Swiss Re Institute

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Wildfire in Canada: fostering resilience through advances in modelling

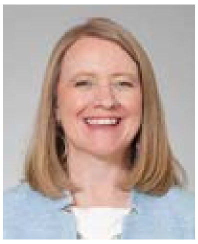
Foreword

Between 2000 and 2014, 13 000 Canadians on average were forced to evacuate their homes each year due to wildfires, a figure that has more than doubled since the 1980s.[1] In 2016 and 2017, the number of evacuations skyrocketed. The 2016 Fort McMurray wildfire destroyed more than 2500 homes and forced more than 88 000 people to evacuate.[2] Wildfires triggered insured losses of almost CAD 5 billion between 2003 and 2017, and even higher economic losses.

The number of people living in wildland-urban interface areas in Canada that are prone to wildfires continues to grow, along with exposure. At the same time, longer periods of warm, dry weather are lengthening fire seasons across Canada and the rest of North America. Hot and dry conditions have also weakened the resistance of trees to insects, leading to widespread beetle infestations that have subsequently created additional fuel for future fires. Warmer temperatures lead to more severe thunderstorms with more lightning – a leading source of ignition. A number of studies on climate change point to a continuation of these trends in the coming years.

In insurance, wildfire risk modelling has lagged behind risk modelling for other natural catastrophes, such as earthquakes, storms and floods. As a result, insurers are now facing risks that have not been adequately reflected in their models. Only recently, risk solutions providers such as AIR, CoreLogic and RMS have started to develop full-scale probabilistic wildfire models. However, predicting what an individual event will look like is nearly impossible. We believe that the probabilistic modelling of wildfire risk can be complemented by utilizing real-time data and applying new techniques that are under development – such as machine learning. In particular, Swiss Re has been analyzing wildfire trends with the goal of predicting wildfire hazard up to a year in advance using novel deep learning techniques, utilizing big data and artificial intelligence.

The latest wildfire modelling work helps insurers gain a better view of their exposures, which in turn is beneficial for pricing, reserving and portfolio management. Furthermore, the accurate pricing of wildfire risk by insurers plays a key role in incentivizing appropriate risk prevention and reduction by individual policyholders as well as entire communities. Here, insurers can be valuable partners to different stakeholders, from policyholders to governments at all levels, to foster wildfire resilience across all of Canada.



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1 Natural Resources Canada.
2 https://www.bbc.com/news/world-us-canada-39726483

Introduction

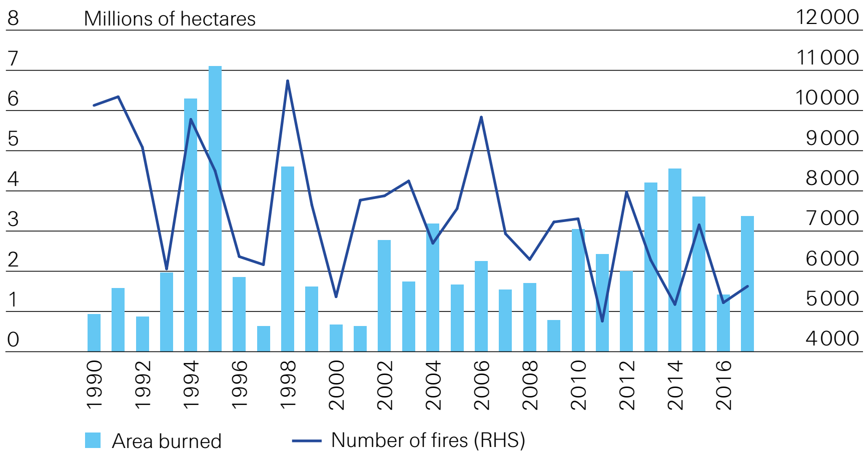
Wildfires have occurred in Canada for thousands of years.

