Project Update
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FPInnovations
Wildfire Operations Research
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Survival zones for wildland firefighters: data collection in five more experimental openings in grass

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UPDATE TO PROJECT PLAN

This year we started recording carbon monoxide (CO) levels in our openings. Because air quality is an important component that affects a firefighter's ability to survive, we obtained four CO monitors that would allow us to address this gap in our data collection.

DATA COLLECTION

Location:	East of Slave Lake, Alberta on land owned by Vanderwell Contractor's 1971 Ltd.
Date:	April 20, 2010
Fuel Type:	Grass (1.25 m tall)
Opening:	Five circular openings 10 m in diameter

We established five rectangular plots of 50 m x 40 m. In each plot, we cut a circular opening 10 m in diameter (Figure 1). We removed the cut grass and placed it outside the opening.

Figure 1. A firefighter cutting a 10 m diameter opening in grass.

In each opening, we set up CO monitors, temperature sensors, radiation sensors, fire intensity sensors, and in-fire cameras.

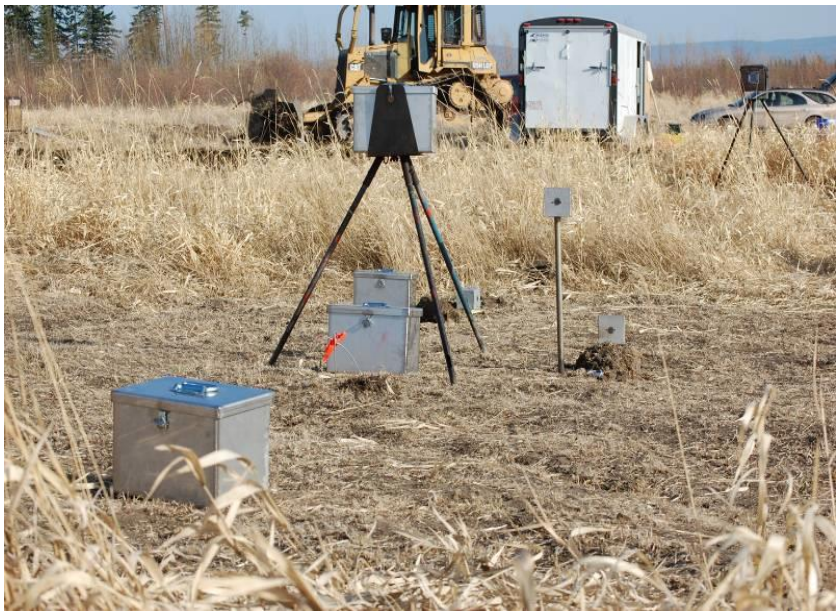

Figure 2. Carbon monoxide sensors (large boxes) and intensity sensors (small boxes) in the opening.

Figure 3. Radiation sensors in the opening.

The weather conditions during testing are summarized in Table 1. Wind data was recorded at a height of 1.8 m in an open area.

Table 1. Weather conditions during testing.

Temperature	11° C
Relative Humidity	50%
Wind speed	7–15 km/h
Wind Direction	ESE

FINDINGS

Fuel Load

Fuel load in the plots ranged from 1.6 to 6.6 metric tonnes per hectare (t/ha) with a mean of 4 t/ha. The degree of curing was 100%.

Fire Behaviour

Mean rate of spread: 50 m/min (range 48–60 m/min) surrounding the opening
15 m/min in the opening

Mean flame length: 1.5 m (range 1.25–1.75 m)

Figure 4. The flame front approaching the first opening. The in-fire camera pictured is 1.6 m tall.

