HOT HOT PEAT!
Managing Boreal Peatland Wildfires in an Era of Climate Change

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Canada’s boreal biome is a mosaic of forests and wetlands shaped by wildfire.
BOREAL BURNING!
Annual burned area in Canada: 2.6 Mha (0.4 to 7.6 Mha)

Fire suppression costs: ~$0.5-1 billion/year

Annual area burned is increasing
Fire management costs are increasing and expected to rise greatly
BOREAL BURNING
Unprecedented Landscape Change

Landscape fragmentation
Wildfire suppression legacy
Warmer climate, increased drought
More people living and working in the boreal
BOREAL BURNING!
Slave Lake 2011

$0.7B in damage

>700,000 ha burned in Alberta

Decline in oil and gas exports: drop in GDP

Fire management issue: Black Spruce → Spotting
BOREAL BURNING!
Fort McMurray 2016

“The Beast”
2,400 buildings destroyed
>$3.5B in damage
>600,000 ha burned

Source: CBC.ca (http://thumbnails.cbc.ca/maven_legacy/thumbnails/759/691/ft-mcmurray-first-nations-northcott-050816.jpg

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Source: CBC.ca (http://thumbnails.cbc.ca/maven_legacy/thumbnails/759/691/ft-mcmurray-first-nations-northcott-050816.jpg
BOREAL BURNING!
Fort McMurray 2016
Fire management issue: Peat → Smouldering

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Photo credit: Leyland Cecco
BOREAL BURNING!
Black Spruce Peatlands

“Alberta’s Public enemy #1”

• problematic for fire managers
• spotting embers up to 2 km
• smouldering fires (hold over)
BOREAL PEATLANDS

Public Enemy #1?

Ecosystem Services
~33% of World’s soil carbon
~10% World’s fresh surface water

**See Maria Strack’s presentation on Jan 31**

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BOREAL BURNING!
Wildfire Propagation

Combustion energy \( (H_{comb}) > \) Ignition energy \( (H_{ign}) \)

- Fuel load, wind speed, flame length
- Evaporate moisture, heat fuel to ignition temperature
BOREAL BURNING!
Wildfire Propagation (natural firebreak)

Natural Firebreak
($H_{\text{ign}} \gg H_{\text{comb}}$)

soil is wet!
BOREAL BURNING!
Wildfire Propagation (natural fuel supply)

$R^2 = 0.44; \ p = 0.0001$

PEATLANDS & WILDFIRE

Wildfire propagation and peat burn severity

Moss species → patterns in peat burn severity
PEATLANDS & WILDFIRE

Peat burn severity is a vertical wildfire propagation problem

Peat Smouldering and Ignition model for landscape scale patterns

Source: Thompson et al., 2015 (International Journal of Wildland Fire); Benscoter et al., 2011 (IJWF)
PEATLANDS & WILDFIRE
High *Sphagnum* water content (and retention) limits the proportion of landscape that can ignite.
Sphagnum the SUPERMOSS

*Sphagnum fuscum*
- keystone species
- high moisture retention
- drought resistant
- fire resistant

*Sphagnum’s kryptonite?*
- shade
- leaf litter
- high tension in dense peat
BOREAL BURNING!
Wildfire propagation and burn severity

PEATLAND AFFORESTATION

Drying and wildfire

- Decrease water table
- Increase peat density
- Increase tree growth and cover
- Decrease Sphagnum moss
- Increase fuel for wildfire
- Increase evapotranspiration
- Increase rainfall interception
- Decrease moisture content
- Increase burn severity

BOREAL BURNING

Horse River Creek Wildfire (Fort McMurray, AB) (>600,000 ha)

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Photo credit: MCPL VANPUTTEN / AFP/Getty Images
PEAT DRYING & WILDFIRE

Drainage/Drying & Wildfire “Experiment”

- Moderately Drained: 18 m ditch spacing
- Heavily Drained: 9 m ditch spacing
- Undrained: > 30 m from ditch

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PEAT DRYING & WILDFIRE

Hydrological drainage (drying) increases burn severity
HD: > 50% of peatland carbon lost via combustion

Source: Wilkinson et al., 2018 (Environmental Research Letters)
BOREAL BURNING!

Hydrological drainage enhanced afforestation (tree productivity)
BOREAL BURNING
Experimental: Drying, wildfire & peatland afforestation
BURNING and REGIME SHIFT

No *Sphagnum* recovery 10 years post-fire

Source: Kettrridge et al. (2015) Nature Scientific Reports
Regime shift increases vulnerability to future wildfire and degrades carbon stock

WILDFIRE MANAGEMENT

REMOVE TREES

RESTORE MOSS

PROJECT

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# Tree removal (fuel treatments)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stem Density/ ha</th>
<th>Canopy Fuel Load kg m(^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4000</td>
<td>1.2 (0.4)</td>
</tr>
<tr>
<td>Stripped</td>
<td>650</td>
<td>0.5 (0.1)</td>
</tr>
<tr>
<td>Thinned</td>
<td>400</td>
<td>0.3 (0.1)</td>
</tr>
</tbody>
</table>

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WILDFIRE MANAGEMENT
Fuel Reduction Experimental Fire
Post-Fire Results: Depth of Burn

Mean DOB (mm):
- Control: $55 \pm 51$ mm,
- Stripped: $50 \pm 54$ mm,
- Thinned: $31 \pm 33$ mm
Post-Fire Results: Carbon Loss

- Peat carbon loss greatest in Stripped treatment
- Thinned treatment has greatest surface fuel carbon loss
- Similar losses to severe peat smouldering fire
Sphagnum Moss Restoration

**See Maria Strack’s presentation on Jan 31**
Sphagnum Moss Restoration

Recall, wildfire propagation: $H_{\text{comb}} > H_{\text{ign}}$

- Restore low density, high moisture content surface layers
- Decrease $H_{\text{comb}}$
- Increase $H_{\text{ign}}$
WILDFIRE MANAGEMENT

Restore Sphagnum Moss – Modelling Assessment

Source: Granath et al. 2016 (Nature Scientific Reports)
BURNING PEAT!

Wainfleet Bog: Drained and Mined (17 kg C m\(^{-2}\) lost)

Source: Granath et al. 2016 (Nature Scientific Reports)
BURNING PEAT!
Burns Bog (Vancouver, BC)
July 3, 2016
BOREAL BURNING!
Moscow 2010 Peat Fires

1,000 smouldering peat fires (200,000 ha burned)
>$10B in damage

Extreme smoke pollution caused > 3,000 deaths

Source: Shaposhnikov et al., 2014 Epidemiology
SUMMARY

Wildfire area burned is increasing due to past fire suppression, more human activity, and increased drought

Black spruce peatlands: Alberta Public Enemy #1

Wildfire severity likely can be mitigated through prescribed burning, fuel treatments and moss restoration
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