CANADIAN WILDLAND FIRE & SMOKE

NEWSLETTER

FALL 2021

Photo: BC Wildfire Service - Firefighters from Mexico helping at Okanagan fire complex.

Spring wildfires in Alberta, Canada

By Cordy Tymstra [1], Piyush Jain [2], Mike Flannigan [3]
[1] Ph.D., University of Alberta, tymstra@ualberta.ca
[2] Researcher, Canadian Forest Service
[3] Professor, Thompson Rivers University

Background and wildfire management reviews

In Canada, lightning-caused wildfires ≥ 2 ha peak during the summer months (June to August), whereas human-caused wildfires ≥ 2 ha peak during the spring (May) (Coogan et al. 2020). In Alberta, wildfire starts in the month of May account for 23% of all wildfires but are responsible for 55% of the total area burned (Tymstra et al., 2021). A large portion of the area burned in Alberta occurs during a small number of burning periods in spring with dry, windy weather. Approximately 83% of the wildfires in May are reported as human-caused or undetermined.

During the 1990 – 2019 period, six external wildfire management reviews were conducted in Alberta as a result of disastrous wildfire seasons dominated by spring wildfire activity (Figure 1). Through the Alberta Emergency Management Agency, Alberta Municipal Affairs also commissioned separate emergency management reviews in 2011 and 2016.

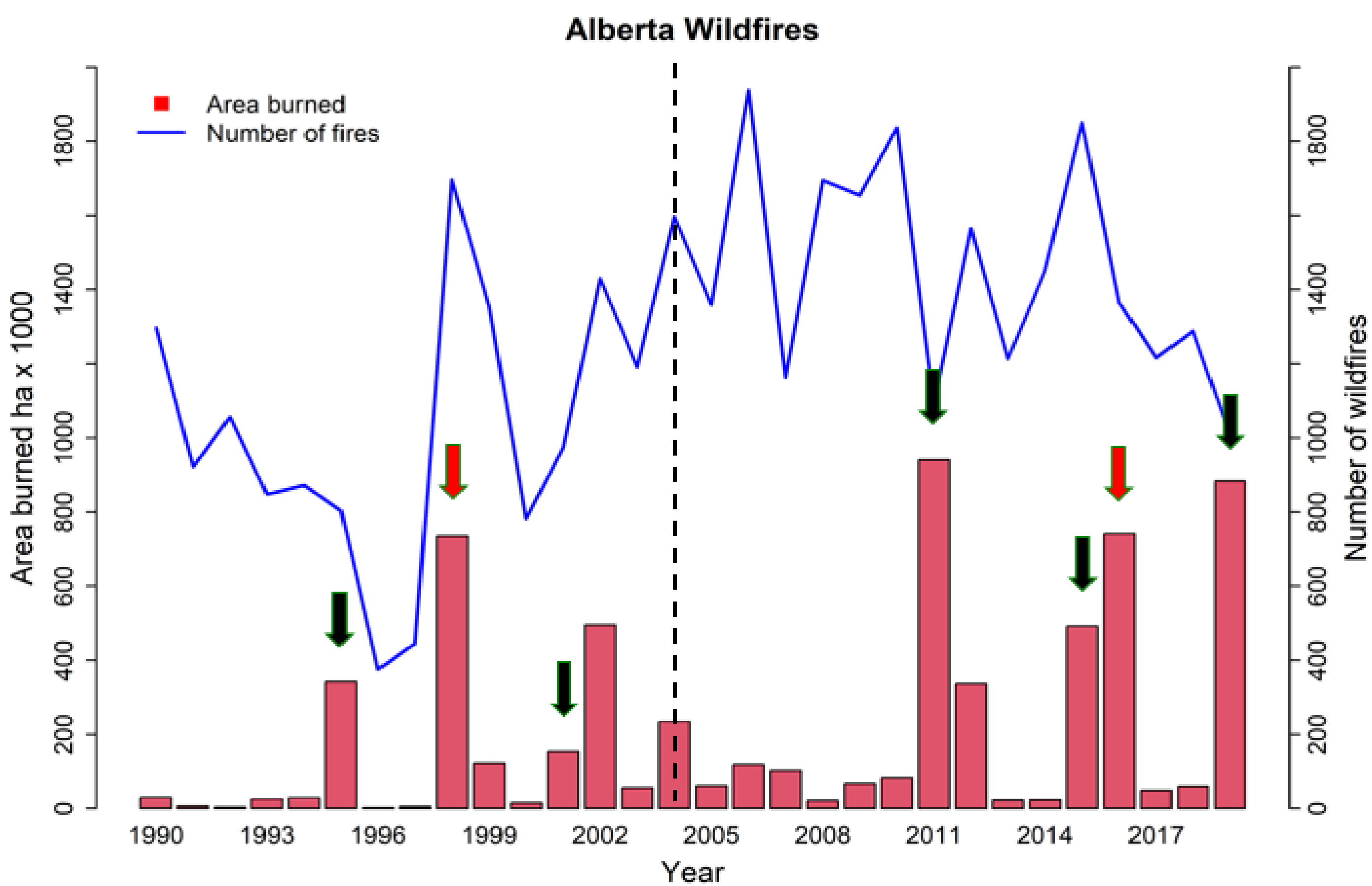


Figure 1. The number of wildfires and area burned in Alberta from 1990 to 2019. The dashed line indicates when Alberta changed their wildfire reporting procedure to include permit related “Order to Remove” fires and small illegal abandoned fires extinguished within 15 minutes. The arrows indicate the years when external wildfire reviews were completed. The red arrows denote the occurrence of a very strong El Niño.

1995 Wildfire Season

Alberta experienced 316 wildfire starts in a 22-day period from May 27 to June 17, 1995. This made 1995 the worst wildfire season since 1982. Of the 316 wildfire starts, 50 occurred in May. The Buildup Index (BUI), a numeric rating of the amount of fuel available for combustion, averaged 120. The BUI reached a maximum value of 180 at High Level, Alberta. The average BUI last exceeded these levels in the 1930s, when major wildfires burned extensive areas of the Eastern Slopes.

Within 24 hours or less, 266 of the 316 wildfires were controlled. Of these, four wildfires accounted for 95% of the total area burned from May 27 to June 17. Only eight wildfires (2.5%) burned uncontrolled for more than four days.

The loss of merchantable timber (41,560 hectares) is projected to be in the range of $100 to $150 million. An internal overview of the spring wildfire outbreak was completed but did not include any recommendations (Provincial Forest Fire Centre 1995).

1998 Wildfire Season

The spring of 1998 became Alberta's worst spring wildfire season. A very strong El Niño in 1997-98 contributed to a hot, dry and early spring start in 1998. During the January 1 to April 30 period, 154 wildfire starts were recorded. Over the next two months, 656 new wildfire starts burned a total of 369,891 ha. Although other severe spring wildfire seasons occurred in Alberta in 1968, 1980 and 1995, the 1998 spring season was the worst because of the proximity of the wildfires to communities and infrastructures. At one time, 11 communities were threatened; several required evacuations. The Government of Alberta issued a province-wide fire ban, for the first time in history.

An external review was prompted by the loss of timber and the evacuation of 2,000 people (KPMG 1999). There are 56 recommendations in this review. Only one recommendation is linked to weather knowledge or forecasts (i.e. monitor over-winter weather and fuel conditions monthly).

2001 Wildfire Season

The 116,000 ha Chisholm Wildfire started on May 23, 2001, and resulted in forest industry losses and the destruction of 10 homes, one cabin and 48 outbuildings in the hamlet of Chisholm. This was the first substantial loss of structures since 1950. The extreme wildfire intensities and atmospheric conditions supported a smoke column that broke into the stratosphere. A review committee identified significant issues and developed recommendations (Chisholm Fire Review Committee 2001). None of the five recommendations in the final report of the review committee are linked to weather knowledge or forecasts.

