



**Early Warning Systems for Enhanced Situational  
Awareness and Preparedness for Spring Wildfire  
Activity: Challenges and Opportunities**

**November 4 – 5, 2019**

**Multi-Hazard Risk and Resilience Workshop**

**by**

**Cordy Tymstra  
University of Alberta**



# *Presentation Outline*

- *Wildfire management in Canada: Overview*
- *Wildfire situational awareness and preparedness*
- *Spring wildfire activity in Alberta*
- *Horizon scanning and foresight: Challenges and opportunities*





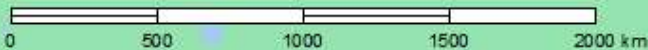
Natural Resources Canada  
Ressources naturelles Canada

# 1980-2018 Forest Fire Perimeters Périmètres des feux de forêt

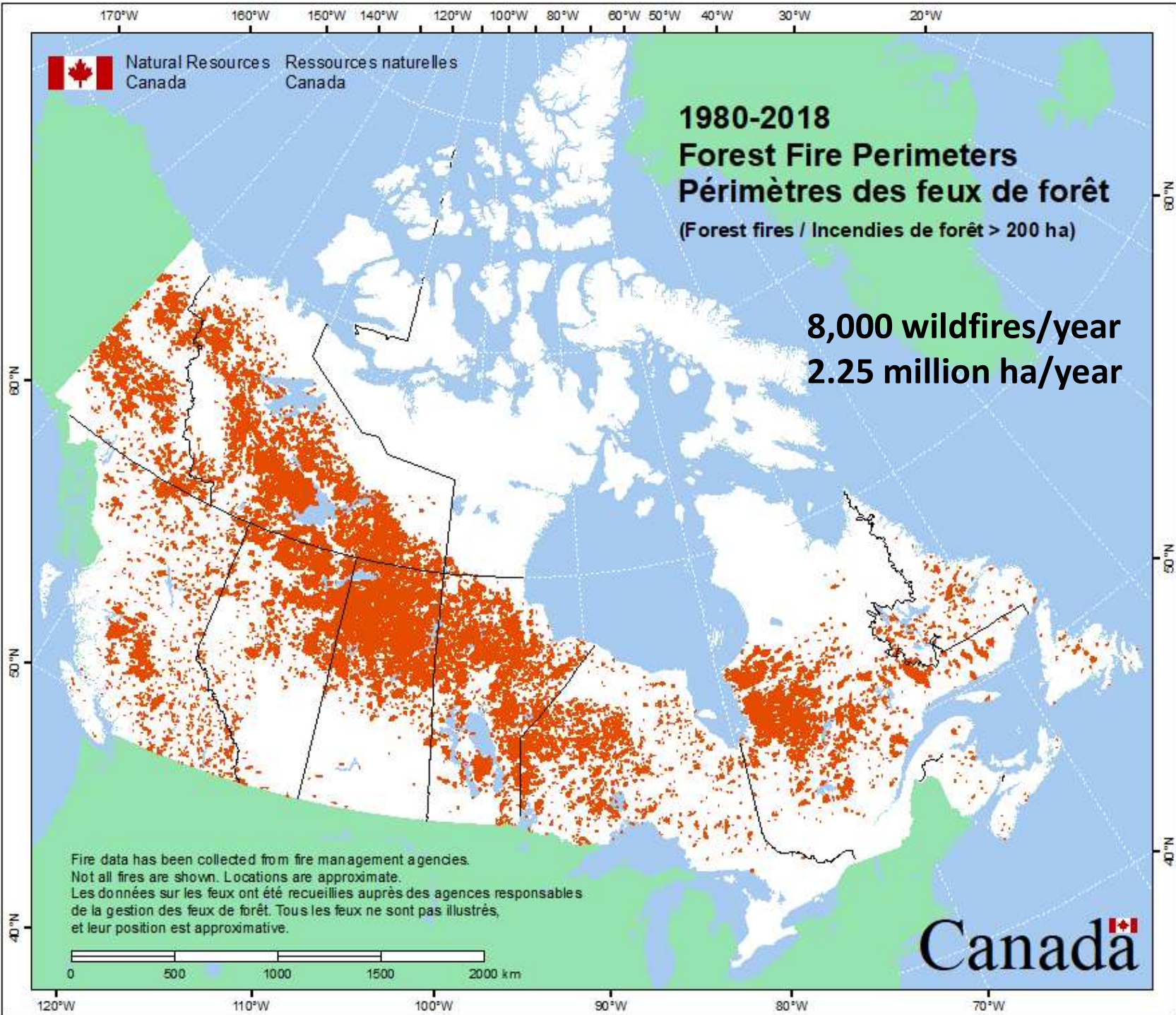
(Forest fires / Incendies de forêt > 200 ha)

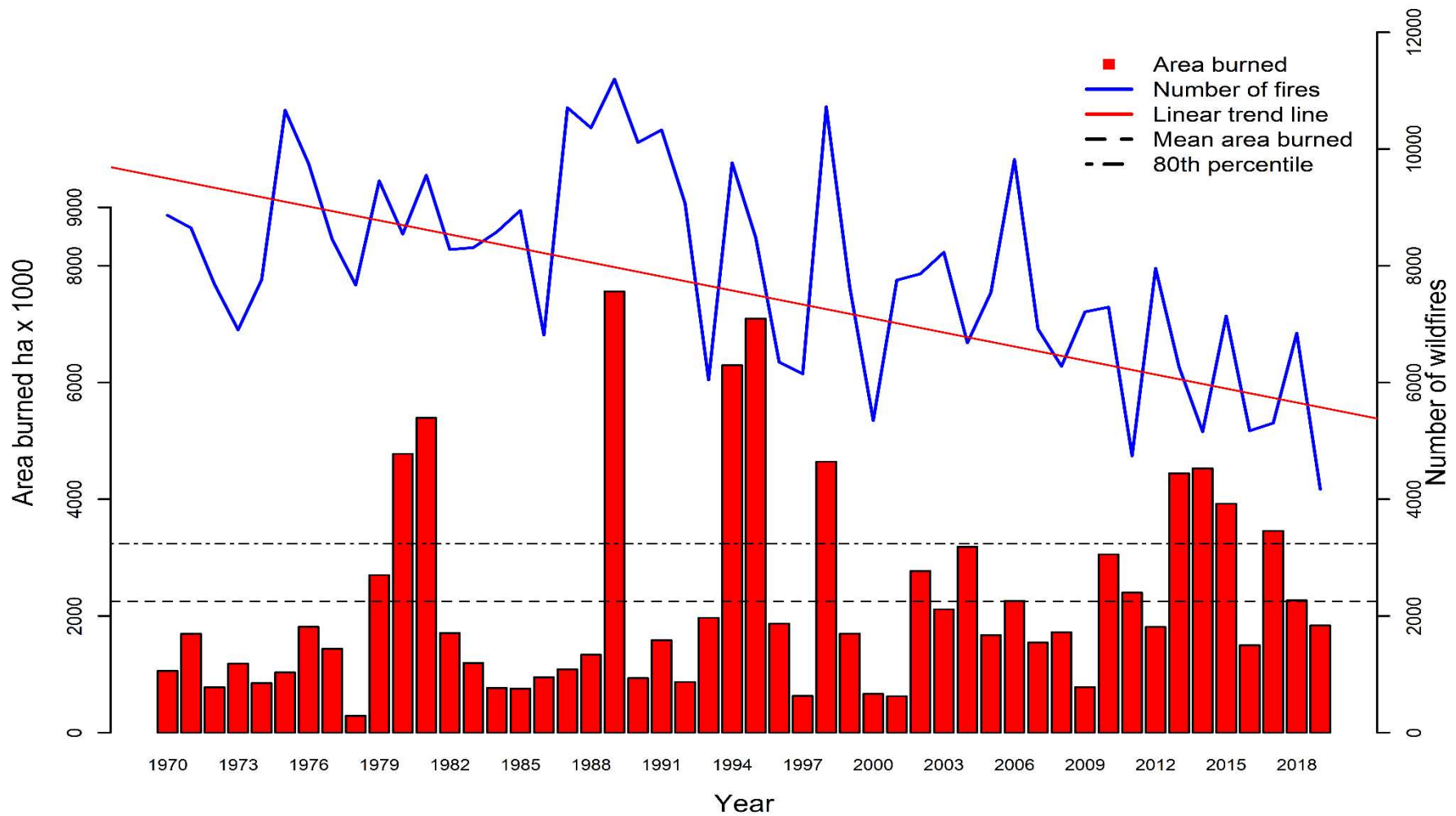
**8,000 wildfires/year**  
**2.25 million ha/year**

Fire data has been collected from fire management agencies.  
Not all fires are shown. Locations are approximate.  
Les données sur les feux ont été recueillies auprès des agences responsables  
de la gestion des feux de forêt. Tous les feux ne sont pas illustrés,  
et leur position est approximative.