Wildfires have occurred for thousands of years and play an important role in the forest renewal process.[3] After lightning strikes, fires ignite and burn regularly in undeveloped forestland, with climatological conditions governing their occurrence and spread. Forests cover nearly 350 million hectares in Canada.[4] Together with about 50 million hectares of non-forest wooded or tree-covered land, this amounts to nearly half of the land area in the country where wildfires can begin.

The number and severity of fires as well as area burned varies significantly from year to year.

Although wildfires occur every year, the number of fires, their severity and the size of area burned varies significantly. Between 1990 and 2017, an average of 7 400 fires happened each year in Canada, typically burning about 2.5 million hectares[5] (see Figure 1) – an area nearly half the size of the province of Nova Scotia.[6] However, the annual area burned can vary by a factor of ten, depending on weather, climate and other environmental conditions, as well as human activity, which includes suppression efforts.[7] It is difficult to find a longer series of consistent data and to determine "occurrence trends with certainty".[8] In recent years, the number of fires per year appears to remain flat or modestly decline, while the area burned appears to be on the rise (see Figure 1).

Figure 1
Number of wildfires in Canada and area burned by year, 1990–2017



Source: National Forestry Database

[3] National Interagency Fire Center, "Wildland Fire: A Natural Process", https://www.nifc.gov/prevEdu/comm_guide/appendix/7SAMPLEFACT_FireFactSheet.pdf, accessed 19 July 2018.
[4] The Arctic ecozones (Arctic Cordillera, Northern Arctic, Southern Arctic), and the Taiga Plains and Hudson Plains ecozones located in Nunavut, amounting to about 260 million hectares, are not inventoried for forests or tree cover. National Forest Inventory. Standard reports, Table 1.0 and Table 4.0, https://nfi.nfis.org/en/standardreports, accessed 19 July 2018.
[5] National Forestry Database, http://nfdp.ccfm.org/en/data/fires.php, accessed July 19, 2018.
[6] Crown Land in Nova Scotia, https://novascotia.ca/natr/land/, accessed July 19, 2018.
[7] B. Stocks et. al., "Large forest fires in Canada, 1959–1997", *Journal of Geophysical Research*, Vol 108, December 2002; and S. Taylor, D. Woolford, C. Dean et. al., "Wildfire prediction to inform fire management: statistical science challenges", *Statistical Science*, 2013.
[8] B. Peter, S. Wang, T. Mogus et. al., "Fire risk and population trends in Canada's wildland-urban interface," 2006. Note, however, that records before the late 1950s are much less reliable than recent statistics, as per B. Stocks et. al., December 2002, op. cit.

Wildfire risk is increasing due to human activity

Wildfire risk increases as more people settle into wildland-urban interface areas.

As people settle into wildland-urban interface (WUI) areas, wildfire risk increases. Human activity in the WUI area brings with it not only exposure of life and property to wildfires, but also an additional source of ignition. Sparks from machinery or trains, escaping campfires, agricultural/forestland management fires, arcing from electrical utility lines, as well as arson are all potential catalysts for wildfires.[9]

The interface area in Canada has grown considerably in recent years.

While it is clear that the extent of the WUI area has grown significantly in recent years,[10] with the rising urbanization of wildland as well as increasing industrial activity across the boreal forest areas, a full mapping of the interface in Canada was completed only recently.[11] The 2017 effort to map the area found that large areas of the country – more than a hundred million hectares – across every province and territory are part of the interface. This includes around 30 million hectares consisting of homes, community and commercial buildings, 10 million hectares of industrial structures (eg, mining, oil and gas extraction facilities) and a significant amount of infrastructure (eg, roads, railways, powerlines), as well as overlap between the three types of interface.

Three of the top 10 fastest growing census divisions in Canada between 2001 and 2015 were in Alberta.

