Long range wildfire forecast for Canada – Hot and Smoky? Is this the new Reality?

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Outline

- Fire in Canada
- Climate Change
- Impacts of climate change on wildfire
- What can we do?
Canadian Fire Statistics

- Incomplete prior to 1970.
- Currently - average of 7000 fires a year burn 2.5 - 3 million ha – doubled since the 1970s.
- Often high intensity/high severity crown fires.
- Area burned is highly episodic:
  - 0.4 to 7.6 million ha
- Lightning fires:
  - 40% of total fires
  - represent 80-90% of area burned
- Fire size:
  - 3% of fires are >200 ha
  - represent 97% of area burned
National map of the “human-wildland interface”
• Canadian fire management agencies among best in the world.
• Canadian Forest Fire Danger Rating System.
• Initial attack but if fire escapes…
• Traditional approach has been total fire suppression – now some regions use appropriate response (modified response).
Data Sources:
Forest Fires - Fire perimeter data has been provided by Canadian fire management agencies. Not all fires are shown. Locations are approximate.
Forest Fires – 3 Ingredients

- **Fuel** – type, loading, moisture, structure.
- **Ignition** - human and lightning
- **Weather** – hot, dry windy. Extreme weather
Fire Issues

• An average of $800 million spent by fire management agencies in Canada a year on direct fire fighting costs. These costs are rising
• Health and safety of Canadians – evacuations – smoke.
• Property and timber losses due to fire.
• Watersheds, water quantity and quality. Landslides
• Balancing the positive and negative aspects of fire.
• Traditional approaches to fire suppression (e.g., crews, air tankers) may be reaching their limit of economic and physical effectiveness.
Fire Impacts

- Location, location location
- Slave Lake May 2011
- Fort McMurray 2016.
- 2017 Chile, Portugal, Spain, South Africa, Ireland, Greenland, USA (CA) and Canada (BC, AB, NT, SK and MB).
- 2018 Greece, California, England, Sweden, BC, ON etc.
- Globally, smoke related fatalities estimated at 330,000 per year
CO2 concentrations are now unprecedented in at least the past 400,000 years
Incoming solar energy heats the Earth, and outgoing heat radiation cools it off.
2016 saw record highs for both land and ocean surface temperatures and set a combined global record for the third year in a row.
Sea ice melts in the spring and summer, and grows in the autumn and winter. Arctic sea ice typically reaches its maximum extent sometime between late February and early April, and since the start of the twenty-first century, those winter maximums have declined. Although Arctic sea ice in 2018 hasn’t broken all previous records for its low wintertime extent, it is still trending well below the 1981–2010 average. But as researchers watched Arctic sea ice in early 2018, they marveled at the high air temperatures over parts of the Arctic. In late February 2018, at Cape Morris Jesup, Greenland, the weather station closest to the North Pole (maintained by the Danish Meteorological Institute), temperatures climbed 45°F above normal for that time of year.
Climate Change Projections

- GCMs project up to a $6^0 \text{C}$ increase in global mean temperature by 2100.
- Greatest increases will be at high latitudes, over land and in winter/spring except the Arctic Ocean when seasonally ice-free.
- Projected increases in extreme weather (e.g., heat waves, drought, floods, wind storms and ice storms).
- Spatial and temporal variability in climate change.
Projected temperature changes vary considerably from year-to-year.
Projections of area burned based on weather/fire danger relationships suggest a 75-120% increase in area burned by the end of this century according to the Canadian and Hadley models respectively.
Area Burned – Alaska W. Canada

- Predicted mean annual area burned (km²/yr) per decade for Alaska and western Canada driven by the NCEP model development datasets (1990–2005) and the CGCM2 A2 and B2 climate scenarios (2006–2100).
Fire & Temperature

- Drier fuels
- Lightning
- Fire season

Photo credit: Government of the Northwest Territories
Methods - 1

• Three GCMs – CanESM2, HadGEM2-ES, CSIRO-Mk3.6.0

• Three RCPs – RCP2.6, RCP4.5, RCP8.5


• Canadian FWI System is a weather based system – temperature, relative humidity, wind speed and precipitation.
Methods - 2

- Calculate the fire intensity, rate of spread, depth of burn, fuel consumption, crown fraction burned using the Canadian Fire Behaviour Prediction (FBP) System as well as days above specified thresholds (e.g., HFI > 2,000 and 10,000 KW/m)

- Fuels – used a national fuel classification (250 m) for the forested regions of Canada. Aggregated fuels to a predominate fuel type for 40 km by 40 km cells.

- Time periods include baseline as well as 2021-2040 and 2081-2099.
Change in days with HFI > 2,000 kW/m

RCP4.5 2021-2040
Change in days with HFI > 10,000 kW/m

RCP4.5 2021-2040
Surface and Crown Fuel Consumption
Escaped Fires….

- Increased fire intensity may lead to more escapes
- Extended attack simulation showed that projected intensity increases resulted in very substantial increases in burned area
  - Driven by the change in frequency of being above suppression intensity thresholds
A wild card – the Jet Stream

- Band of fast moving air – energy derived from the temperature difference between equatorial regions and polar regions.
- Jet streams determine the strength and movement of the synoptic weather systems.
- Climate change is causing a weakened of the jet stream as the temperature difference between the equator and poles decreases.
- Atmospheric patterns – stagnate, meandering – more extremes – droughts, floods, heat and cold.
Development

• Now more than ever Canadians live and work in the forest.
• Development increasing in parts of the country.
• More people = more fire and more exposure to fire.
• We can make communities more fire-resistant but not fire-proof.

In the last 10 years, 60% of new homes in the U.S. have been built on lands adjacent to fire-prone public lands.

Op-Ed Why do we keep putting people in the way of wildfire? The wrong carrots and sticks.
How can we manage wildland fire

- Fuel, ignitions and hot, dry windy weather are part of our future so we need to learn to live with fire.
- That is, we have to allow fire on the landscape but when and where we want it (Appropriate Response).
- From the wildland fire perspective 3 ingredients but we can only manage the fuel and human-caused fires.
- Context for Canada – climate change = more extreme weather = more fire on the landscape.
- FireSmart Canada – fuel management, planning, education, cooperation, training and development.
Manage wildland fire in the future

- Update the Canadian Forest Fire Danger Rating System.
- Need for an Early Warning System
- Use machine learning (AI) to identify severe fire weather episodes (Self Organized Maps).
- Use machine learning in building fire occurrence prediction systems.
- Enhance existing fire decision support systems
- More remote sensing
- Focus on community zones (sprinklers) and Initial Attack
- Emergency management phases – prevention, mitigation, preparedness, response, recovery (review)
- Explore fuel management, in concert with harvesting, grazing and carbon management.

Courtesy of Steve Taylor CFS
Regional Variability

- Possibility of semi-permanent (blocking) patterns of the synoptic weather systems.
- More extremes – drought and fire and precipitation and flooding depending on where the ridges and troughs are.
Area Burned in BC by Year (as of September 9, 2018)
Summary

- Fire and weather are strongly linked

- Changes in forest fires may be the greatest early impact of climate change on forests

- Fire activity will increase in a changing climate, but will be variable in time and space

- Longer fire seasons and this can be a problem for fire management as high intensity fires will occur outside the traditional/historical fire season.
More fire occurrence, more crown fires (higher intensity), increased fuel consumption and more area burned.

More fire activity in the future and our fire management approaches have to adapt to this new reality.

May be entering new territory with no historical analogues. The unknown unknowns.

Fire and society interactions will increase in the future.

Need for significant investment in research and development