

# Canadian Wildland Fire & Smoke Newsletter

Fall 2018

“Connecting diverse wildland fire, emissions, air quality and modelling communities.”

## Reflection on the 2018 fire season

by Mike Flannigan, Director, Canadian Partnership for Wildland Fire Science, Edmonton, Alberta, [flanniga@ualberta.ca](mailto:flanniga@ualberta.ca)

As winter approaches the fire season has come to a close. In my short article on ‘What’s on tap for the 2018 wildfire season?’ in the Spring Newsletter (page 2) I asked — Will we have another record breaking year in BC? I did not expect the answer to be "yes" but that is exactly what happened (2017 area burned = 1.216 Million ha; 2018 currently sits at 1.349 Million ha). Figure 1 shows the annual area burned for British Columbia 1950-2018. The area burned in BC in 2017 and 2018 is greater than 4 % of the forested area of BC, which is also more than what has burned in the previous 27 years.

One aspect of wildfires that garnered lots of attention this fire season was smoke. Here in Edmonton, we had the worst air quality in the world for part of August due to the wildfires in BC. In the future, more Canadians will be impacted by wildfire smoke if fire activity continues to increase as expected. The more we study wildfire smoke, the more we find out that it is even more hazardous to our health than previous thought.

What about 2019? Well, it depends on the day-to-day weather during the 2019 fire season. However, some research suggests that the weakening of the jet stream (which favours more stagnant patterns) and less ice in the western Arctic are creating favourable conditions for strengthening and

anchoring the west coast upper ridging during the fire season. If true, then the new reality for BC is more fire activity at least from a weather perspective (of course, fuels, ignitions, and fire management activities, along with the fire weather determine how much fire activity there will be). Also, it appears that we will likely have a weak El-Nino this winter, and sometimes the El Nino influence carries over into the fire season. Only time will tell.

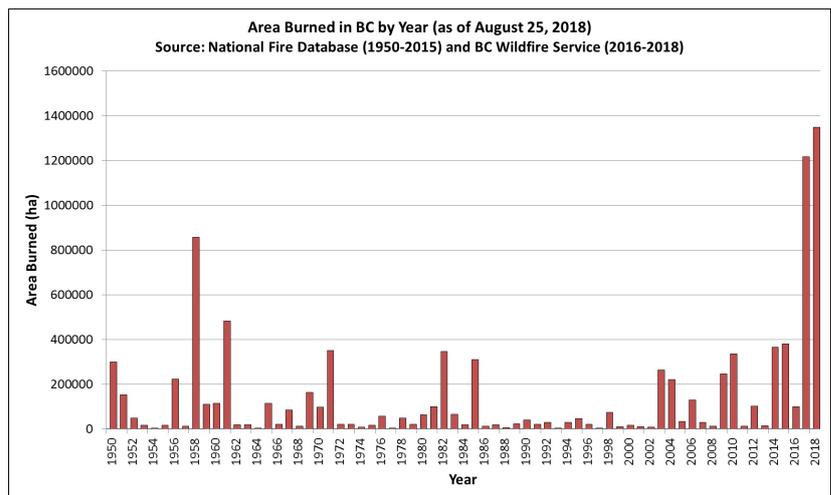


Figure 1. Area burned in British Columbia 1950-2018

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## Exploring mulching treatment intensity: Productivity trials and fire behaviour observations

by Steven Hvenegaard

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### Background

Mulching is a mechanized forest fuel treatment technique, it is often prescribed in Alberta to increase stem spacing and reduce the crown bulk density of a stand, thereby reducing the potential for active crown fire in forested stands within or adjacent to a community or other values at risk. During these operations, the reduction of aerial fuels is achieved through the selective removal and mulching of unwanted stems to achieve a prescribed stem spacing.

During mulching operations, standing stems and surface fuels are converted to mulched chips or shredded fibre and displaced to the surface fuel layer. The

characteristics of the resultant mulch fuel particles (volume, size, and shape) are dependent on a number of factors including stand density, species, mulcher type, and the fuel treatment intensity.

In Alberta and other parts of Canada, mulching of forest fuels is also conducted very extensively at an industrial scale to create utility corridors and achieve vegetation management objectives along industrial rights-of-way (Figure 1).

