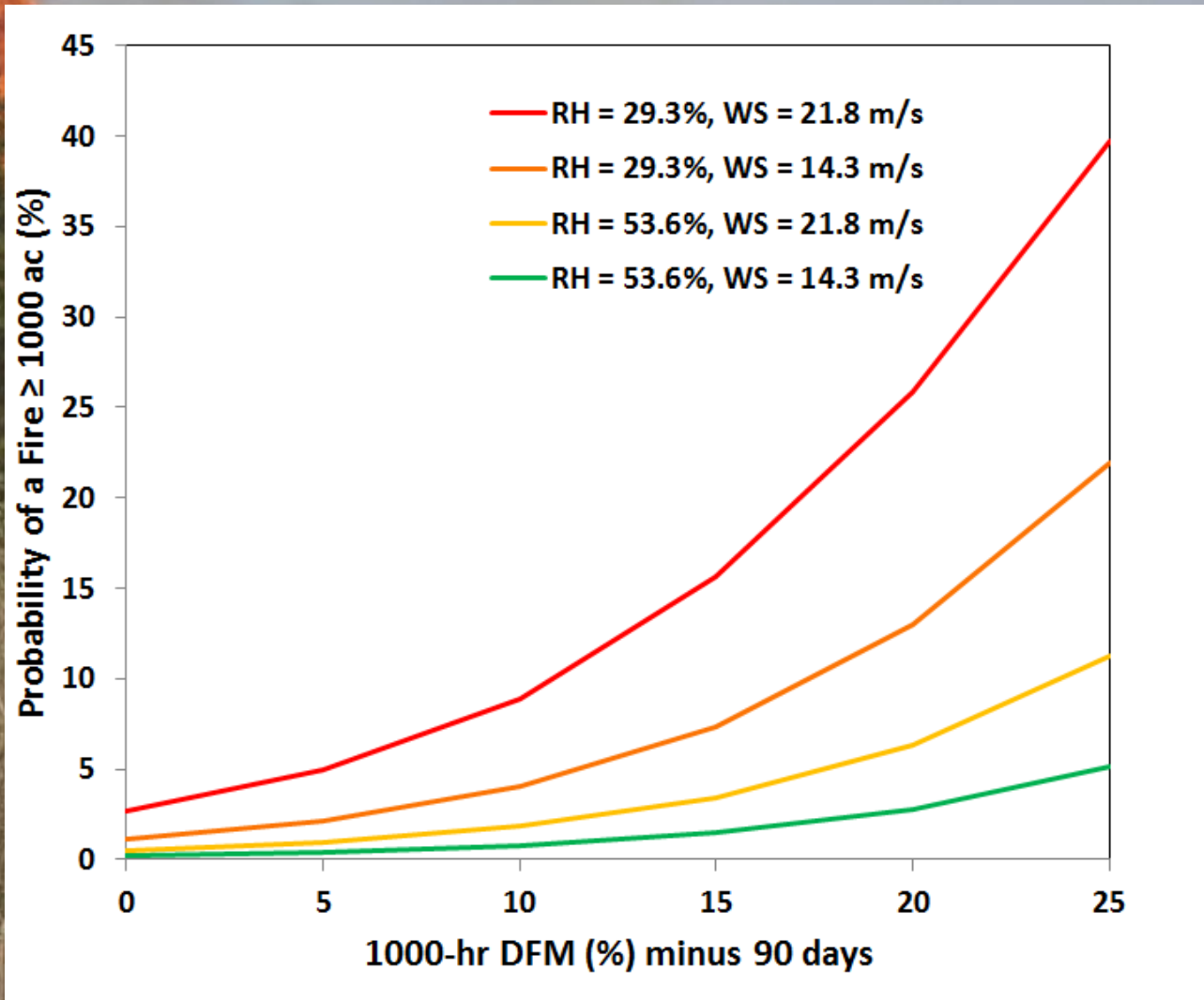
Growing Season

Fractional Available Water



Dormant Season

1000-hr Dead Fuel Moisture



Dormant Season

LIVE

ON THE PHONE:

Large Multi-Day 2011 Growing Season Wildfires

COMANCHE COUNTY WILDFIRE

11:01 70°

RUSTY SURETTE
RED CROSS SPOKESMAN



KWTN - DT

Keystone/Terlton Complex

August 5-10, 2011

20,129 acres (8146 ha)

