Moisture Dynamics and Probability of Sustained Flaming in Masticated Fuelbeds

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INTRODUCTION

- Canada's FireSmart program outlines protection measures designed to: (i) decrease fire behaviour potential; (ii) reduce potential for ignitions, and; (iii) improve capability of fire suppression resources[1] in the wildland-urban interface (WUI).
- Fuel management prescriptions can be applied in WUI zones because the removal of hazardous fuels from the forest environment should theoretically reduce potential fire behaviour[2]. Much of this is achieved through mechanized treatments that reduce surface fuels, increase crown base height and reduce crown density via thinning.
- More recently, fire management has considered the mastication (mulching, chipping) of thinned trees and understory vegetation, as this presents a more economically viable option to reduce surface fuel loads over manual extraction and transport off-site.
- Although mastication is becoming increasingly popular across fire management districts in Alberta, little is known about the properties of these manufactured fuelbeds. Limited publications are available from studies conducted primarily in the United States[3].
- Mastication has been applied to boreal forests across many regions of Alberta, and some designs (layout, type of thinning, etc.) deviate significantly from prescriptions employed in the United States. This presents an opportunity to investigate novel fuel management techniques in unstudied fuel types.

OBJECTIVES

The objectives of this study are:

(i) to assess moisture dynamics at multiple depths through the fuelbed profile, and;

(ii) to determine probability of sustained flaming under a range of moisture conditions.

METHODS

Experiment I: Moisture dynamics of masticated fuelbeds

Destructive sampling for moisture content was carried out at an experimental site near Carldale, AB, with treatments consisting of: (i) mastication following high-thinning (Figure 1, A); (ii) mastication following low-thinning (B), and; (iii) control (C). For every sampling event, three locations were randomly selected within each treatment. Masticated samples were collected at 0-2 and 5-10 cm below the fuelbed surface and sealed in airtight containers. Wet and dry weights were recorded. Fire weather indices (Fine Fuel Moisture Code [FFMC] and Duff Moisture Code [DMC]) were calculated with meteorological observations from nearby weather stations.

Figure 1. Fuel management treatments at Carldale, AB site.

Experiment II: Sustained flaming in masticated fuelbeds

In-situ sustained flaming tests were performed at the Horse Creek, AB experimental site, following the standard two-minute match drop protocol[4]. Weather observations and fuel moisture content were recorded for every test. Fuelbeds were also reconstructed in laboratory, conditioned to a range of moisture contents, and the same match drop test applied.

RESULTS

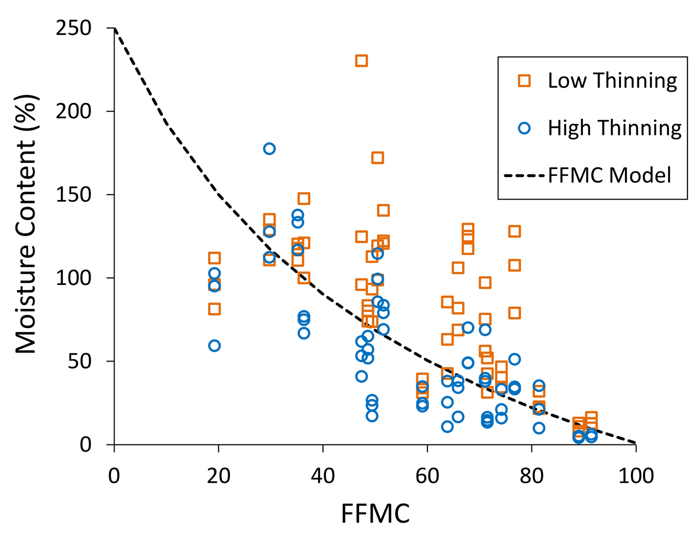

Figure 2. Moisture content of surface mulch vs. FFMC under high- and low-thinning fuel management treatments. FFMC model is depicted as a solid line, presenting FFMC and corresponding moisture equivalents.

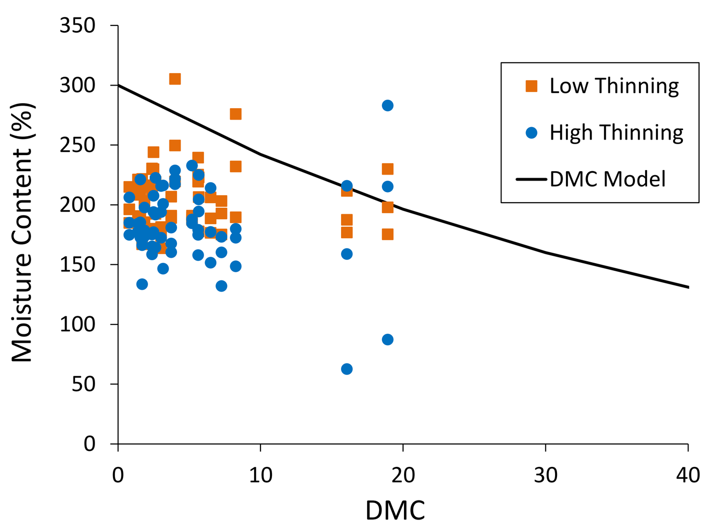

Figure 3. Moisture content of deep mulch (~5-10 cm) vs. DMC under high- and low-thinning fuel management treatments. DMC model is depicted as a solid line, presenting FFMC and corresponding moisture equivalents.