2011 Wildfire Season

From May 11 to 15, 2011, 189 wildfire starts in Alberta threatened 23 communities and values-at-risk (e.g. camps, worksites, parks). Fifty-two of these wildfires occurred in the Lesser Slave Area. Three wildfires, known as the Flat Top Wildfire Complex, burned 22,400 ha and resulted in the evacuation of 15,000 people. About a third of the town of Slave Lake was destroyed (435 residential structures and 19 non-residential buildings). This was the first major wildfire to have a substantial impact on a community since a spring wildfire destroyed the village of Lac La Biche in 1919. The Flat Top Wildfire Complex also burned residential structures in neighbouring communities (Canyon Creek, Widewater, and Poplar Estates). The forest industry reported considerable impacts, including reductions in long-term timber supply and loss of seedlings in regenerated areas.

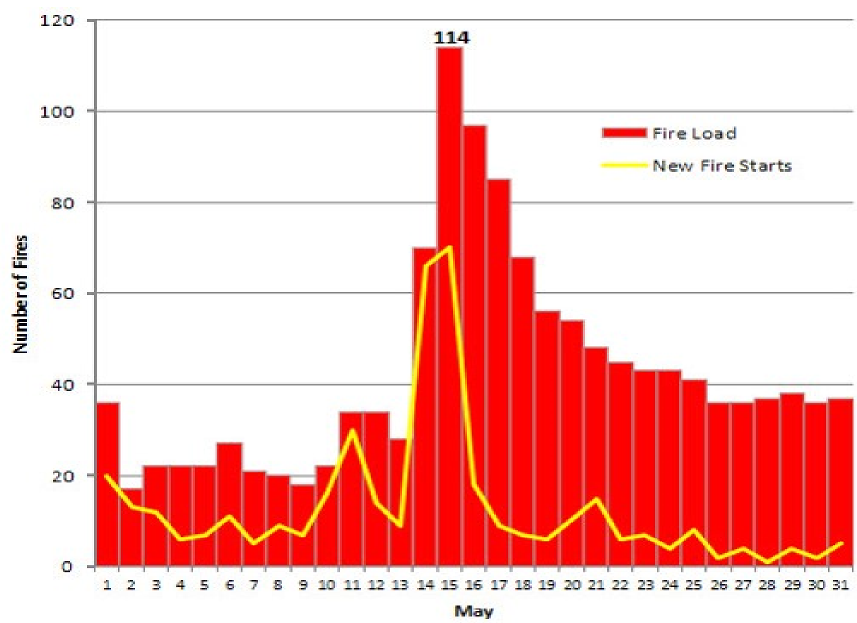


Figure 2. Number of wildfires (fire load and new starts) during May 2011.

The Flat Top Complex Wildfire Review Committee final report (Flat Top Complex Wildfire Review Committee 2012) includes 21 recommendations. For the first time, two specific weather-related recommendations were made. Recommendation 11 suggests Fire Weather Advisories be issued that include wildfire behaviour potential. Recommendation 20 indicates the need for the prediction of wind events, including approaches for worst-case probability modeling.

2015 Wildfire Season

The 2015 wildfire season experienced a large number of wildfires. A total of 1,786 wildfires burned 492,000 ha. There were 493 wildfire starts in May, followed by 459 more in June. A record of 64 wildfires exceeded 200 ha in size. A review was completed of the 2015 wildfire fire season and Alberta's wildfire management program (MNP 2016). In the report, none of the four recommendations and 18 opportunities for improvement are related to weather knowledge or forecasts.

2016 Wildfire Season

A very strong El Niño in 2015-16 contributed to an early spring start in 2016. The Horse River Wildfire started on May 1, 2016, and escaped initial suppression efforts due to hot, dry, and windy conditions. On May 3, the wildfire burned into the Fort McMurray Urban Service Area, forcing 88,000 people to evacuate under short notice. Over 2,800 structures, primarily houses, were destroyed, causing insured losses of over $3.70 billion. The Horse River Wildfire continued burning through the summer, reaching a final size of 589,552 ha.

The lessons learned from the Horse River Wildfire include:

- Wildfire prevention regulatory tools require implementation during years with a very strong El Niño;
- The period between snowmelt and green-up is a critical preparedness period;
- The influence of atmospheric stability and mixing height on surface winds and the occurrence of a low-level jet are important information the Fire Behaviour Analyst needs to consider;
- The time between inversion breakdown and blowup can be short and occur quickly;
- Extreme wildfire behaviour and rate of spread can occur during the evening, and;
- During spring, aspen stands with an understory of shrubs, forbs/grass and confer saplings will support high-intensity wildfire activity.

Ten recommendations were made in an assessment of the Horse River Wildfire (MNP 2017), which focused on preparedness and response. Recommendation 2 identifies the need to "improve fire weather forecast materials by extending the length of the forecast outlook period and by working closely with the Alberta Wildfire Coordination Centre, Planning Section to design products that directly link weather forecasts with predicted fire behaviour."

2019 Wildfire Season

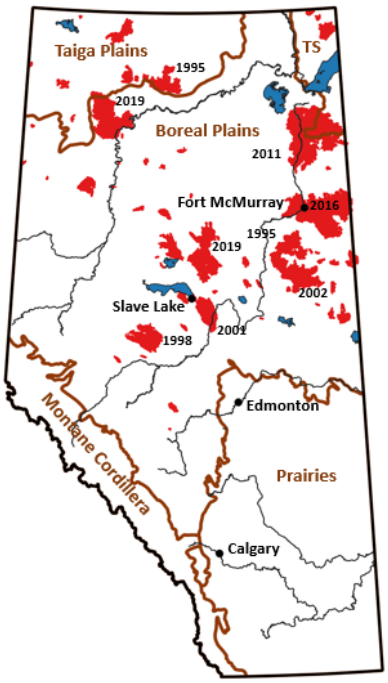
2019 was one of Alberta's worst spring wildfire seasons in terms of area burned. There were multiple wildfire complexes during 2019 wildfire season. 75 percent of the total area burnt (883,414 hectares) was accounted for by one wildfire (Chuckegg Creek Wildfire) and two wildfire complexes (McMillan Wildfire Complex and Battle Wildfire Complex). About 30% (301 fires) of the total number of wildfires during the 2019 season occurred during the month of May. One CN railway bridge and 16 homes were destroyed, and 10,000 people were evacuated.

A wildfire review was completed to focus on operational aspects related to managing the spring wildfires and the impact on and perspectives from Albertans, partners and stakeholders (MNP 2020). The final report includes 15 recommendations. Recommendation 5 was linked to weather knowledge or forecasts; it identified the need to "improve quality and integration of fire weather and behaviour functions to support strategic preparedness and response."

Characterization of initial fire weather conditions for large spring wildfires in Alberta

Tymstra et al. (2021) evaluated surface and 500-hPa synoptic weather patterns and fire weather indices for 80 large wildfires that started in May and attained an extinguished size greater than 1,000 ha during the 1990-2019 period (Figure 3). A mixed approach was used to identify spread events during the initial four-day period, with Day 1 typically being the day when the wildfire started and was reported. A spread event occurred on Day 1 if the reported wildfire size exceeded 200 ha or the noon Initial Spread Index (ISI) was ≥ 9. Spread days occurred on the following three days if the wildfire doubled in size from the previous day or the ISI was ≥ 9. This resulted in 212 spread days out of 320 days (80 wildfires x 4 initial days). In Alberta, the Very High ISI category ranges from 9 to 15.

The 80 wildfires were grouped into two general cause categories (lightning and human-caused). The groups were then spatially and temporally grouped into 29 lightning-caused and 25 human-caused spread event groups. This grouping facilitated the classification of surface and 500-hPa synoptic weather patterns influencing the wildfires within the spread event groups. Surface (3-h intervals) and 500-hPa (2x per day) synoptic weather patterns were analyzed for the first four days for all 80 wildfires. Archived weather maps were accessed from the National Oceanic and Atmospheric Administration.



