Wildfire Smoke

Impacts on Air Quality in Alberta

Introduction

When wildfires consume trees and plant material, they emit smoke. Wildfire smoke can be transported long distances, over provincial, territorial, and national borders. Wildfire smoke episodes often cover large areas of the province.

Wildfire smoke is made up of gases and particles. Smoke inhalation can irritate the eyes and respiratory system, and can worsen chronic heart and lung diseases. Smoke also causes reduced visibility.

Communicating Health Risk during Smoke Events

The Air Quality Health Index (AQHI) helps Albertans understand what the air quality in their communities means to their health.

The AQHI provides a simple number from 1 to 10 to indicate the health risk associated with local air quality. The higher the AQHI number, the greater the health risk and need to take precautions. There are four health risk categories within the scale: 1 to 3, Low risk; 4 to 6, Moderate risk; 7 to 10, High risk; and 10+, Very High risk. Occasionally, when the amount of air pollution is extremely high, such as during a forest fire smoke event, the AQHI may exceed 10.

Special Air Quality Statements or air quality advisories may be issued when there are elevated pollution levels (AQHI of 7 or higher), such as when smoke from wildfires may affect air quality in communities.

For the vast majority of the time, air quality is at Low or Moderate risk in Alberta. In 2018, High or Very High risk AQHI values occurred 1.2% of the time in Alberta. Most of the High or Very High risk AQHI values were due to wildfire smoke.

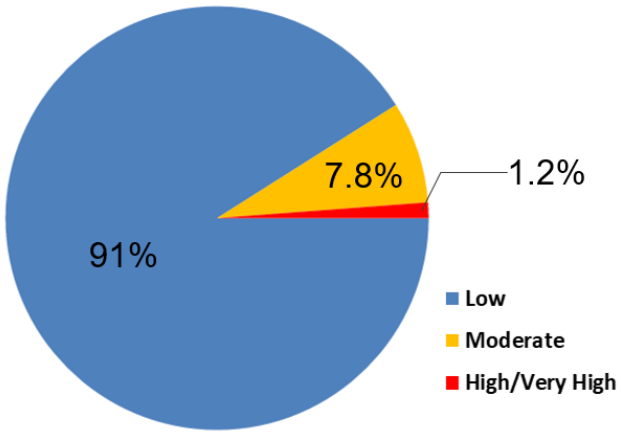

Figure 1 Percentage of hours in each AQHI risk category, low, moderate and high/very high risk, for Alberta in 2018. Data were obtained from: https://www.alberta.ca/access-air-quality-and-deposition-data.aspx.

Air Quality Episodes in Alberta due to Wildfire Smoke

One of the major components of smoke with a risk to human health is fine particulate matter ($PM_{2.5}$). $PM_{2.5}$ is made up of very small particles, with a size of 2.5 micrometers or smaller. $PM_{2.5}$ can be inhaled into the lungs, and may cause symptoms such as coughing or may worsen existing heart and lung conditions. $PM_{2.5}$ is generally the largest contributor to high AQHI values during wildfire smoke events.

Alberta has a set of Ambient Air Quality Objectives (AAAQOs) and Guidelines (AAAQGs), which can be compared to actual air quality measurements to report on the state of Alberta's environment. Most of the time, levels of $PM_{2.5}$ are below the objectives and guidelines. In the winter, exceedances of $PM_{2.5}$ objectives and guidelines are most often caused by emissions from automobiles and industry during stagnant weather conditions. In the summer, wildfire smoke causes most exceedances of $PM_{2.5}$ objectives and guidelines.

The number of summertime exceedances of the $PM_{2.5}$ guideline[1] shows that the effect of wildfire smoke varies from year-to-year and across the province (Figure 2).

