

Health Impact Assessment of Wildfire Smoke in Canada

Carlyn Matz, PhD

Water & Air Quality Bureau
Health Canada

carlyn.matz@canada.ca



Wildfire Activity in Canada

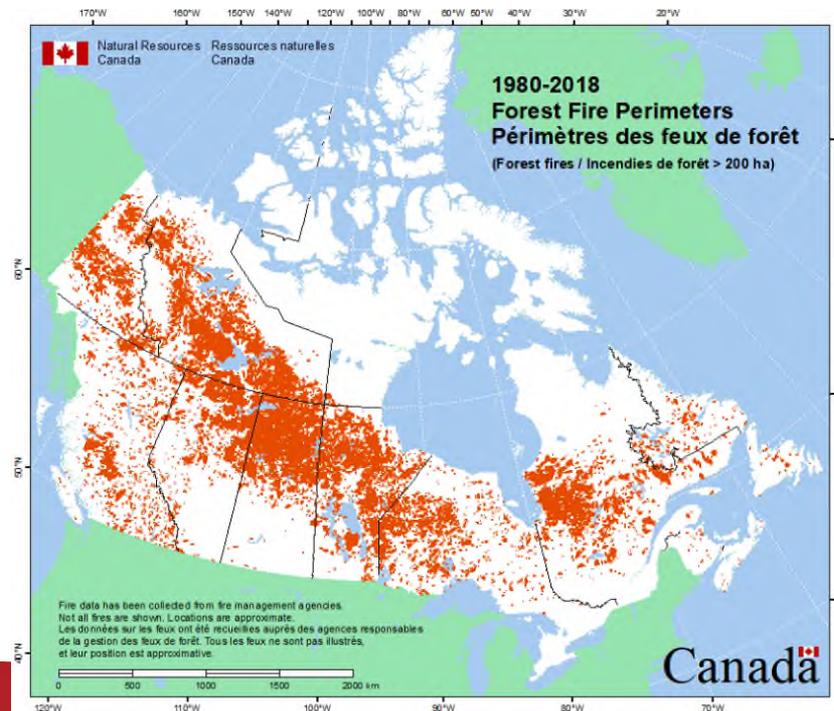
- Canada has about 9% of the world's forests
- Approximately 8,000 wildfires occur each year in Canada burning on average 2.5M ha/year
 - ~45% are caused by lightning strikes, usually in remote areas, and account for 81% of the area burned
 - ~55% are caused by human activity, usually in more populated areas and more likely to be reported and extinguished
- Most frequent wildfire activity is in British Columbia, followed by the boreal forest zones of the Prairie provinces, Ontario, Quebec, Yukon, and the Northwest Territories



<https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/cfs/assets/file/484>

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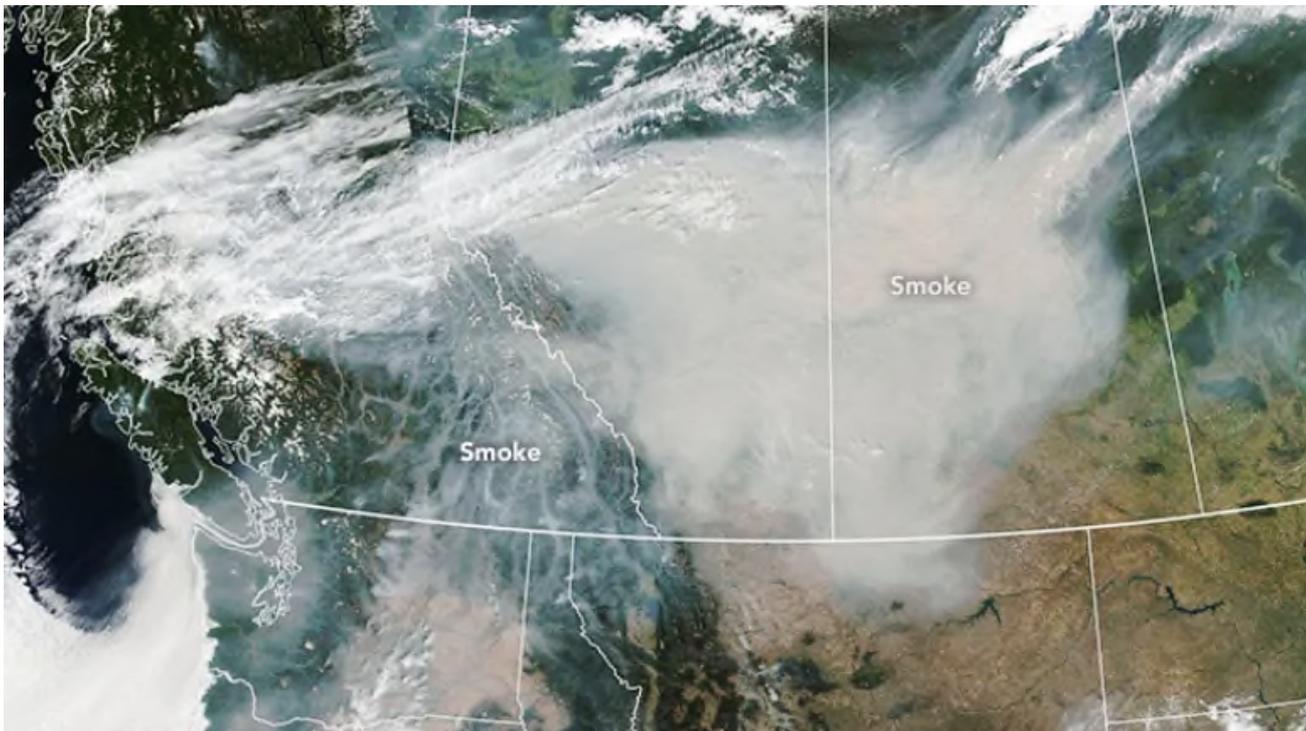
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<https://cwfis.cfs.nrcan.gc.ca/ha/nfd/b?wbdisable=true>