10:02 84°



KOTV - DT



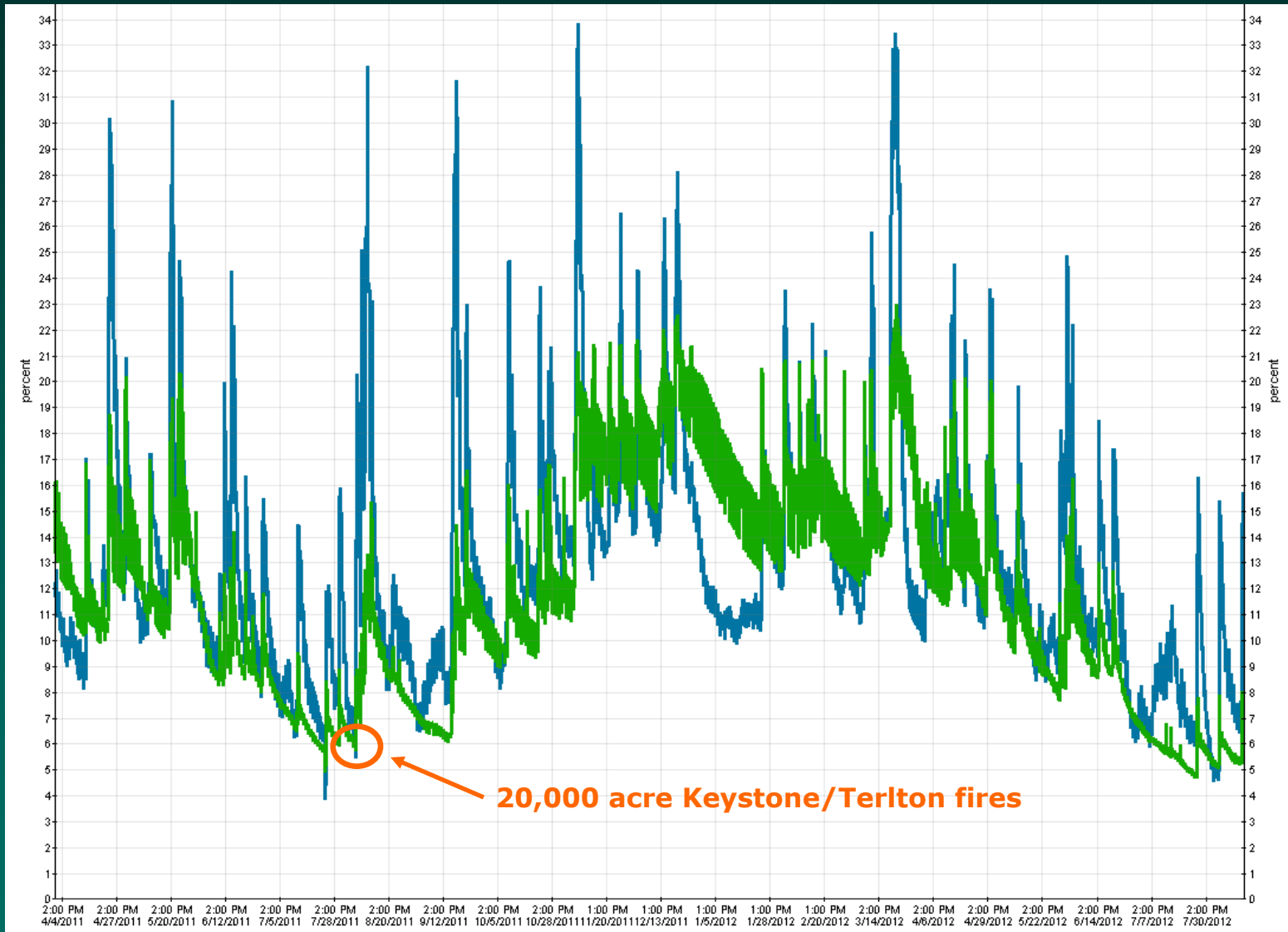
10:03 84°



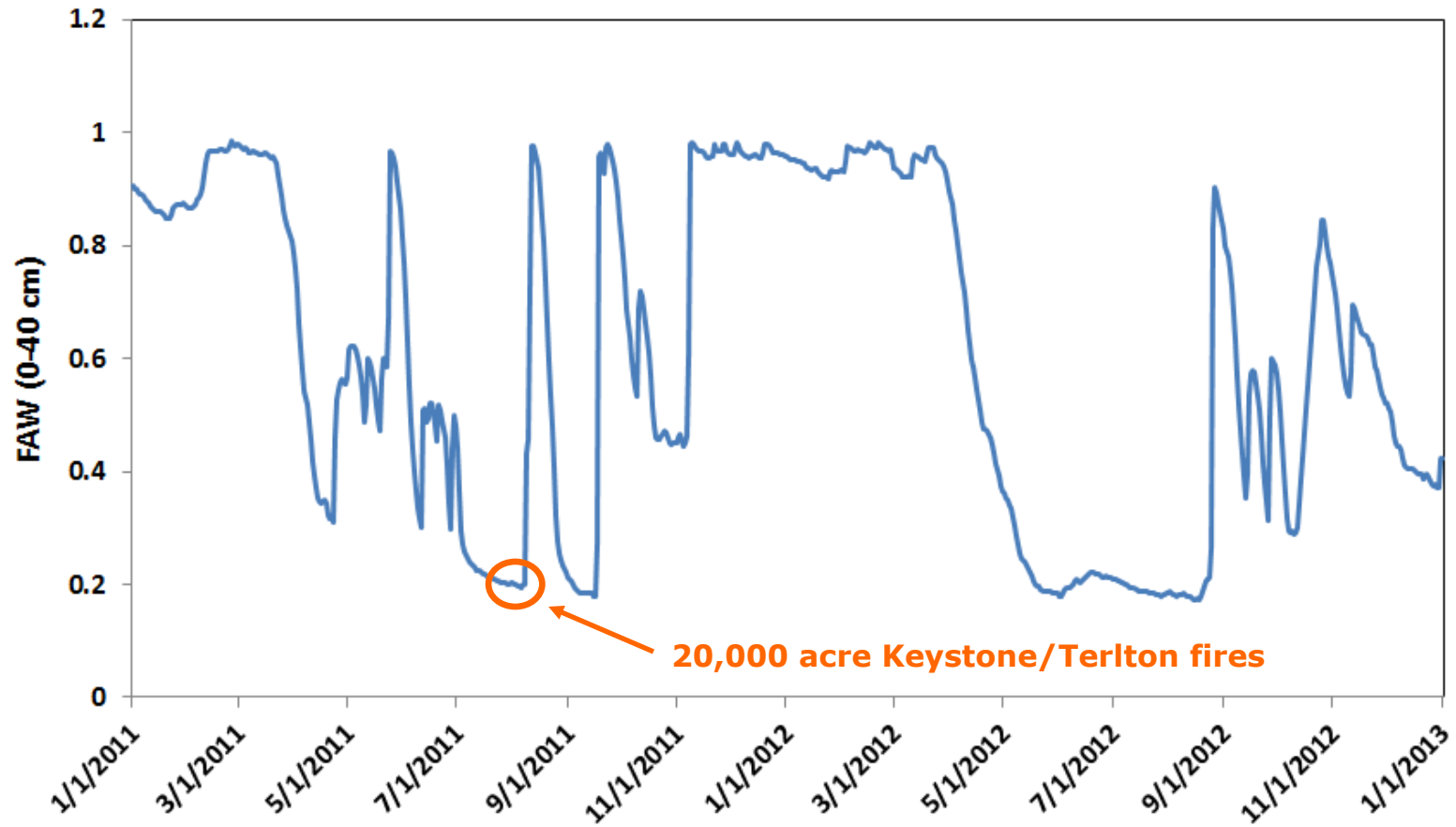
NewsOn6.com



100-hr (blue) and 1000-hr (green) Dead Fuel Moisture (Oilton)



Fractional Available Water (FAW) (Oilton)



LIVE

ON THE PHONE:

Ferguson Fire

September 1-10, 2011

39,907 acres (16,150 ha)

COMANCHE COUNTY WILDFIRE

11:01 70°

RUSTY SURETTE
RED CROSS SPOKESMAN



KWTV - DT

LIVE

ON THE PHONE:

COMANCHE COUNTY WILDFIRE

11:02 70°

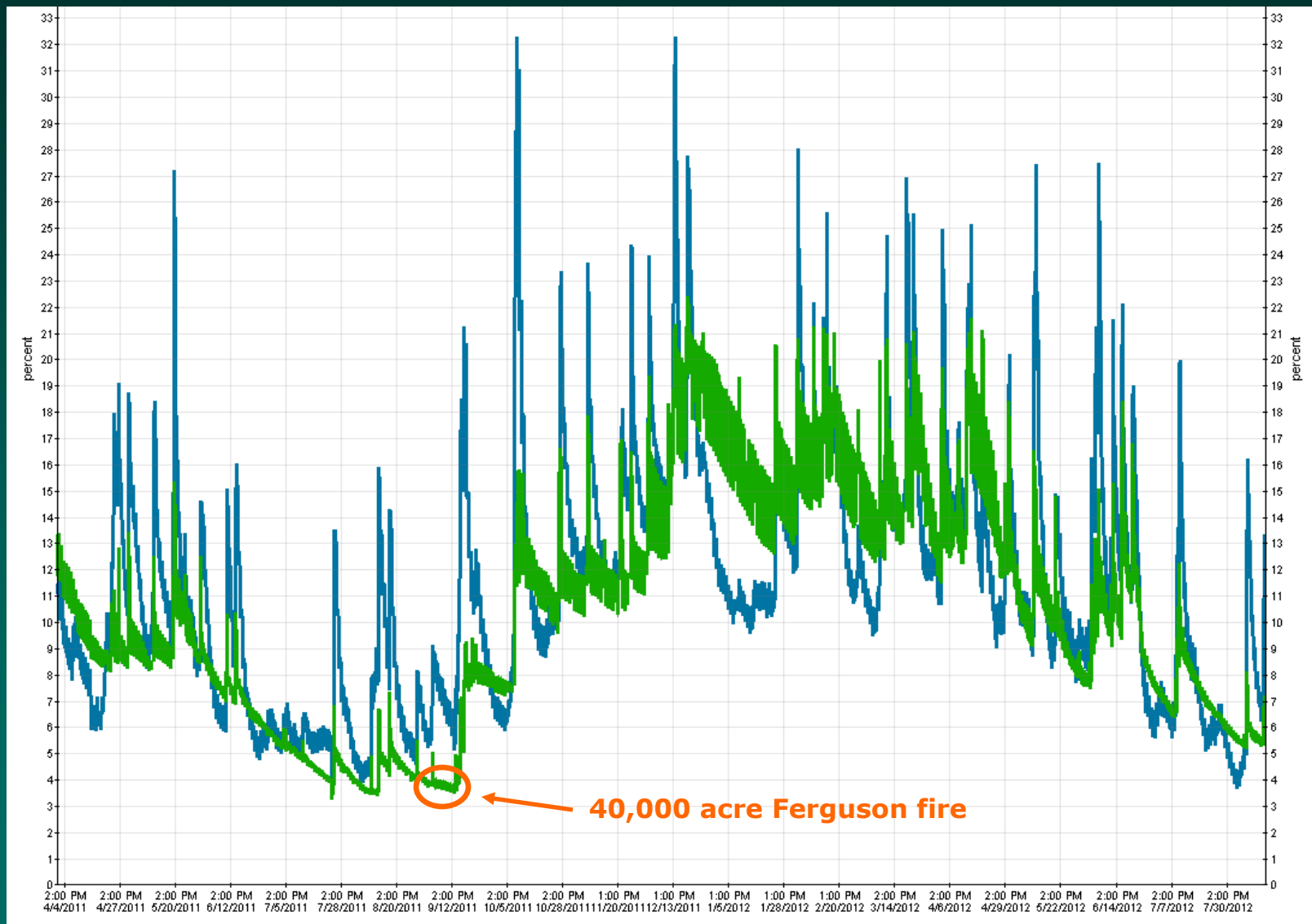
RUSTY SURETTE
RED CROSS SPOKESMAN