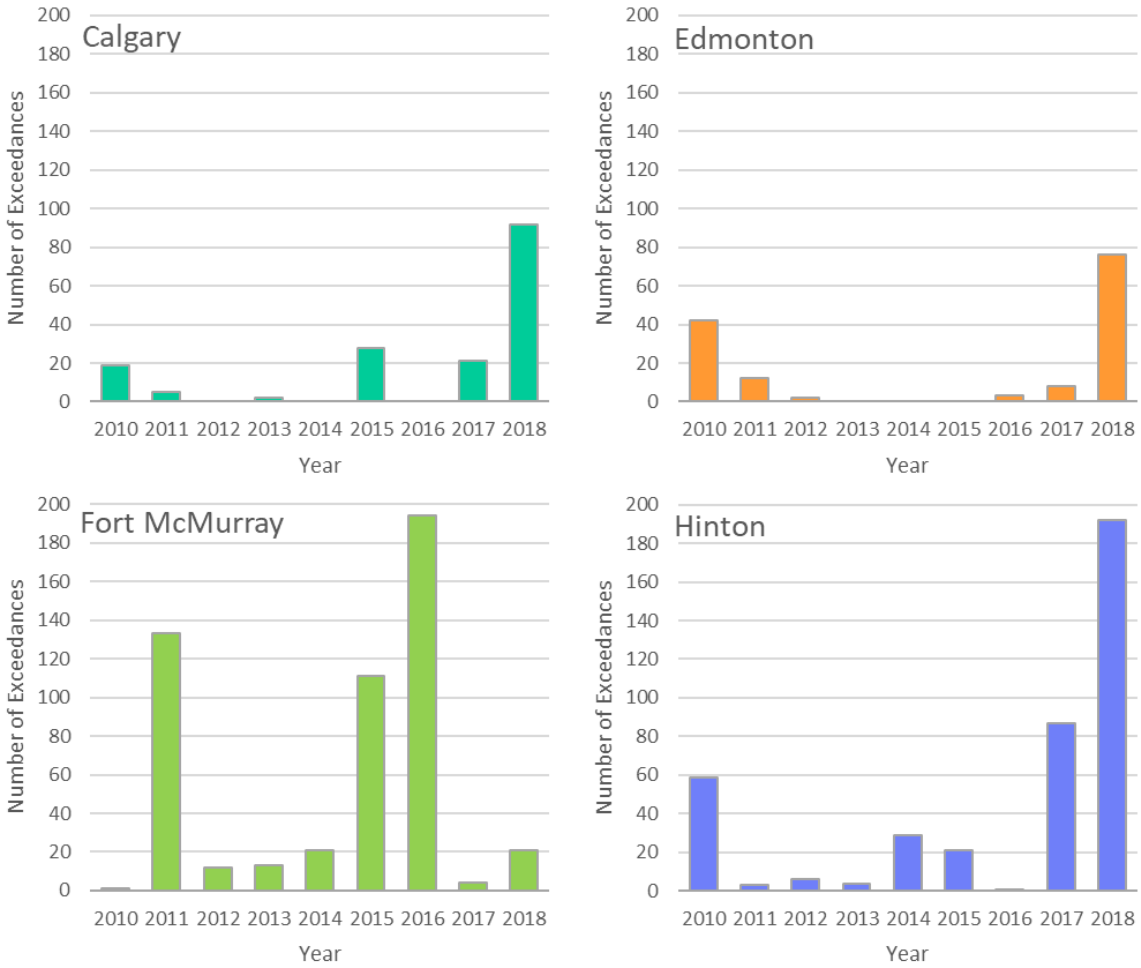

Figure 2 Number of times that $PM_{2.5}$ exceeded the air quality guideline in the summer (May-September) from 2010-2018 shown for the Calgary Northwest, Edmonton Central, Fort McMurray-Athabasca Valley and Hinton stations. Data were obtained from: https://www.alberta.ca/access-air-quality-and-deposition-data.aspx.

[1] The Alberta Air Quality Guideline for fine particulate matter is 80 µg m^{-3} for a 1-hour averaging period.

Levels of $PM_{2.5}$ depend on the locations of wildfires, type of fuel available, as well as meteorological conditions, such as wind speed and wind direction.

In some cases, nearby fires affect local air quality. Communities located near the boreal forest, like Fort McMurray, experience more frequent smoke episodes than more southern communities. In an extreme example, Fort McMurray experienced very high levels of $PM_{2.5}$ in 2016 due to the Horse River Fire, which entered the community.

Smoke can also be transported over long distances and can cover large areas. In 2018, Edmonton, Calgary, and Hinton all experienced more $PM_{2.5}$ guideline exceedances than in previous years (Figure 2) because of the record-breaking wildfire season in British Columbia. Smoke was transported into Alberta and covered much of the province for days at a time (Figure 3).

Monitoring and Forecasting Wildfire Smoke

Air quality is monitored by Alberta Environment and Parks and airsheds using continuous air monitoring stations in more than 30 communities across Alberta. Real-time data from these continuous stations are used to inform the public on current air quality conditions through the AQHI.

During wildfire smoke events, portable air quality monitors (E-BAMs) can be deployed in areas not covered by permanent air monitoring stations. These instruments measure and report one-hour concentrations of $PM_{2.5}$.