When there's fire, there's smoke

- Smoke from wildfires results in higher exposures to pollutants in smoke in areas close to the fire, as well as at distance as smoke can travel thousands of kilometers
- Wildfires are a leading contributor to population-weighted PM_{2.5} exposure in Canada, accounting for 17% (Meng et al. 2019)



<https://www.cbc.ca/news/technology/bc-fires-satellite-1.4789298>

Canadian Health Impact Assessment of Wildfire Smoke

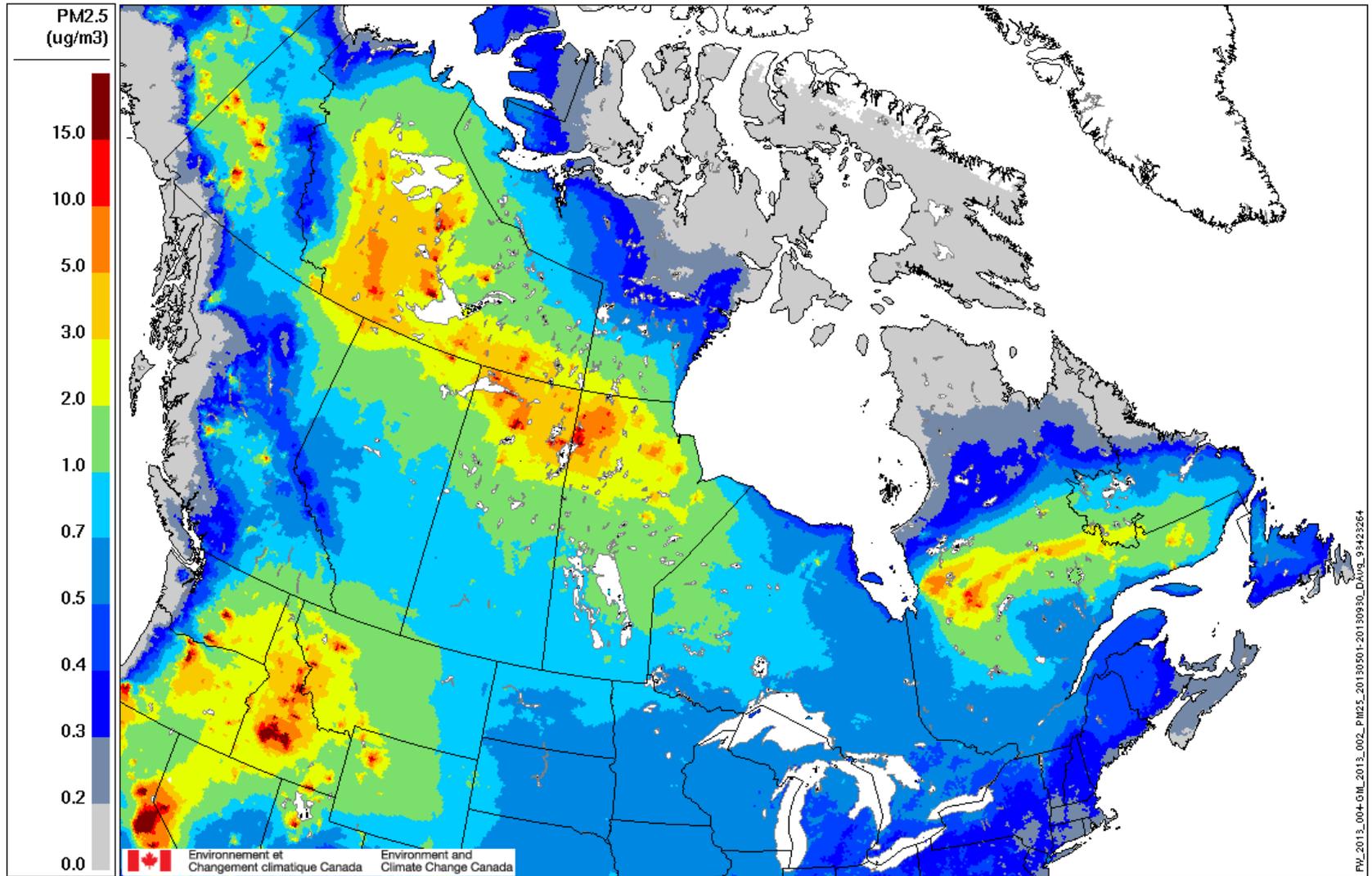
- Important to characterize national population health impacts of wildfire smoke
- Canadian air pollution health impacts from wildfires during recent years were estimated using a multi-step modelling approach:
 - AQ modelling to estimate wildfire-PM_{2.5} concentrations across Canada
 - Estimate the health impacts (mortality and morbidities) attributable to wildfire-PM_{2.5}
- Provides an understanding of the current health impacts as climate change is expected to increase wildfire season length, as well as frequency and intensity of wildfires