The census division that includes Fort McMurray was the fastest growing in terms of population among all census divisions across Canada between 2001 and 2015, at 4.1% annually.[12] In fact, three of the top 10 fastest growing census divisions over that time period were in Alberta.[13] It is therefore likely that there are many other potential high-risk towns in the WUI in Alberta that have grown rapidly over the past decade. Furthermore, areas in other provinces, such as the east and north of Vancouver in British Columbia or areas between Toronto and Ottawa in Ontario, may face similar wildfire risk levels as seen in Fort McMurray in 2016. These regions in western and eastern Canada do not reach hazard levels as high as Alberta's, but they are areas with dense populations and high asset concentrations. The high exposure amplifies the overall wildfire risk in those spots, making it comparable to Fort McMurray.

9 S. Taylor, D. Woolford, C. Dean, et. al., 2013, op. cit.; and P. Pickell, N. Coops, C. Ferster et. al., "An early warning system to forecast the close of the spring burning window from satellite-observed greenness", *Canadian Wildland Fire&Smoke Newsletter*, Fall 2017.

10 Natural Resources Canada, at http://www.nrcan.gc.ca/forests/fire-insects-disturbances/fire/14470, accessed 25 July 2018.

11 L. Johnston and M. Flannigan, "Mapping Canadian wildland fire interface areas", *International Journal of Wildland Fire*, 22 December 2017.

12 Alberta Census Division 16, population figures from Statistics Canada, Table 17-10-0084-01: Annual demographic estimates by census division, age and sex, based on the Standard Geographical Classification (SGC) 2011, accessed 1 October 2018.

13 Across a total of nearly 300 census divisions in all of Canada.

Insured losses from wildfires have risen sharply

Insured losses from wildland fire events remained relatively low until 2003.

Loss of life and property from wildfires is not new to Canada. For example, the 1916 Matheson fires in Ontario – the country's deadliest so far – killed more than 200 people and destroyed a number of towns and villages.[14] More than 136 000 people had to be evacuated between 1986 and 2003 due to wildland fire threats.[15] However, insured losses from wildland fire events remained low until the early 2000s, particularly in comparison to losses from other types of natural catastrophes. Prior to 2003, no single wildfire event in the country caused more than CAD 10 million in losses.[16]

Between 2003 and 2017, a number of large wildfires caused almost CAD 5 billion in insured losses, and even more sizable economic losses.

Since then, a number of catastrophic events have led to significant wildfire-driven losses, with cumulative insurance payouts amounting to almost CAD 5 billion between 2003 and 2017 (see Table 1).[17] The 2003 fire near Kelowna, British Columbia led to around CAD 250 million of insurance payouts in today's dollars. In 2011, the Slave Lake wildfire in Alberta destroyed about a third of the town and caused nearly CAD 600 million in insured losses. The 2016 fire near Fort McMurray in Alberta, which led to the evacuation of the entire town of about 88 000, now ranks as the costliest natural disaster in Canada's history, with insured losses of CAD 3.8 billion. Insured losses from the Elephant Hill and Williams Lake fires in British Columbia together exceeded a further CAD 100 million in 2017. Further, in 2018, British Columbia experienced yet another severe wildfire season. For all years, the insured losses were just a fraction of the total economic losses.

Table 1
Insured losses from large wildfires, 2003–2017, in millions of CAD, 2017 dollars

Year	Location	Insured loss incl. loss adjustment expense (Millions CAD, 2017 dollars)
2003	Kelowna, BC	254
2011	Slave Lake, AB	575
2016	Fort McMurray, AB	3 813
2017	Elephant Hill, BC	46
2017	Williams Lake, BC	91

Source: Swiss Re Institute, IBC, CatIQ

[14] "A century later, Great Matheson Fire of 1916 still deadliest in Canadian history", *CBC News*, 29 July 2016; M. Campbell, "What can we learn from the worst fires in Canadian history," *Maclean's*, 5 May 2016; and K. Hirsch, "A chronological overview of the 1989 fire season in Manitoba", *The Forestry Chronicle*, August 1991.
[15] S. Taylor, B. Stennes, S. Wang et. al., "Integrating Canadian Wildland Fire Management Policy and Institutions: Sustaining Natural Resources, Communities and Ecosystems," 2006.
[16] Ibid.
[17] Insured loss estimates in this paragraph, from Swiss Re Institute, reported in millions of CAD, 2017 dollars.