Mulch fuel beds resulting from these operations are often characterized by a uniform bed of fine to medium sized particles with little intact round wood. The fuel bed characteristics produced

in these industrial operations has been referred to as an ‘industrial standard’ produced through a ‘normal’ treatment intensity. This normal intensity mulching treatment is typically applied on a smaller scale in mulching treatments in the wildland-urban interface to produce a ‘regular’ mulch fuel bed (Figure 2).

Mulching productivity trials in the wildland-urban interface are generally conducted by documenting mulching operations that apply the normal treatment intensity; however, few trials (Halbrook et al 2006, Hvenegaard and Hsieh 2014) have explored the productivity of different fuel treatment intensity practices. Similarly to, most experimental fires in mulch fuels



Figure 1. Mulch fuel environments in a newly constructed utility corridor (left) and in a maintained right-of-way (right)

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Figure 2. A normal intensity mulching treatment in the wildland-urban interface (left) with resulting regular mulch fuel bed (right).

have been conducted in regular mulch fuel beds created through the normal treatment intensity. While these two areas of research have provided good insights into equipment productivity and potential fire behaviour, fuels managers want to explore how different fuel treatment intensities will impact treatment productivity and potential fire behaviour in the resultant mulch fuel beds. A clearer understanding of the effects of various mulching intensities on productivity and fire behavior can aid fuel managers in prescribing a mulching intensity that

effectively mitigates wildfire risk and minimizes fuel treatment cost.

Unit 2 at the Pelican Mountain FireSmart research area<sup>1</sup> has been dedicated to studying how altering the treatment intensity of a mulching operation impacts machine productivity, the resultant fuel bed characteristics and fire behaviour potential. In February 2018, mulching operations were conducted using three distinct mulching intensities in separate subunits. Machine productivity for each treatment intensity was

documented. In August 2018, experimental fires were conducted in the three subunits to document fire behaviour in these distinct fuel environments.

## Mulch treatments

Unit 2 was delineated into three sub-units that were mulched at different treatment intensities to produce three distinct mulch fuel beds. (Figure 3). A normal intensity mulching treatment includes knocking over stems and processing these stems, branches and surface fuels using at least two passes. This results in a bed



Figure 3. Fine (left), regular (middle) and coarse (right) mulch fuel beds resulting from the three different treatment intensities applied in unit 2.

<sup>1</sup>For more info about the Pelican Mountain FireSmart Research Area click here for the spring 2018 issue of the Canadian Wildland Fire and Smoke Newsletter.

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of uniformly-sized chipped debris with a minimal amount of intact round wood.

Both the low and high intensity mulch treatments were exploratory treatments which are not commonly applied as forest fuel treatments. The low intensity treatment redistributed standing fuel to the surface and included only minimal mulching. The resulting coarse mulch fuel bed includes a large volume of round wood debris and an undisturbed duff layer.

The high intensity treatment redistributed standing fuel to the surface, thoroughly mulched the treatment area, and intentionally mixed the mulch with the duff layer whenever possible to create a fine mulch fuel bed. This treatment intensity is not typically applied because of the additional cost and the unknown benefits. In previous mulching studies, mulcher operators have been reluctant to mulch below the surface fuel layer and mix duff fuels because of potential damage to the mulcher head.

During the mulching operations,

we assessed qualities of each fuel bed (e.g., amount of intact round wood, disturbance of duff layer, separation of branches) to subjectively label the treatment intensities as high, normal and low intensity.

## Productivity

The productivity of forest fuel treatment operations is typically expressed as the number of hectares treated per productive machine hour (ha/PMH). With a large variability in stem height, diameter and density across a forest stand or landscape, we felt that the volume of biomass processed per productive machine hour (kg/PMH) could be applied as a meaningful productivity metric. Prior to treatment, the Alberta Wildland Fuels Inventory (AWFI) program crews completed a fuel inventory in each subunit. We used stand inventory data (diameter at breast height) for each subunit as an input to the biomass equations (Lambert, Ung and Raulier 2005) that allowed us to calculate processed biomass for each subunit.

We used subunit area (ha), biomass per area (kg/ha) and mulching time (PMH) to calculate two productivity metrics – (1) biomass/mulching time (kg/PMH) and (2) area/mulching time (ha/PMH)

Basic observations and preliminary review of the productivity data indicate that a higher intensity fuel treatment requires more mulching time and, reduces the productivity of the mulcher, compared to a lower intensity operation. Likewise, a forest stand with a greater volume of biomass to process requires more mulching time and results in lower machine productivity. While these results seem fairly intuitive, this approach to quantifying productivity as a function of stand characteristics, treatment type, and treatment intensity can provide a decision support tool to aid in budgeting for and executing mulch fuel treatments.