AIR QUALITY MODELLING

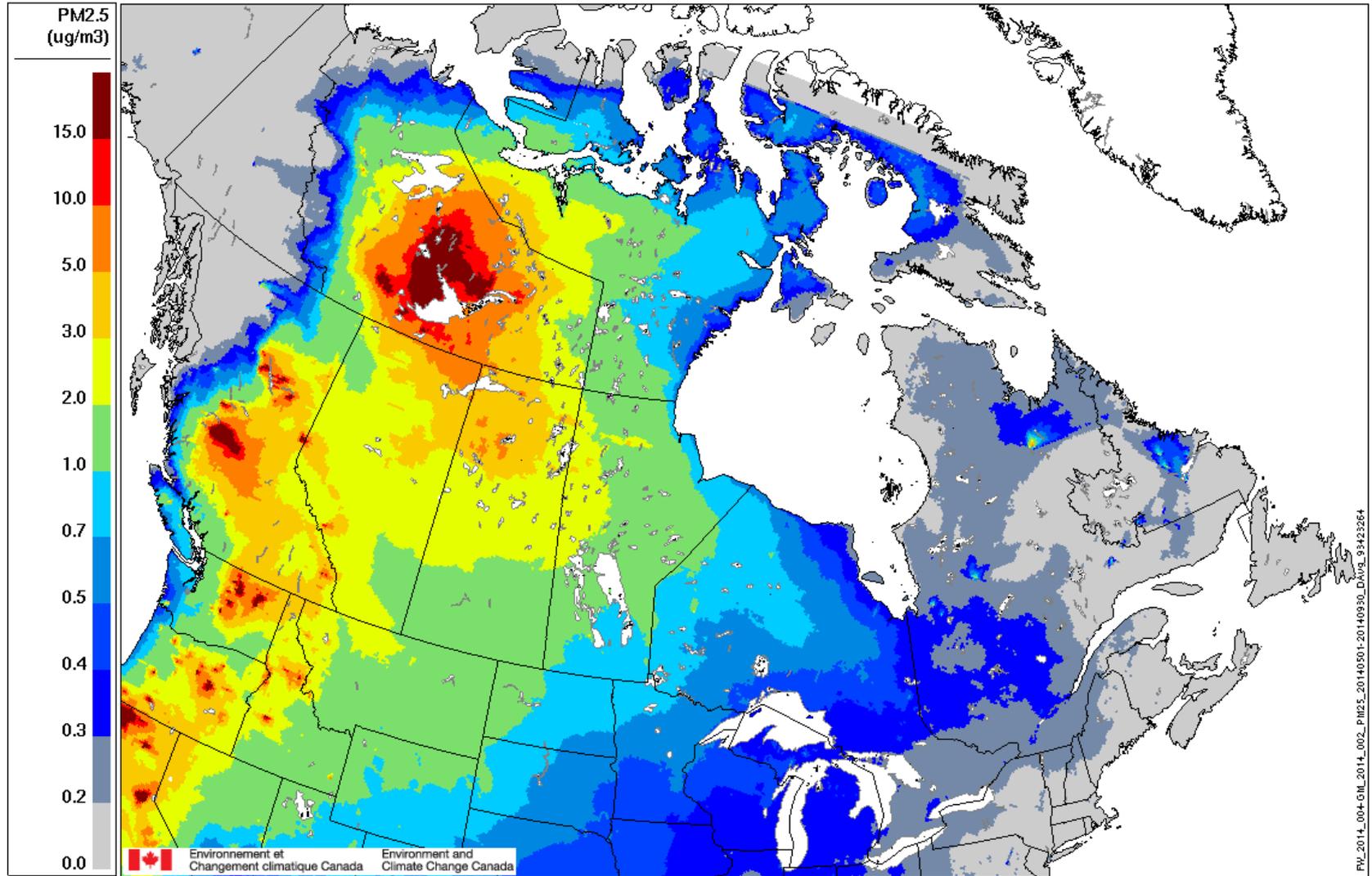
AQ Modelling Methods

- Daily air quality across Canada for the period 2013-2015 and 2017-2018 was estimated by Meteorological Service of Canada (ECCC) using two operational models:
- (1) GEM-MACH includes atmospheric chemistry, meteorological processes, and Canadian, U.S., and Mexican anthropogenic emissions and biogenic emissions
 - Forecasts are available for the entire year
- (2) FireWork uses the same air quality forecasting system as GEM-MACH, and incorporates Canadian and American near-real time hourly emissions from wildland, prescribed and agricultural fires
 - Forecasts are available for the fire season (May to September)
- Wildfire-PM_{2.5} concentrations were quantified as the difference between FireWork and GEM-MACH results
 - Effectively removing the anthropogenic and non-wildfire natural sources of PM_{2.5}