Fire Intensity

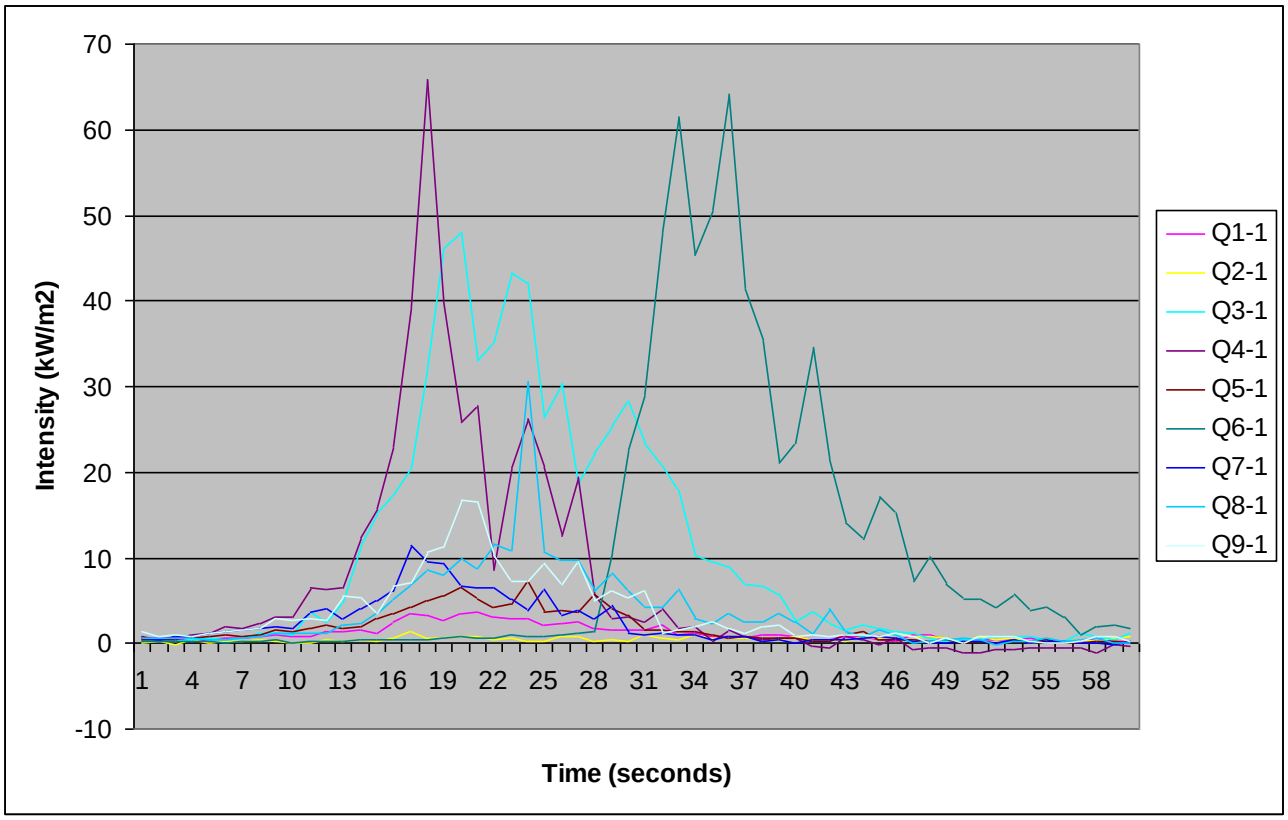

Figure 5. Intensity (kW/m^2) recorded in the first opening.