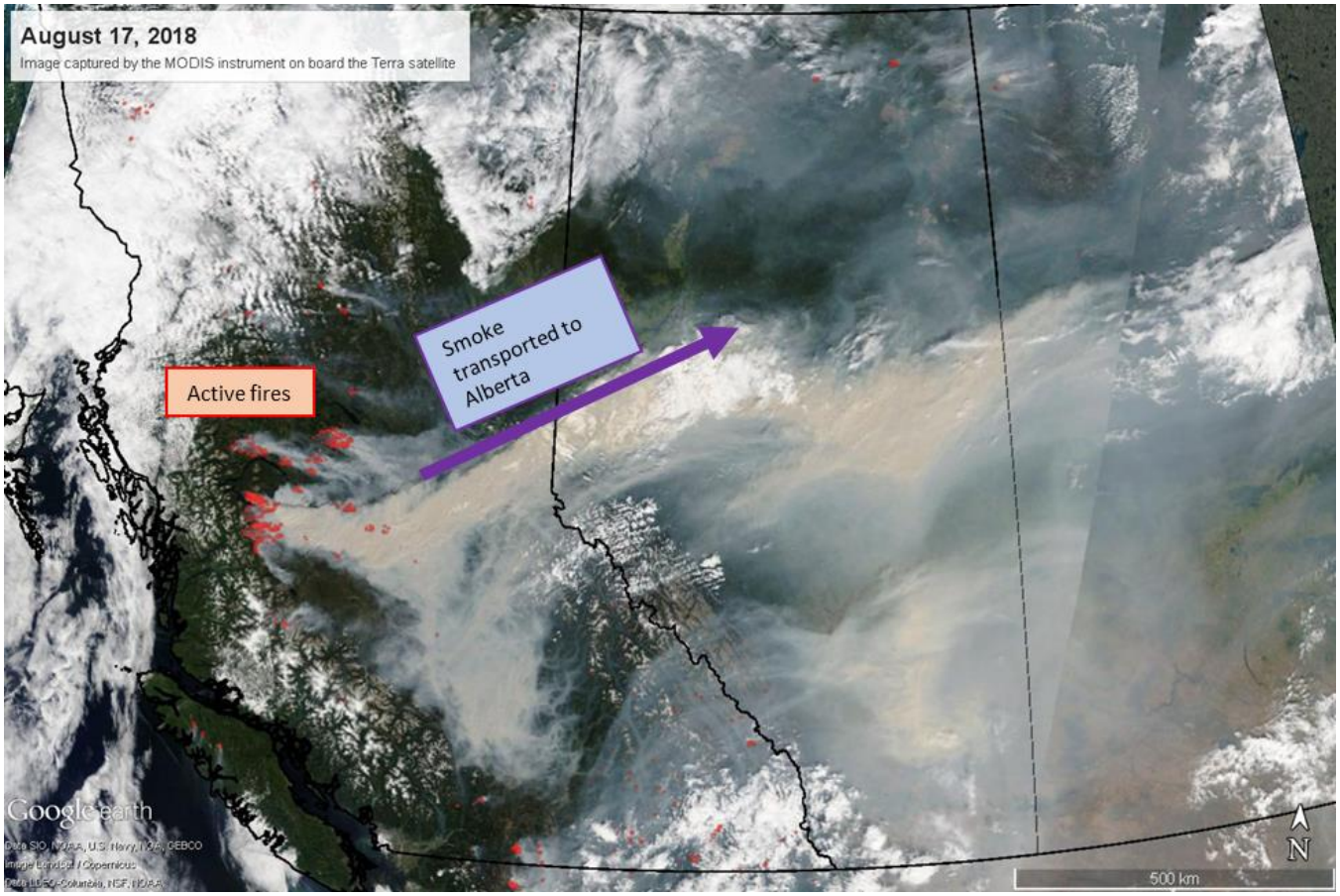

Figure 3 Satellite map shows smoke originating from the 2018 wildfires in British Columbia and being transported eastward over Alberta. The brownish haze covering most of central/southern Alberta is smoke.

Imagery provided by services from the Global Imagery Browse Services (GIBS), operated by the NASA/Goddard Space Flight Center Earth Science Data and Information System (ESDIS) project.

In response to emergency wildfire events, more intensive air quality monitoring may be undertaken. Emergency response monitoring informs decisions to protect the health of the public and emergency response personnel. For example, during the 2016 Horse River wildfire in Fort McMurray, $PM_{2.5}$ and other components of smoke were measured using equipment such as the Mobile Air Monitoring Laboratory (MAML) and canister samples.

Smoke from wildfires is forecasted by BlueSky, a smoke modelling framework used during the fire season. BlueSky combines wildfire information, such as location and size, with weather forecasts. The system identifies areas that are expected to be impacted from wildfire smoke, and estimates the associated smoke concentrations. In addition, wildfire smoke forecast maps are available through the Government of Canada's FireWork system. FireWork is an air quality prediction system that indicates how smoke from wildfires is expected to move across North America over the next 48 hours.