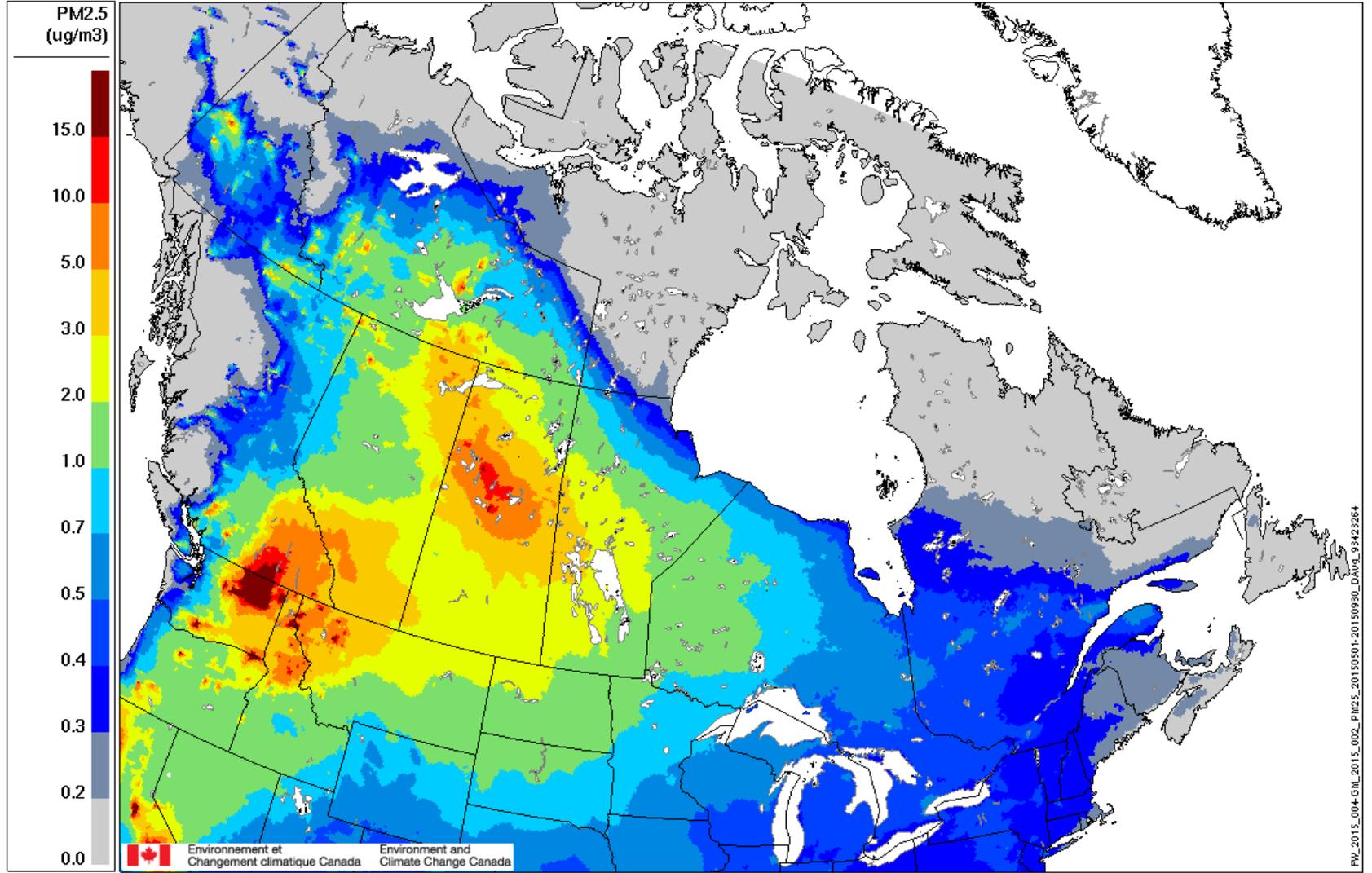
AQ Modelling Results for Wildfire-PM_{2.5} for 2013



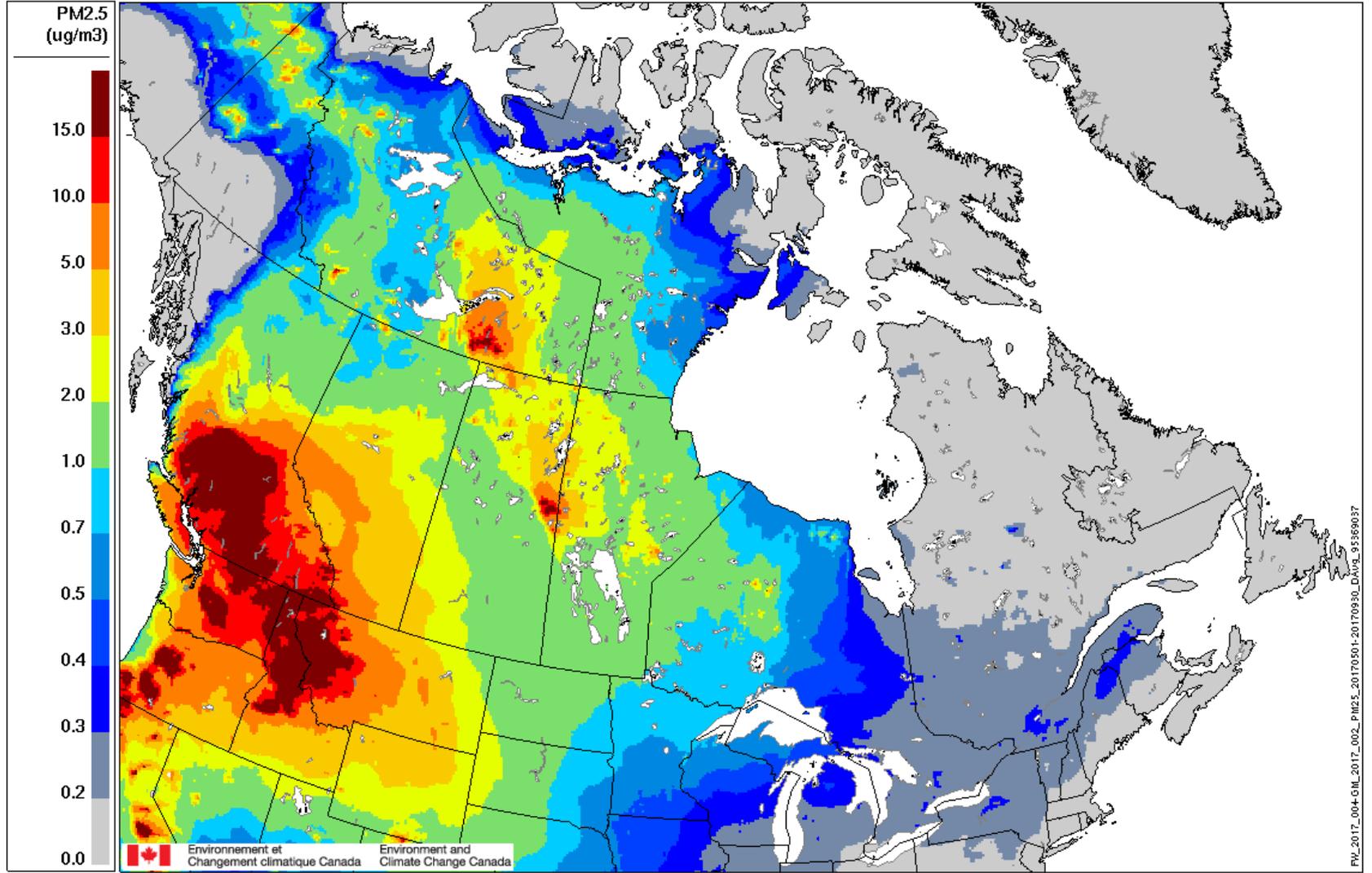
AQ Modelling Results for Wildfire-PM_{2.5} for 2014



