Soil Moisture Drives Wildfire Occurrence in the Southern Great Plains

Erik S. Krueger[1], Tyson E. Ochsner[1], J.D. Carlson[1], David M. Engle[1], Dirac Twidwell[2], Samuel D. Fuhlendorf[1]
[1] Oklahoma State University, Stillwater, OK 74074
[2] University of Nebraska-Lincoln, Lincoln, NE 68588

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Introduction

- Soil moisture is physically linked to fuel production and live fuel moisture.
- **Research regarding the influence of soil moisture on wildfires is scarce** and **models characterizing soil moisture-wildfire relationships have not been developed**.
- Our research was aimed at filling these knowledge gaps.

Objectives

How is Soil Moisture Related to the Occurrence of Wildfires?

We identified relationships between soil moisture, as Fraction of Available Water Capacity (FAW), and the occurrence of large wildfires in Oklahoma.

Is the Relationship Seasonal?

We developed daily probabilistic models using FAW and weather that describe the wildfire probability for growing (May-October) and dormant season (November –April) fires.

Methods

- FAW and weather were determined for 504 Oklahoma wildfires ≥ 405 ha from 2000-2012 using data from the Oklahoma Mesonet.
- FAW is the amount of plant available water (PAW) in the soil relative to maximum plant available water:

$$FAW = (\theta - \theta_{WP})/(\theta_{FC} - \theta_{WP})$$

- FAW ranges from 0 (no PAW) to 1 (maximum PAW).
- Statewide daily wildfire probability was determined using logistic regression and statewide average FAW and weather.

Results and Discussion

Large Wildfires Occurred Throughout Oklahoma…

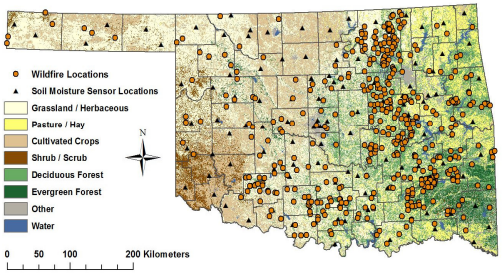

Figure 1. Locations of 501 Oklahoma wildfires ≥ 405 ha from 2000-2012, locations of Oklahoma Mesonet soil moisture sensors, and Oklahoma land cover.

…AND More Frequently when Soil Moisture was Low

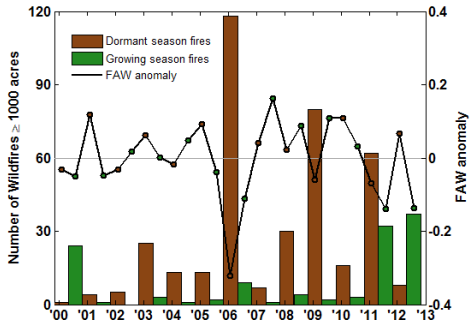

Figure 3. Statewide average seasonal fraction of available water capacity (FAW) anomaly and growing (May-October) and dormant-season (November-April) wildfires ≥ 405 ha in Oklahoma from 2000-2012.

- Growing seasons when FAW was lowest (`00, `06, `11, and `12) coincided with high growing season wildfire occurrence.
- Similarly, dormant seasons when FAW was lowest (`06-`07, `08-09, and `10-`11) coincided with high wildfire occurrence, but dormant seasons of high wildfire activity also occurred when FAW was above average (`02-`03 and `07-`08).
- Dormant seasons of high wildfire activity occurred after a period of above average FAW, suggesting fuel production also influences dormant season wildfire activity.

Nearly All Large Growing Season Wildfires Occurred at Low Soil Moisture…

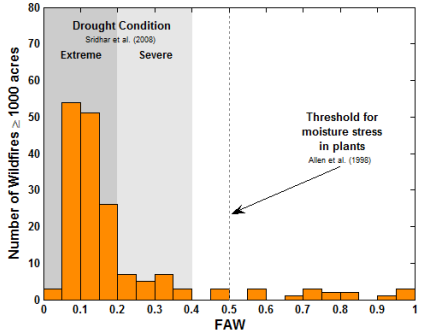

Figure 4. Frequency distribution of fraction of available water capacity (FAW) for growing-season wildfires ≥ 121 ha in Oklahoma from 2000-2012.

- 91% of growing season fires ≥ 121 ha occurred at FAW < 0.5, a commonly used threshold for moisture stress in plants.
- 77% occurred under extreme drought.

…BUT Soil Moisture and Weather Work Together

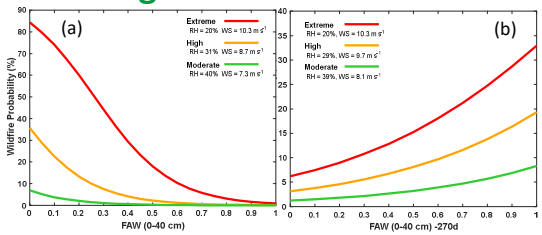

Figure 5. Daily probability of wildfire occurrence in Oklahoma during the growing (a) and dormant season (b) as a function of statewide average fraction of available water capacity (FAW) and three levels of wildfire conditions. Extreme conditions approximate NWS criteria for fire weather warnings in Oklahoma.

- Growing season wildfire probability increased as FAW decreased (Fig. 5a), and dormant season probability increased as lagged FAW (-270d) increased (Fig. 5b).
- For both seasons, wildfire probability was high only when FAW **AND** weather were conducive to wildfires.

Conclusions

Why does Soil Moisture Drive Wildfire Occurrence?

LOW SOIL MOISTURE
= low fuel moisture and eventual desiccation
= increased wildfire danger **NOW**

HIGH SOIL MOISTURE
= high fuel moisture and increased growing season fuel production
= decreased wildfire danger **NOW** and increased wildfire danger **LATER**

IF weather conditions are also conducive to wildfires

The strong dependence of wildfires on soil moisture suggests that wildfire danger assessments would be improved by including measured soil moisture.

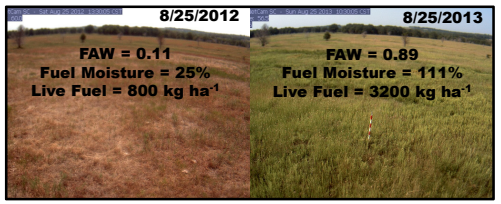

Figure 6. Phenocam photographs taken 25 August 2012 and 2013 at Marena, OK.

Acknowledgements
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