Canada





**Approximately 40% of wildfires are caused by lightning, but they account for about 80% of the total area burned.**



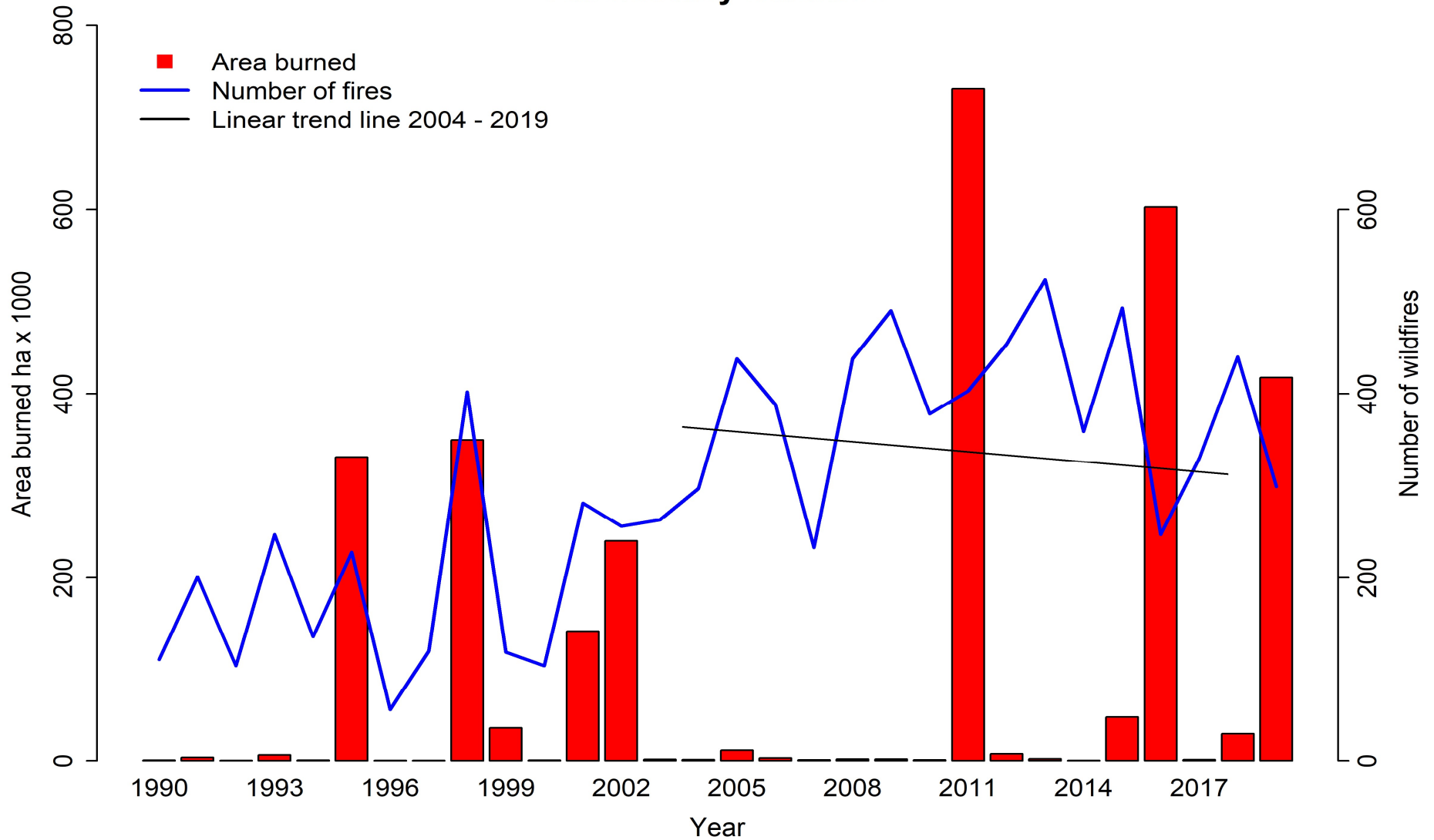
- ***Stocks (2002)***

- ❖ ***3% of wildfires > 200 ha = 97% of area burned (1959 – 1997)***

- ***Updated to 2017***

- ❖ ***4% of wildfires > 200 ha = 99% of area burned***

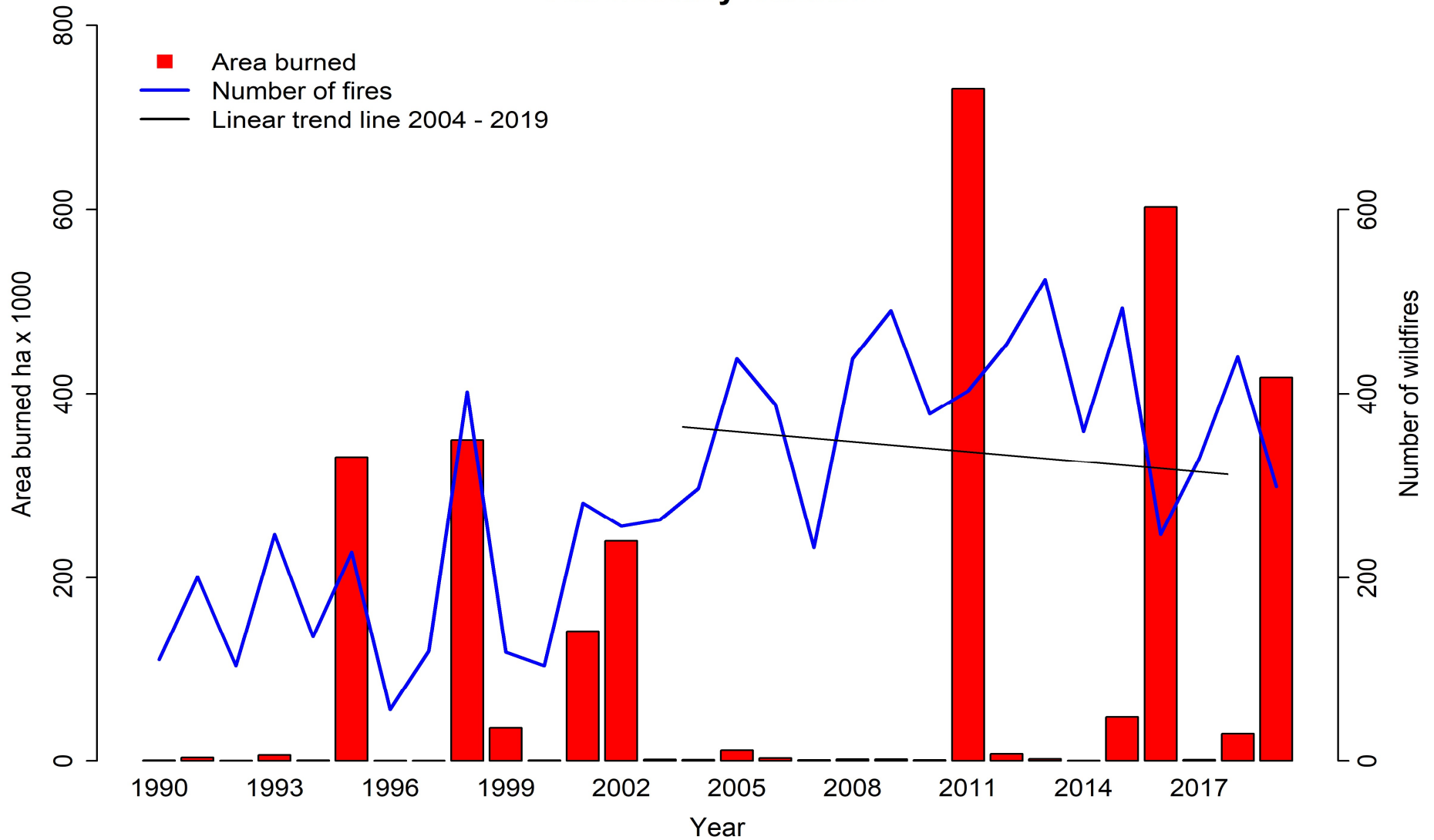
## Alberta May Wildfires



**1995: Minimum reporting size changed from 0.1 to 0.01 ha**  
**2004: OTR and XA wildfires were reported**



## Alberta May Wildfires



**May accounts for 23% of the total number of wildfires and 55% of the total area burned March 1 – October 31 (1990 – 2019). Lightning causes 17% of wildfires; humans cause 83% of wildfires in May.**







CANADIAN INTERAGENCY FOREST FIRE CENTRE INC.  
CENTRE INTERSERVICES DES FEUX DE FORÊT DU CANADA INC.



## CIFFC R Us

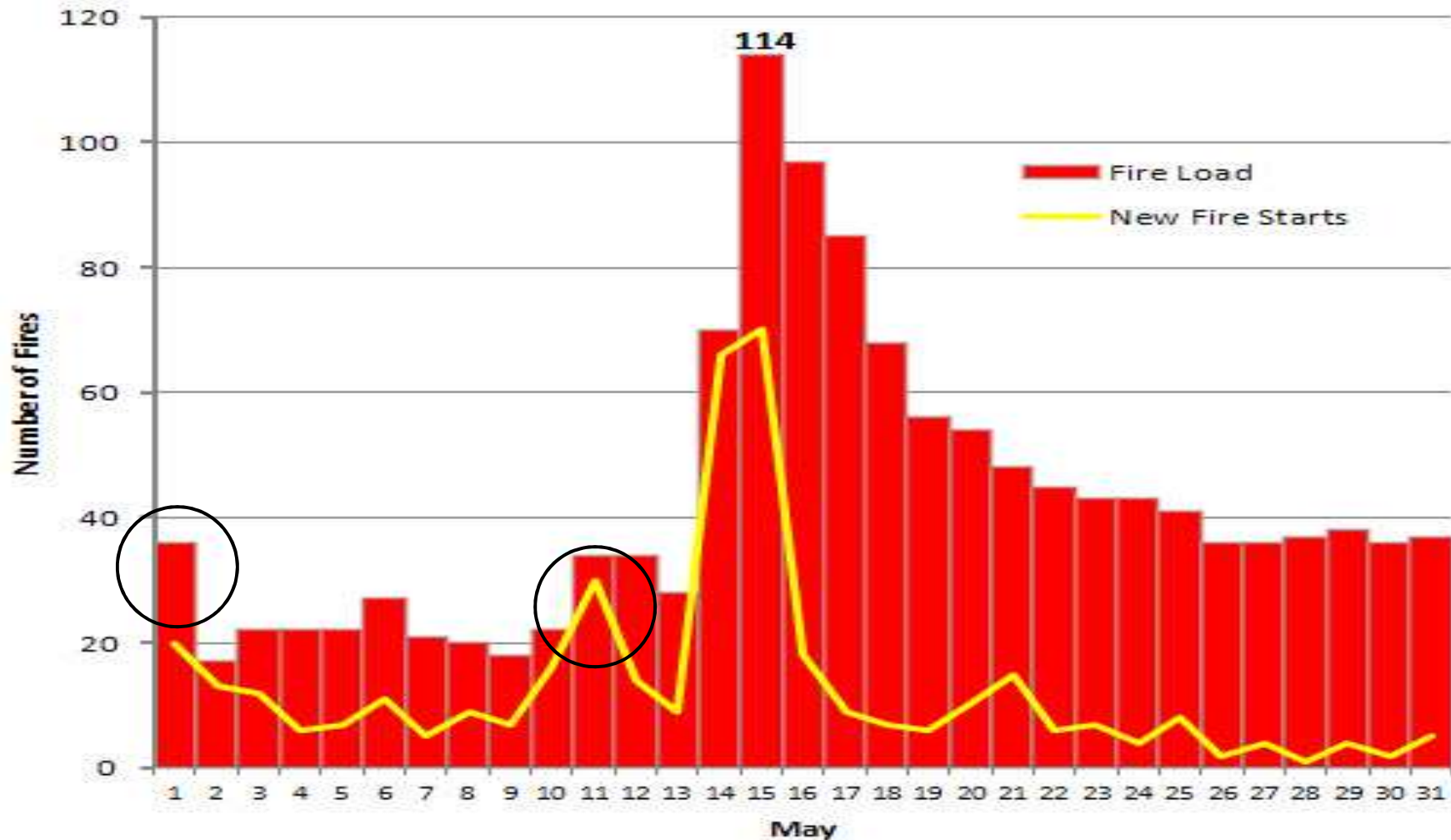
**Coordinates resource sharing, mutual aid, and information sharing;**