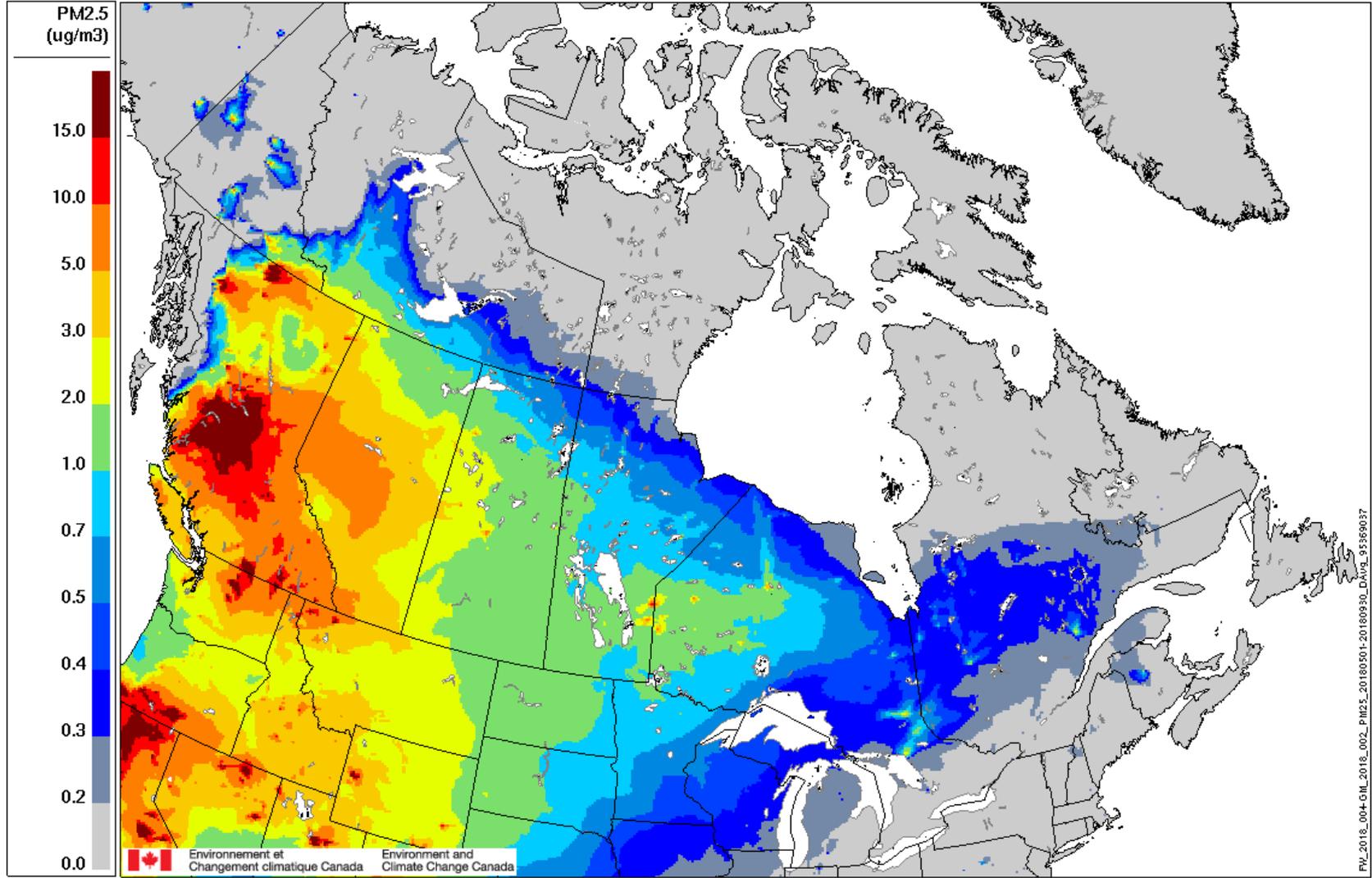
AQ Modelling Results for Wildfire-PM_{2.5} for 2015



