Soil moisture influences fuel moisture content in Oklahoma grassland

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Introduction

- Fire is an integral part of many Southern Great Plain (SGP) ecosystems but wildfires can major economic loss to society as evidenced by the recent large wildfires in Fort McMurray in Canada and in Kansas-Oklahoma.
- A critical variable influencing wildfire danger is fuel moisture content, but current fuel moisture content estimates based on weather data or remote sensing measurements are sometimes
- Improved estimates of fuel moisture content may be possible using measured soil moisture data since soil moisture is physically linked to the physiological characteristics of plants.
- **Our <u>Objective</u> is** to create a model for estimating grassland fuel moisture content using soil moisture measurement and supporting data.

Materials and Methods

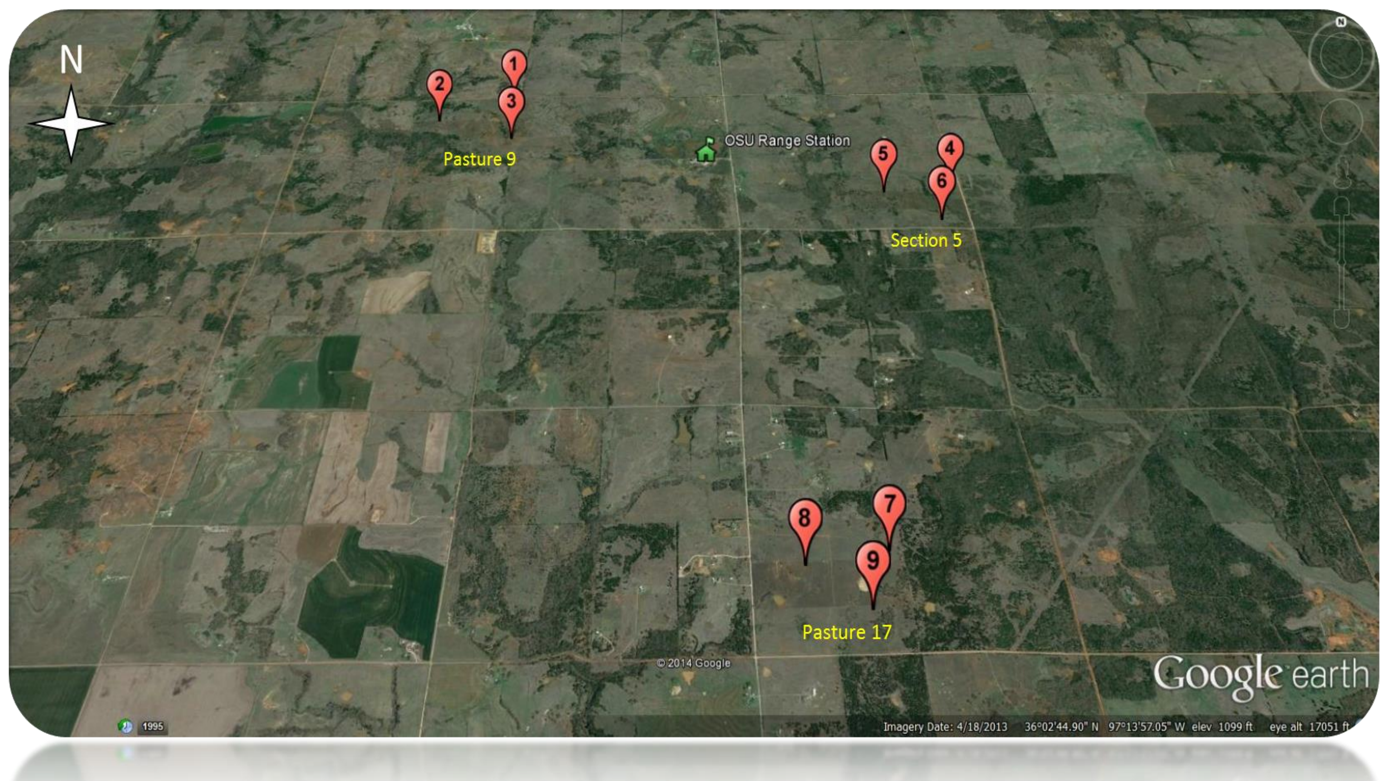

Fig 1. Measurement sites in the long-term patch burning study at the Range Research Station near Stillwater, Ok. The soil types ranges from silty clay loam to very fine sandy loam. The main vegetation types are little bluestem, big bluestem, indiangrass, post oak and eastern redcedar