## Fire Behaviour

In August 2018, Alberta Agriculture and Forestry collaborated with FPInnovations

**Need more wildfire research tools? Check out the tips and tools at [canadawildfire.org](http://canadawildfire.org) to see an annotated list of useful weather and wildfire websites.**

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and the Canadian Forest Service to conduct independent experimental fires in each of the three distinct mulch fuel environments created in Unit 2. We collected comparative fire behaviour data by measuring the rate of spread, fire intensity, and depth of burn throughout the burn in each separate fire. Additional data was collected with heat flux sensors, infrared and visible light cameras.

Wind was the primary influence on fire growth during the experimental fires on August 21 and 22. Under light wind conditions (5 km/h, gusting 8 km/h) on August 21, minimal fire growth occurred in all the separate fires. The next day, with increased wind speed (10 km/h, gusting 17 km/h), the rate of spread and fire intensity were more active. Fire behaviour in the coarse mulch fuel environment

was most vigorous compared to the somewhat glacial spread rate in the fine mulch fuels (Figure 4). During the August 22 fires, we observed rates of spread in the coarse, regular and fine mulch fuel beds of 1.2, 0.3 and 0.2 m/min, respectively.

## Next Steps

Further action will be needed to determine how many passes are required to achieve the desired fuel bed characteristics based on fire behavior reduction objectives. This information will assist fuel management practitioners in developing appropriate cost effective mulching prescriptions.

The Pelican Mountain FireSmart research area provides continued opportunities for experimental fires to capture fire behaviour data in mulch fuel types. The

three distinct mulch fuel environments created in Unit 2 provide several research opportunities that can be explored on an ongoing basis. Potential projects include comparative studies in vegetative regrowth and mulch decomposition in various mulch fuel environments and the temporal changes in fire behaviour potential for each subunit.

A more complete description of the mulching treatment intensities and resulting mulch fuel environments with a detailed analysis of productivity data from this study can be accessed in a forthcoming [FPInnovations](#) technical report. A separate report will present fire behaviour data from the experimental fires in the three mulch fuel environments.



Figure 4. Vigorous fire behaviour in coarse mulch fuels (left) compared to low intensity fire behaviour in fine mulch fuels (right) during August 22 trials.



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### Wildfires will only get worse unless we learn how to live with them

by Mike Wotton<sup>1</sup> and Mike Flannigan<sup>2</sup>

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Wildfire activity and its impact are increasing around much of the world. We see it on the news every summer now. Different locations (and sometimes the same locations) and different impacts – sometimes terrible, tragic impacts – but everywhere there seems to be wildfire these days, these years. This is the reality and its coming was predictable even several decades ago. And, it will only get worse. The effort we put into adapting to this changed world will influence how easily we co-exist with fire.

Why is fire activity increasing in Canada and other parts of the world? Simply, things have changed. There are more people and their things on the landscape.

People cause more than half of all fires, and fires threaten to burn the things we value, be it homes, infrastructure or beautiful forest views. Lastly, and probably most importantly, weather patterns are changing. Hot, dry, windy conditions – those conducive to fires starting and spreading – are becoming more frequent.

As wildfire will remain a recurring feature in our lives, we have to learn to live with it. To live with it, we must understand it. We have to change our view of fire. It is not the enemy but just a natural process, one that has historically helped maintain many vegetated ecosystems. However, it is at times uncontrollable by even our modern technologies.

During the first decades of the 20th century, large wildfires, both from lightning and from

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**Photo 1. The Snowy Mountain wildfire is visible from Cawston, B.C., on Aug. 2, 2018. Weather patterns are changing, as hot, dry, windy conditions – those conducive to fires starting and spreading – are becoming more frequent.**

those escaping from land-clearing activities, burned large areas and even led to major community burnovers with considerable fatalities, similar in number to those we see in parts of the world today. The answer then was the formation of provincial fire-management organizations to find and fight those fires and, nationally, the investment in a research program that would provide fire managers the tools to anticipate and better prepare for burning conditions.