AQ Modelling Results for Wildfire-PM_{2.5} for 2017

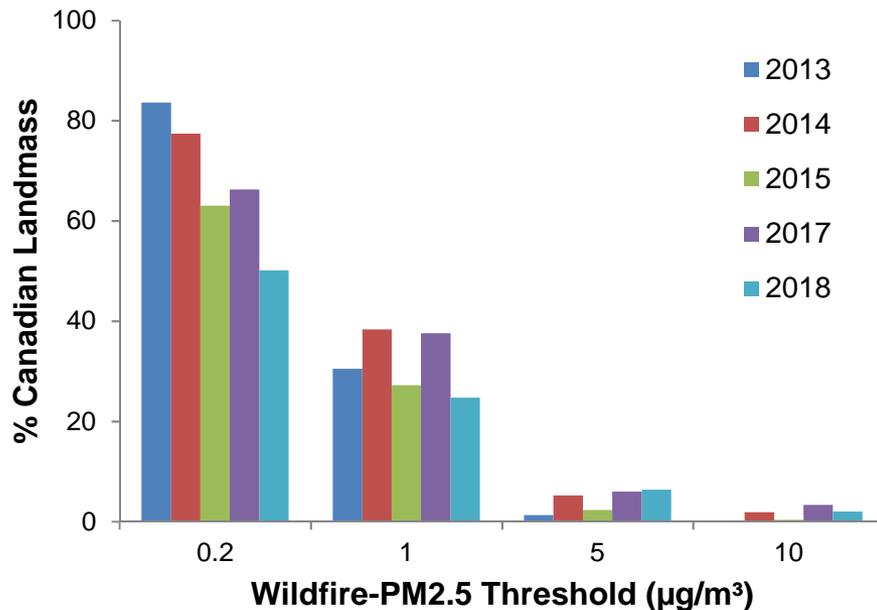


AQ Modelling Results for Wildfire-PM_{2.5} for 2018

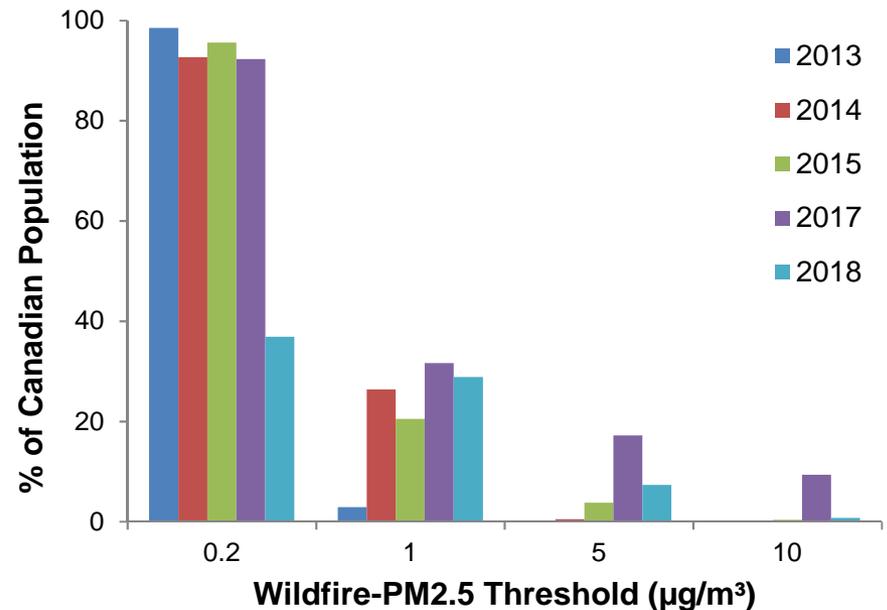


Canadian Wildfire-PM_{2.5} Exposure

- AQ modelling demonstrated substantial temporal and spatial variability in wildfire-PM_{2.5} concentrations, year to year
- Canada has a large landmass (9.985M km²)
- And a sparse population (37M people) that is not evenly distributed



- 20-40% of landmass had wildfire-PM_{2.5} levels of $\geq 1 \mu\text{g}/\text{m}^3$ over wildfire season



- Except for 2013, 20-30% of the population was exposed to wildfire-PM_{2.5} levels of $\geq 1 \mu\text{g}/\text{m}^3$ over wildfire season

