Fire and Climate Change

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Outline

- Fire background
- Climate change and impacts of climate change on fire activity
- Peatfire – a wildcard
Fire Impacts

- Location, location location
- Australia 2009, 2013, Russia 2010 and southern USA 2011
- Alberta 2011
- Waldo Creek Fire & High Park Fire 2012
- Smoke fatalities estimated at 330,000 per year
Canadian Fire Statistics

- Incomplete prior to 1970
- Currently - average of 8000 fires a year burn 2 million ha – 1 million ha in the early 1970s
- AB 1400 fires 140,000 ha
- SK 560 fires 600,000 ha
- MB 510 fires 140,000 ha
- 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
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
- 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 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 climax succession models not applicable to much of the boreal
- WYSIWYG applies
- Strategies – serotinous cones, suckering, sprouting, bark thickness and avoidance
Forest Fires – 4 Key Factors

- Fuel - loading, moisture, structure etc.
- Ignition - human and lightning
- Weather - temperature, precipitation, atmospheric moisture and wind; sunshine, upper atmospheric conditions (blocking ridges)
- Humans - land use, fragmentation, fire management etc.
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 either at the landscape level (strategically) or areas of high value (e.g., communities)
There are definite linkages between climate oscillations/patterns and fire activity at scales of 2-50 years. Understanding these relationships will help prepare fire seasonal forecasts as well as multi-year forecasts. Climate oscillations/patterns such as ENSO, PDO, AO and AMO influence climate and weather and thereby fire activity. Just starting to understand the relationships – interactions between these processes.

Atmospheric CO$_2$ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
2010 Mean Annual Temperature Anomalies
Climate Change Projections

- GCMs project 1.4 – 5.8°C increase in global mean temperature by 2100
- Greatest increases will be at high latitudes, over land and winter/spring
- Projected increases in extreme weather (e.g., heat waves, drought, floods, wind storms and ice storms)
- Observed increases across west-central Canada and Siberia over past 40 years
Impacts of a Changing Climate are already evident

- Spruce Beetle
- Mountain Pine Beetle
- Forest fires and smoke
- Drought impacts on regeneration
- Aspen dieback
- Winter harvesting problems
- Permafrost melting
- Wind throw / blow down
- Spruce budworm
- Eastern forests (increased growth?)
Minimum annual extent of Arctic sea ice is decreasing faster than all model projections.
Polar Ice Cap – Rapidly melting
Variability

- Variability – a real problem for fire with respect to extremes – a few critical days are responsible for most of the area burned
- Fire then flood
- Flood then fire
- Wind – average unchanged but more variable; more extreme wind events
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).

Trend Observations

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

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. 10% 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.
Fire and Carbon

Fire plays a major role in carbon dynamics: it can determine the magnitude of net biome productivity

1) combustion: direct loss

2) decomposition of fire-killed vegetation

3) Change in vegetation type: different sink potential when there is a change in vegetation type. 
Example forest stand renewal – young successional stands have potential to be greater sinks than mature stagnant forests
The role of Peat

- 700 Pg carbon stored in the boreal forest ~30-35% of the global terrestrial biosphere. Peat is a major component.
- Climate change will mean the melting of permafrost, more droughts which suggest peat fires will be more common.
- Peat fires can release significant amounts of GHGs for example peat fires in Indonesia during 1997 released the equivalent of 20-50% of global fossil fuel emissions. Peat in the boreal dwarfs the amount of peat in tropical regions.
- Difficult to extinguish; can burn through winter under the right conditions.
Fire and Weather Feedbacks: potentially positive

Fossil Fuel emissions: increase greenhouse gases

Cause warmer conditions

Weather becomes more conducive to fire: more fire

Carbon released from more fire enhances greenhouse gases further
Fire and weather are strongly linked

A warmer world will have more fire - Changes in forest fires may be the greatest early impact of climate change on forests

Increased risk in the future due to increased fire activity – there will be more incidents like Slave Lake, Kelowna, Colorado Springs etc. in the future

Traditional approaches to fire management may no longer be viable

There is the potential for a positive feedback with fire and GHGs
The best way to have a good idea is to have lots of ideas. -Linus Pauling
Modern fire management is challenging today; new approaches will be needed in the future.

Less sophisticated fire management approaches will be completely overwhelmed.
Global Wildland Fire

- On average about 350-450 M Ha burn every year. Larger than the size of India
- No idea as to how many fire starts though people are probably responsible for about 90% of the starts
- Largest area burned is in grasslands and savannas
- Fire is a necessary component in some ecosystems
Future Global Fire Regimes

- Used the Canadian Forest Fire Danger Rating System. The CFFDRS is used across Canada and in many parts of the world.
- Used a cumulative DSR to determine the severity of the fire season. The DSR is function of the FWI to provide a measure of the control difficulty to suppress a fire.
- Changes in fire season length
Options and Adaptations

- Health and safety of Canadians through improved fire weather and fire behaviour systems. The Canadian Forest Fire Danger Rating System is used across Canada and in many parts of the world.
- Adaptation options for fire management agencies with respect to climate change altered fire regimes including community protection.
- Adoption of the Canadian Wildland Fire Strategy.
Used NCEP reanalysis data to calculate the Canadian Fire Weather Index System components including DSR for the world 1971-2000.

The Canadian FWI System is used across Canada and in many parts of the world.

Used a cumulative DSR to determine the severity of the fire season. The DSR is function of the FWI to provide a measure of the control difficulty to suppress a fire.
Three emission scenarios –A1B, A2, B1 from three GCMS – Canadian, Hadley and French IPSL. Superimposed anomalies from a future decade/baseline to the NCEP data - calculated the FWI System components with the revised NCEP data.