The state of wildfire modelling in insurance

Rising insured and economic losses are driving insurers' interest in wildfire modelling ...

The trends of increasing human activity in the interface area and of rising insured and economic losses have heightened interest in wildfire modelling in the insurance industry. While a significant amount of research has been conducted in the operational wildfire management sphere, wildfire risk modelling in insurance has lagged behind risk modelling in other insurance-relevant spheres related to natural catastrophes, such as earthquakes, storms and floods.

... especially since wildfire losses can affect a number of business lines.

Wildfires can affect a number of lines of business. Traditional property and liability lines are most directly impacted by wildfire risk, the latter for instance if utility companies or railroad operations are found to be at fault for igniting a fire or causing a damaging conflagration. Business interruption and contingent business interruption policies – the latter of which is increasingly covered by innovative insurance structures – can be triggered because of a fire, or more indirectly from smoke and ash that travels significant distances. Agriculture and forestry insurers also face direct losses from wildfires. In addition, exposure to smoke poses short-term health risks, and the carcinogenic components in smoke can even have longer-term health consequences.[18] Once a fire is extinguished, the increased potential for flooding, landslides and debris flow can lead to further damages, as seen with the 2017 California fires.

Operational-focused wildfire research over a number of decades has led to the development of numerical fire danger rating systems.

Much of the operationally-focused fire research over a number of decades has sought to develop numerical fire danger rating systems. These methods capture daily fire potential based on the cumulative effects of weather (eg, temperature, humidity, precipitation, wind conditions) at a specific location, given the topography, available vegetation and its condition for fuel, along with other variables.[19] Such an assessment of fire potential allows for a more effective allocation of fire management resources over space and time. In Canada, the Canadian Forest Fire Danger Rating System (CFFDRS) and its two main sub-systems, the Fire Weather Index System and the Fire Behaviour Prediction System underlie the work of all fire management agencies in terms of predicting the risk of fire ignition, its potential spread, behavior and intensity.[20]

Even though a myriad of models exist, predicting wildfire activity is a major challenge.

A myriad of other wildfire models, developed for many different purposes, also exist.[21] By and large, the various hazard and/or risk models can be divided into short-term and long-term analyses (see "Hazard vs risk"). Short-term fire potential is strongly correlated to current weather conditions, and the related models are used for example in loss prevention and mitigation, for fire management and/or resource allocation. Long-term fire analysis involves factors that change more gradually and can help guide land use planning, longer-term fire management budget and resource planning, and other such activity.[22] Overall, given the complex interplay among the factors that affect wildfire activity and its impact – ie, weather and climatologic conditions, interface locations, and even suppression activity – predicting wildfire activity is a major challenge.[23] While some of the existing models are in many ways relevant for insurers' wildfire risk assessment, a lot of open questions remain.

[18] Lloyd's, 2013, op. cit.
[19] S. Taylor, D. Woolford, C. Dean et. al., 2013, op. cit.; M. Salehi, L. Rusu, T. Lynar et. al., "Dynamic and Robust Wildfire Risk prediction System: An Unsupervised Approach", 2016.
[20] S. Taylor, B. Stennes, S. Wang et. al., 2006, op. cit.; Girardin and Wotton, "Summer Moisture and Wildfire Risks across Canada", March 2009; BC Wildfire Service, "Provincial Strategic Threat Analysis. 2015 Wildfire Threat Analysis Component"; M. Kirchmeier-Young, F. Zwiers, N. Gillett et. al., "Attributing extreme fire risk in Western Canada to human emissions", *Climatic Change* (2017) 144:365–379, 15 July 2017.
[21] For example, see D.W. Ohlson, B.A. Blackwell, B. Hawkes et. al., "Wildfire Risk Management System – An Evolution of the Wildfire Threat Rating System"; S. Taylor, D. Woolford, C. Dean et. al., 2013, op. cit; P. Pickell, N. Coops, C. Ferster et. al., Fall 2017, op. cit.; "New method can predict where lightning will spark wildfires", *Canadian Underwriter*, 12 March 2018.
[22] C. Lautenberger, "Overview of Wildland Fire Hazard Modeling and Mapping", 2013.
[23] Swiss Re, "Fueling resilience. Climate and Wildfire Risk in the United States", 2015.