Changes in Wildfire Activity since 1990

Most smoke episodes in Alberta are caused by local wildfires and fires in British Columbia. This is because winds most often blow from the west, causing smoke to be transported from British Columbia to Alberta. Since 1990, the number of wildfires in Alberta and British Columbia has remained steady[2], but the area burned (Figure 4) has increased[3]. Spikes in the area burned are caused by abnormally large fires, such as the Richardson Backcountry Fire (~577,000 hectares) in 2011 and the Fort McMurray Horse River Fire (~590,000 hectares) in 2016. The largest areas burned are for the most recent years, 2017 and 2018, during which British Columbia had back-to-back record-breaking fire seasons.

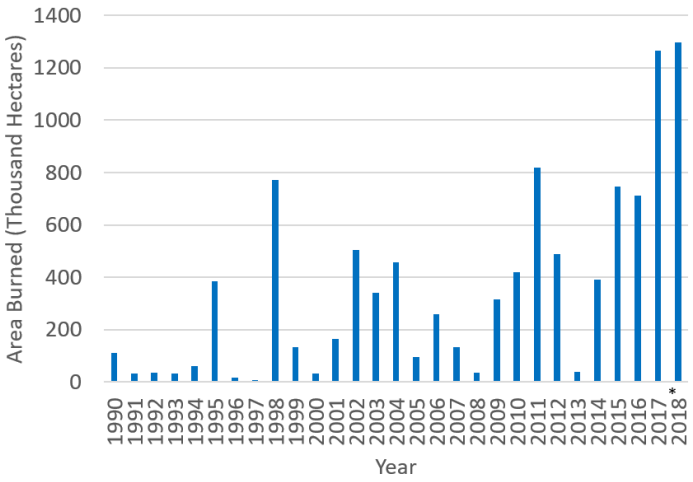

Figure 4 Area burned by wildfires in Alberta and British Columbia (1990-2018).

Data were obtained from Alberta Agriculture & Forestry and National Forestry Database.

**2018 data for British Columbia was not QA/QC, and was obtained from https://www.cbc.ca/news/canada/british-columbia/state-emergency-bc-wildfires-1.4803546.*

[2] Trend calculated using annual fire data from the Alberta Agriculture & Forestry and National Forestry Database for 1990-2017. Least squares linear regression was used to calculate the coefficient and p-value (p-value = 0.62).

[3] Trend calculated using annual area burned data from the Alberta Agriculture & Forestry and National Forestry Database for 1990-2017. Least squares linear regression was used to calculate the coefficient and p-value (p-value = 6.8×10^{-4}).

Significance

The number and size of wildfires in North America have been increasing over the past few decades. This has been caused by increasing dry/hot conditions related to climate change, changes in land-use, and fire management practices. In the future, higher temperatures will lead to greater fire risk[4] and the annual burn area in the boreal forest is projected to increase, with some of the largest increases predicted in north-eastern Alberta[5].

Therefore, wildfire smoke is an emerging air quality issue in Alberta and is a priority area of Alberta Environment and Parks (AEP). AEP is actively researching the impact of wildfire smoke emissions on air quality, with a recent focus on the 2016 Fort McMurray Horse River Wildfire. AEP is also evaluating and improving monitoring of wildfire smoke to effectively support air quality forecasting and reporting to the public.

Project Contact

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Air Quality Resources

Real-time air quality data is available from the Air Quality Health Index at airquality.alberta.ca/map.

Wildfire smoke forecasts are available from firesmoke.ca and weather.gc.ca/firework.

Air Quality Advisories

Environment and Climate Change Canada issues Special Air Quality Statements, available at:

weather.gc.ca/warnings

Alberta Health Services may also issue air quality advisories: albertahealthservices.ca/news/air.aspx

Wildfire Smoke Research

Alberta Environment and Parks' researchers are actively involved in studies about wildfire smoke and air quality. Recent publications examine $PM_{2.5}$ and other air pollutants during the Horse River Wildfire in the Fort McMurray area.

Adams et al. 2019. Satellite-derived emissions of carbon monoxide, ammonia, and nitrogen dioxide from the 2016 Horse River wildfire in the Fort McMurray area. *Atmospheric Chemistry and Physics*, 19, 2577-2599

Wentworth et al. 2018. Impacts of a large boreal wild fire on ground level atmospheric concentrations of PAHs, VOCs and ozone. *Atmospheric Environment*, 178, 19-30.

Landis et al. 2018. The impact of the 2016 Fort McMurray Horse River Wildfire on ambient air pollution levels in the Athabasca Oil Sands Region, Alberta, Canada. *Science of the Total Environment*, 618, 1665–1676.

[4] Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p., available at: https://changingclimate.ca/site/assets/uploads/sites/2/2019/04/CCCR_FULLREPORT-EN-FINAL.pdf

[5] Boulanger, Y., Gauthier, S., & Burton, P. J. (2014). A refinement of models projecting future Canadian fire regimes using homogeneous fire regime zones. *Canadian Journal of Forest Research*, 44(4), 365–376. https://doi.org/10.1139/cjfr-2013-0372