That approach has been successful for decades – some might argue too successful, but that is a nuanced discussion for another time. Canadian fire-management agencies are among the best in the world at managing wildfires. The products of

Canadian fire science not only inform fire-management activities every day throughout the country, but are used in many different locations around the world to provide early-warning systems.

The challenges presented by increasing wildfire activity will continue to grow. If we desire to maintain our current levels of public safety, we must re-envision how we manage fire in Canada. We will need to look harder for situations where low-risk fires can be allowed to burn unsuppressed, freeing up resources to respond to more imminent threats and letting fire play its natural role. It's an approach that necessitates taking more, but measured risk, with the end goal of preventing major

losses of what we value most. Fire agencies are embracing these ideas, sometimes as part of continuing strategic planning, sometimes as part of necessity.

However, it is an approach that requires fire managers to be equipped with comprehensive and scientifically sound, real-time information for estimating and managing risk in challenging and complex scenarios. It is an approach that can only succeed if we invest in research that focuses on greater understanding of wildfires.

So as we face increased unmanageable wildfire activity in the 21st century, we need, as we did a century ago, public investment (at both the provincial and federal level) in wildfire management and fire research to reduce this risk. What will it take to move us forward? We have seen the Fort McMurray wildfire – the costliest natural disaster in Canadian history – record-breaking years and evacuations across the country, but no significant investment in research. We hope the catalyst for action is not multiple fatalities from wildfires as it was in the past century. The increased risks we face from wildfire will only continue to worsen without significant investment and change.

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## A proposed experimental methodology for assessing the effects of biophysical properties and energy content on live fuel flammability

by Oleg Melnik

Wildfire Technologist, FPInnovations, Edmonton, Alberta, oleg.melnik@fpinnovations.ca

[Full thesis available here](#)

### Thesis Abstract

The effectiveness of fire management tactics and the safety of firefighters strongly depends on the reliability of fire behaviour predictions that is currently limited by a lack of understanding of the flammability of live fuel. Until now wildland fire modeling has been primarily based on the flammability of dead fuel under the assumption that live fuel has a very limited effect on fire behaviour. However, analysis of the existing data indicated that live fuel constitutes over 48-60% of fuel consumed during the passage of a crown fire flame-front and hence strongly influences its intensity and behaviour.

Aiming to provide a physics-based input for live fuel flammability in wildfire modelling, this study introduces a new experimental methodology for quantifying flammability as fuel's contribution to the energy release of the incoming frontal flame. Using a methane flame to simulate a frontal flame, flammability was measured with an oxygen consumption

calorimeter as the change in energy release of the methane flame during the first 60 seconds (average flame-front residence time) of its interaction with live fuel. Evaluating flammability directly in a flame allowed us to better represent the conditions of oxygen deficiency and high concentrations of water vapor as well as high-intensity combined radiative and convective ignition heat transfer within the flame-front. The methodology resulted in fast consistent ignition and almost complete consumption of the same plant material as consumed during the passage of a flame-front – fresh twigs one to nine millimeters in diameter with

attached foliage, or shoots.

The live fuel's energy release contribution to the incoming flame was significantly lower than its energy content measured traditionally, suggesting substantial reduction in energy release caused by high water content of live fuel and oxygen deficiency. Due to the sensitivity of the method to this reduction in energy release, the variation in live fuel flammability for white spruce was more than twice that measured using existing techniques. For new shoots, in the beginning of the season, flammability showed substantially negative values,