Hazard vs risk

Wildfire risk is often inconsistently defined.

Wildfire risk is inconsistently defined throughout wildfire literature, with the terms hazard and risk sometimes used interchangeably. However, in insurance parlance, these two concepts are distinct.

For insurers, the terms hazard and risk are not interchangeable; a hazard is a natural process or phenomenon with undesirable outcomes…

A hazard is a natural process or phenomenon with undesirable outcomes, such as injury, loss of life, property damage or other types of social and economic disruption.[24] For wildfire, the hazard depends on the frequency and intensity of fires, and can be estimated on a number of spatio-temporal scales. A variety of approaches that consider some or all of the underlying drivers, such as weather and atmospheric conditions, fuel availability and conditions, topography and the presence of prevention and suppression activity, have been developed to determine the potential fire behavior and therefore the wildfire hazard.

…while risk refers to the probability of an event occurring, its behavior or intensity, as well as its impact.

While the term hazard does not describe the likelihood of the event occurring, wildfire risk, by contrast, includes the probability of a wildfire, its behavior or intensity, as well as its consequences in terms of the impact on financial values and ecological systems. The probability of wildfire for a particular location encompasses the likelihood of ignition, as well as the probability of burn, where the ignition may have happened elsewhere, sometimes tens of miles away.

[24] Terminology in this and the following paragraph based on discussion in: C. Miller and A. Ager, "A review of recent advances in risk analysis for wildfire management", *International Journal of Wildland Fire* 2013, 22, pp 1–14, 14 September 2012; C. Lautenberger, 2013, op. cit.; UNISDR, "Words into Action Guidelines: National Disaster Risk Assessment. Hazard Specific Risk Assessment. 6. Wildfire Hazard and Risk Assessment", 2017; and L. Johnston, "Current research on Canada's interface areas", *Canadian Wildland Fire & Smoke Newsletter*, Spring 2018.

Quantification of wildfire risk in insurance needs to improve

The proper quantification of wildfire risk in insurance remains a challenge.

For insurers, the proper quantification of wildfire risk is still a challenge, which is highlighted by the fact that the recent large wildfire disasters in Canada were largely unmodelled events.[25] Fire is a covered risk in property policies in Canada, regardless of source, yet if insurance premiums do not reflect true risk, this can lead to moral hazard and inefficient decisions about fire protection and wildfire risk management. To avoid this, risk premiums should be adequately priced according to the underlying region-specific wildfire risk.

Some vendors have started to develop full-scale probabilistic wildfire models.

Some risk solutions providers such as AIR, CoreLogic, Eqecat and RMS have started to develop full-scale probabilistic wildfire models for regions with comparatively high exposure, such as California and Australia.[26] More recently, the work has also been undertaken in Canada.[27] These probabilistic models aim to provide assessment scores for wildfire risks that are based on a variety of region/location specific characteristics. Some of the factors that are considered include natural and man-made sources of ignition, long- and short-term weather and climatological conditions at the location of ignition that could impact how a fire spreads, prior suppression efforts in the area that could have an influence on the amount of existing fuel loads, as well as current suppression access and capabilities. Solution providers are aiming to understand region-specific and even location-specific wildfire risk. However, their models do not yet have a forward-looking view of physical conditions that show causal effects on igniting wildfires in the near future, such as surface temperature, human interactions or snow covers in the winter season. Swiss Re has been focusing on these forward-looking aspects.

However, predicting what an individual event will look like is nearly impossible.