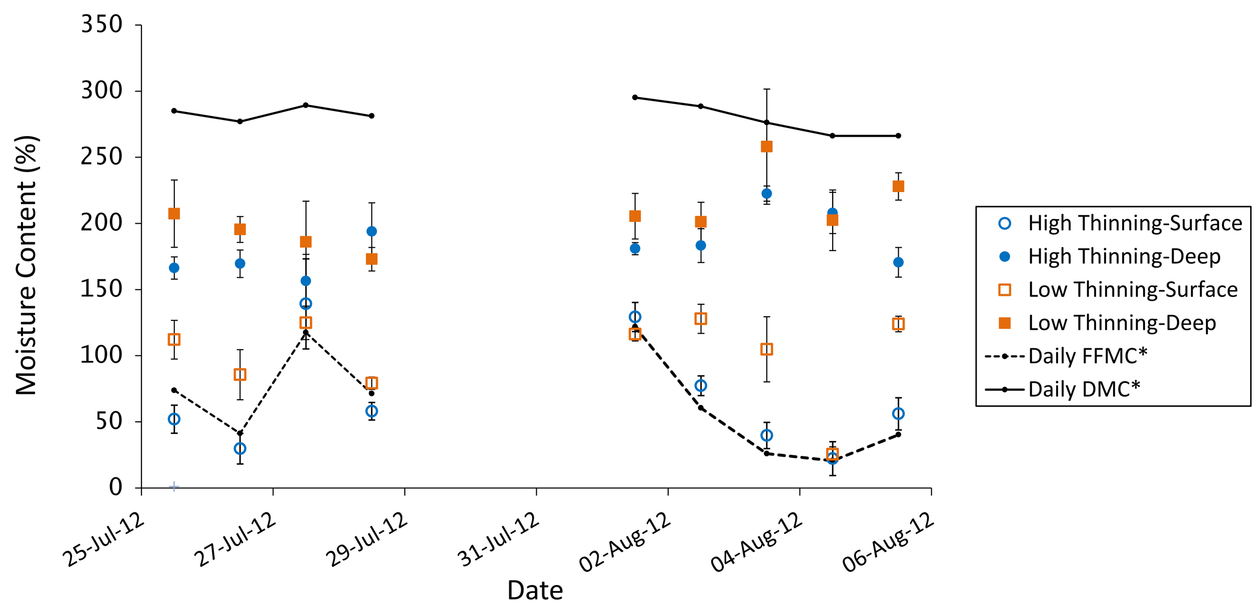

Figure 4. Moisture content of surface mulch and deep mulch (~5-10 cm) under high- and low-thinning fuel management treatments. Daily FFMC and DMC are depicted as dashed and solid lines, respectively. Bars represent ± 1 standard error. *Daily FFMC and DMC have been converted to moisture content equivalents.