Calculated cumulative DSR and fire season length – present and future.
Options and Adaptations - 2

- Protecting buildings and communities
- FireSmart programs aimed at reducing risk to your property and communities
- Building materials – landscaping; defensible space helps but spotting appears to be a serious problem
- Treating fuels near communities – removing fuel, changing fuel type from conifer to deciduous, sprinklers
- More people living and working in the forest – risk will increase
- [http://partnersinprotection.ab.ca/](http://partnersinprotection.ab.ca/)
Only 2% of Canadians deny climate change, suggests poll
Prairie respondents least likely to believe climate change occurring due to human activity

The Canadian Press
Posted: Aug 15, 2012 7:00 AM MT
Last Updated: Aug 15, 2012 8:40 AM MT

Read 574 comments
Climate Change & Fire Protection

- A simple level of protection experiment
  - Used Ontario’s level of protection analysis system
  - Climate change scenarios for 2040 (2×CO₂)
    - Increased fire occurrence
    - Increased spread potential
  - A range of resource increases over current levels

- Results:
  - To maintain current level of fire escapes – must double the fire suppression resources in Ontario

Changes in number of fires escaping initial attack

Graph showing changes in resource levels (fire crews, helicopters, airtankers) from current levels.
GCMs Daily method
Global surface temperatures are rising
Options and Adaptations

- Updated and enhanced fire danger rating systems
- Global Early Warning Systems
- Regional cooperation – resource sharing
- Training and education – FireSmart, FireWise programs
- Promotion and enforcement of policies and practices that will discourage unwanted fires
Cumulative DSR Anomalies
b1 2091-2100 / NCEP 1971-2000 (Canada/FRance/PSU/Hadley Model Agreement)

Legend:
- Red: Increase (3 scenarios agree)
- Orange: Mostly Increase (2 scenarios agree)
- Yellow: No Change (>= 2 scenarios agree)
- Green: Mostly Decrease (2 scenarios agree)
- Blue: Decrease (3 scenarios agree)
- Light Green: Undetermined (0 scenarios agree)

Scale: 1,500, 3,000, 7,500, 11,700, 15,600 Kilometers
Summary

- Fire and weather are strongly linked; a warmer world will have more fire

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

- Traditional approaches to fire management may no longer be viable

- Potential for significant positive feedback through peatfires

- Need for international cooperation
  Early warning system
  Sharing resources
  Cooperative research

http://www.ualberta.ca/~wcwfs/
2010 Mean Annual Temperature Anomalies
Fire – weather/climate Interactions

- We still have a lot to learn about climate patterns and fire activity.
- There are definite linkages between sea surface temperatures and patterns and fire activity at scales of 2-50 years.
- Understanding these relationships will help for seasonal forecasts as well as multi-year forecasts.
- Climate oscillations/patterns such as ENSO, PDO, AO and AMO influence climate and weather and thereby fire activity.
- Just starting to understand the relationships – interactions between these processes.
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Canada Annual Area Burned

Area burned (ha) and number of fires in Canada from 1921-2006

- Million hectares burned
- Area Burned (ha)
- Number of Fires
- Date
- 1921-1930
- 1931-1940
- 1941-1950
- 1951-1960
- 1961-1970
- 1971-1980
- 1981-1990
- 1991-2000
- 2001-2010

- 0
- 2
- 4
- 6
- 8
- 2000
- 1920
- 1940
- 1960
- 1980
- 2000
- 0
- 20000
- 40000
- 60000
- 80000
- 100000
- 120000
- 15000000
- 20000000
- 25000000
- 30000000
- 0
- 10000
- 20000
- 30000
- 40000
- 50000
- 60000
- 70000
- 80000
- 90000
- 100000
- 110000
- 120000
- 130000
- 140000
- 150000
- 160000
- 170000
- 180000
- 190000
- 200000
- 210000
- 220000
- 230000
- 240000
- 250000
- 260000
- 270000
- 280000
- 290000
- 300000

Area Burned (ha) – Number of Fires
Precipitation Change by 2050
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
- 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
Blocking (Stationary) Ridges

- Important to fire activity because descending air associated with upper ridges - warm/hot, sunny and dry conditions
- Last 7-10 days or more and allows the forest fuels to dry out (FFMC and DMC to increase significantly)
- When the upper ridge breaks down there can be thunderstorms with strong gusty winds and often have a change in wind direction
- Models suggest that in the future there will be stronger blocking ridges that may last longer than present day
Wildland Urban Interface

- On average a total of 5500 people are evacuated from 10 communities per year.
- On average 20 communities with about 70000 people are threatened by large fires each year.

Reasons for evacuations:
- Threat life/property: 62%
- Smoke and health: 14%
- Transportation: 3%
- Unknown: 21%
Fire Impact & Wildland Urban Interface - A recent example

- Slave Lake -065; May 14 ignition – rapid spread May 15 afternoon
- 4700 ha
- Over 400 structures burned; damages over 740 Million $
- Winds 50-60 km/h Gusting 89km/h Rh 15% Temp 20C
- Spotting 2km
People and Fire

- Human impacts on fire:
  - Land use change including clearing and abandonment
  - Fire management
  - Ignitions accidental and deliberate

- Fire impacts on humans:
  - Loss of life, infrastructure evacuations, air quality, water quality
  - Fire suppression costs
  - Indirect, climate change and ecological benefits
Fire Management

- Wide range of fire management activities and effectiveness
- Many billions of dollars spent every year on direct fire management
- Fire management replacing fire suppression in some regions – delicate balancing act; protection vs. ecology