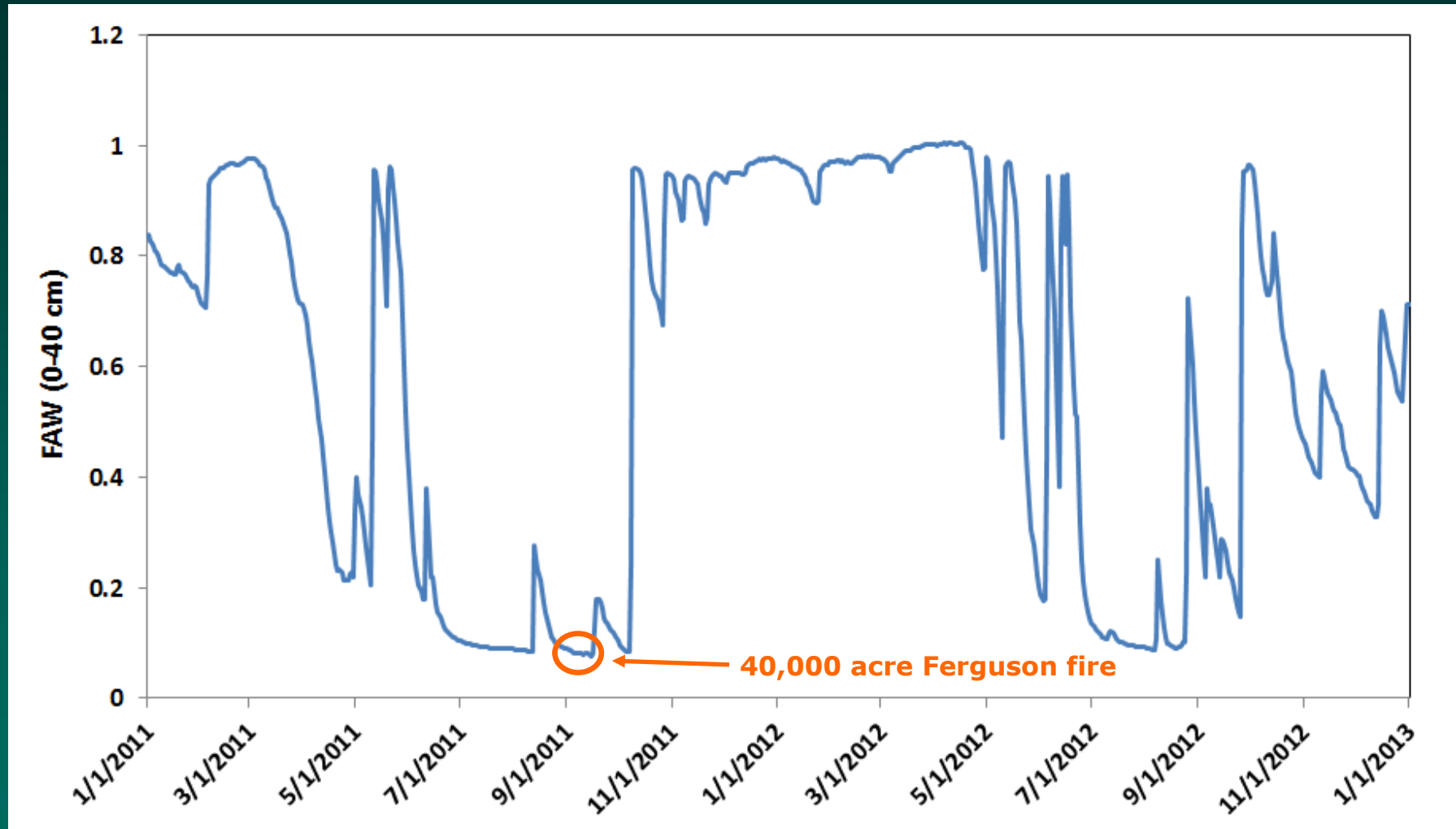
News9.com



100-hr (blue) and 1000-hr (green) Dead Fuel Moisture (Medicine Park)