**Facilitate communication, cooperation, coordination and collaboration to advance wildland fire management in Canada.**

**CIFFC 2.0...?**

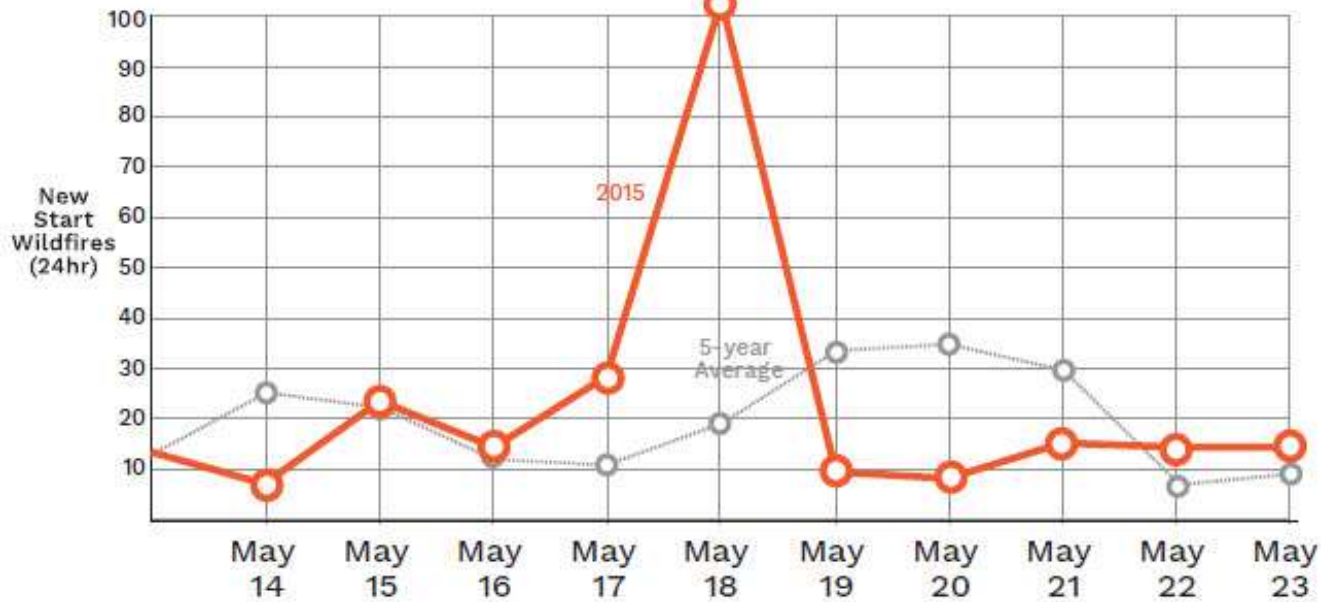
**May 11 – 15, 2011**

**22 on-going fires + 189 new starts = 211 fires**



**53 new fires in Lesser Slave Area May 14 – 15, 2011  
(all except 2 were human-caused fires)**

# Alberta 2015



## 2015 Resources

1,128 imported fire fighters

Resource Request Orders:  
14 agencies

4 - 5 days  
(in Canada)

~20 days  
~10 days with agreement in place (outside Canada)

# Alberta Wildfire Management Branch Resource Exchange



**2011 – 2019: 120,000 person days imported vs  
35,000 person days exported**



## ***2017 British Columbia Fire Season***

- **1,347 wildfires burned 1.2 million ha (worst fire season on record)**
- **Over 220 wildfires started July 6 - 8**
- **65,000 people displaced**
- **Provincial emergency declaration July 7 to Sept. 15 (70 days!)**
- **Canadian Armed Forces assisted (first time since 2003)**



**British Columbia reported 173 wildfires on July 7, 2017**



# *Wildland Fire Management Approach*

## **Zonation (based on suppression priority)**

### *Response Types:*

- **Full suppression response zone**
- **Modified suppression response zone**
- **Monitored/no response zone**

## **No zonation (risk-based appropriate response)**

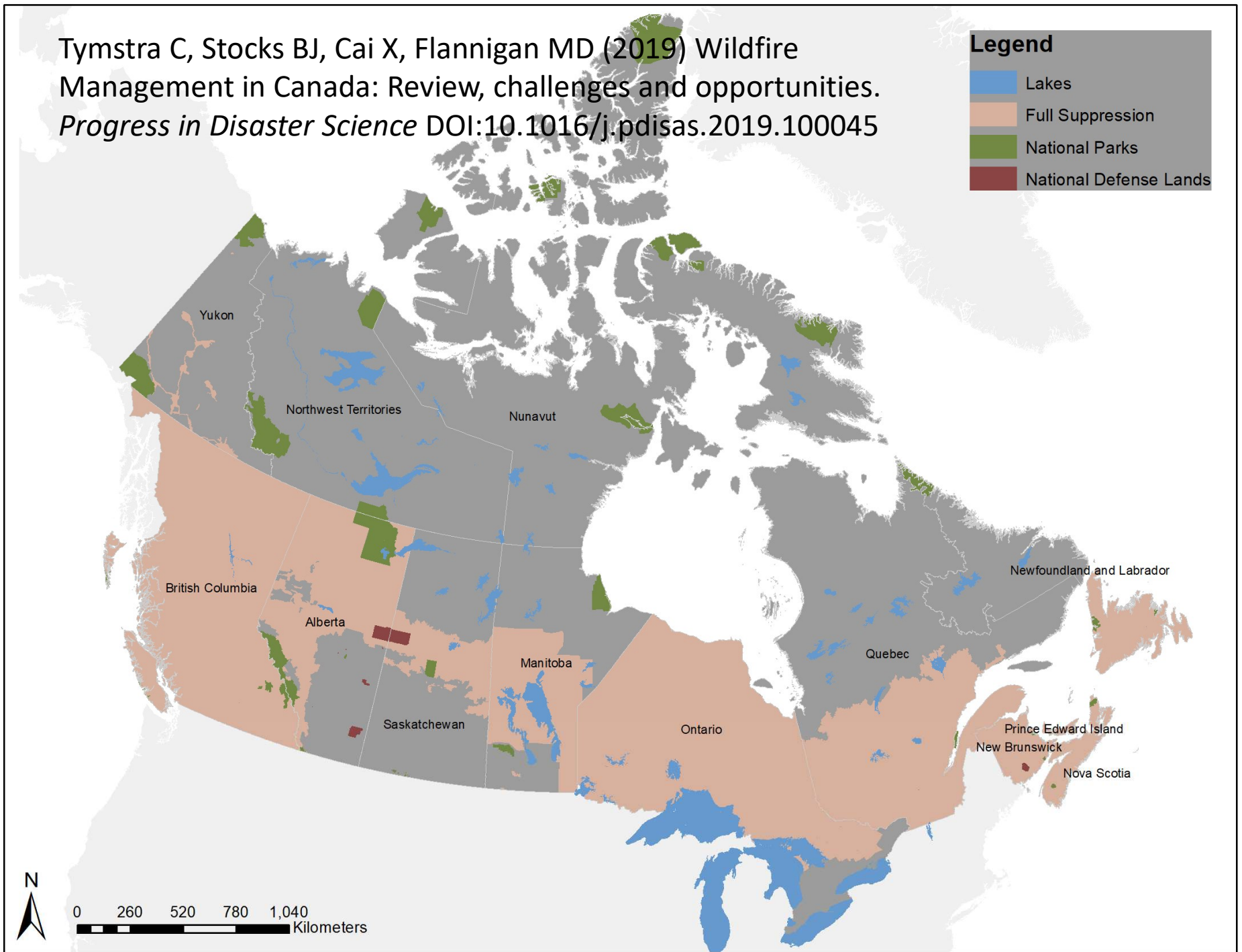
- **Manage risk on a fire-by-fire basis to balance negative impacts, response costs, positive impacts, and land use objectives**



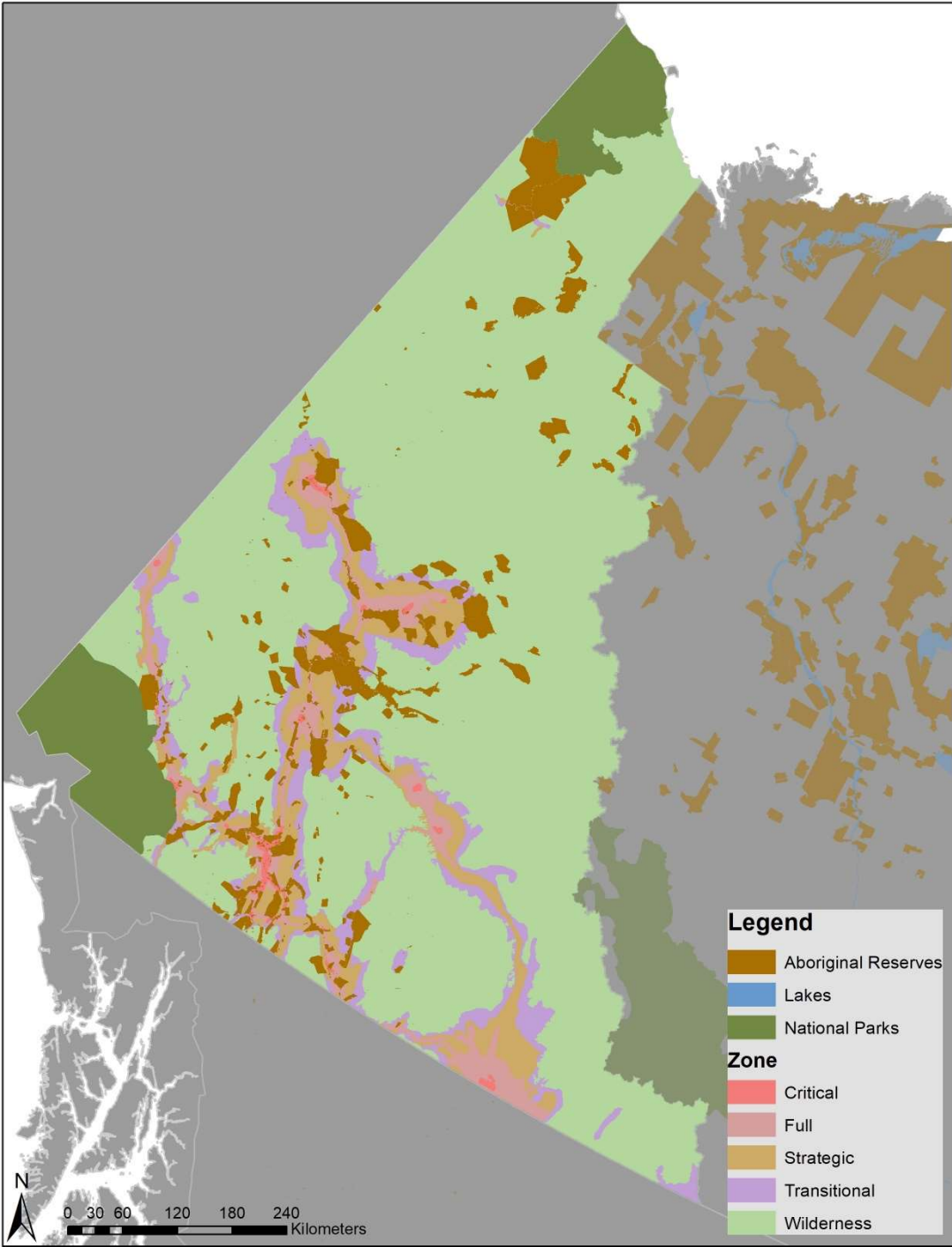
Tymstra C, Stocks BJ, Cai X, Flannigan MD (2019) Wildfire Management in Canada: Review, challenges and opportunities.  
*Progress in Disaster Science* DOI:10.1016/j.pdisas.2019.100045