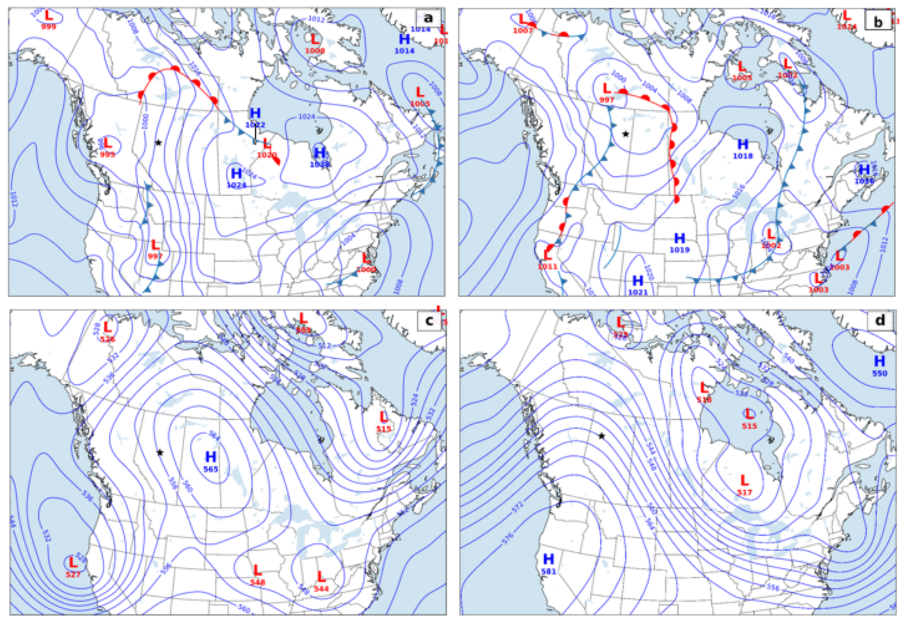


Figure 3. (left) Wildfires greater than 1,000 ha in size that started during the month of May. Wildfires greater than 100,000 ha are labelled by year. The five ecozones in Alberta are delineated and labelled. TS, Taiga Shield Ecozone. Source: Modified from Tymstra et al. (2021).

Figure 4. (right) Surface and 500-hPa analysis on May 15, 2011 (a, surface map; c, 500-hPa map), and May 4, 2016 (b, surface map; d, 500-hPa map). Surface maps are 1800 MDT (a) and 1200 MDT (b). 500-hPa maps are 0600 MDT. The black stars represent the town of Slave Lake and Wildfire SWF065-2011 (maps a and c), and the Fort McMurray Urban Service Area and Wildfire MWF009-2016 (maps b and d).

A total of 212 wildfire spread events occurred: 123 lightning-caused on 79 calendar days and 89 human-caused on 70 calendar days. When combined, 92 individual calendar days occurred with one or more spread events during the study period (1990 – 2019).

The two most frequent synoptic-scale weather patterns were Pattern 1 (Figures 4b and d): surface trough or low with an upper ridge or high, and Pattern 4 (Figures 4a and 4c): surface ridge or high with an upper ridge or high (Table 1). Pre-frontal and frontal passage activity were the predominant features associated with 48% of the combined 92 individual calendar spread day events. Strong south-southeast winds from a surface high centered east of Alberta (west of Hudson Bay) and supported by an upper ridge, and a surface low typically positioned southwest of the ridge occurred on 26% of the 92 calendar spread days.

The Fine Fuel Moisture Code (FFMC), Initial Spread Index (ISI) and Buildup Index (BUI) from the Canadian Forest Fire Weather Index System were calculated for the 212 wildfire spread events and the 108 wildfire non-spread events using the ERA5 surface meteorology data (McElhinny et al. 2020). If gusts were recorded from the nearest Alberta fire weather station, the probable maximum 1-min average wind speed was calculated and used to recalculate the FFMC and ISI values.

Maximum, median and bootstrap 95% confidence intervals for FFMC, ISI and BUI, are summarized in Tables 2 and 3 (modified from Tymstra et al. 2021) by cause and period (Period 1 = 1990–2004 and Period 2 = 2005-2019). For all wildfire spread day events (n= 212), the median FFMC is very high (91). The median ISI is also very high (13.7). Human-caused wildfire spread day events (n=85) have a significantly higher median ISI (16.7) compared to the median ISI for lightning-caused wildfire spread day events (12.2).

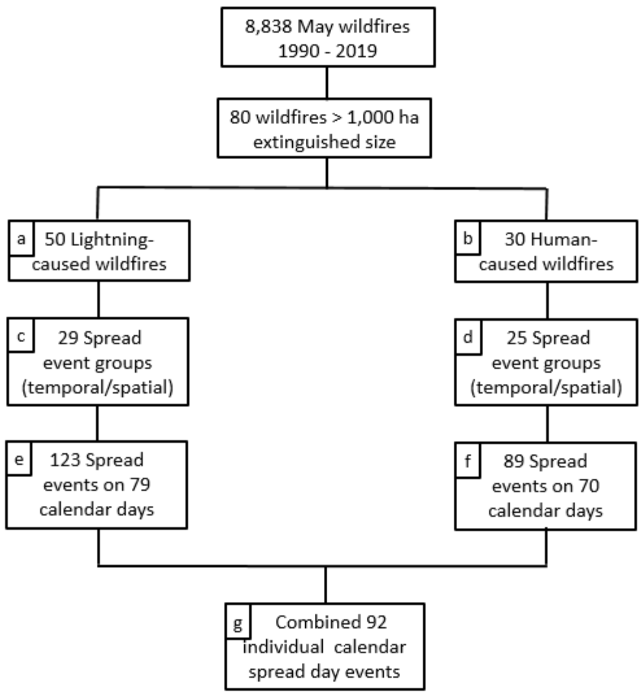


Figure 5. Flowchart of calendar day spread days. The 80 wildfires greater than 1,000 ha are grouped by cause (boxes a and b) and then clustered into spatial-temporal spread event groups (boxes c and d). The total number of spread event days by cause are shown in boxes e and f. The combined number of individual calendar spread day events is shown in box g. These 92 calendar spread day events have one or more spread events.

Synoptic-scale Weather Pattern	Surface + Upper (500 hPa) Weather Pattern	Number of Spread Day Events			
		Total	Pre-Frontal/ Gusts	Frontal Passage/ Gusts	Gusts
Trough/Low + Ridge/High	1a: Trough + Ridge	26	4/3	8/7	11
	1b: Trough + High	1	0	1/1	0
	1c: Low + Ridge	32	2/1	17/8	9
	1d: Low + High	2	0	0	0
Trough/Low + Trough/Low	2a: Trough + Trough	5	0	4/1	0
	2b: Trough + Low	3	0	1/1	1
	2c: Low + Trough	1	0	1/1	0
	2d: Low + Low	1	0	0	0
Trough/Low + Other	3a: Trough + Col	5	0	0	3
	3b: Trough + Zonal Flow	1	0	0	1
	3c: Low + Other	1	0	0	1
Ridge/High + Ridge/High	4a: Ridge + Ridge	12	1/1	2/2	6
	4b: Ridge + High	0	0	0	0
	4c: High + Ridge	40	5/2	6/3	18
	4d: High + High	2	0	0	2
Ridge/High + Trough/Low	5a: Ridge + Trough	0	0	0	0
	5b: Ridge + Low	0	0	0	0
	5c: High + Trough	4	0	2/2	1
	5d: High + Low	2	0	2/0	0
Ridge/High + Other	6a: Ridge + Col	1	0	1/0	0
	6b: High + Zonal Flow	4	0	0	3
	6c: High + Col	2	0	1/1	0
Other + Ridge	7a: Col + Ridge	3	0	1/1	0
Other + Other	8a: Col + Col	1	0	0	1

Table 1. Synoptic-scale weather patterns and associated pre-frontal, frontal passage, and gust occurrences for the 149 calendar days with spread events (boxes e and f in Figure 5). Modified from Tymstra et al. (2021).