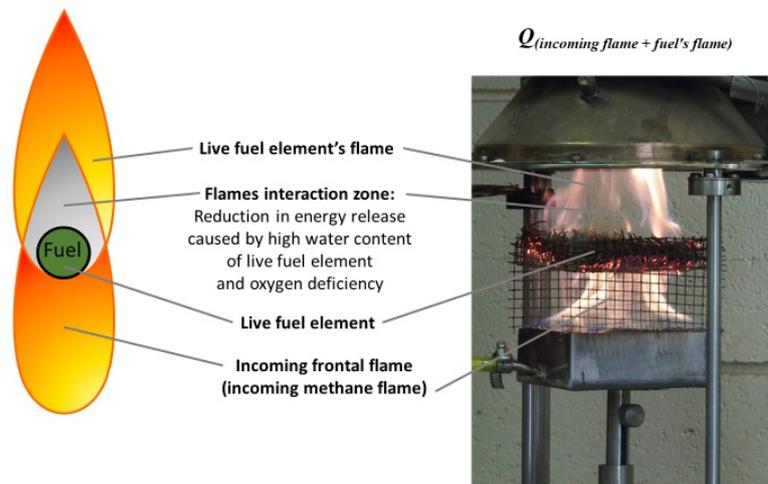
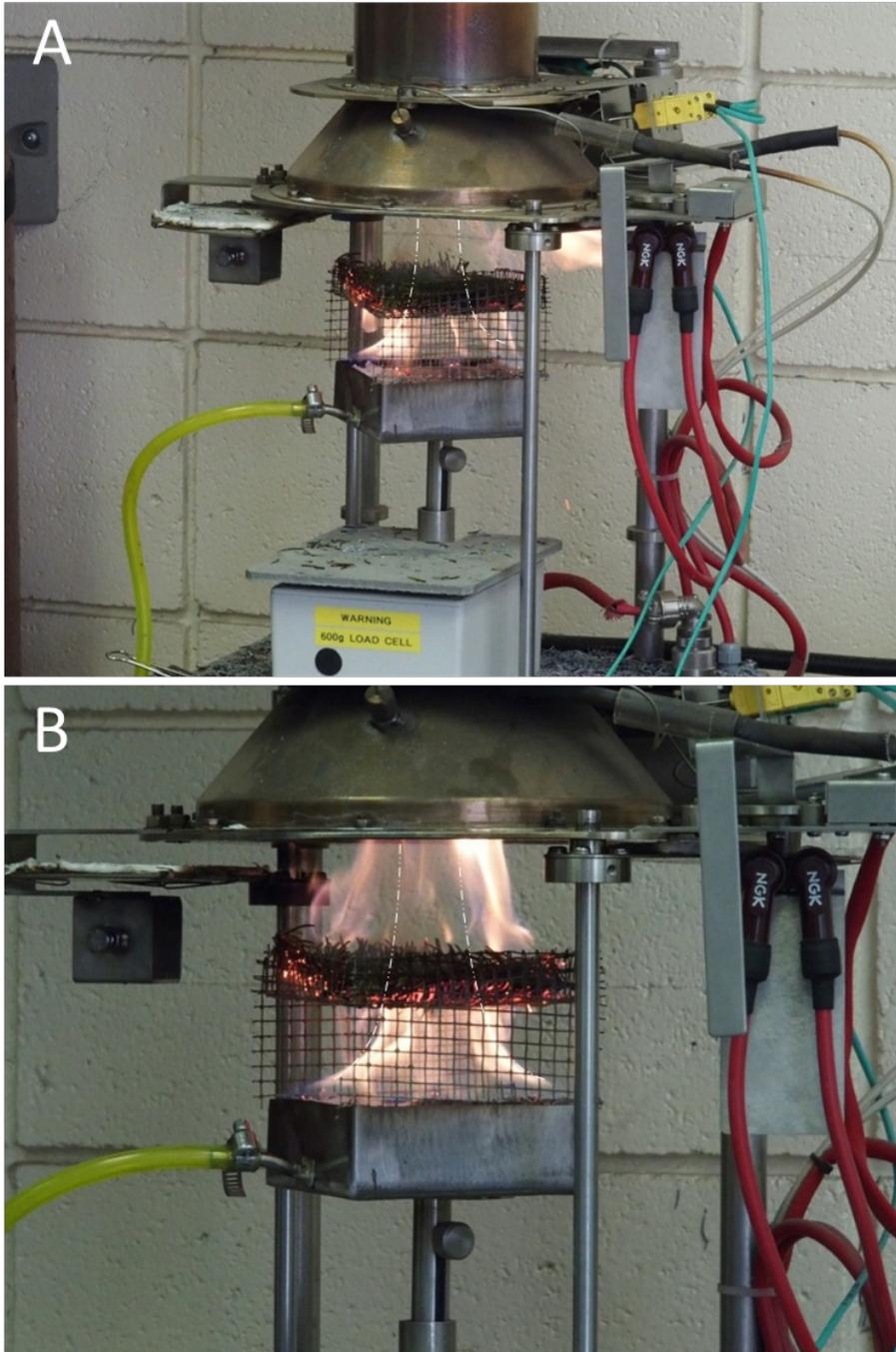


Figure 1. Evaluating energy-generation component of the flame's energy balance instead of fuel's energy content.