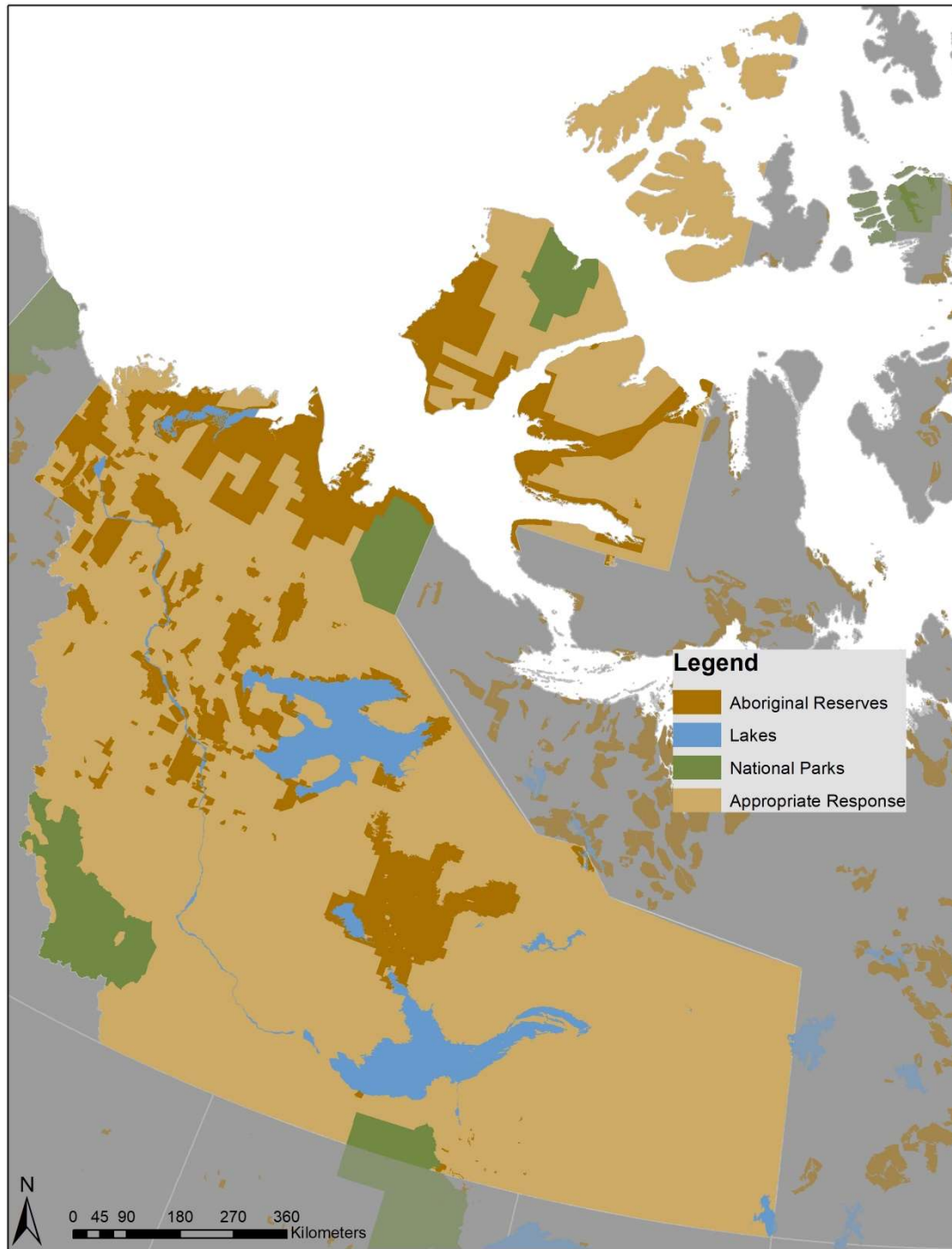
**Legend**

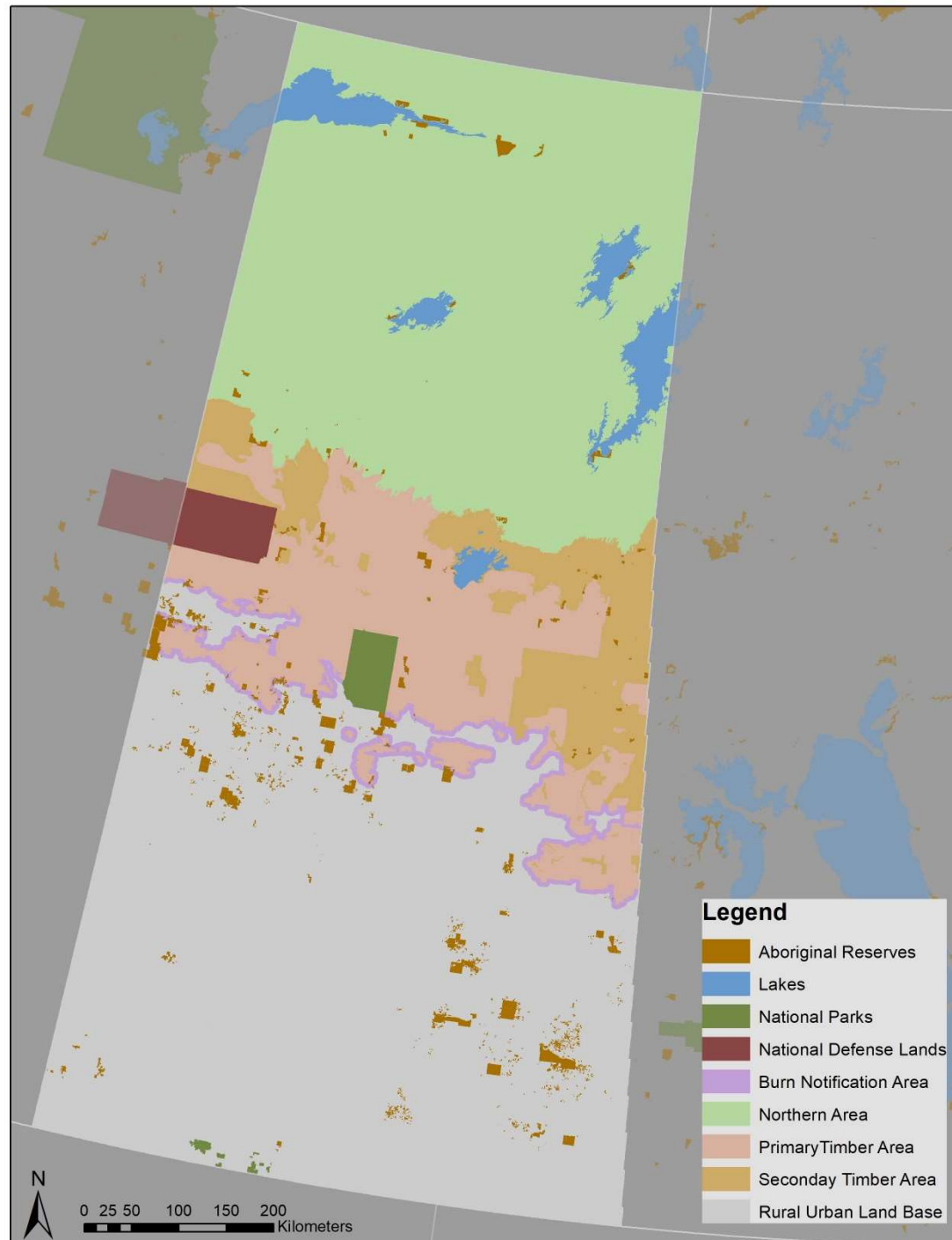
- Lakes
- Full Suppression
- National Parks
- National Defense Lands