Spread Day Events	*n*	FFMC		ISI		BUI	
		x̃ 0.95 CI	Max	x̃ 0.95 CI	max	x̃ 0.95 CI	max
All (1990 – 2019)	212	91 90.0 – 91.0	96.4	13.7 12.5 – 15.2	68.4	47.5 43.5 – 51.5	132
All lightning-caused wildfires (1990 – 2019)	127	91 90.0 – 91.0	95	12.2 11.0 – 13.5	30.3	49 42.0 – 53.0	132
All human-caused (1990 – 2019)	85	92 90.7 – 92	96.4	16.7 14.6 – 22.0	68.4	46 38.0 – 46.0	102
Period 1 (1990 – 2004) All	104	90 88.1 – 90.0	93	13.2 11.2 – 15.1	68.4	41 35.0 – 45.0	92
Period 2 (2005 – 2019) All	108	92.3 91.9 – 93.0	96.4	14.1 12.5 – 15.8	53.7	53 48.0 – 58.5	132
Period 1 (1990 – 2004) lightning-caused	85	90 89.0 – 90.0	93	12.7 10.8 – 14.3	30.3	38 33.0 – 42.0	83
Period 2 (2005 – 2019) lightning-caused	42	92 90.7 – 92.0	95	17.8 14.3 – 25.95	29	84 67.0 – 92.0	132
Period 1 (1990 – 2004) human-caused	19	90 87.0 – 90.0	93	16.6 9.6 – 25.7	68.4	53 35.0 – 58.0	92
Period 2 (2005 – 2019) human-caused	66	92 (0.367) 90.7 – 92.0	96.4	17.8 (2.972) 14.4 – 25.6	53.7	46 (3.155) 29.0 – 49.0	102

Table 2. Median (x̃), maximum (max), and bootstrap confidence intervals (CI) for FFMC, ISI and BUI by cause and period for the spread day events. The coloured pairs indicate significant differences between the medians.

Non-Spread Day Events	*n*	FFMC		ISI		BUI	
		x̃ 0.95 CI	Max	x̃ 0.95 CI	max	x̃ 0.95 CI	max
All (1990 – 2019)	108	87 82.6 – 87.0	93	4.4 3.7 – 5.0	26.1	45 41.0 – 50.5	134
All lightning-caused wildfires (1990 – 2019)	77	86 82.0 – 87.0	93	4.4 3.2 – 5.0	18.2	43 35.0 – 46.0	134
All human-caused (1990 – 2019)	31	87 77.0 – 87.5	93	4.8 2.4 – 5.8	26.1	50 41.0 – 59.0	89
Period 1 (1990 – 2004) All	60	85 79.5 – 87.0	93	4.4 3.0 – 5.0	18.2	38.5 34.0 – 43.0	89
Period 2 (2005 – 2019) All	48	87 81.0 – 88.0	93	4.6 2.7 – 5.5	26.1	57 47.5 – 68.0	134
Period 1 (1990 – 2004) lightning-caused	47	83 78.0 – 87.0	93	4.4 3.1 – 5.1	18.2	35 30.9 – 38.0	74
Period 2 (2005 – 2019) lightning-caused	30	87 81.0 – 89.0	93	4.3 2.1 – 5.5	8.6	68.5 52.0 – 80.0	134
Period 1 (1990 – 2004) human-caused	13	87 77.0 – 87.5	90	4.4 1.7 – 5.1	8.2	66 39.0 – 69.0	89
Period 2 (2005 – 2019) human-caused	18	87.5 78.0 – 89.0	93	5.0 1.8 – 6.5	26.1	47.5 37.0 – 56.0	82

Table 3. Median (x̃), maximum (max), and bootstrap and confidence intervals (CI) for FFMC, ISI and BUI by cause and period for the non-spread day events. The coloured pairs indica-te significant differences between the medians.

A small percentage of days in the spring are wildfire spread days. They are associated with critical synoptic-scale weather patterns that support extreme wildfire behaviour. Spring wildfires in Alberta are wind-driven and characterized by very high to extreme FFMC and ISI. Wildfires in the spring can occur and spread quickly and become very challenging to manage. Although very high to extreme BUI values are not a prerequisite for extreme wildfire behaviour in the spring, when they do occur, more suppression effort is required to contain the wildfires. BUI values increased significantly from Period 1 to Period 2 for all wildfires, and lightning-caused wildfires alone, suggesting a drier boreal forest in the future will result in more wildfire arrivals, and in particular from lightning.

The maximum median FFMC value observed during all 212 spread day events was 96.4. Values ≥ 94 only occurred during the second period (2005-2019) and when the relative humidity was very low or extreme (x = 21%). The spring wildfire season's severity is partly due to the low live foliar moisture content just before the onset of plant photosynthesis. As well, air masses sourced in northern Canada are very dry because water bodies are frozen, resulting in little moisture in the atmosphere.

Since spring is the most dangerous season for wildfires and accounts for the majority of structural losses in Alberta, enhanced situational awareness and preparedness is necessary during this critical period. This requires an understanding of the spring synoptic weather patterns associated with extreme wildfire behaviour. An understanding of how these patterns evolve is also essential. Continuing research on wind extremes, the variability associated with gusts, and the conditions when winds aloft influence surface winds is recommended to provide intelligence support for wildfire operations. Lastly, the majority of spring wildfires in Alberta are human-caused and hence preventable. Prevention regulatory tools have to date have been underutilized. More effort is required to reduce human-caused wildfires, particularly during the spring season.

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The 2021 Fire Season in Canada

By Mike Flannigan, Thompson Rivers University, mflannigan@tru.ca

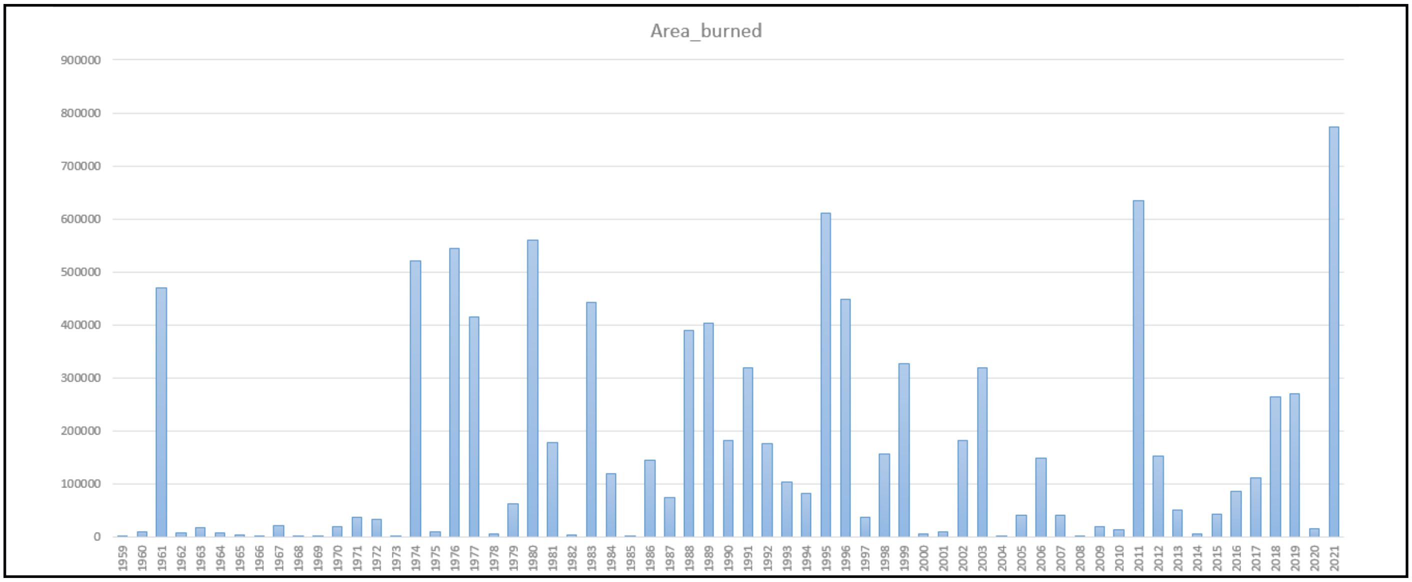


Figure 1. Ontario area burned 1959 - 2021

This fire season got off to an early start, with large fires in Manitoba in May. British Columbia, Saskatchewan, Manitoba, and Ontario all had substantial amounts of area burnt, which isn't necessarily the most significant variable (more on that later). In 2021, Ontario had the largest area burnt on record since 1959. (Figure 1). Manitoba had over 1 million hectares that burned, while both Saskatchewan and BC were not that far off from 1 million hectares each as well. In BC, the top three years in terms of area burned have occurred in the last 5 years (2018, 2017 and 2021, respectively) for the period 1950 – 2021. In Canada, around 4.2 million ha have burned and this is well above normal.