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indicating a significant reduction in the resulting energy release and intensity of the incoming flame. As measured in 2014, and in a good agreement with the historical seasonality of extreme wildfires in Canada, live fuel demonstrated four seasonal maximums in flammability in early May, July, and August, and in the end of October. Most likely due to the effects of drought, this trend is missed by the Canadian fire model which assumes one seasonal maximum in flammability around June 1st. A new metric, fuel’s energy content, was as successful in predicting live fuel flammability as water or dry matter contents using the more traditional gravimetric approach. When using the volumetric approach, the variation in flammability was even better explained by energy content (adjusted  $R^2 = 0.78$ ) than by water content (adjusted  $R^2 = 0.64$ ). The volumetric multivariable model substantially improved the prediction of flammability (adjusted  $R^2 = 0.87$ ).

The new methodology successfully predicted flammability as energy release on fresh mass or volume basis

Figure 2. Flammability as a net effect of the burning fuel on the energy release of the incoming flame. A) New shoots B) Flammability of 1-year shoots



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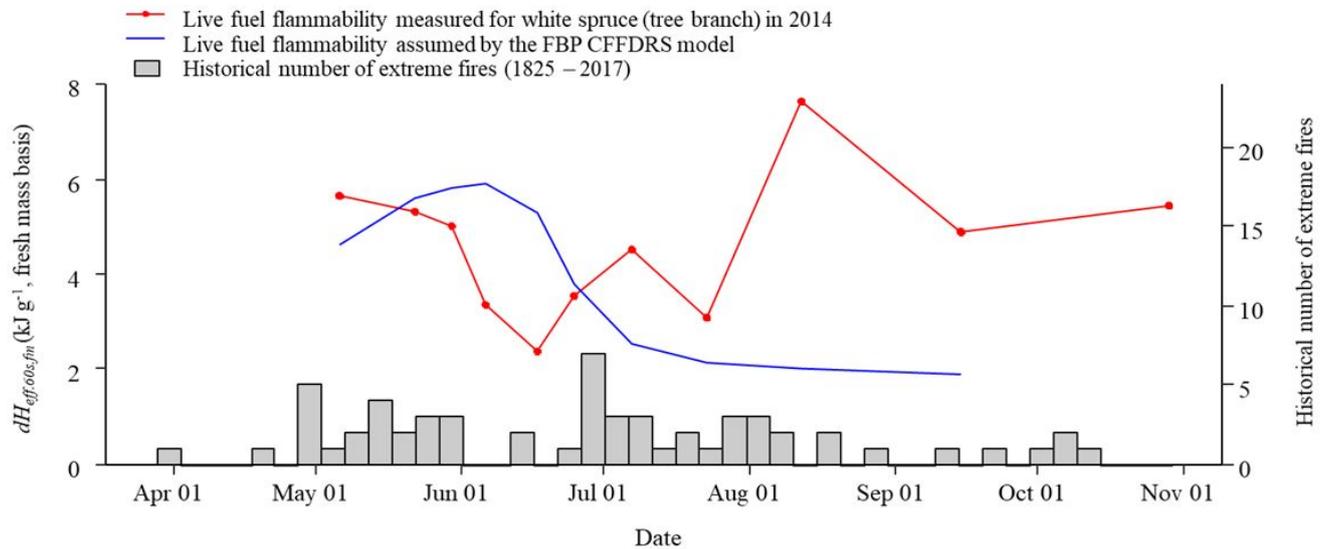
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**Figure 3. Seasonal trend of live fuel flammability compared with the historical seasonality of extreme wildfires in Canada.**

instead of the traditional mass loss basis. This allows for modelling the potential energy release of the forest stand under extreme fire-weather conditions without separately modelling fuel consumption and hence provides a realistic approach for the development of a numerical energy release- and stand

characteristics-based fuel classification. Flammability defined as energy release contribution to the frontal flame can be used as a physics-based input in wildfire modelling since it represents the energy-generation component of the frontal flame’s energy balance on a fuel element scale. This allows

for replacing the existing semi-empirical operational models based on foliar moisture content and simplified physical models based on time to ignition by a new generation of models based on an actual energy balance.