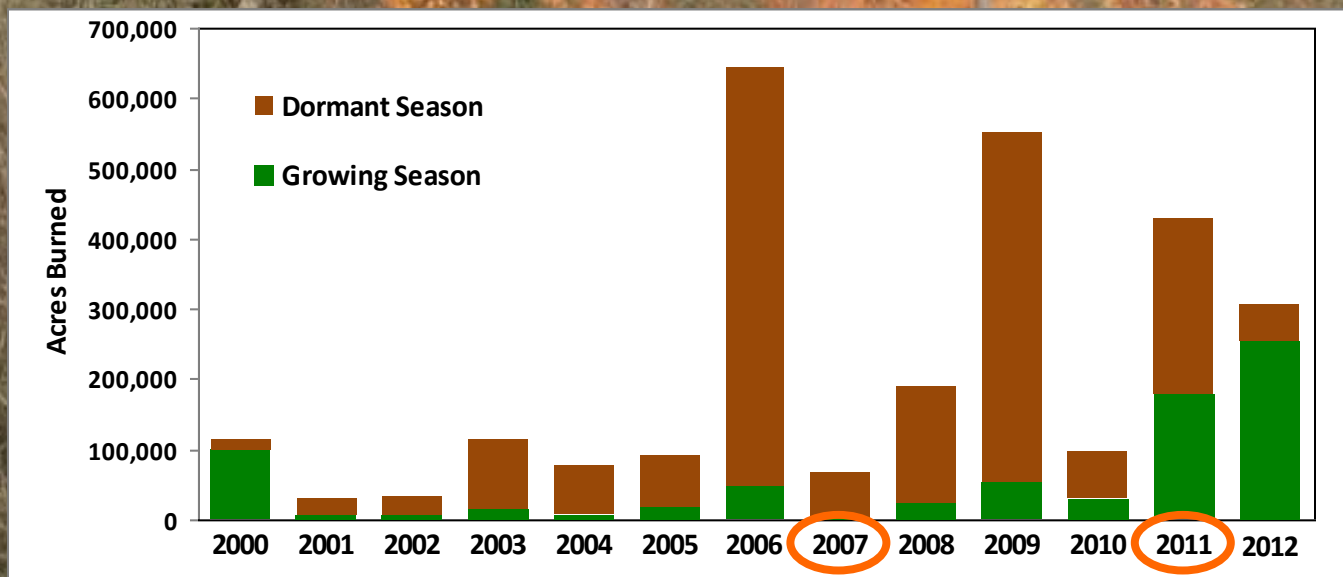
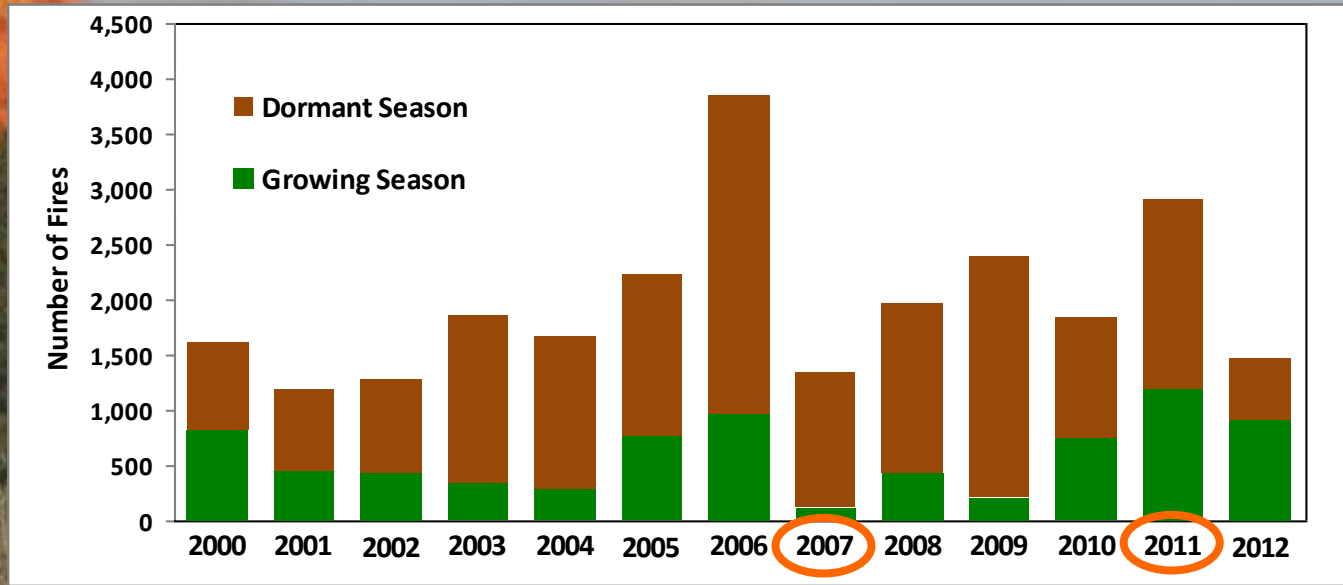
Fractional Available Water (FAW) (Medicine Park)



