5.1 The Effect of Solar Insolation on the Burning Rate of Shallow Fuel Beds

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1. Introduction

The factors affecting wildland fire spread and intensity can be attributed to the condition of the fuels, the local atmospheric environment and fuel orientation (including topography). Fire models have been presented that attempt to replicate the influence of these variables on fire (Rothermel 1972, Catchpole and others 1998).

Solar insolation has been observed to affect fire intensity (Campbell 1995). Most if not all wildland firefighters have heard stories of or personally observed nearly instantaneous reductions in fire intensity when the sun is obscured and conversely observed an increase in fire intensity when the vegetation and fuels are exposed to sunlight after the passage of a cloud. However, little if any quantitative work can be found exploring this effect. This study reports preliminary data from a set of experiments designed to explore the effect of solar heating on the burning rate of fine dead woody fuels.

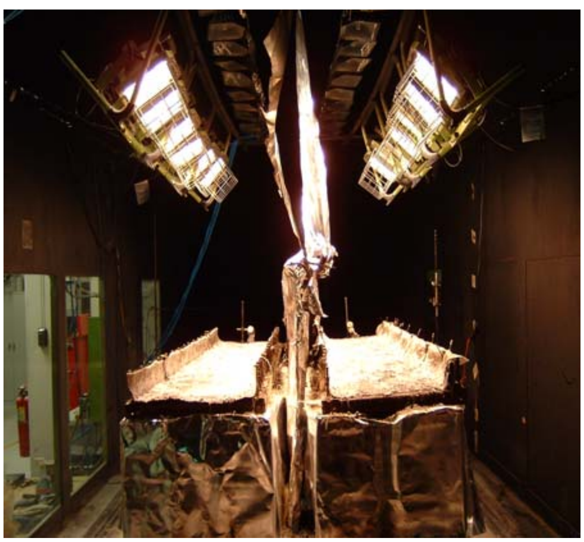

Figure 1 – Photo of the experimental setup in USDA Forest Service large wind tunnel facility in Missoula, Montana. Halogen lamps above fuel tray provide simulated solar insolation.

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2. Methods

A set of experiments was conducted to explore the effect of solar irradiation on the burning rate of fine dead woody fuels. The experiments consisted of exposing a nominally 0.4m wide by 2.4m long fuel bed (fig. 1) to two different levels of irradiation generated by halogen lamps and igniting one end of the fuel beds at the same time as the lights were turned on. The experimental setup included two parallel fuel beds with separately controlled heating sources and shielding between the beds. For each experiment both beds were ignited simultaneously. Typically only one of the beds was exposed to heating from the lamps. The irradiation effect was characterized by the time required for the flame to fully burn the length of the 7.5cm deep by 2.4m long fuel bed. Approximate surface incident flux levels were 400 and 800 W/m^2 (0.4 and 0.8 solar constants respectively).

The effect of the irradiation was characterized by comparing the times required by the two beds to burn. The experimental procedures include randomly assigning which bed was irradiated and which was not. This included cases wherein both beds were simultaneously not heated or heated.

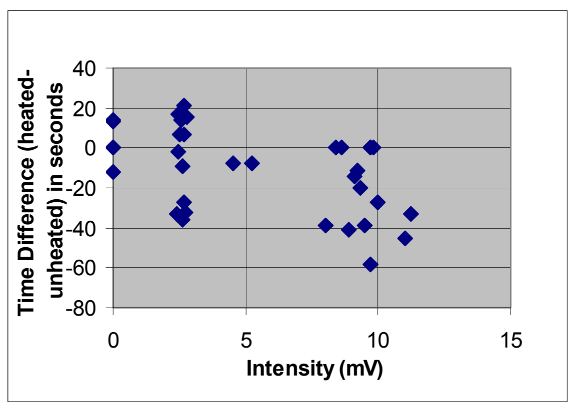

Figure 2 – Difference between time to burn irradiated bed and nonheated bed in seconds. Insolation intensity is characterized in this figure by the raw signal from the solar pyroanemometer (conversion is roughly 10mV=0.8 solar constants).

3. Results and Discussion

Preliminary results from the experiments are presented in Figure 2 as the difference between the time that took the heated bed to burn and that of the unheated bed. Intuitively, one would expect the heated bed to consistently burn faster resulting in negative differences in Figure2. However, for the lower level of irradiation (~0.4 solar constant) there was no statistically significant difference between the irradiated and nonirradiated beds. This level of heating is roughly what is present on a sunny day in March in Missoula, Montana.

When the heating intensity in increased to roughly 0.8 solar constants (approximately the solar irradiation expected in the summer time in Missoula, Montana). The data indicate a consistent difference between the heated and unheated beds.

3.1 Summary

It is apparent from this small set of measurements that solar heating can affect the burning of fine dead woody fuels. The exact mechanism for this phenomenon is not clear; however, the velocity measurements suggest that increases in local turbulence may be a contributor. This may occur through enhanced mixing of oxygen into the reaction zone. Additional experiments are planned to further characterize the variables and mechanisms in this process.

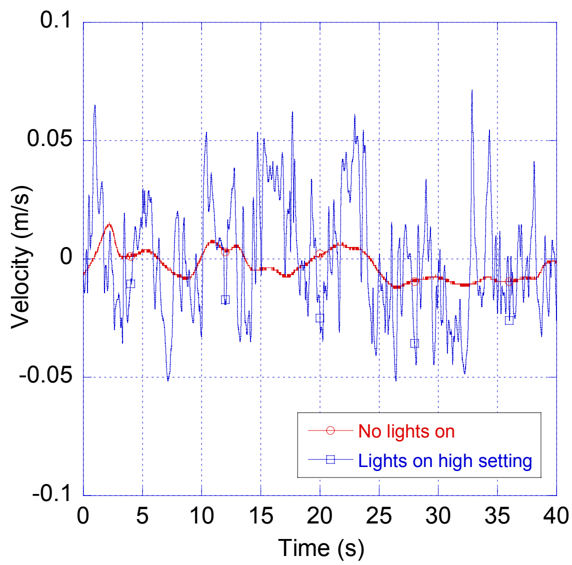

Figure 3 – Hot film anemometer measurements of velocity 7.5cm above the fuel bed with and without irradiation. These measurements are not directional. Measurements were initiated within 30 seconds of turning on the heating lights.

4. Acknowledgements

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5. Bibliography

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