Climate Change and Wildland Fire Intensity

Mike Flannigan, Mike Wotton and Ginny Marshall
University of Alberta, University of Toronto, Natural Resources Canada – Canadian Forest Service
Outline

• Fire in Canada
• Climate change
• Fire Intensity and Climate change
Fire Impacts

- Location, location location
- Slave Lake May 2011
- Fort McMurray 2016
- Smoke related fatalities estimated at 330,000 per year
Canadian Fire Statistics

- Incomplete prior to 1970
- Currently - average of 7000 fires a year burn 2-2.5 million ha – about 1 million ha in the early 70s
- Primarily crown fires
- Area burned is highly episodic
  - 0.4 to 7.6 million ha
- Lightning fires
  - 35% of total fires
  - represent 85% of area burned
- Fire size
  - 3% of fires are >200 ha
  - represent 97% of area burned
Forest Fires – 3 Ingredients

- Fuel – type, loading, moisture, structure, chemical composition etc.
- Ignition - human and lightning
- Weather - temperature, precipitation atmospheric moisture and wind; upper atmospheric conditions (blocking ridges), sunshine
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 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)
Projected temperature changes vary considerably from year to year.

CCCma Surface Temperature Change Projection for 1990
Simulated by CGCM1 (http://www.cccma.bc.ec.gc.ca)
Fire & Temperature

- Key variable in fire activity for 3 reasons
  - First, the amount of moisture the atmosphere can hold is highly sensitive to temperature. This drives fuel moisture; if temperature increases then significant increases in precipitation are needed to compensate. Approx. 15% increase in prec. for every degree of warming.
  - Second, temperature has a strong positive correlation with lightning...the warmer it is the more lightning we have.
  - Third, the warmer it is the longer the fire season; particularly important at high northern latitudes.

Future Fire

- Changes in climate (including warmer temperatures, changes in precipitation, atmospheric moisture, wind, and cloudiness) affect wildfires
- Direct, indirect, and interactive effects of weather/climate, fuels, and people will determine future fire activity

Area burned
Fire occurrence
Fire season
Fire intensity
Fire severity


Relative change (percentage increase) in fire occurrence between future and baseline scenarios for the Canadian Climate Centre GCM. Relative change is given as the percentage increase in number of fires predicted by the GCM (future scenario minus baseline scenario) divided by the total number of fires in the baseline scenario (i.e., (N2020-2040 – N1975-1995)/ N1975-1995); “no data” is shown in white.
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.
• 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.
Percent change in days with HFI > 2,000 kW/m

RCP4.5 2021-2040
Change in days with HFI > 2,000 kW/m

RCP4.5 2021-2040

Legend:
- < 0
- 0
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 +
Change in days with HFI > 10,000 kW/m

RCP4.5 2021-2040
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

Summary

- Significant increases in fire intensity expected in a warmer world especially towards the end of the century.

- Increases in the number of days with head fire intensity above 2,000 and 10,000 kW/m may significantly impact fire management with increases in fire escapes and area burned.
Alberta is Different

- Spring fires
- Human-caused
- 10 year average of 1500 fires burning 200,000 ha
- 2015 1700 fires burned almost 500,000 ha
Trend Observations

- Is area burned correlated with increasing temperature?
- Is this caused by anthropogenic effects?

Fire Issues

- An average of $800 million spent by fire management agencies in Canada a year on direct fire fighting costs
- Health and safety of Canadians – evacuations, impacts on economic activity – smoke
- Property and timber losses due to fire
- Balancing the positive and negative aspects of fire (Appropriate Response)
- Traditional approaches to fire suppression (e.g., crews, air tankers) may be reaching their limit of economic and physical effectiveness
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 may be causing a weakening 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
Weather is a component in all 3 natural factors – fuel, ignitions (Lightning) -.

Options -Weather – we can’t control; only options are fuel and human-caused fire ignitions

Prevention – education, restricted fire zones, reduce or eliminate industrial activity during periods of high fire danger, enforcement

Fuel – modifications – fuel break, reduce fuel load or change fuel type (deciduous versus conifer) either at the landscape level (strategically) or areas of high value (e.g., communities)
Fire & Temperature

- Key variable in fire activity for 3 reasons
- First, the amount of moisture the atmosphere can hold is highly sensitive to temperature. This drives fuel moisture; if temperature increases then significant increases in precipitation are needed to compensate. Approx. 15% increase in prec. for every degree of warming.
- Second, temperature has a strong positive correlation with lightning…the warmer it is the more lightning we have.
- Third, the warmer it is the longer the fire season; particularly important at high northern latitudes.
http://www.esrl.noaa.gov/gmd/ccgg/trends/
Percent change in days with HFI > 10,000 kW/m

RCP4.5 2021-2040
Change in days with HFI > 10000 kW/m

RCP4.5 2021-2040
Fire & Temperature

• Key variable in fire activity for 3 reasons
• First, the amount of moisture the atmosphere can hold is highly sensitive to temperature. This drives fuel moisture; if temperature increases then significant increases in precipitation are needed to compensate. Approx. 15% increase in prec. for every degree of warming
• Second, temperature has a strong positive correlation with lightning...the warmer it is the more lightning we have.
• Third, the warmer it is the longer the fire season; particularly important at high northern latitudes.
Fire Ecology - Boreal

- Boreal – stand renewing crown fires removes competition, allows sunlight to reach the forest floor and reduces or removes the organic layer (prepares the seed bed)
- Standard succession models not applicable to much of the boreal
- WYSIWYG applies
- Strategies – serotinous cones, suckering, sprouting, thick bark, seed bank
Change in days with HFI > 2000 kW/m

RCP4.5 2021-2040
Percent change in days with HFI > 2000 kW/m

RCP4.5 2021-2040