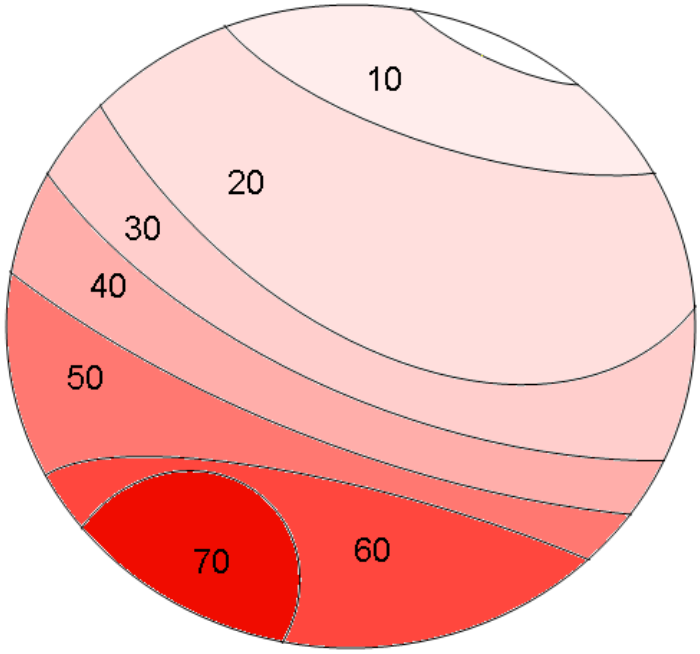

Figure 6. The average maximum values for the intensity sensors (kW/m^2).

Human tolerance is approximately 7 kW/m^2 without personal protective equipment (PPE) and Ackerman (2010) showed that firefighters have 35 seconds of protection from their PPE at 10 kW/m^2. So the back edge of our openings appear to be survivable—assuming a firefighter is wearing his protective clothing and the residence time of the fire is under 20 seconds.

Carbon Monoxide

The sensors closest to where the fire hit the openings had the highest mean value of 1747 ppm and peaked at 2000 ppm in four fires (Figure 7). The sensors in the middle of the opening and at the back of the opening had values of 859 and 863 ppm respectively. The elevated sensors had the lowest mean readings of 547 ppm, while the ground sensors had an average mean reading of 859 ppm. These CO levels did not last long enough to cause damage to humans.

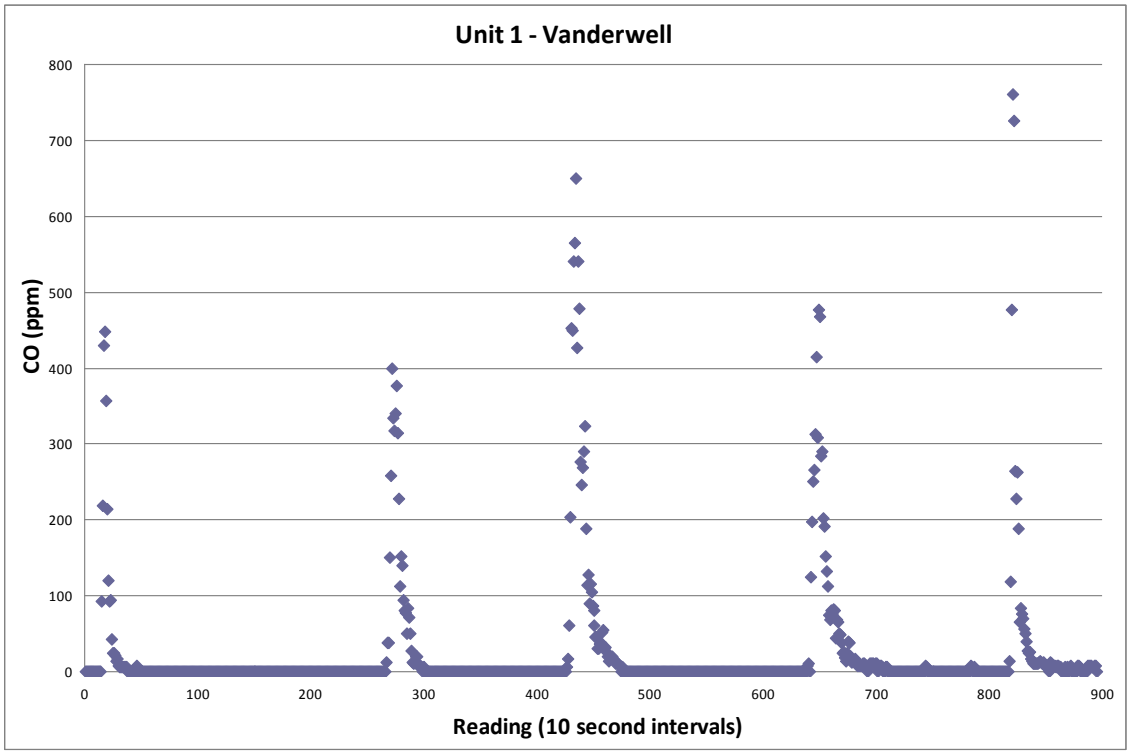

Figure 6. Carbon monoxide recorded by a sensor in the middle of the first opening at 1 m above the ground.