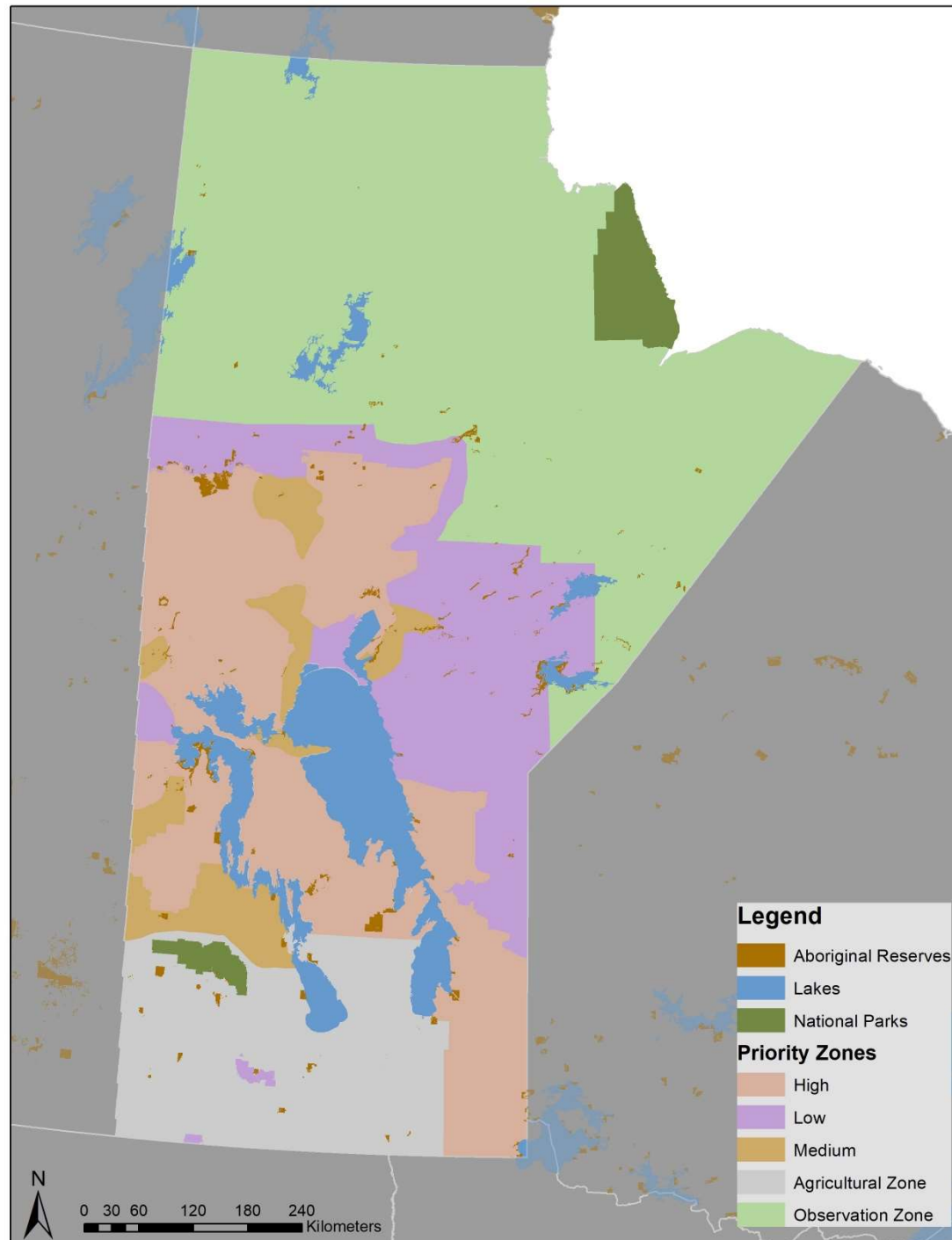






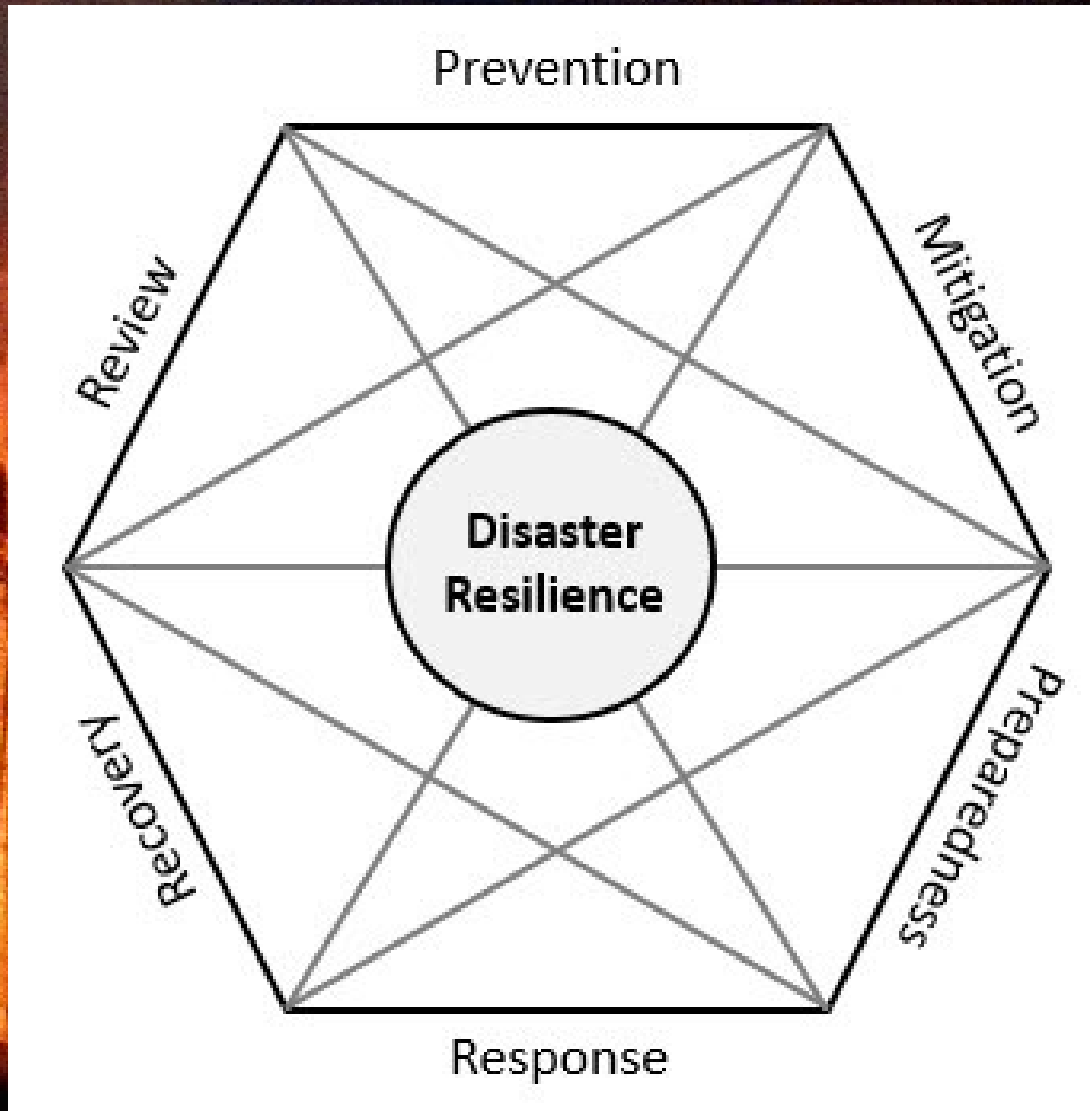












# Bigger, Hotter and Faster Wildfires...**More Disasters!**

Wildfire management consists of six phases: *prevention, mitigation, preparedness, response, recovery, and review*. Wildfire preparedness deals with “readiness” and being able to cope with an anticipated wildfire situation.

Firefighting resources are prepositioned based on a situational awareness of what is projected to happen tomorrow.

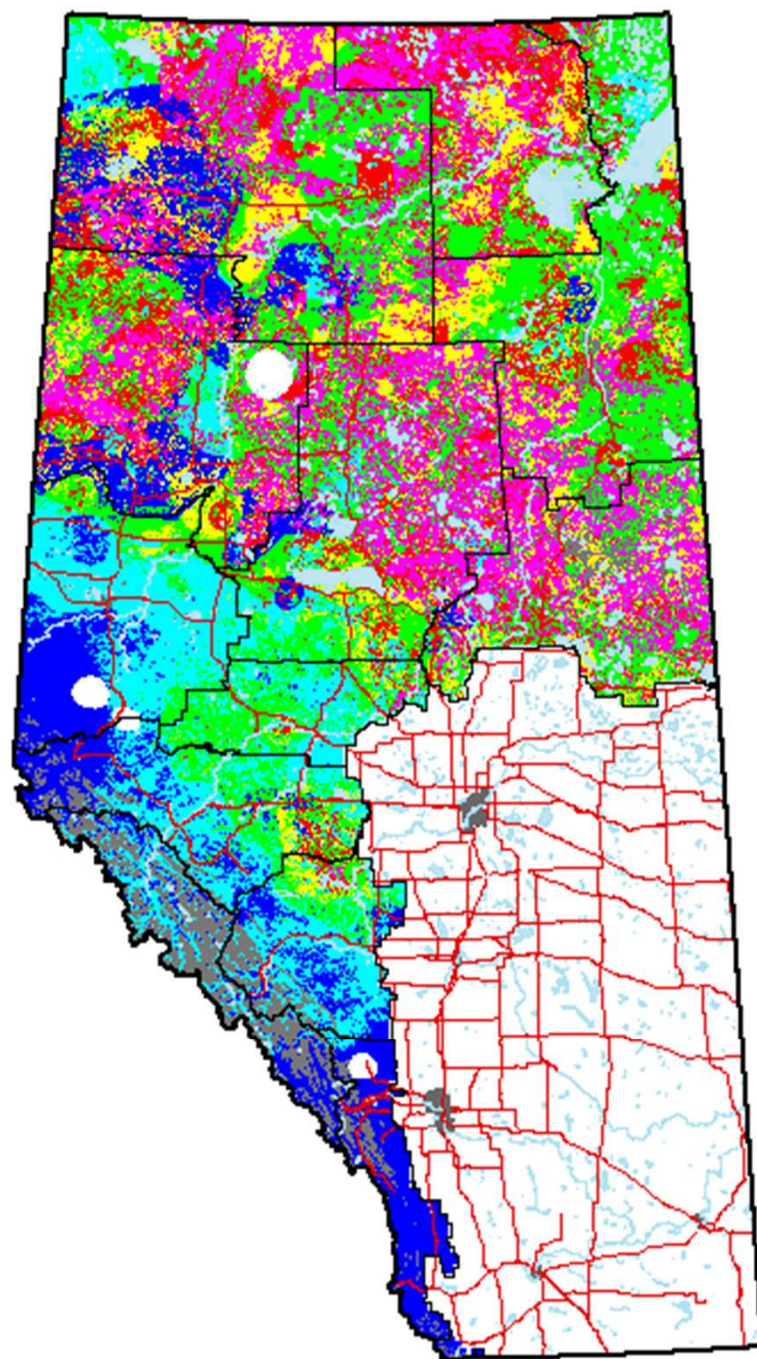


Preparedness...

# Alberta

## Head Fire Intensity

for May 18, 2019

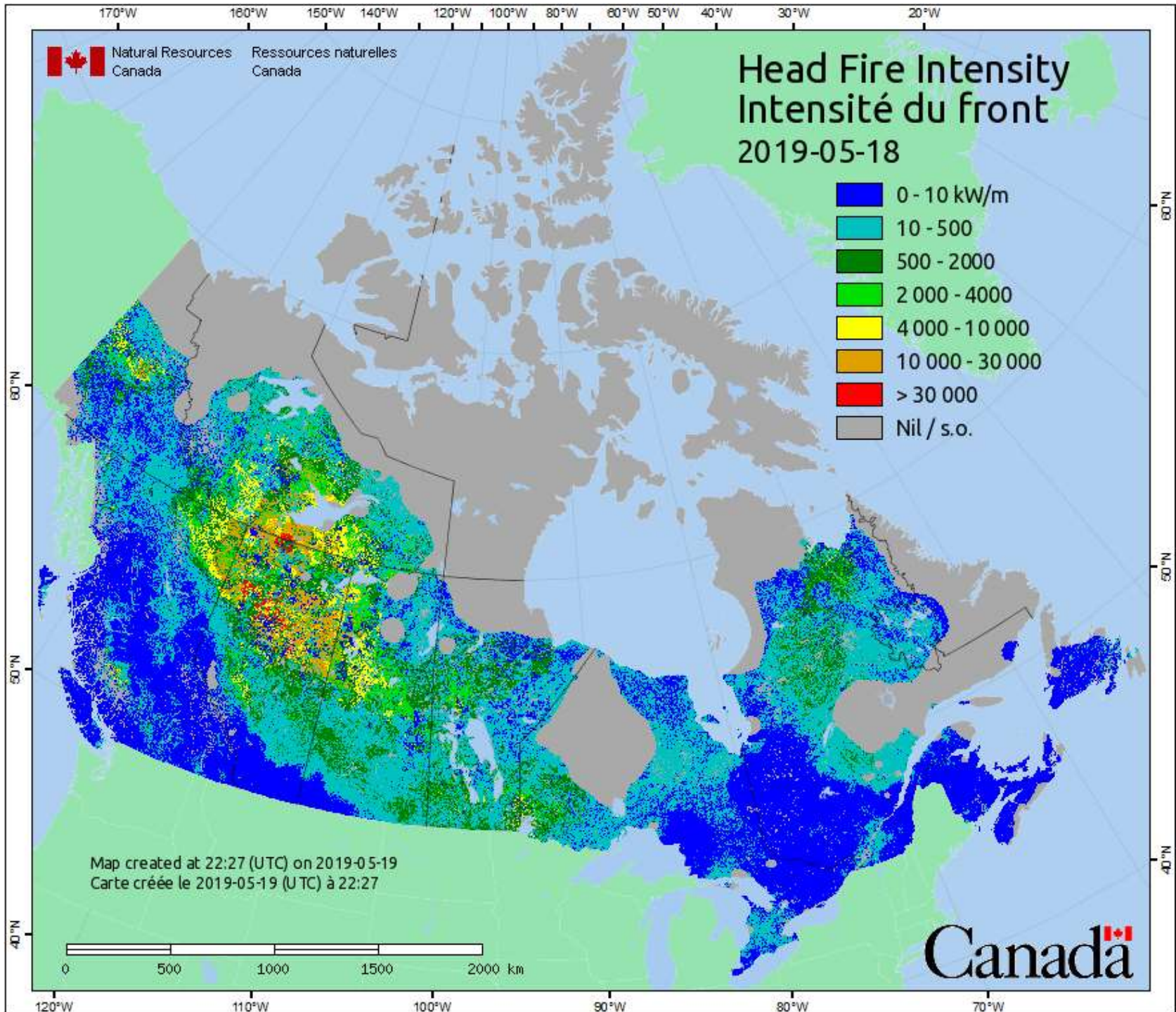


Alberta  Government

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Map created on May-18 at 14:06