- Research was conducted at the Oklahoma State University Range Research station located near of Stillwater, Oklahoma.
- Fuel moisture content (FMC) of mixed live and dead herbaceous vegetation was measured every two weeks from April to October in 2012 and 2013. Vegetation within a 0.5 × 0.5 m^2 quadrat was clipped and fresh and dry weight were recorded (Fig.3.). Twelve samples were clipped in each of three patches in each of three pastures during each round of sampling. FMC was calculated as follows:
  FMC = (FW-DW)/DW × 100
  where, FW= Fresh weight of plant material and DW = Dry weight of plant material.
- Soil moisture in form of plant available water (PAW) and fraction available water capacity (FAW) were calculated from soil moisture measurements at 5, 10, 20, and 50 cm using reflectometry-based sensors as shown in Fig. 2 (Model 655, Campbell Scientific, Logan, UT). PAW and FAW are calculated as follows:

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

where, θ is measured volumetric water content, θ_{WP} is volumetric content at permanent wilting point measured at -1500 kPa, θ_{FC} is the field capacity corresponds to -10 kPa and d represents the thickness (mm) of the layer represented by the measurements.

- Time series of FMC, PAW, and FAW were plotted to visualize the relationship between the variables as in Fig. 5.

Fig 2. CS-655 soil moisture sensors

Fig 3. Vegetation sampling of mixed herbaceous samples in 0.5 × 0.5 m^2 quadrat

Result and Discussion

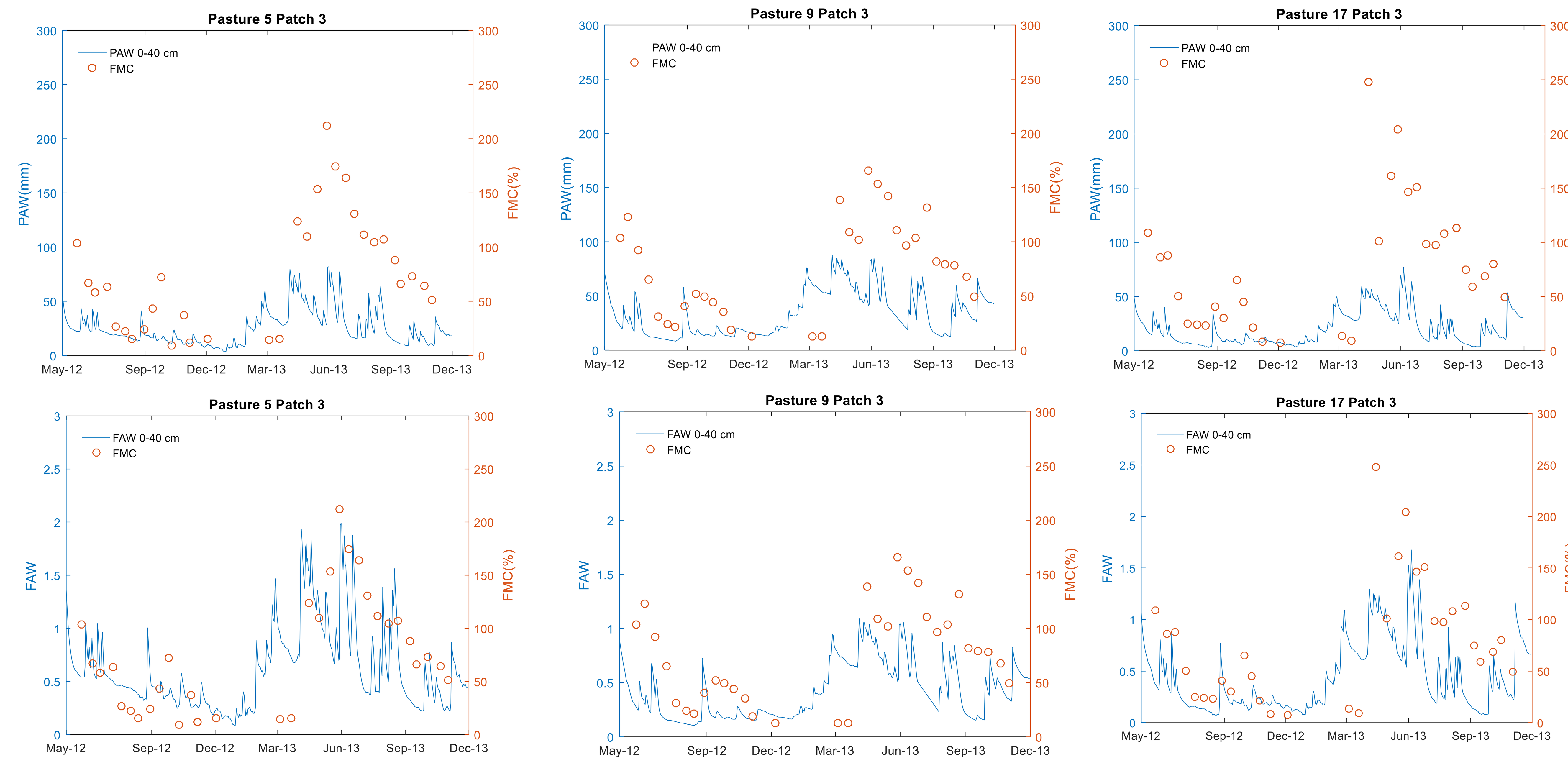

Fig 4. Time series of mixed live and dead fuel moisture content (FMC) along with soil moisture expressed as plant available water (PAW) (top) and fraction of available water capacity (FAW) (bottom) during 2012 and 2013 near Stillwater, OK.

- Soil moisture and FMC were generally lower during 2012, a drought year, than during 2013.
- FAW and PAW increased over winter months(2012-2013) but FMC did not show a similar increase because the vegetation was dormant.
- FMC during August 2012 was much lower than during August 2013, likely due to the preceding low soil moisture levels during the summer of 2013. The significant relationship observed between FMC with PAW and FAW (Fig 4) in grasslands confirm previous result (Qi et al. 2012; Krueger et al. 2015).