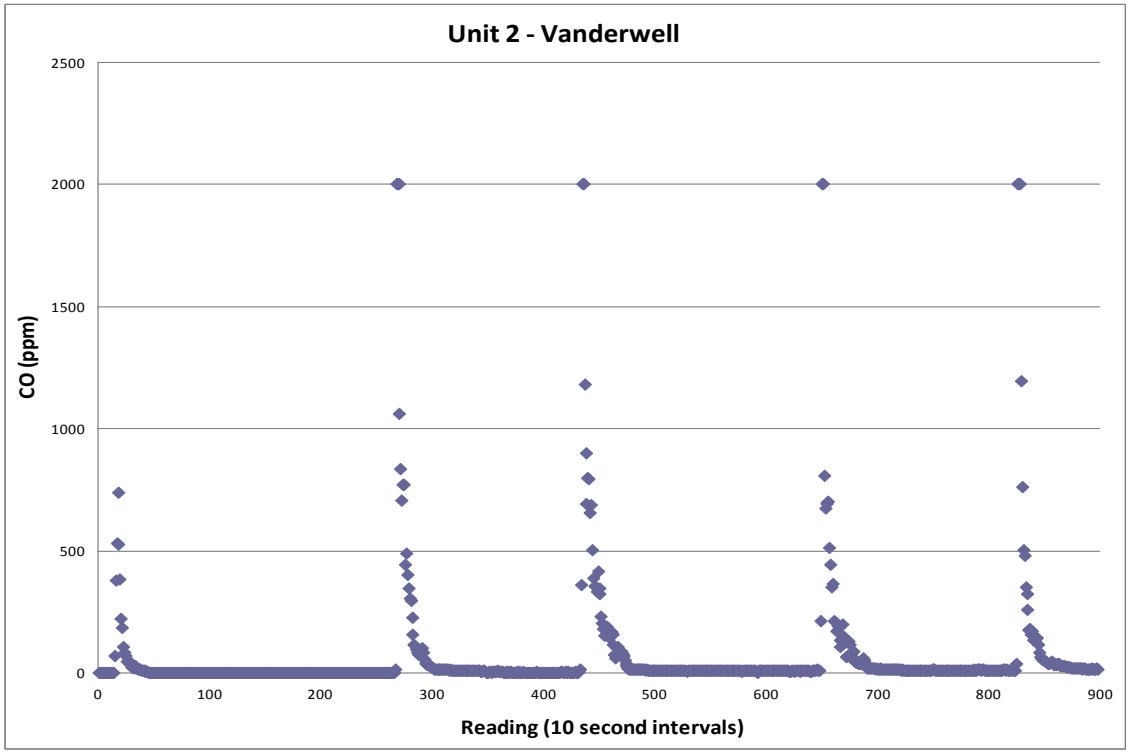

Figure 7. Carbon monoxide recorded from a sensor at the front edge of an opening.

Table X. Physiological effects of CO concentrations.

Concentration of CO (ppm)	Signs and Symptoms
50	Permissible exposure level for 8 hours as set by the US Occupational Safety and Health Administration (OSHA).
200	Mild frontal headache in 2 to 3 hours.
400	Frontal headache and nausea after 1 to 2 hours. Occipital headache after 2.5 to 3.5 hours.
800	Headache, dizziness, and nausea in 45 minutes. Collapse and possible death in 2 hours.
1600	Headache, dizziness and nausea in 20 minutes. Collapse and death in 1 hour.
3200	Headache and dizziness in 5 to 10 minutes. Unconsciousness and danger of death in 30 minutes.
6400	Headache and dizziness in 1 to 2 minutes. Unconsciousness and danger of death in 10 to 15 minutes.
12800	Immediate unconsciousness. Danger of death in 1 to 3 minutes.