In comparison to other modelled natural catastrophe risks, wildfire is a "complex paradigm with many elements".[28] There is only a limited amount of historical data from which vulnerability curves can be developed to link hazard with actual damage to properties.[29] Meanwhile, the number of inputs a probabilistic wildfire model needs to consider is enormous. In addition, physical characteristics of the surrounding interface locations are critical – such as construction and roof type, clearance distance, surrounding vegetation, and more – as lofted embers often create exposure in secondary locations. Meanwhile, the built environment and mitigation work in the interface area is rapidly changing, adding further layers to an already complex risk landscape.[30] Predicting what an individual event will look like is nearly impossible. By contrast, predicting the conditions under which wildfires get ignited and become larger events is feasible with higher confidence.

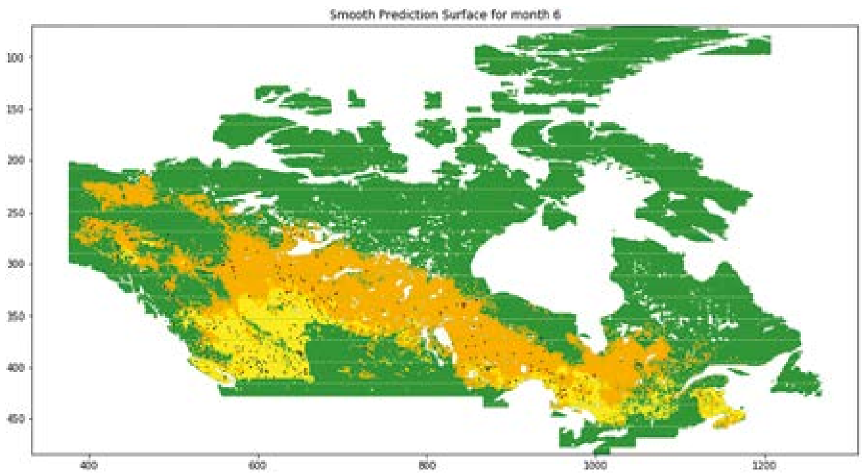
[25] S.W. Taylor, B. Stennes, S. Wang et. al., 2006, op. cit.; and "Wildfire has 'very different pattern' of impacted areas: CatIQ Catastrophe Conference speaker", *insuranceinstitute.ca*, 8 February 2017.
[26] Lloyd's, "Wildfire: a burning issue for insurers?" 2013.
[27] A. Frith, "Improving Wildfire and Flood Risk Mitigation in Canada", *www.air-worldwide.com*, 18 December 2017, http://www.air-worldwide.com/Blog/Improving-Wildfire-and-Flood-Risk-Mitigation-in-Canada/; K. Van Leer, "California wildfires – understanding and addressing the risk", *www.insurancebusinessmag.com*, 22 December 2017; and http://www.rms.com/models/wildfire, accessed 25 July 2018.
[28] L. Johnston, Spring 2018, op. cit.
[29] G. Booth, "Insurers feel the heat from wildfire risk", *Reactions*, 7 September 2016.
[30] *insuranceinstitute.ca*, 8 February 2017, op. cit.

New real-time techniques can be used to improve wildfire risk modelling

Swiss Re believes that probabilistic modelling can be complemented by utilizing real-time data. In one new approach, machine learning methods are being used to help predict wildfire intensity-frequency curves several months in advance.

We believe that the probabilistic modelling of wildfire risk can be complemented with a number of avenues utilizing real-time data and applying new technologies to understand wildfire risk better. One new approach is to predict annualized wildfire loss or intensity-frequency curves several months in advance to better understand: a) multi-year trends and b) the seasonality of wildfire hazard and thus the expected losses or burned areas. In collaboration with MIT, Swiss Re has been utilizing deep learning as a special form of machine learning to analyze several years and months of satellite images.[31] This approach allows Swiss Re's experts to predict wildfire hazards by learning spatial and temporal relationships of the atmosphere and biosphere as well as human interactions within the natural system. Machine learning-based models have a major advantage over probabilistic simulation models because they can detect inter-relationships between underlying features that cannot be parametrized (eg, vegetation zones and lightning or surface temperature and prior burned area several months in advance).