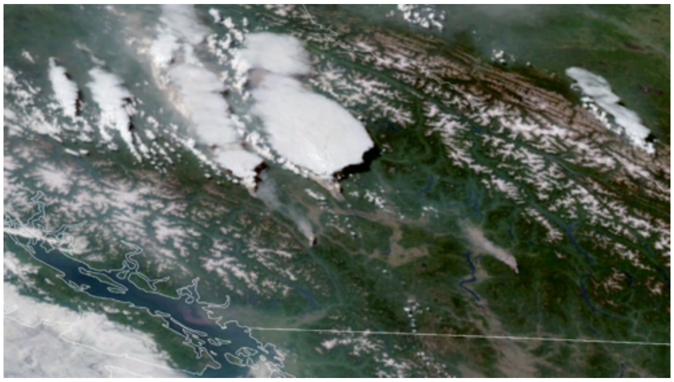
Spring started dry for the southern areas of Canada from northwestern Ontario to British Columbia. Then fires started in Manitoba, followed by active fires in northwestern Ontario and Saskatchewan. Towards the end of June, a historic heatwave hit the Pacific Northwest and spread throughout Alberta and Saskatchewan. The all-time high temperature for Canada (45°C) was shattered several times and by many degrees, with temperatures nearing 50°C in Lytton, British Columbia, at the end of June. Tragically, the heat was followed by a devastating fire that took the lives of two people and destroyed much of the town of Lytton. This heatwave was a result of a large blocking ridge in the upper atmosphere. Fire researchers have known for decades that these blocking ridges are associated with significant fire activity. To read more on the 2021 heatwave and subsequent fires, see the following story at https://www.canadawildfire.org/heatwave.

Is area burned the best metric of fire season severity? Probably not. In our Canadian forests, wildfire is a natural process that may be helpful in some circumstances, so having more "good fire" on the landscape is not a negative. What metric should we use instead of area burned? Fire Impacts might be a more useful metric and would include direct fire impacts such as: loss of life, homes & structures lost, evacuations required, watersheds & species at risk, economic impact. Even though the numbers are not finalized for 2021, we can guess that the 2021fire season had significant impacts across all of these metrics.

Wildland fire smoke was also a significant issue during the 2021 fire season. The more we find out about smoke, the more we will find out how bad it is for us. Additionally, recent studies have found that wildland fire smoke makes us more susceptible to COVID-19 — many regions of Canada experienced weeks of extremely poor air quality due to smoke. For more about how to prepare for wildland fire smoke, see a story in The Conversation at https://theconversation.com/prepare-for-the-worst-10-steps-to-get-ready-for-wildfire-smoke-158357

On June 30, 2021, a massive pyroCb (Figure 2) near Kamloops BC generated thousands of lightning strikes and started tens of fires up to 40 km downwind, which is the most lightning strikes, and fire starts that I have ever seen from one pyroCb. There have been over 50 pyroCb events in North America this year, the most on record, but the dataset on pyroCb's is limited.

Also notable is that there were a few days in later July where there were active fires from YK & BC all the way through to Quebec. It is extremely rare to see active fires over such a large longitudinal band. As I write this story in early October, there are very active



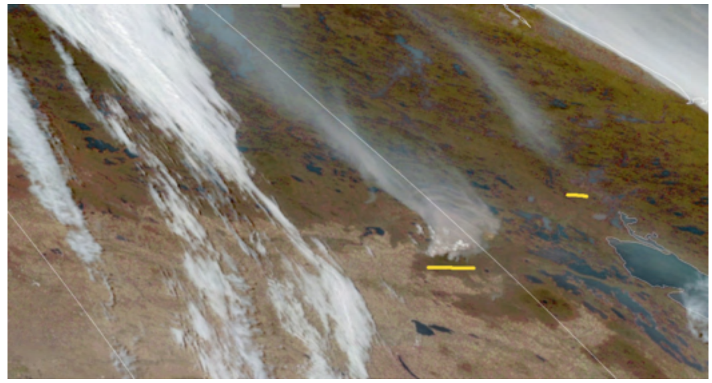


Figure 2 (Left). June 30, 2021 near Kamloops, pyroCb clouds. Figure 3 (Right). Fire activity in Saskatchewan in October 2021

fires in Saskatchewan (Figure 3) that are unusual. Still, even more remarkable is that these fires are burning through the night, and nights are long in October. We may be seeing more and more night-time burning as our climate changes. What will the 2022 fire season bring? Who knows, but if we have another hot and dry year, we will see more wildland fire and more smoke. Fire is a multi-faceted issue that will need multi-prong approaches as there is no cure for wildfire. We all have to learn to live with wildfire.

COMING SOON...

THE EMBER

A CANADA WILDFIRE BULLETIN

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Cultural Safety in Wildland Firefighting: Indigenous Perspectives in Canada

By Natasha Caverley, President, Turtle Island Consulting Services Inc., indigenouswffoshproject@gmail.com

Storytelling is a way that individuals share and make sense of their lived experiences. Indigenous perspectives give essential narratives on interweaving cultural values, career development, capacity building, occupational health and safety, and when it comes to wildland firefighting, the use of fire on the land (managing wildfires and engaging in cultural burning revitalization). Honouring and recognizing Indigenous voices is particularly important given that wildland fire crews across Canada respond to more frequent and increasingly severe, and complex wildfires each year.

Background

Turtle Island Consulting Services Inc. (TICS Inc.) began a journey in early 2021 to listen to, recognize, and share the expertise, wisdom, views, and stories of Indigenous wildland firefighters operating in Canadian wildfire crews/teams. This journey included exploring topics on cultural safety, occupational health and safety, job satisfaction, work-related experiences with the COVID-19 pandemic, work-related illnesses and/or injuries, and general health.

Funded by Natural Resources Canada – Emergency Management Strategy – Wildland Fire Resilience Initiative, the Giving Voice to Cultural Safety of Indigenous Wildland Firefighters in Canada Project Team was comprised of Indigenous and non-Indigenous scholar-practitioners: Marty Alexander (Ph.D., RPF), Natasha Caverley (Ph.D., CCC), Joe Gilchrist (Traditional Fire Keeper), James MacGregor (Ph.D.), Brad McDonald (SCO, CFEI, CFVI, CFII), and Kathy Offet-Gartner (R.Psych - Alberta, Ph.D.). Throughout the study, project guidance was offered to the TICS Inc. Project Team by Dr. Amy Cardinal Christianson (Natural Resources Canada), Len Garis (National Indigenous Fire Safety Council Project), and David Watson (Natural Resources Canada).

Figure 1. Indigenous wildland firefighters engaged in suppressing a high-intensity, free-burning surface fire in the boreal forest region of northern Alberta during the mid-1980s. Photographer unknown - provided to Dr. M.E. Alexander (RPF) courtesy of the Alberta Forest Service, Forest Technology School, Hinton, AB.

Introduction

The Giving Voice to Cultural Safety of Indigenous Wildland Firefighters in Canada Project consisted of two phases:

- Phase One - an online survey
- Phase Two - virtual circle sessions (aka fireside chats)

Both phases explored the state of occupational health and safety (includes cultural safety) for current and former Indigenous wildland firefighting personnel across Canada.

Individuals who self-identified as Indigenous and participated in wildland firefighting and/or fire operations for at least one fire season in Canada were eligible to participate in Phase One and Phase Two of the project. Wildland firefighters and other wildland fire operations employees, including support workers, were referred to as “wildland firefighting personnel.”