Dr. Marty Alexander, a former senior fire behavior research officer with the Canadian Forest Service (1976-2010), received the Ember Award from the International Association of Wildland Fire (IAWF) for 2018. Marty has also previously received the International Wildland Fire Safety Award from the IAWF in 2003.

The purpose of the IAWF Ember Award is to recognize sustained excellence in wildland fire research and to encourage innovation, exploration, application, and dissemination of important research results.

In semi-retirement, Marty has continued to stay active in the field of wildland fire science, with a particular emphasis on the application of fire behavior knowledge to ensure the safety of firefighters and members of the public.

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## Not the new normal: an AI approach to BC wildfires

by Matt Toner

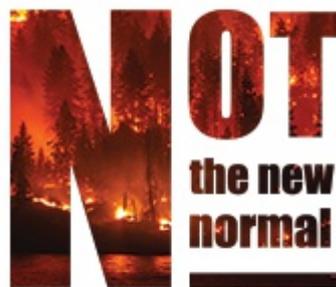
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### The Fiction and the Science

Even today, when most people think of artificial intelligence (AI), they think of it as the stuff of science fiction: robots and replicants, benign or malevolent. Agent Smith in the Matrix. Hal 9000. Skynet becoming self-aware.

It's fantastic entertainment and a great reason to buy a movie ticket... but the reality is both more prosaic and much more likely to actually change your life for the better. Artificial intelligence applications and machine learning (ML) techniques are being used in myriad of medical circumstances, they are powering better job searches, analyzing reams of legal decisions, and lie behind the recommendation algorithms that suggest what movies you'll wind up watching. They are used to teach robots to play soccer. And they'll even park your car.

Perhaps it's inevitable then, that we have the confidence to harness the potential of artificial



intelligence to make a dent in some of the biggest problems facing us on a hyper-local level. And for British Columbians today, there are few problems that operate at the scale, the speed and with the immediacy of wildfires.

### The Problem

Over the past decade, fire seasons and activity have been increasing in British Columbia... and while this has mainly been a concern for the professionals and those interior communities directly impacted, the 2017 and 2018 seasons were something entirely new to most in the Lower Mainland. Even the most disinterested city-dweller could see the haze. They could smell

the smoke. And as the sun set every night over English Bay - red like a maraschino cherry - people had reason to ask one another if this was really going to be “the new normal.”

Certainly, anyone reading this knows that the numbers are worrisome. 2017 and 2018 set new record highs for total area burned (~2.5 million hectares) and cost (~\$1 billion), both stats that are immediately shocking simply in terms of the economics. But when you start to factor in the social costs of the tens of thousands of evacuees and the environmental costs of hundreds of thousands of tons of greenhouse gases released, there's a lot not to love.

As those in the profession know all too well, these seasons also presented challenges in resourcing and response. These quickly surpassed the capacity of the BC Wildfire Service (BCWS), which is structured to manage and respond to fires based on historical average and above average fire seasons. What's

European Commission - Press Release

Increase prevention efforts needed to curb the growing risk of future wildfires

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**Photo 1: Matt Toner\* speaking at the Not the New Normal Symposium**

more, increased fire activity across North America has limited the availability for resource sharing between agencies; a common solution to help manage above-average fire seasons. And, to make things even more grim, the BCWS has also been increasingly relied on to assist with flood response... and 2017 and 2018 have also set new records for floods in BC.

So not only is the problem getting worse, our province's ability to grapple with it is itself under pressure. Given that the underlying climactic conditions driving fires show no signs of easing in the near term, we need to up our game when it comes to prevention, prediction, suppression and education using traditional, contemporary and experimental techniques.

## The Proposed Solution

This process began with series of conversations in the summer of 2017 between the BC Greens and

the BC NDP... and the above phrase may or may not have been used. But there was a keen interest in how we might adapt the advanced technologies and apply them to this very real problem.

Each year, wildfire season presents a unique series of complex, multi-faceted problems that unfold on a provincial level, which means that there are an almost unmanageable number of factors that could be studied, analyzed and improved. But the most tractable seemed to be the province's predictive response to wildfires. Not only is this a core mitigation competence that determines the effectiveness of, well, just about every subsequent action, it is also where the general consensus held there was obvious room for improvement.