# Fire Intensity (kW/m)

At 4,000 kW/m aerial suppression resources become challenged and at 10,000 kW/m are ineffective at directly controlling the fire line

**Wotton et al. (2017) Environmental Research Letters**

**Potential climate change impacts on fire intensity and key wildfire suppression thresholds in Canada**

The frequency of the number of days when fire intensity exceeds a threshold of 10,000 kW/m will double in some regions in the northern and eastern boreal forest

# Climate Change Wildfire Impacts

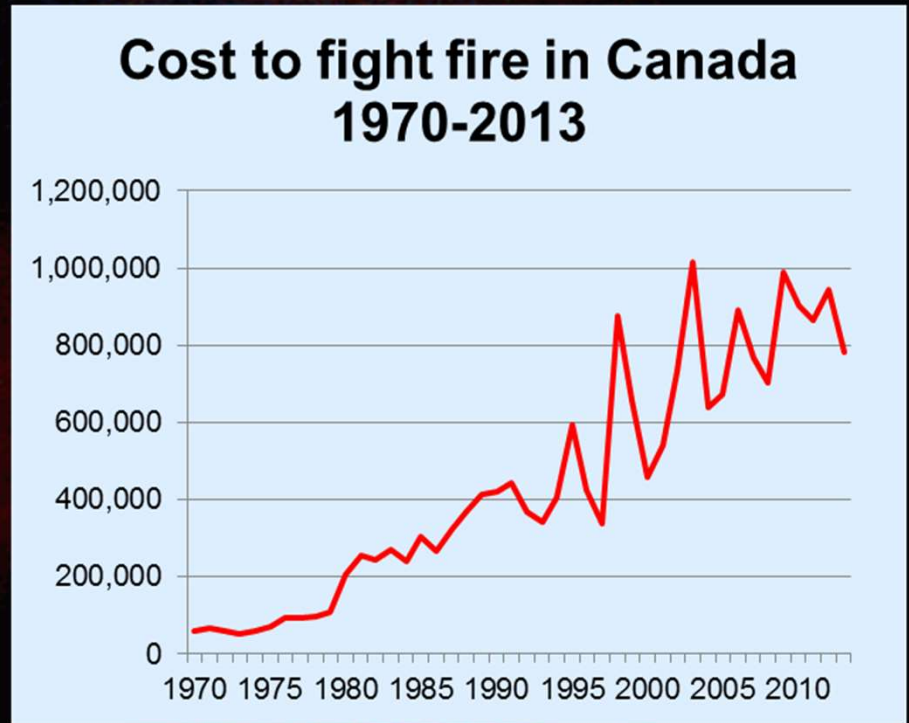
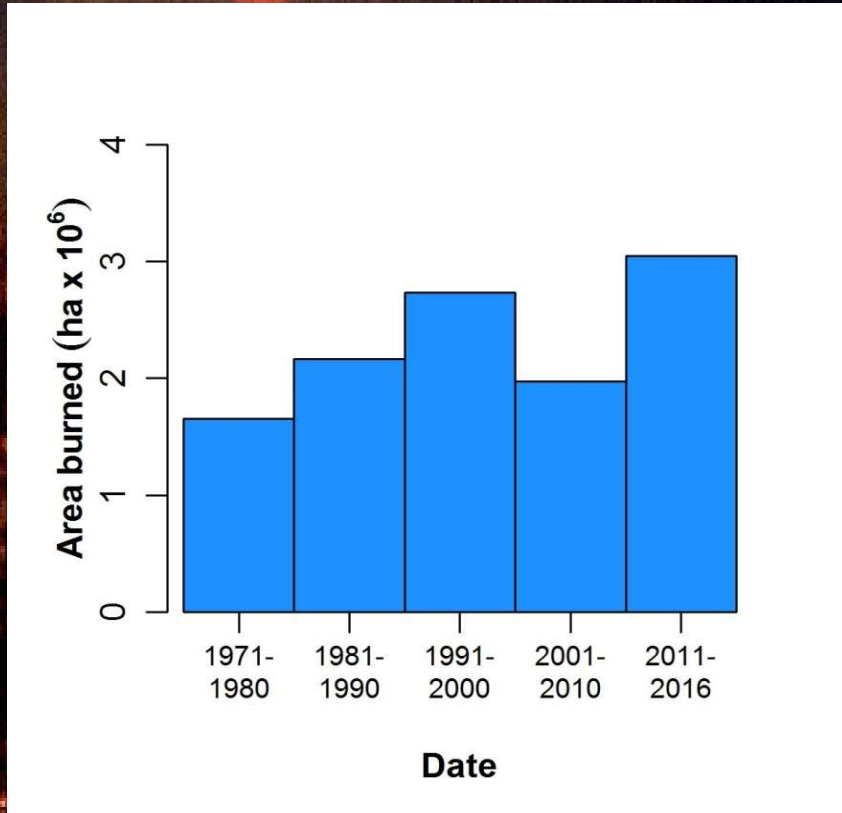


Lightning wildfires have increased 2 – 5 %/year since 1975 in the boreal forest **Veraverbeke et al. (2017), Nature Climate Change 7, 529-534**

- Extended wildfire seasons
- More extreme weather events (i.e. wind)
- Extended periods of drying
- More wildfire arrivals?

} More  
area  
burned





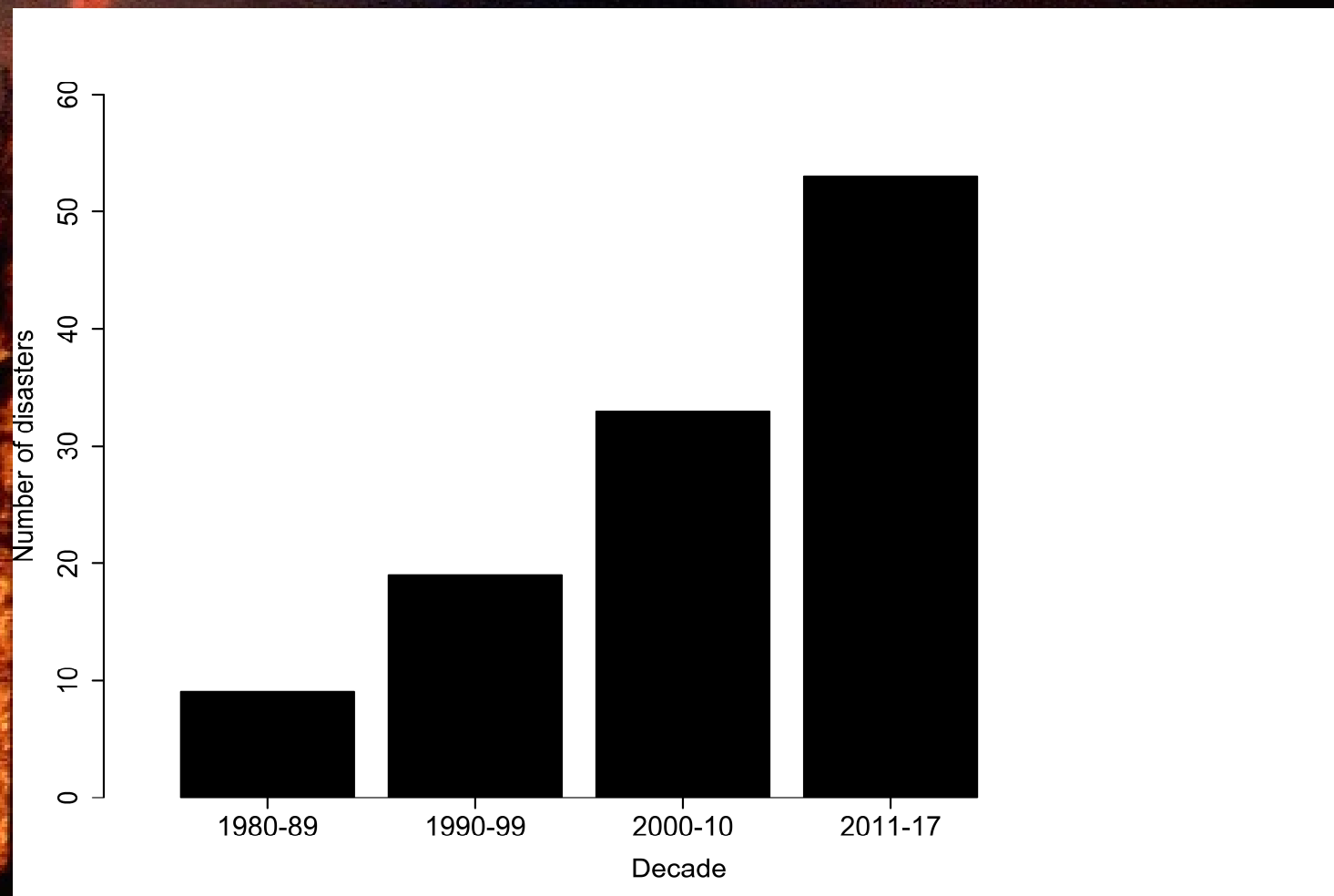
## Canada

## BC

2017 5,305 wildfires 3,346,768 ha **1,265 wildfires 1,212,134 ha**  
 2018 6,845 wildfires 2,266,588 ha **1,999 wildfires 1,348,522 ha**