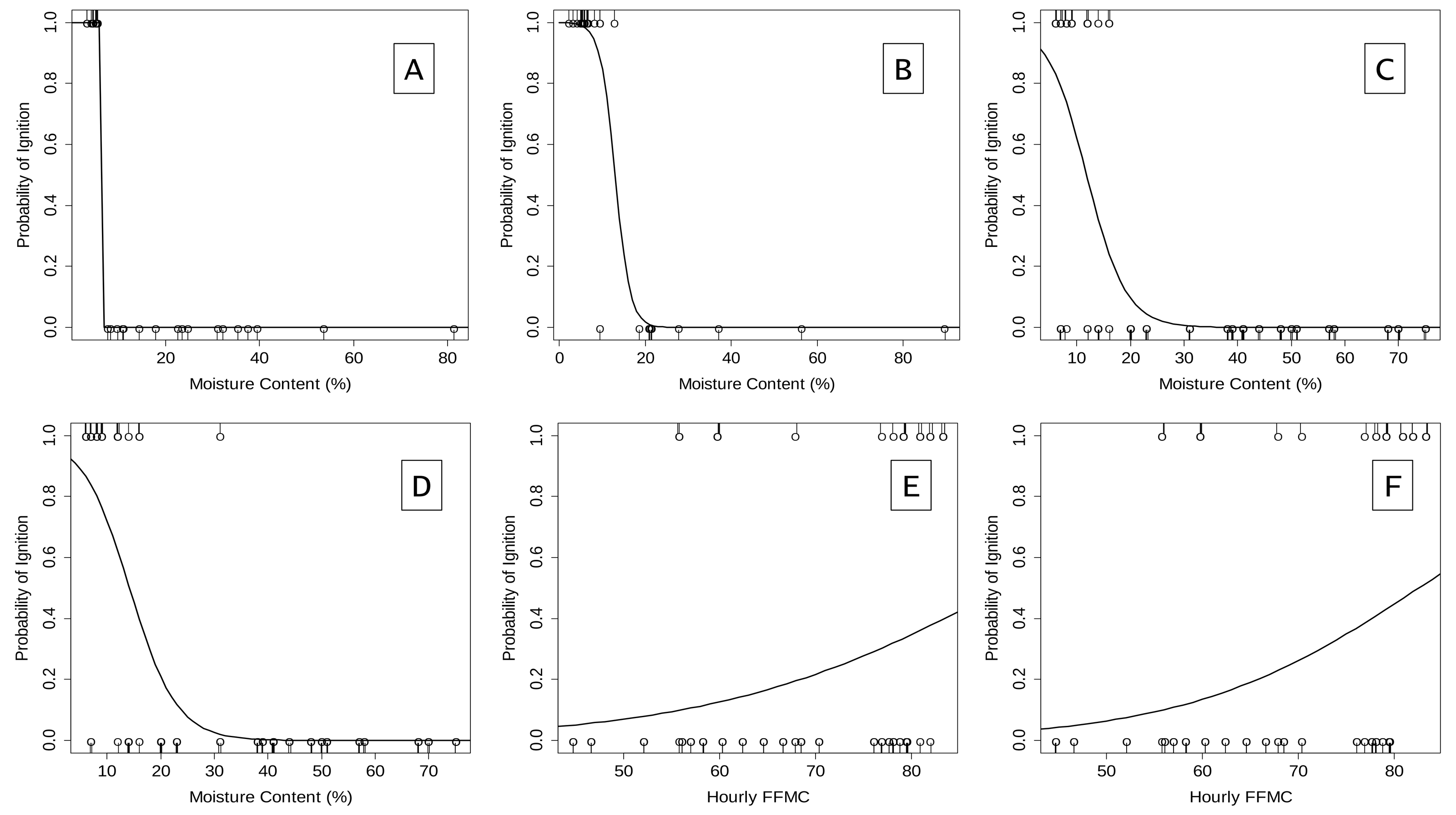

Figure 5. Data test points and logistic regression models presenting probability of ignition by moisture content and FFMC. (A. Lab, single match; B. Lab, triple match; C. In-situ, single match; D. In-situ, triple match; E. In-situ, single match; F. In-situ, triple match.)

Table 1. Summary statistics for logistic regressions (Figure 5, A-F). Standard error indicated in parentheses. *Complete separation occurred in the dataset; moisture content was found to be a perfect predictor for the outcome variable, ignition probability.

Model	Parameter	Estimate	p-value	C-statistic
A. Lab, single match*	Intercept	123.200 (45465.130)	0.998	1.000
	Moisture Content	-18.520 (6747.390)	0.998	
B. Lab, triple match	Intercept	7.459 (3.107)	0.017	0.992
	Moisture Content	-0.575(0.280)	0.040	
C. In-situ, single match	Intercept	3.241 (1.115)	0.004	0.934
	Moisture Content	-0.274 (0.088)	0.002	
D. In-situ, triple match	Intercept	3.230 (0.999)	0.001	0.946
	Moisture Content	-0.228 (0.069)	0.001	
E. In-situ, single match	Intercept	-5.841 (2.122)	0.006	0.708
	Hourly FFMC	0.065 (0.029)	0.025	
F. In-situ, triple match	Intercept	-6.792 (2.114)	0.001	0.750
	Hourly FFMC	0.082 (0.029)	0.004	

SUMMARY

- Most FireSmart fuel management applied thus far has been based on anecdotal evidence of the effectiveness of removing and re-distributing forest fuels.
- The critical step to understanding the efficacy of mastication prescriptions is to examine how physical properties and moisture dynamics of these new fuelbeds contribute to fire behaviour.
- Changes in fuelbed composition over time and rates of understory regeneration will likely have significant implications on the susceptibility of wildfire at the wildland-urban interface.
- A proactive approach to fire management via fuel treatments may potentially reduce direct suppression costs and potential damages.
- Future studies might investigate post-treatment regeneration along a chronosequence of masticated sites, variability in masticated fuel loading across fuel types and fire behaviour and severity of masticated fuelbeds.

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