It was also an obvious area where

AI / ML techniques could be brought to bear. There was solid research starting to emerge across the country by people like Mark Crowley at the University of Waterloo and initial applications being developed by people like Mike Flannigan at the University of Alberta. Those served as inspiration points for the project being initiated in British Columbia.

Over the summer, provincial government stakeholders, AI researchers, fire fighters, ecologists and data scientists began a process of collaboration that was literally unprecedented: how could we best develop a cross-disciplinary framework for a machine-learning approach that could specifically improve British Columbia's predictive response? This solution would require us to encapsulate the considerable subject matter expertise that had



**Photo 2: Attendees taking in the speakers.**

\*Matt Toner is the former Deputy Leader of the BC Green party and a technology-focused innovator who presently lives in Vancouver. He was the chair of the first Not the New Normal symposium.

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**Photo 3:**  
Symposium  
Speaker Desiree  
Matel-Anderson,  
Chief Wrangler  
of FIT (Field  
Innovation  
Team), and CEO  
of the Global  
Disaster  
Innovation  
Group

season, with discussion to be tightly focused on defining a specific, iterative approach for a first generation predictive AI model. We called this the “Not the New Normal” symposium because - heck - nobody wants the 2017 / 2018 seasons to become something that is just accepted with a shrug.

That sentiment seemed to be widely shared by those we contacted. We had originally planned / hoped for 20 people to get around the same table to thrash things out: once word got around, however, the number of interested participants quickly shot up towards 50, with another 20 who were prevented from attending because of earlier professional obligations. The emerging industry association for

been build up over decades of fighting fires, settle on one or more modelling approaches that we felt would yield results, and - most importantly - ensure that we had the data necessary to power this machine.

silo-ed groups into the same room: online discussions, one-on-one meetings, and small working groups will only get you so far. So a one-day symposium was planned in Vancouver following the conclusion of the 2018 fire

We also had to make sure this approach had broad buy-in from local government stakeholders, impacted communities, and the firefighters themselves. While theoretical study is useful, at the end of the day, those folks needed a tool that they could actually use in the field with confidence.

## The Starting Point

Obviously, to get the kind of broad-based understanding that translates into actual support, you need to get these somewhat



**Photo 4:** Symposium Speaker Mark Crowley, Assistant Professor in the Pattern Recognition and Machine Intelligence group at the University of Waterloo

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AI in British Columbia - fittingly called AInBC - was also quick to the table, as this was the gnarly sort of problem they had been looking to help solve. Clearly, the time was right for this sort of discussion.

Maybe too many people, in a way. The day's schedule was packed with articulate, passionate and knowledgeable speakers that ranged from those training Aboriginal fire crews in far distant communities to ML researchers in the United States, with presentations that covered quantitative modelling approaches already tried to more experimental techniques that were on the cusp of yielding interesting results. And also the noble failures: what had been tried, what were the stumbling blocks, and what we might learn from those experiences.

In truth, it may have been information overload for the panel of government stakeholders that were the primary audience for this message. While these folks needed that kind of information to underwrite the costs of building the wildfire AI, it was a literal firehose of things too important to miss. Even so, those surveyed after the event reported an extremely high level of satisfaction with the event and were committed to personally helping advance the mission still further.

## What Comes Next

The overwhelming consensus of the assembled participants was that the project should proceed with the design and development of a first generation AI. This was very much the informal sentiment going in to the day, with the symposium's discussion much more focused on the ways and means to create such a model can be used in tandem with the province's traditional predictive model during the 2019 wildfire season. This would allow us to “dial in” the model and tune it to be even more accurate as we move forward.

Even with that unanimity of purpose, there was also recognition that the project is inherently dependent on differing cycles for business, government and academia. Such alignment is crucial, but - hopefully - also manageable. Working groups are already underway to blend a

variety of approaches and requirements so that the momentum developed to this point isn't squandered. And, let's face it, there are a LOT of specifics that need to be nailed down, from the availability and granularity of the data, to the specific modelling approaches that will be attempted, to the basic requirements of bringing this thing to life as working software. The real work very much lies in front of us.

But that first instance of collaboration and the goodwill and introductions generated will carry us a long way. In fact, Mark Crowley and Mike Flannigan - mentioned earlier in this article - have already been talking about how the practical ways they can bring their work together... maybe as a battalion of fire-fighting terminators?

I, for one, would pay to see that movie.