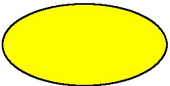





# Wildfire Disasters in Canada by decade

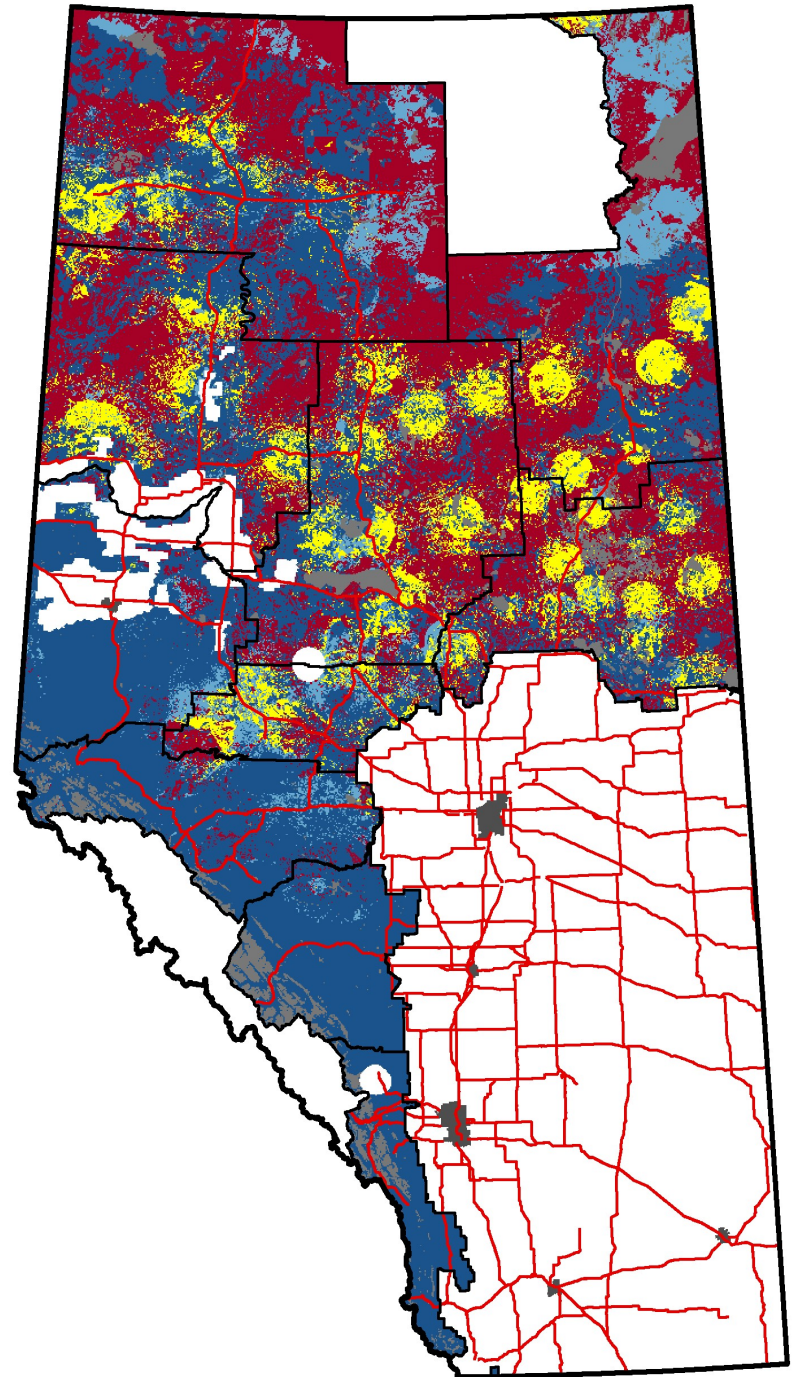


# Alberta

## Coverage Assessment

for May 18, 2019

-  Not Covered
-  Partially Covered
-  No Resources Required
-  Covered
-  Coverage+
-  Non Fuel
-  No Data



*Alberta*  Government

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Map created on Oct-28 at 11:00

<b>Current Plan Date</b> May 18, 2019	<b>Forest Area</b> High Level	<b>Weather Stream</b> AM Revised Forecast	<b>Duty Officer</b> Smith, Jason
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**Sign Off**

Signed Off: **AWCC Reviewed**

Status: **AWCC Reviewed**

AWCC Reviewed:

Last Modified: **5/18/2019 10:50 AM**

**Preparedness**

Preparedness Level: **3**

72hr Preparedness Level: **4**

**Coverage**

HFI1	HFI2	HFI3	HFI4	HFI5	HFI6	Mean HFI Class	Mean HFI
12	3	25	13	18	29	5	7252

Covered:	11%	
Covered +:	35%	
Partially Covered:	6%	
Not Covered:	48%	
No Resources Required:	0%	

**52%**  
Coverage

**IA Coverage Modifier**

IA Coverage Modifier: SC Seasonal considerations

Comments:

Extreme ISI values affecting coverage

**PPS Comments**

HH06 exported to Peace River  
HFB04, HFB05, HFB06 exported to Manning






DAY OFF LOOKOUTS: Ponton and Adair

<b>PPS Totals</b>	<b>Crews:</b> 17	<b>Aircraft:</b> 13	<b>Equipment Groups:</b> 0
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<b>Current Plan Date</b> May 18, 2019	<b>Forest Area</b> Edmonton	<b>Weather Stream</b> AM Revised Forecast	<b>Duty Officer</b> Wog, Brian
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<b>Sign Off</b>			
<b>Signed Off:</b>	✓	<b>AWCC Reviewed:</b>	✓
<b>Status:</b>	AWCC Reviewed	<b>Last Modified:</b>	5/18/2019 10:49 AM

<b>Preparedness</b>	
<b>Preparedness Level:</b>	3
<b>72hr Preparedness Level:</b>	3

<b>Coverage</b>							
HF1	HF12	HF13	HF14	HF15	HF16	Mean HFI Class	Mean HFI
9	12	24	12	14	29	5	7796
Covered:		8%			<b>65% Coverage</b>		
Covered +:		47%					
Partially Covered:		11%					
Not Covered:		35%					
No Resources Required:		0%					

<b>IA Coverage Modifier</b>
<b>IA Coverage Modifier:</b>
<b>Comments:</b>
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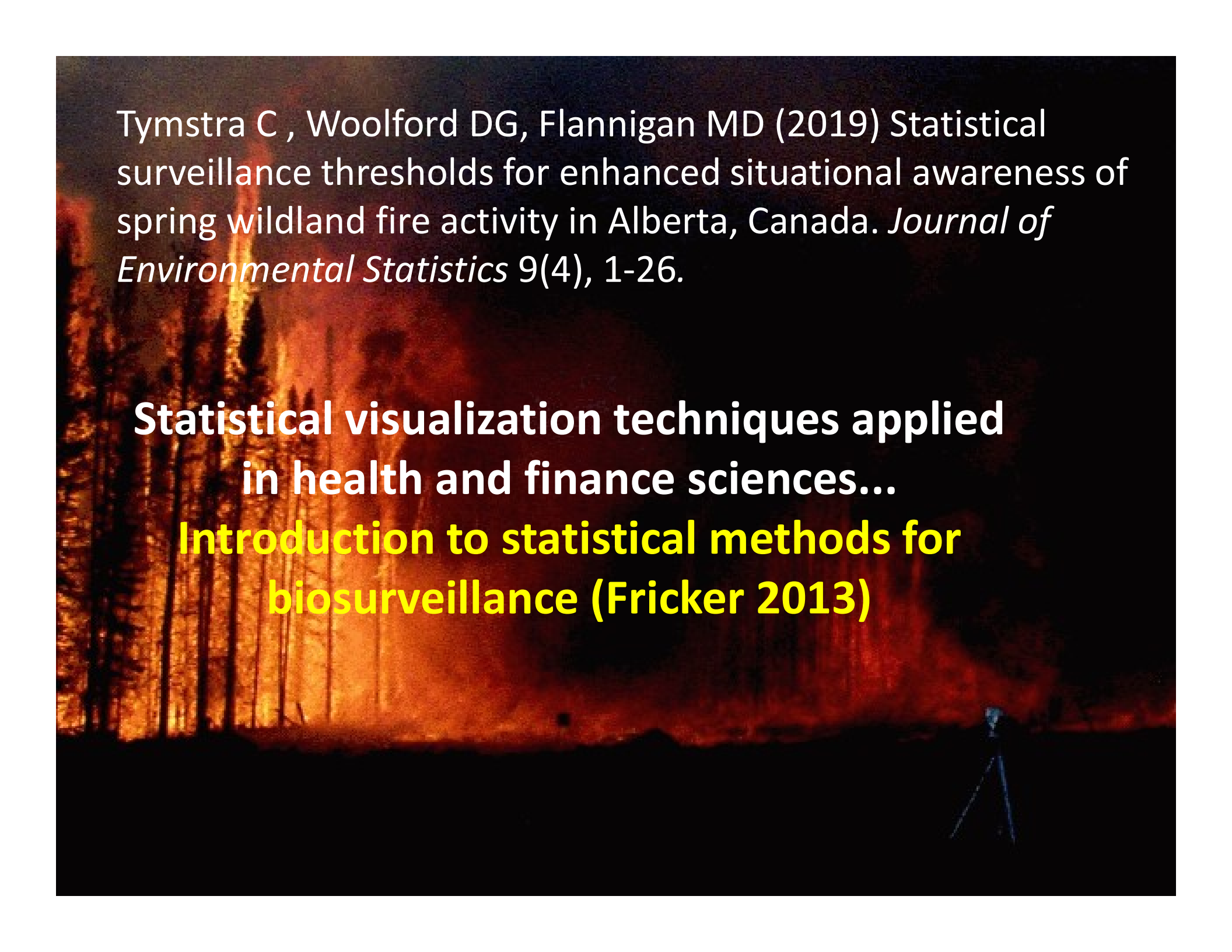
<b>PPS Comments</b>
<div style="border: 1px solid gray; height: 150px;"></div>

<b>PPS Totals</b>	<b>Crews:</b> 0	<b>Aircraft:</b> 0	<b>Equipment Groups:</b> 0
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## Alberta Wildfire Coordination Centre Preparedness Levels