Credit: Canada Gazette: 1998–2007.

Temperature

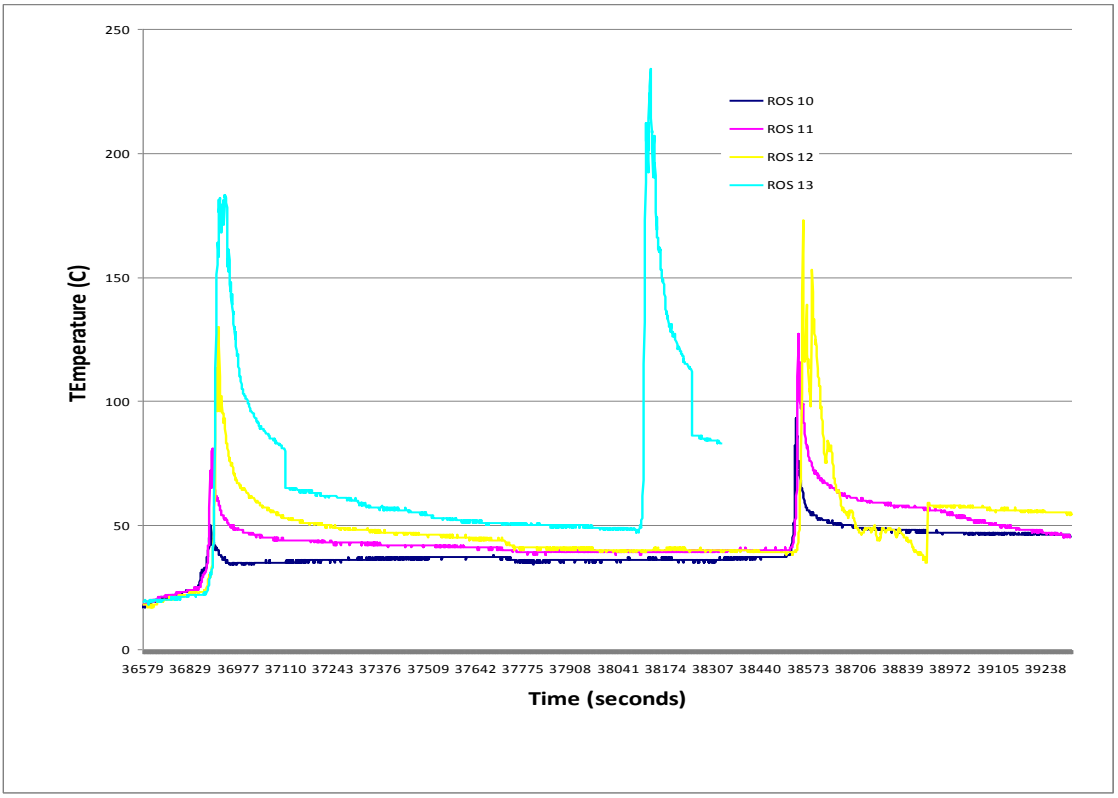

Figure X. Temperature profile for sensors spaced 1 m apart.

Preliminary Conclusions

So far, we have collected data in ten openings. In nine of those, the back area (directly across from where the fire hit the opening) exhibited fire intensities that were theoretically survivable. Under light, steady wind conditions the fire behaviour in our openings meet the requirements for human survival. All our tests so far have been in grass and on level terrain. Nine tests were in winds less than 15 km/h, but one test was in winds greater than 15 km/h. The entire opening in that test burned and intensities were above the survival threshold (7 kW/m^2).

While viewing the videos, we noticed that an unburned, cone-shaped area just outside the back end of the opening develops as the fire passes over the opening. This area does eventually burn, but it may provide a bit more survivable space at the back end of the opening. where intensity values are lowest.