HEALTH IMPACT ASSESSMENT

Wildfire Smoke Health Impact Assessment (HIA) methods

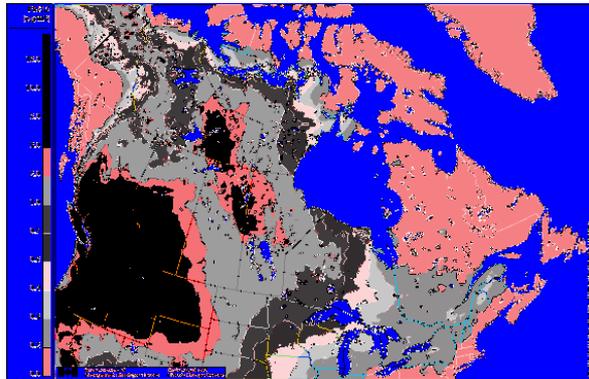
- Mortality and morbidities attributable to wildfire-PM_{2.5} were estimated using Health Canada's [Air Quality Benefits Assessment Tool \(AQBAT\)](#)
- AQBAT estimates the **number of excess health outcomes** attributable to a change in ambient air pollution concentrations based on:
 - baseline incidence rates of the health outcomes,
 - population counts,
 - concentration response functions (CRFs) derived from epidemiological studies,
 - and a change in air pollution concentration
- AQBAT also calculates the **economic value of the health impacts**, considering the potential social welfare consequences, including medical costs, reduced workplace productivity, pain and suffering, and the impacts of increased mortality risk

Source



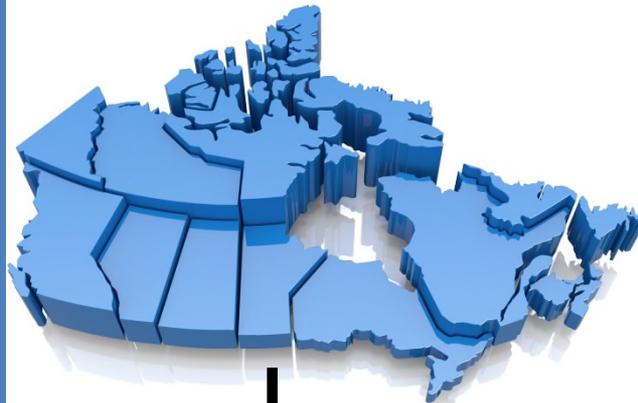
*Atmospheric
modelling*

FireWork and GEM-MACH



Input to AQBAT

Change in ambient air pollution concentrations



*Population
Data*

*Concentration
Response
Functions*



Change in population exposure

Change in health effects



*Endpoint
Valuation*



Value of health impact

AQBAT

Slide credit: Dave Stieb

Acute and Chronic Health Impacts of Wildfire-PM_{2.5}

- Acute health impacts:
 - the change in seasonal (May to September) average wildfire-PM_{2.5} was assumed to equal the average seasonal change in daily concentrations
 - Representative of the short-term or **seasonal impacts of exposure to wildfire-PM_{2.5}**
- Chronic health impacts
 - the seasonal increment in wildfire-PM_{2.5} was averaged over the entire year, counting all days outside the season as 0 µg/m³
 - Representative of the potential impacts of **sustained or recurring exposure to estimated wildfire-PM_{2.5} over the long term**

Wildfire Smoke: National Acute Health Impacts

	2013	2014	2015	2017	2018
Acute Mortalities	54	70	97	240	131
Acute Mortality Valuation	\$410M [\$120M- \$830M]	\$520M [\$160M- \$1.1B]	\$730M [\$220M- \$1.5B]	\$1.8B [\$530M- \$3.7B]	\$980M [\$280M- \$2.0B]
Acute Respiratory Symptom Days	1 400 000	1 900 000	2 500 000	6 100 000	3 400 000
Asthma Symptom Days	100 000	140 000	190 000	420 000	240 000
Child Acute Bronchitis Episodes	2 600	3 400	4 600	10 000	6 000
Respiratory Emergency Room Visits	170	230	310	710	420
Respiratory Hospital Admissions	34	45	61	140	83
Cardiac Emergency Room Visits	60	75	110	250	140
Cardiac Hospital Admissions	46	57	80	190	110
Restricted Activity Days	750 000	1 000 000	1 400 000	3 200 000	1 800 000
Acute Morbidity Valuation	\$73M [\$13M- \$177M]	\$97M [\$17M- \$240M]	\$131M [\$24M- \$320M]	\$310M [\$58M- \$750M]	\$170M [\$33M- \$420M]

Wildfire Smoke: National Chronic Health Impacts

	2013	2014	2015	2017	2018
Chronic Mortalities	570	730	1 000	2 500	1 400
Chronic Mortality Valuation	\$4.3B [\$1.5B-\$8.2B]	\$5.5B [\$2.0B-\$11B]	\$7.6B [\$2.7B-\$15B]	\$19B [\$6.7B-\$35B]	\$10B [\$3.8B-\$20B]
Adult Chronic Bronchitis Cases	530	710	960	2 300	1 300
Chronic Morbidity Valuation	\$230M [\$0-\$620M]	\$320M [\$0-\$830M]	\$420M [\$0-\$1.1B]	\$1.0B [\$0-\$2.6B]	\$560M [\$0-\$1.5B]

Comparison of Canadian wildfire smoke health impacts

- Canadian annual wildfire smoke health impacts economic valuation:
 - \$410M-\$1.8B for acute impacts
 - \$4.3B-\$19B for chronic impacts
- Annual health impacts attributable to Canadian air pollutant emissions from
 - all on-road and off-road diesel vehicles/engines: \$5.5B (Health Canada, 2016)
 - all on-road and off-road gasoline vehicles/engines: \$7.3B (Health Canada, 2017)
- Annual health impacts attributable to wildfire smoke for continental US (Fann et al. 2018):
 - \$11-20B for short-term (acute) impacts
 - \$76-130B for long-term (chronic) impacts