In total, 193 individuals commenced the online survey with 102 completing all of the core sections (cultural safety, occupational health and safety), while six people participated in the virtual circles.

Objectives, Outcomes, and Drivers

Key project objectives were to enhance the understanding of cultural safety in relation to wildland firefighting based on Indigenous narratives and supported by relevant literature in the areas of cultural psychology, employee well-being and motivation, Indigenous healing and helping approaches, person-environment fit, and workplace relationships.

Project outcomes included (i) identifying cultural safety and related performance measures that are relevant for Indigenous wildland firefighting personnel in Canada, (ii) informing and recommending methods, strategies, and proposed next steps in creating culturally safe work environments for Indigenous wildland firefighting personnel, and (iii) enhancing capacity building of Indigenous Peoples across Canada with regards to wildland fire management.

By understanding Indigenous perspectives on cultural safety, occupational health and safety, and holistic well-being (mind, body, and spirit), opportunities are created to develop Indigenous-informed career pathing in wildland firefighting (from preemployment, recruitment and selection to training, promotion and retention) – all as a means of supporting community protection and implementing facets of the Truth and Reconciliation Commission of Canada (TRC) Calls to Action and the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Did you know?

Though not an exhaustive list, the following are notable clauses from the *TRC Calls to Action* and *UNDRIP* that the TICS Inc. Project Team strategically linked to cultural safety, occupational health and safety, and Indigenous wildland firefighting:

TRC Calls to Action #7. *We call upon the federal government to develop with Aboriginal groups a joint strategy to eliminate educational and employment gaps between Aboriginal and non-Aboriginal Canadians.*

TRC Calls to Action #43. *We call upon federal, provincial, territorial, and municipal governments to fully adopt and implement the United Nations Declaration on the Rights of Indigenous Peoples as the framework for reconciliation.*

UNDRIP Article 7(1). *Indigenous individuals have the rights to life, physical and mental integrity, liberty and security of person.*

UNDRIP Article 21(1). *Indigenous peoples have the right, without discrimination, to the improvement of their economic and social conditions, including, inter alia, in the areas of education, employment, vocational training and retraining, housing, sanitation, health, and social security.*

UNDRIP Article 24(2). *Indigenous individuals have an equal right to the enjoyment of the highest attainable standard of physical and mental health. States shall take the necessary steps with a view to achieving progressively the full realization of this right.*

UNDRIP Article 29(1). *Indigenous Peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for Indigenous Peoples for such conservation and protection, without discrimination.*

Cultural Safety, Identity, and Career

The Giving Voice to Cultural Safety of Indigenous Wildland Firefighters in Canada Project highlights connections between career and identity. One cannot meaningfully understand and facilitate Indigenous-informed wildland firefighting career development initiatives without understanding how culture and self-identity are inextricably linked and are an integral part of an individual's life context – examining one's own cultural practices and harmonizing values, beliefs, experiences, interests, attitudes, and behaviours into all facets of career/life development.

Recognizing the above, it is essential to listen and give voice to cultural safety for Indigenous wildland firefighting personnel in Canada to enhance capacity building as well as identify strengths and barriers to occupational health and safety throughout their careers. In the existing literature, little is known about how Indigenous wildland firefighting personnel view and experience occupational health and safety, how inviting and inclusive wildland firefighting work environments are, as well as cultural safety on the fireline. Culturally safe wildland firefighting initiatives provide opportunities for Indigenous Peoples to connect or re-connect with their identities by being on the land, using traditional ecological knowledge and practices (e.g., cultural burning), and sharing of cultural skills and stories by Elders, Traditional Knowledge Keepers, and Fire Keepers.

Visit http://www.turtleislandconsulting.ca/cultural-safety.html for additional information on this first-of-its-kind research in Canada. The project executive summary and final report are readily available on this site.

Concluding Remarks

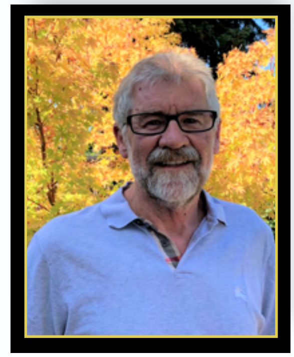
Over the coming months, the TICS Inc. Project Team will be sharing project findings and recommendations from the Giving Voice to Cultural Safety of Indigenous Wildland Firefighters in Canada Project through a podcast, cross-jurisdictional webinars, and articles. Knowledge sharing for this project is intended to help shape the future of wildland firefighting across Canada, particularly as it relates to cultural safety, equity, diversity, and inclusion.

Picea Mariana Award 

Over the last year, Canada Wildfire created the Picea Mariana Award to recognize individuals who have provided exemplary service to the organization. We had the pleasure of collaborating with Kelly Wiens (www.kellyartworks.ca) on the design of this one-of-a-kind pin (shown above).

This year, we honour Sarah Gooding and Cordy Tymstra as the inaugural recipients of the Picea Mariana Award. They have been involved from the start and have remained critical contributors over the last decade. Their unwavering support, effort, and devotion were essential in the inception of the Western Partnership for Wildland Fire Science and the expansion to Canada Wildfire. We appreciate all the time they have taken away from their own work and busy schedules to ensure that we have voice, procedures, and tools to succeed.

From the whole Canada Wildfire team, congratulations and many thanks!



Supporting Indigenous-led fire stewardship can help conserve global biodiversity

By Kira M. Hoffman[1], Emma L. Davis[2], Sara B. Wickham[3], & Andrew J. Trant[4]

[1]Postdoctoral Researcher, Faculty of Forestry, University of British Columbia and the Bulkley Valley Research Centre, kira.hoffman@ubc.ca

[2]Weston Postdoctoral Researcher, School of Environment, Resources and Sustainability at the University of Waterloo

[3]Ph.D. Candidate, School of Environment, Resources and Sustainability at the University of Waterloo

[4]Associate Professor, School of Environment, Resources and Sustainability at the University of Waterloo

Last summer, as our wildfire research team worked in record temperatures near Fraser Lake, B.C., I watched anxiously as lightning strikes flashed red on my weather tracking app. Elsewhere in our province's interior, thousands of lightning strikes were produced by pyro-convective storms, generating many of the over a hundred new wildfires that started in a matter of hours. Though it was only the first few days of July, the fire risk was extreme; first responders were already stretched thin—and tragically, lives, homes and the community of Lytton had been lost.

Canada urgently needs improved methods to reduce wildfire risk, as the climate warms and large and uncontrollable wildfires now commonly exceed our capacities for fire suppression. We've been extinguishing fires in Canada for over 100 years, and though these efforts save lives, protect property and reduce damage in the short term, many of Canada's forested areas are now stuck in what fire scientists call a 'wildfire suppression trap' (M. A. Parisien et al. 2020). The past century of intensive firefighting has broken crucial natural and cultural fire cycles, leaving too much fuel on the land. Unsurprisingly, we're now facing more destructive wildfires than ever before—affirming that full containment fire suppression tactics are often impractical, unsustainable, and ecologically

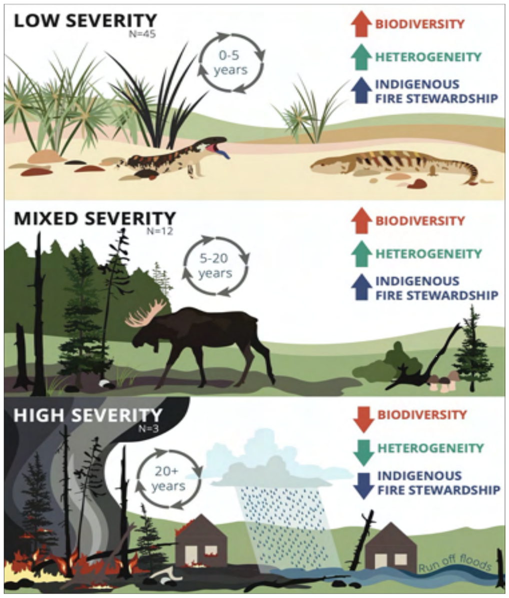


Figure 1. A global review of publications on Indigenous fire stewardship demonstrated widespread increases in biodiversity forms (woody and non-woody plants, animals, and microbes) and habitat heterogeneity related to the frequent application of cultural fire within low- and mixed-severity fire cycles. Declines in biodiversity and habitat heterogeneity were related to the introduction of high-severity fire to ecosystems and human communities that had experienced decades of fire suppression and exclusion of Indigenous fire stewardship practices. Infographic conceptualized by KM Hoffman, EL Davis, and AJ Trant and designed by Align Illustration.

detrimental in fire-prone landscapes (D. B. McWethy, et al. 2019).