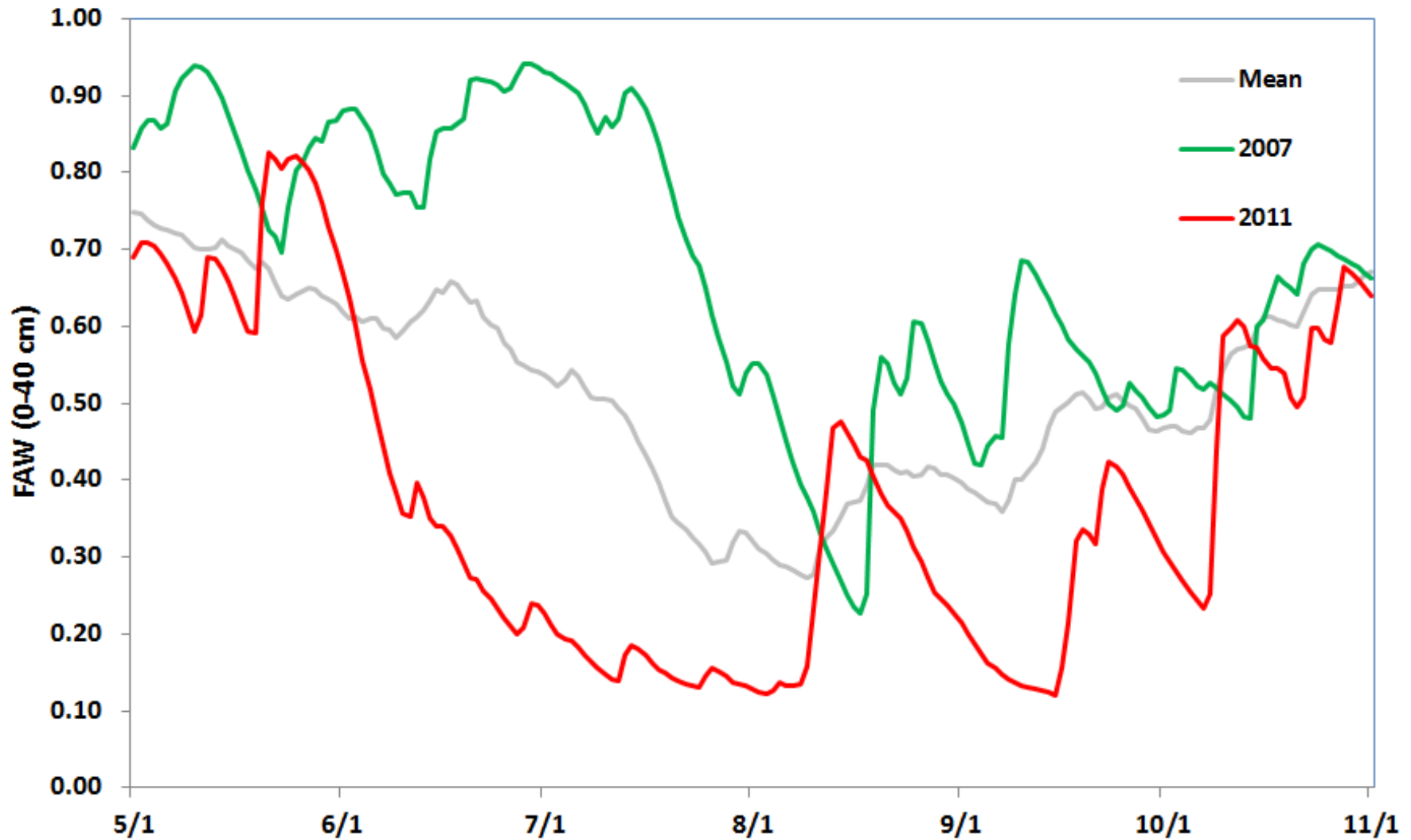
A large fire is burning in a field of tall grass and brush. The fire is intense, with bright orange and yellow flames rising from the vegetation. In the background, there is a dense forest of trees, some of which are also on fire. The sky is a pale, overcast blue. The text is overlaid on the image in a white, bold font.