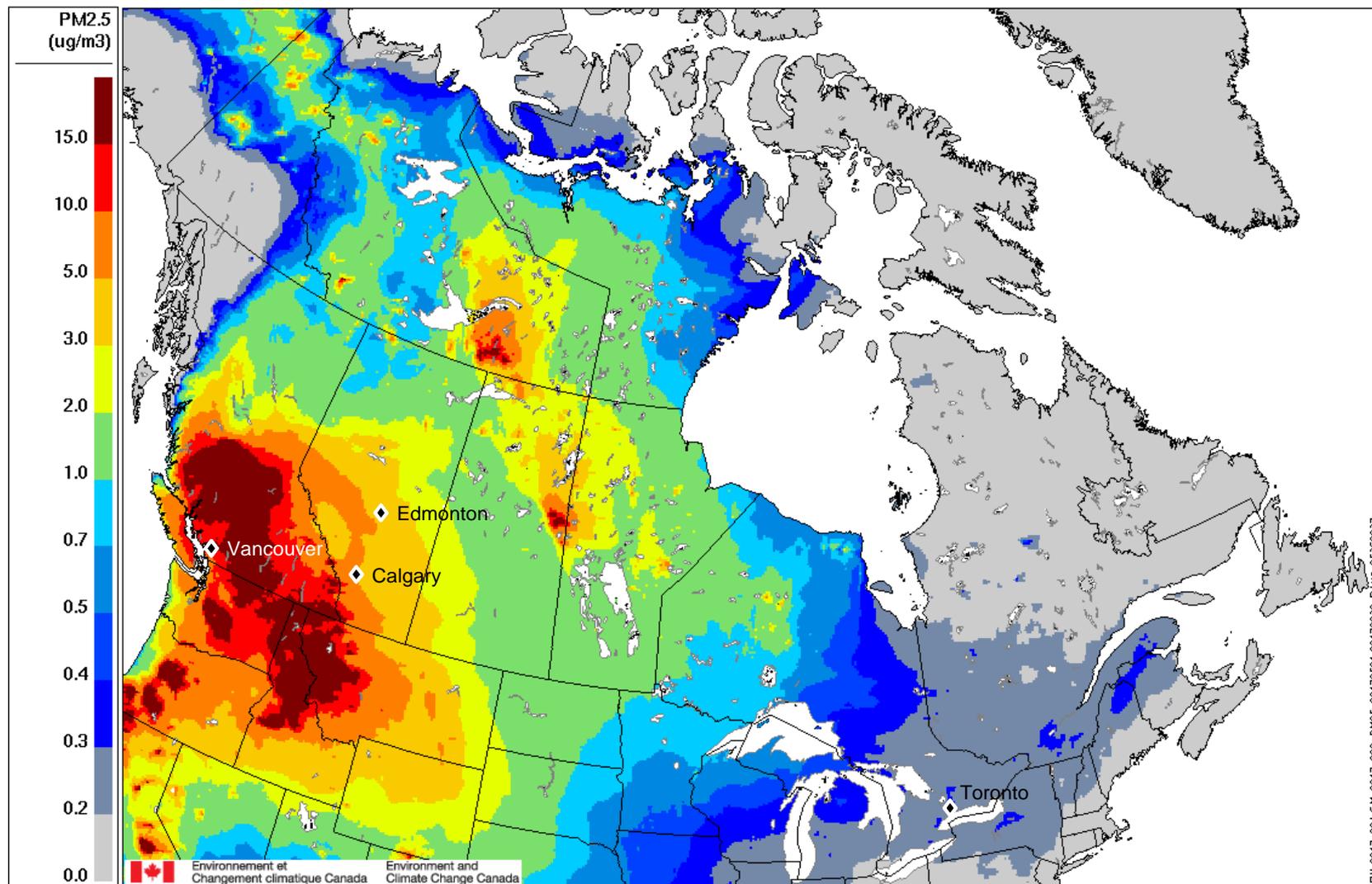
Regional Differences in Wildfire-PM_{2.5} Health Impacts

Top 10 most impacted Census Divisions for 2013-2015, 2017-2018

CD (Province)	Average wildfire-PM _{2.5} exposure (µg/m ³)	Acute exposure mortality	Valuation
Greater Vancouver (BC)	1.5	100	\$770M
Calgary (Alberta)	1.5	50	\$370M
Edmonton (Alberta)	1.3	46	\$350M
Central Okanagan (BC)	3.1	24	\$180M
Okanagan-Similkameen (BC)	4.4	22	\$170M
Fraser Valley (BC)	2.0	21	\$160M
Thompson-Nicola (BC)	3.7	19	\$150M
Capital (BC)	1.1	16	\$120M
Cariboo (BC)	5.3	13	\$98M
Toronto (Ontario)	0.2	13	\$96M

- BC and Alberta experienced the greatest number and severity of fires
 - Population centres in close proximity to fire activity
- Toronto is the largest Canadian population centre, not in close proximity to fire activity
 - Long-range transport of wildfire smoke and large population size

Regional Differences in Wildfire-PM_{2.5} Exposure (2017 as example)



Acknowledgements

- Project team and contributors:
 - Health Canada: Marika Egyed, Dave Stieb, Guoliang Xi, Robyn Rittmaster
 - Environment and Climate Change Canada: Jacinthe Racine, Radenko Pavlovic, Jessica Miville
 - BC Centre for Disease Control: Sarah Henderson

Questions?

Please send any inquiries to: carlyn.matz@canada.ca