Extreme wildfires are becoming increasingly common worldwide and are having extraordinary impacts on people and the species and ecosystems on which they depend (D. B. McWethy, et al 2019). Although Indigenous peoples comprise only 5% of the world's population, they protect approximately 85% of the world's biodiversity through stewardship of Indigenous-managed lands (L. T. Kelly, et al., 2020; S. T. Garnett, et al.2018,). Much of this is attributed to long-term and widespread relationships with, and dependence on, fire which has been applied as a tool for managing landscapes for millennia (R. W. Kimmerer, F. K. Lake, 2001).

To better understand the impacts of Indigenous fire stewardship on biodiversity and species function across Earth's major terrestrial biomes, our research team conducted a review of relevant primary data papers published from 1900 to present. We examined how the frequency, seasonality, and severity of human-ignited fires can improve or reduce reported metrics of biodiversity and habitat heterogeneity, as well as changes to species composition across a range of taxa and spatial and temporal scales.

We reviewed over 800 articles and found that almost all applicable studies (N=53) reported increases in biodiversity as a result of the application of repeated low severity fire as a component of Indigenous fire stewardship (Fig. 1). More than half of the studies concluded that habitat heterogeneity was increased by the use of fire. All studies reported that fire stewardship occurred outside of the window of uncontrollable fire activity, and plants (woody and non-woody vegetation) were the most intensively studied life forms. Unfortunately, the displacement of Indigenous peoples and place-based societies that rely on and routinely practice fire stewardship has resulted in significant declines in biodiversity and the functional roles of people in shaping pyrodiverse systems.

As more fires burn out of control, it's clear that we need to evolve approaches to wildfire management. In Canada, this will mean more prescribed fire and Indigenous-led cultural burning, which has long been used to reduce fire impacts and enhance the overall health of the land (F. K. Lake, A. C. Christianson, 2019). It will also mean recognizing the expertise of Indigenous fire practitioners, reducing barriers to access technical training, educating the public on wildfire risk reduction techniques, and collaborating with communities and regional districts on wildfire mitigation plans. Canada has an opportunity to evolve fire suppression policies that reflect the best available science and millennia of Indigenous knowledge. Given the vulnerability of Indigenous peoples to the impacts of wildfire and the consequences of uncontrolled wildfire on Indigenous lands, it is more important than ever to support Indigenous-led fire stewardship that revives essential cultural practices, protects human communities, and enhances biodiversity.

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Network Team Measures Fire Impacts in the Field and from the Sky

By Laura Chasmer[1] & Sandra Kinash[2]
[1] Associate Professor, University of Lethbridge
[2] Knowledge Translation & Mobilization, University of Alberta, skinash@ualberta.ca

This past July, Maxim Okhrimenko was beginning his work onboard a plane using a lidar scanner to measure the impact of mountain pine beetles over Banff National Park when smoke started filling the valley. The smoke was drifting in from wildfires in British Columbia and Saskatchewan. His work was halted as the plane flew back to Calgary and remained grounded for three weeks until he and the pilot got the all-clear to fly.

Wildfire smoke grounding a research plane reinforces why Okhrimenko's work is so urgently needed. He is a post-doctoral fellow at the University of Lethbridge on a large team led by Drs. Laura Chasmer and Chris Hopkinson, part of the Canada Wildfire NSERC Strategic Network (the Network). The Network is working to better equip Canadian wildfire management agencies to respond to changing wildfires.

The University of Lethbridge Network team is evaluating fire impacts and changes in vegetation. They are using technologies like lidar and drones to improve efficiency in data collection and to better understand wildfire impacts. Over the past summer, the team worked across several locations, including Waterton, Banff, and Jasper National Parks, where they completed fieldwork in addition to using remote sensing technologies such as lidar and drones.

Photo by Laura Chasmer, taken in Waterton Lakes National Park, Alberta. Chasmer and Hopkinson's team uses drones with multi-spectral sensors plus photography to collect measurements in addition to complementary fieldwork and lidar.

Measuring Varying Fuels, Vegetation Regeneration and Tree Fall Rate at Waterton National Park

At Waterton National Park, the team established fire fuel plots, from treeline to valley, following the Next Generation Canadian Forest Fire Danger Rating System (NG-CFFDRS) framework. These plots were measured in the field and from the sky with drones collecting multi-spectral imagery. Marcus Merlonghi is using the plot data to determine fuel load by calculating biomass. He is looking at how fuels vary from treeline to valley on north and south facing slopes in a national park with a long history of fire suppression.

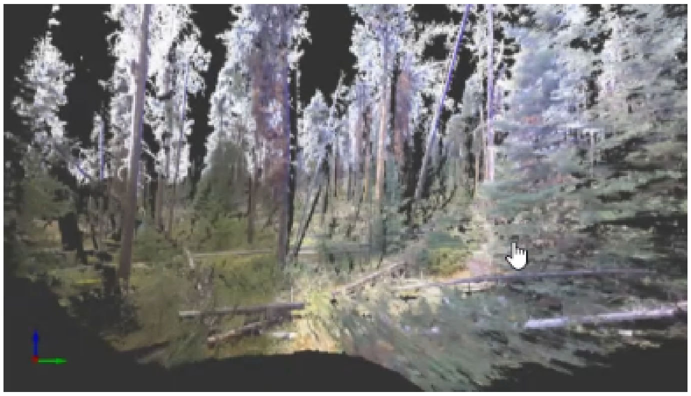
Another study considered 60 micro plots to investigate vegetation regeneration. Using three years of post-fire regeneration data from the micro plots, Jesse Aspinall developed a machine-learning-based model to measure faster and slower rates of regeneration and environmental drivers associated with rates of growth.

The team also has three years of drone data after the 2017 Kenow Fire. There is interest in knowing how quickly the trees in burned areas will fall. Saeid Parsian will use artificial intelligence (AI) methods for identifying the fallen, and standing tree stems to determine the amount of biomass and the rate of tree fall. The team has noted rapid pine seedling growth in areas with coarse textured soil but little to no seedling growth in areas that have moist organic soils.

Two different types of terrestrial laser scanning systems have also been compared in burned regions within the study area. The comparison revealed that the older Teledyne Optech ILRIS, which is not eye-safe, had much cleaner data than the newer Polaris system.

Mountain Pine Beetle Impacts at Banff and Jasper National Park

A bit further north in Banff National Park, the team put fuel plots in forested ecosystems with different structures following NG-CFFDRS. In those plots, they also used terrestrial laser scanning and imagery collected by drones combined with airborne lidar. The



Images supplied by Zhouxin Xi. (left) Colourized terrestrial laser scan of Jasper plot 1 containing more complex debris and moss. Black areas show occlusion, where laser pulses are blocked by features in the foreground. To resolve occlusion, multiple scans from different directions into each plot are required. Photographs taken by drones are unable to capture ladder fuels in closed canopies as the understory is occluded. (right). Colourized terrestrial laser scan of Jasper plot 7 with grass ground. Red areas on the trees show mountain pine beetle decimation. Black areas show occlusion.

team also travelled to Jasper National Park, where they implemented the same process.

Banff National Park has used a variety of fuel management practices to help contain and prevent the spread of mountain pine beetle. The team was able to see the positive results of these practices by noting lower amounts of fuels in the red and grey attack phase in Banff when compared to the Jasper site. In Jasper, numerous fuel plots were set up in mountain pine beetle stands across a range of attack phases. The team observed that as time passed following a mountain pine beetle attack, fuels began accumulating towards the ground, and trees fell. In these places, the redistribution of fuels to the forest floor caused the forest canopy to open, resulting in regeneration of mixed pine and spruce trees. Zhouzin Xi, and Parsian are developing AI models to automatically identify fuels and determine fuel load from lidar and drone data.