Figure 2
Distribution of wildfire hazard with respect to the expected intensity of fires, six months ahead



Note: Modelling using data as of November 2015. Green represents areas where no fires are predicted in six months' time. Yellow represents areas where small fires are likely and orange represents areas where large fires are likely in six months' time. Black dots are actual fires in April/May 2016.

Source: Swiss Re

Risk estimations may become more robust through combining probabilistic simulation models and machine learning-based hazard models.

Wildfire risk estimations may become more robust if existing probabilistic simulation models with emphasis on vulnerabilities and exposures are combined with machine learning-based hazard models. This could significantly improve the ability of insurance companies to assess the wildfire risk their customers face. Figure 2 depicts how spatial wildfire hazard changes with respect to the intensity of wildfires can be predicted months in advance. In the figure, expected fire conditions six months ahead are shown utilizing data from November 2015 along with actual fires from April/May 2016, but the model can generate predictions up to twelve months in advance.

[31] N. Le Vine, Z. El Hjouji, L. Lecluse et. al., "Improving Wildfire Predictability via Machine Learning", American Geophysical Union, NH038, Fall Meeting, Washington D.C. December 10-14. 2018, forthcoming.

Fostering resilience through advances in modelling

Accurate wildfire risk assessment will become ever more pertinent …

Accurate wildfire risk assessment will become increasingly important given that catastrophic fires such as Fort McMurray and Slave Lake are likely to reoccur. A confluence of factors – from rising activity in the interface to climate change – is contributing to rising wildfire risk.

… as rising human activity in the interface area …

Recent research suggests that wildfire activity has already increased throughout much of North America, including in Canada.[32] This trend is projected to continue as more rainfall leads to more vegetation, adding to the fuel, which in turn has a higher likelihood of burning as summer temperatures increase. The ongoing development of both residential communities and high-value industrial and resource extraction facilities in interface areas bring with it rising exposure as well as anthropogenic sources of ignition (see "Oilsands – what could happen?"). In some parts of the hazard area, years of successful suppression efforts have created wildlands rife with fuel.[33]

… along with climate change contributes to rising wildfire risk.

At the same time, longer periods of warm, dry weather are lengthening fire seasons across Canada and the rest of North America.[34] On average, the western wildfire season has lengthened from five months in the 1970s to around seven months today.[35] Hot and dry conditions have also weakened the resistance of trees to insects, leading to widespread beetle infestations that have subsequently created additional fuel for future fires.[36] Warmer temperatures also lead to more severe thunderstorms with more lightning – a leading source of ignition.[37] A number of studies on climate change point to a continuation of these trends.[38] Under some scenarios, the number of fire spread days are forecast to more than double in eastern Canada over the next century, and rise by more than 50% in western Canada "where the fire potential is already high".[39]

[32] X. Wang, M. Parisien, S. Taylor et. al., "Projected changes in daily fire spread across Canada over the next century", *Environmental Research Letters*, 12 (2017), 2 February 2017.
[33] G. McGillivray, "Bravery alone won't keep wildfire out of town", InsBlogs.ca, 4 April 2018.
[34] S. Taylor, D. Woolford, C. Dean et. al., 2013, op. cit; Nicola Jones, "Stark Evidence: A Warmer World Is Sparking More and Bigger Wildfires", *Yale Environment 360*, 2 October 2017.
[35] Swiss Re, 2015, op. cit.
[36] Munich Re Topics Online, "Wildfire in the US and Canada", 28 September 2016; and https://www.nwf.org/~/media/PDFs/Global-Warming/NWF_WildFiresFinal.ashx, accessed 25 July 2018.
[37] M. Flannigan and M. Wotton, "How will Canada manage its wildfires in the future?" *theconversation.com,* 26 November 2017.
[38] B. Stocks and B. Wotton, "The History of Forest Fire Science and Technology in Canada and Emerging Issues Relevant to the Canadian Wildland Fire Strategy," 2006; Lloyd's, 2013, op. cit.; Nicola Jones, 2 October 2017, op. cit.; Paul D. Pickell, Nicholas C. Coops, Colin J. Ferster, et. al., Fall 2017, op. cit.
[39] Xianli Wang, Marc-André Parisien, Steve W Taylor, et. al., 2 February 2017, op cit.