**Effect of FAW on Growing Season Fire Activity during
a “Normal FAW” GS, a “High FAW” GS,
and a “Low FAW” GS**

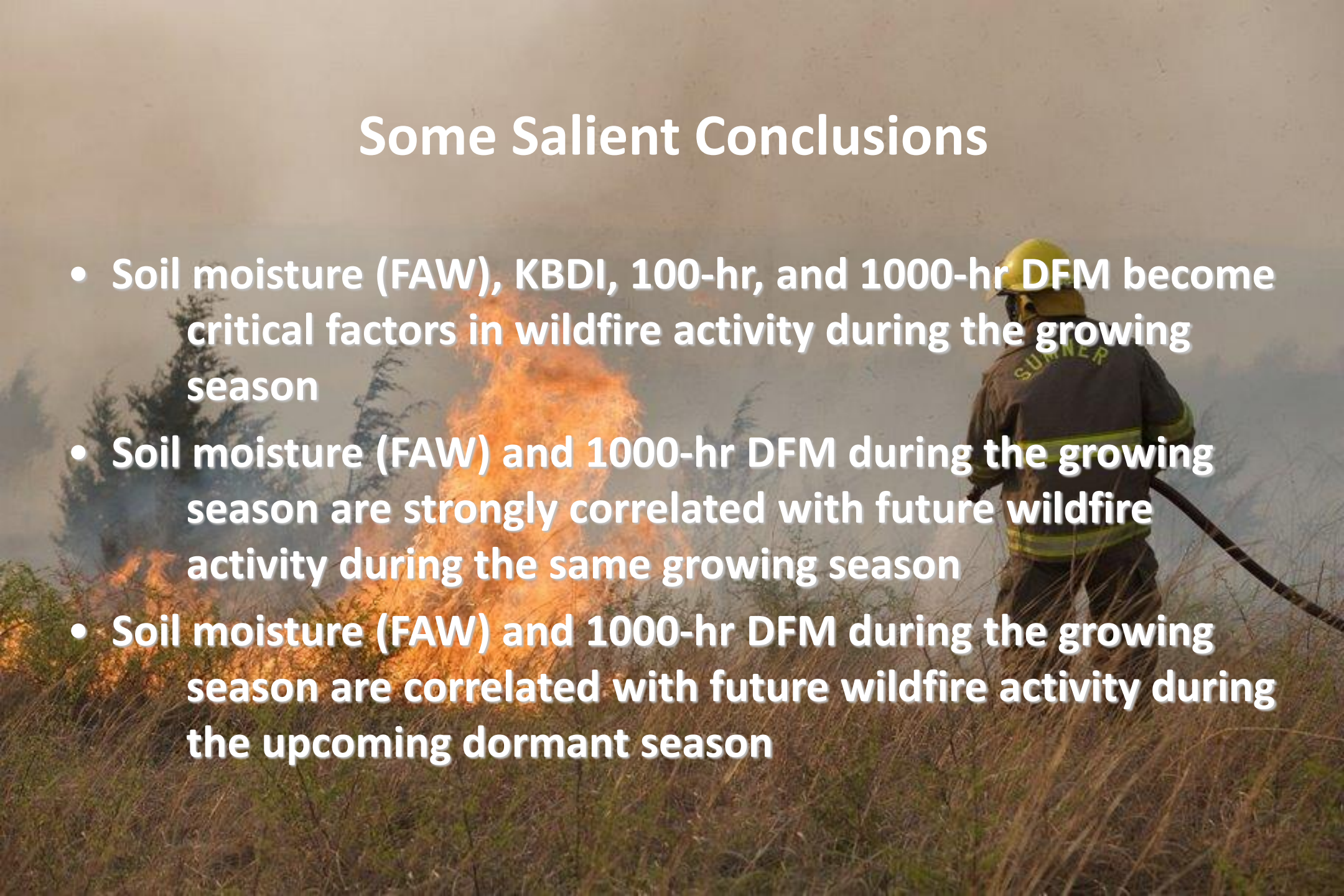
Oklahoma Wildfires by Year (2000-2012)



Effect of FAW on Growing Season Fire Activity



Some Salient Conclusions

- Soil moisture (FAW), KBDI, 100-hr, and 1000-hr DFM become critical factors in wildfire activity during the growing season
 - Soil moisture (FAW) and 1000-hr DFM during the growing season are strongly correlated with future wildfire activity during the same growing season
 - Soil moisture (FAW) and 1000-hr DFM during the growing season are correlated with future wildfire activity during the upcoming dormant season
- 
- A firefighter in a yellow helmet and dark jacket with "SUMNER" on the back, holding a hose, stands in a field of tall grass with a large fire burning in the background.

Funding Acknowledgements

Joint Fire Science Program

JFSP 11-1-2-19 (2011-2015)

Oklahoma Cooperative Extension Service

Oklahoma Agricultural Experiment Station



A large fire is burning in a field of tall grass and trees. The fire is intense, with bright orange and yellow flames rising from the ground. The background shows a line of trees, some of which are green and some are bare. The sky is a pale, overcast blue. The text "Questions?" is overlaid in the center of the image in a white, italicized font.

Questions ?