- The low R^2 values shows that soil moisture does not fully control the value of FMC, but they are related. It may be the consequence of combining growing season measurements (when soil moisture-FMC link are closely linked) of both dry year 2012 and wet year 2013 (Table 1(A)).
- The R^2 is more, RMSE is less when we compared individual year. The difference lies in the significance of dry year vs non-significance for wet year.

Table 1. R^2 and Root mean square(RMSE) along with P-value obtained in linear regression model of fuel moisture content of (FMC) of mix with either PAW for growing season in A (May 22, 2012 to October 2, 2013) , B(growing season 2012) and C(growing season 2013)

(A) Soil Moisture	FMC(%)		
	R^2	RMSE	P-value
PAW(mm)	0.32	36.13	7.21e-11
FAW	0.33	36.08	1.38e-11

(B) and (C) Soil Moisture	FMC(%)		
	R^2	RMSE	P-value
PAW(mm)	0.22(B) 0.34(C)	33.29(B) 28.24(C)	1.53e-14(B) 0.33(C)
FAW	0.16(B) 0.42(C)	34.53(B) 26.46(C)	1.32e-15(B) 0.64(C)

Fig 5. Recent wildfire in Fort McMurray in Canada occurred on May 1, 2016

Conclusion

- Fuel moisture content of grassland vegetation was significantly related to soil moisture variables, PAW and FAW
- Growing season wildfires in August 3, 2012 occurred when soil moisture expressed in PAW and FAW were less than 50 mm and 0.5 respectively. These finding is consistent with the results of Krueger et al. (2015) where they found that growing season wildfire extent was greatest (93,043 ha) when FAW values is less than 0.5.
- Growing season soil moisture and FMC were relatively high in 2013, and the incidence of growing season wildfire in Oklahoma was relatively low (10,720 ha burned) (NIFC, 2013).
- Soil moisture is significantly related to grassland FMC, but more is needed to identify the precise form of that relationship.
- One complicating factor is the spatial variability of soil moisture which are influenced by small- scale factors such as soil type, topography, species type and large scale factors such as precipitation and evapotranspiration (Qi et al. 2012).
- Similarly, FMC is influenced by vegetation physiological activities whereas soil moisture is related to texture, structure and depth of soil.
- Despite these challenges, our data provide support to the hypothesis that soil moisture data may prove useful for estimating fuel moisture content and improving wildfire danger ratings.

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