Tristan Skretting is analyzing the fuel data collected from Jasper. Based on different stages of mountain pine beetle disturbance and varying fuel distributions, she is running wildfire simulations in Prometheus and other publicly available fire behaviour models to see how these forests may burn if there were a fire. She is also comparing how the fuels would burn with varying air temperatures.

Hopkinson is processing structure for motion data created from overlapping imagery collected by drones. The team collected high-resolution point clouds, allowing them to identify the species, degree of mortality, and the mountain pine beetle attack phases. By using drones in an open canopy area, they were able to capture a lot of the coarse woody debris on the forest floor. Airborne imagery can potentially outperform and be less time consuming than terrestrial laser scanning (depending on canopy openness). The team is working to combine technologies such as airborne lidar, terrestrial lidar, and drone imagery to see what each can and can't quantify, as well as what inaccuracies they produce.

Evaluating Changes in Permafrost Thaw and Regeneration in the Northwest Territories

The team travelled further north, ranging from western Northwest Territories up to Inuvik. Here, they flew airborne lidar along their repeating multi-temporal transects that have been used to collect data since 2008. Linda Flade is focusing on areas where wildfires have intersected these transects. Flade is evaluating changes in the vegetation structure and regeneration as well as the rate and change of permafrost thaw across the various ecosystems surveyed along the transects. She is investigating changing forested permafrost plateaus. More specifically, Flade is examining how permafrost drives changes in biomass and fire fuels in areas that have burned over the last 50 years and areas that have not recently burned but are thawing. Flade is using equations she developed from harvested shrubs and short stature trees collected across NWT and applying these to more than 1,000 small field plots she collected. These equations characterize the biomass components, including available fuel load for plateau, peatland, and ecotonal tree and shrub species.

Investigating Seismic Disturbance, Loss of Carbon in Peatlands and more in the Fort McMurray Region

In northeastern Alberta, Kailyn Nelson is using airborne lidar to calculate the depth of burn and measure carbon loss due to wildfires. Airborne lidar can be used to calculate the depth of burn when pre- and post-fire data exist. Nelson found that uncertainty increases over time as vegetation regenerates, affecting both the depth of burn and carbon loss calculations. She has tested different model parameterizations to determine the best way to define elevation variability with the highest accuracy. She then used the optimal method to learn the range of accuracy of the model and the uncertainties in determining carbon loss in peatlands. Nelson will calculate how much carbon was lost based on the depth of burn over hundreds of peatlands and will use machine learning methods to identify areas that are more likely to burn more severely in the future. Nelson is also working with Sophie Wilkinson, a member of the McMaster University Network team, to examine the impacts of draining peatlands on the depth of burn using airborne lidar.

Humaira Enayetullah is looking at bog and fen peatlands with and without seismic line disturbances. Using a fire chronosequence of five different ages since wildland fire, she is investigating how seismic lines impact peatlands and their biomass regeneration in the years since fire. Enayetullah is also evaluating whether fires of different severities reduce the impacts of seismic lines. This will help her determine if there is a point in time where the seismic line is no longer impacting the vegetation regeneration in these peatlands. Humaira also developed a machine learning method to differentiate shrubs, coniferous and deciduous trees.

Chinyere Ottah is studying the 2016 Horse River Wildfire south of Fort McMurray. She is looking at pre-fire lidar data from 2014 and immediate post-fire lidar data. Ottah has used lidar data to calculate the biomass that was available to burn for upland and peatland vegetation prior to the Horse River Fire using airborne lidar data and equations. She then calculated biomass loss from combustion within open bogs, treed and shrubby bogs, open fens, treed and shrubby fens, and forested areas adjacent to the peatlands. Ottah is ranking the total loss of carbon from these ecosystems and comparing the loss of biomass with Landsat burn severity indices.

Photo by Laura Chasmer. Kailyn Nelson is studying post-fire ecosystem characteristics associated with the depth of burn in peatlands after the 2016 Horse River fire, south of Fort McMurray, AB.

Sam Gerrand took airborne lidar data collected in the oil sands region to determine the impacts of different types of disturbances, including seismic lines, mining, and climate change. He determined which types of disturbances caused an increase or decrease in fuels within bog and fen peatlands and their transition zones. These were compared with non-disturbed peatlands. Gerrand adopted Flade's biomass and carbon partitioning equations for shrubs and short-statured peatland tree species from southern Northwest Territories. From this, he developed equations to determine the fuel loads for peatlands and created a heat map of areas that are high and low risk. The maps also show areas where fuels have either increased or decreased over the last 10 years.

Gerrand also made a comparison between the more technical software for processing lidar data (LAStools and TerraScan) and compared it with LiDR (an R-based open-access toolset). He found that using the LiDR package introduces some uncertainties in variables like vegetation height compared with LAStools and TerraScan.

Collaborating on Red Pine and Mixed Wood at York Regional Forest in Ontario

Some team members are engaged in research further east. In the York Regional Forest, Ontario, they put field plots in an area that has been studied by Hopkinson and Chasmer for 20 years using lidar and field measurements. At this location, they worked on a red pine plantation and mixed wood site where they established fuel plots combined with terrestrial laser scanning, assisted by Xi. They are using a Teledyne Optech Galaxy lidar system, a very high-density pulse system. This is in collaboration with one of the University of Toronto Network teams, led by Patrick James, who surveyed the plots using a Leica BLK terrestrial laser scanning system.

Fire Return Intervals and Peatland Shape Characteristics

Using field data from the Utikama Region Study area in north-central Alberta, Emily Jones looked at fire return intervals and the rate at which vegetation grew back following short interval and long interval fires. Jones looked at how the soil, hydrological, and vegetation characteristics varied within peatlands and compared measured vegetation structure with lidar-based measurements. She tested her hypotheses to determine if she could find the same general trends and characteristics by scaling about 300 micro-plot field measurements to more than 100 peatlands using lidar data.

Jones is also measuring post-fire regeneration using airborne lidar datasets at her sites. These will be compared with Landsat and other long-term satellite imagery. She plans to incorporate the fuels within a Google Earth Engine's big data framework, using what is collected on the ground with lidar data to calibrate and evaluate long-term Landsat and Sentinel remotely sensed data and climate-mediated fuel changes. She's looking at how the variability observed in the fire fuels can be moved into the NG-CFFDRS.

Chasmer is looking at the shape characteristics of peatlands to better understand how shape, topography, and other thematic information (including moss cover, slope) impact fire severity. She is assessing whether these characteristics impact loss of biomass and overall changes to the post-fire environment. Chasmer is investigating how the depth of burn varies depending on shape and found that some shapes correspond with a smooth post-fire topography while other areas have an uneven post-fire typography, including deep hollows and upraised hummocks. This needs to be validated using field data as there is uncertainty in the ability of airborne lidar to quantify the depth of some hollows. She is also investigating how to differentiate Sphagnum and feather mosses using the multi-spectral characteristics of lidar.

Using boreal ecosystems, Chasmer is working with Hatfield Consultants to explore slope-pixel-based change detection models in cloud computing frameworks like Google Earth Engine. They are examining pre-fire, post-fire, and general ecosystem changes.

Canada Wildfire Continues to Share the Latest Network Results

The University of Lethbridge Network team is working in many locations across Canada using a range of technologies to identify unique aspects across a wide range of geography that can be used in forest and fire management. They are assisted by collaborations of over 20 individuals across Canada.

To receive access to Network publications, graduate student theses, and Network team updates, go to CanadaWildfire.org or subscribe to the Canadian Wildland Fire and Science Newsletter, and The Ember (a new monthly newsletter) at CanadaWildfire.org/subscribe.

Canada Wildfire
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EDITORS: Renée Beaulac and Karen Blouin
VISIT CANADAWILDFIRE.ORG FOR MORE INFO