Oilsands – what could happen?

Wildfires in 2015 and 2016 temporarily halted oil production, but did not damage oilsands facilities.

In May 2015, wildfires in northern Alberta led to a preventative temporary shut-down of around 10% of the province's total oilsands output.[40] A year later, the catastrophic Fort McMurray wildfire halted the production of nearly a million barrels of oil a day for about a week.[41] Aside from destroying a worker accommodation camp near Fort McMurray, the fires did not cause damage to the actual oilsands facilities. If the fire had reached the actual mines or oil production plants, the insured and economic losses would have been exponentially higher.

The risk of actual facility damage may be larger than expected.

Bitumen, the main component of oilsands, does not ignite easily. However, natural gas and diluent, substances used to help extract, process and transport bitumen, are highly flammable, and are frequently stored near the process plants in large tank terminals. Buffer zones in the form of vegetation-free ground usually separate oilsands facilities from nearby forestland. The buffer distance is often based on rule-of-thumb guidelines, which may not be sufficient. Yet despite vast operations in the interface areas, models to assess and manage wildfire risk as it pertains to "technological accidents triggered by natural disasters" are lacking.[42] Hence, the risk of actual facility damage may be larger than expected.

Accurate pricing of wildfire risk helps improve resilience

The latest wildfire models are helping insurers to understand better their exposure to wildfire risk.

Insurers benefit from having a clear view of their wildfire exposures for pricing, reserving and portfolio management, especially since wildfire losses can potentially have an impact on a number of lines of business. Tracking the accumulation of wildfire risk for an insurance portfolio is an important first step. The Fort McMurray wildfire highlighted that Canada has pockets of high property values that are exposed to elevated risk of wildfire. As economic activity continues to expand further north into wildfire territory, Fort McMurray is not the only such area. With environmental conditions contributing to the increasing risk of wildfire, all possible factors need to be recognized to assess the risk properly. Models that derive insights for wildfire probabilities from environmental factors that are observable in real time can be a valuable ingredient to improve the understanding and quantification of wildfire risk.

The accurate pricing of wildfire risk can also play a key role in fostering wildfire resilience across communities.

The accurate pricing of wildfire risk by insurers plays a key role in incentivizing appropriate risk prevention and reduction by individual policyholders as well as entire communities.[43] Here, insurers can be valuable partners to governments at all levels to foster resilience going forward. Specifically, there is an alignment of interest with those in urban planning and zoning, public safety standard setting, mitigation and loss prevention planning at the municipal, provincial and federal levels. Hence, an increased understanding of wildfire risk by insurers could potentially strengthen the collaboration between insurers, governments and other stakeholders, while fostering wildfire resilience across all of Canada.

[40] D. Healing, "Fire shuts down 233 000 barrels per day from oilsands", *Calgary Herald*, 25 May 2015.
[41] G. Morgan, "More oilsands production shutdown as Fort McMurray fire continues to rage, knocking one million barrels offline," *Financial Post*, 5 May 2016 and "The raging Fort McMurray fires that threatened Alberta's oilpatch may have also boosted its bottom line," *Financial Post*, 20 July 2016.
[42] N. Khakzad, "Impact of wildfires on Canada's oilsands facilities", *Natural Hazards and Earth System Sciences Discussions*, 6 July 2018.
[43] For more details, see Swiss Re, 2015, op. cit.

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