Preparedness Levels	Wildfire Situation Assessment	Coordination Issues	AWCC Considerations
5	<ul style="list-style-type: none"> <li>Many areas of Extreme fire danger.</li> <li>Anticipated fire load (7 days) is extreme.</li> <li>There is a single very large wildfire or a number of large wildfires out of control.</li> <li>Wildfires displaying extreme fire behavior with significant growth potentials for multiple days.</li> </ul>	<ul style="list-style-type: none"> <li>There is a potential for creating wildfire complexes.</li> <li>There is a significant community or industrial infrastructure that is impacted.</li> <li>Severe shortage of resources over multiple deployments.</li> <li>Wildfire Management Representative is present in a local EOC.</li> </ul>	<ul style="list-style-type: none"> <li>Discuss fire bans, forest closures and activity restrictions.</li> <li>Multiple Consequence Management Officers covering extended operations in AEMA POC.</li> <li>Consider Provincial Wildfire Spokesperson.</li> <li>Consideration of importing IMT's.</li> <li>Consider CIFFC rep in AWCC.</li> </ul>
4	<ul style="list-style-type: none"> <li>Very High overall fire danger with areas of Extreme fire danger.</li> <li>Anticipated fire load (7 days) is heavy.</li> <li>Fires likely to escape containment objectives.</li> <li>Significant fire behavior with short term large fire growth potential.</li> </ul>	<ul style="list-style-type: none"> <li>Resource shortages over a 1 to 2 deployment timeframes.</li> <li>Importing of resources required.</li> <li>Multi-agency involvement (could include Unified Command).</li> <li>Municipal EOC's activated.</li> </ul>	<ul style="list-style-type: none"> <li>Consider activating Deputy DO and Deputy PAC.                             <ul style="list-style-type: none"> <li>Daily conference calls between AWCC &amp; Area Fire Centres.</li> </ul> </li> <li>AWCC Logistics function increased in capacity.</li> <li>Staff and facilities dedicated to briefing and receiving imported resources.</li> <li>Mandatory participation by all qualified headquarters wildfire staff.</li> <li>Consider shifting key positions.</li> <li>IMT 1 activated and/or prepositioned. Multiple IMT teams possible.</li> <li>Non-WMB staff requested.</li> <li>Discuss fire bans.</li> <li>Consequence Management Officer may be activated into AEMA POC due to wildfire.</li> <li>Media activity is high. High demand for the FYI fire line.</li> </ul>
3	<ul style="list-style-type: none"> <li>High overall fire danger with potential for pockets of Very High and Extreme fire danger.</li> <li>Anticipated (7 days) fire load is high.</li> <li>Increased risk of wildfires escaping containment objectives.</li> <li>Potential for values to be threatened.</li> <li>Potential for smoke or public health impacts.</li> </ul>	<ul style="list-style-type: none"> <li>Resources not adequate for all Areas.</li> <li>Importing minimal single resources or small number of crews occurring or anticipated.</li> <li>Potential for multi-agency involvement.</li> <li>Media interest increasing.</li> <li>Potential resource shortages forecasted or resources not adequate.</li> </ul>	<ul style="list-style-type: none"> <li>Provincial Fire Behavior Specialist based in AWCC.</li> <li>Weather forecasts include fire behavior predictions.</li> <li>Provincial priorities set by AWCC and communicated.</li> <li>IMT 2 teams are engaged in Areas or placed on standby Provincially.</li> <li>Effective information flow to AEMA POC is increased.</li> <li>AWCC logistics function activated.</li> <li>Staff expected to work extended hours.</li> <li>Resources requested through CIFFC and/or Northwest Compact.</li> <li>AWCC may directly move Area resources to higher priorities.</li> <li>Discuss fire restrictions.</li> <li>Intelligence function activated in AWCC.</li> </ul>
2	<ul style="list-style-type: none"> <li>Moderate overall fire danger with potential for pockets of High fire danger.</li> <li>Wx forecasts show increased fire danger or short duration severe events (i.e., high winds).</li> <li>Fire load increasing but manageable (low-moderate).</li> </ul>	<ul style="list-style-type: none"> <li>Adequate resources in Province for all incidents.</li> <li>Minimal movement between Areas may be required for individual or crew resources.</li> <li>Resources available for export.</li> </ul>	<ul style="list-style-type: none"> <li>Multi-fire potential but significant fire growth not expected.</li> <li>AEMA POC updated as required.</li> <li>Key AWCC positions put on standby.</li> <li>Importing resources not required.</li> <li>Consider fire advisories.</li> </ul> <p><u>Exporting Resources Out-of-Province</u></p> <ul style="list-style-type: none"> <li>AWCC Duty Manager consulted prior to exporting resources.</li> <li>Exporting multiple crews and overhead.</li> <li>Exporting teams.</li> <li>Anticipating multiple deployment.</li> <li>Additional AWCC position may be activated.</li> <li>Potential for media interest.</li> </ul>
1	<ul style="list-style-type: none"> <li>Low fire danger.</li> <li>Current and anticipated fire load is low.</li> </ul>	<ul style="list-style-type: none"> <li>Adequate resources in Areas.</li> <li>Resources available for export.</li> </ul>	<ul style="list-style-type: none"> <li>Normal operations.</li> <li>Air tanker groups can be on Green Days or exported.</li> <li>Manpower can be exported.</li> <li>AWCC Duty Officer Reviews Suppression Plans</li> </ul> <p><u>Exporting Resources Out-of-Province</u></p> <ul style="list-style-type: none"> <li>AWCC Duty Manager consulted prior to exporting resources.</li> <li>Exporting single resources and individual crews.</li> </ul>

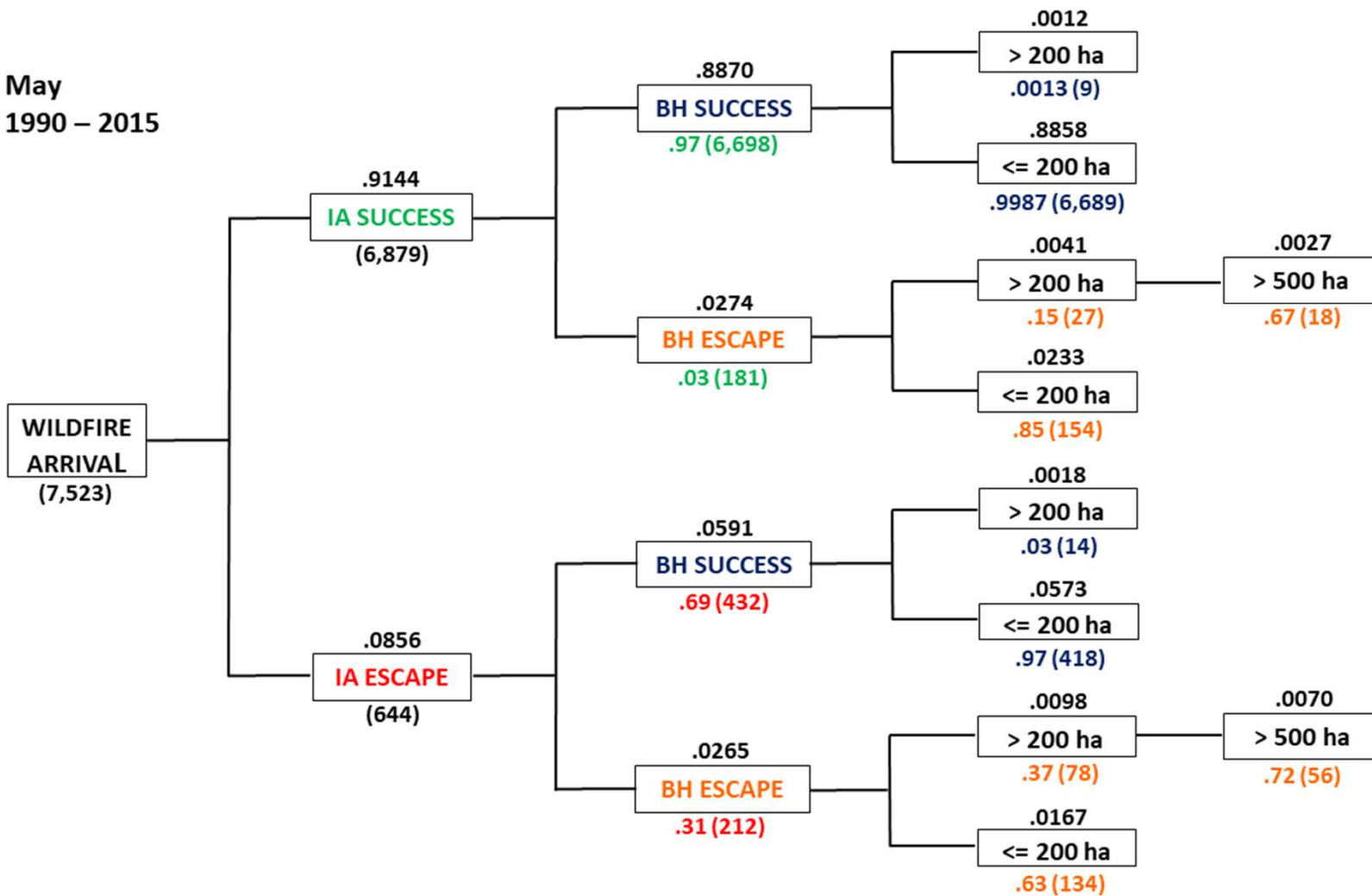


Tymstra C , Woolford DG, Flannigan MD (2019) Statistical surveillance thresholds for enhanced situational awareness of spring wildland fire activity in Alberta, Canada. *Journal of Environmental Statistics* 9(4), 1-26.

**Statistical visualization techniques applied  
in health and finance sciences...**

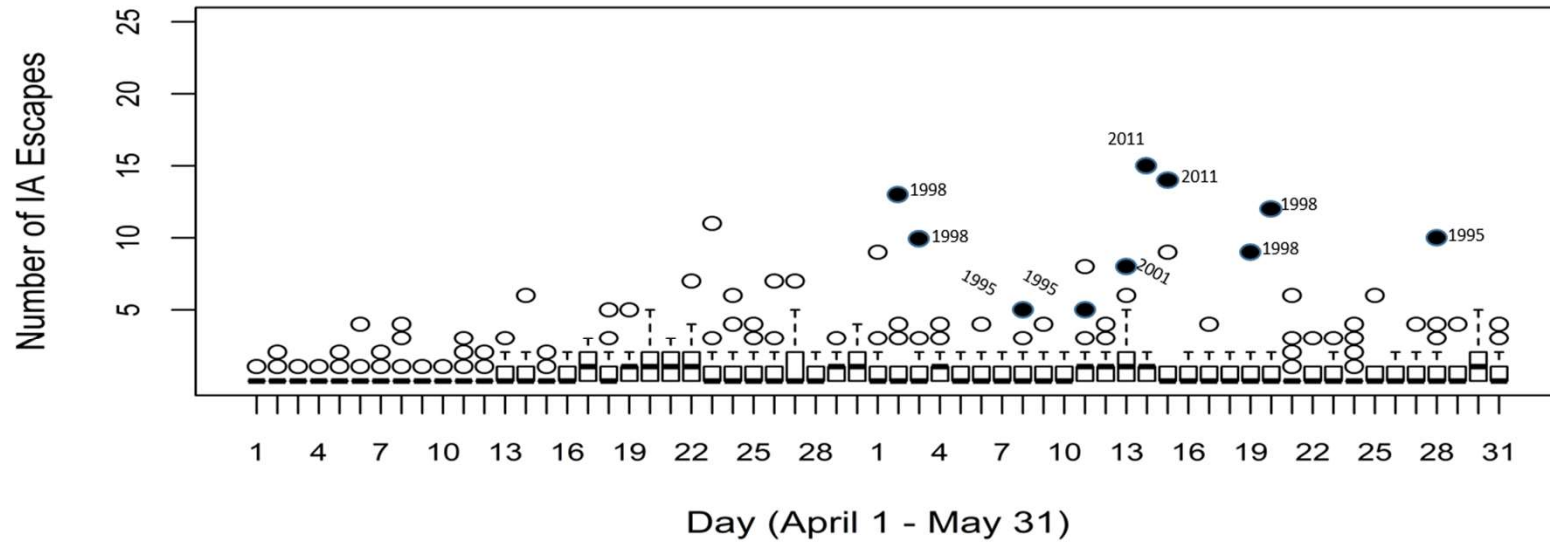
**Introduction to statistical methods for  
biosurveillance (Fricker 2013)**

May  
1990 – 2015

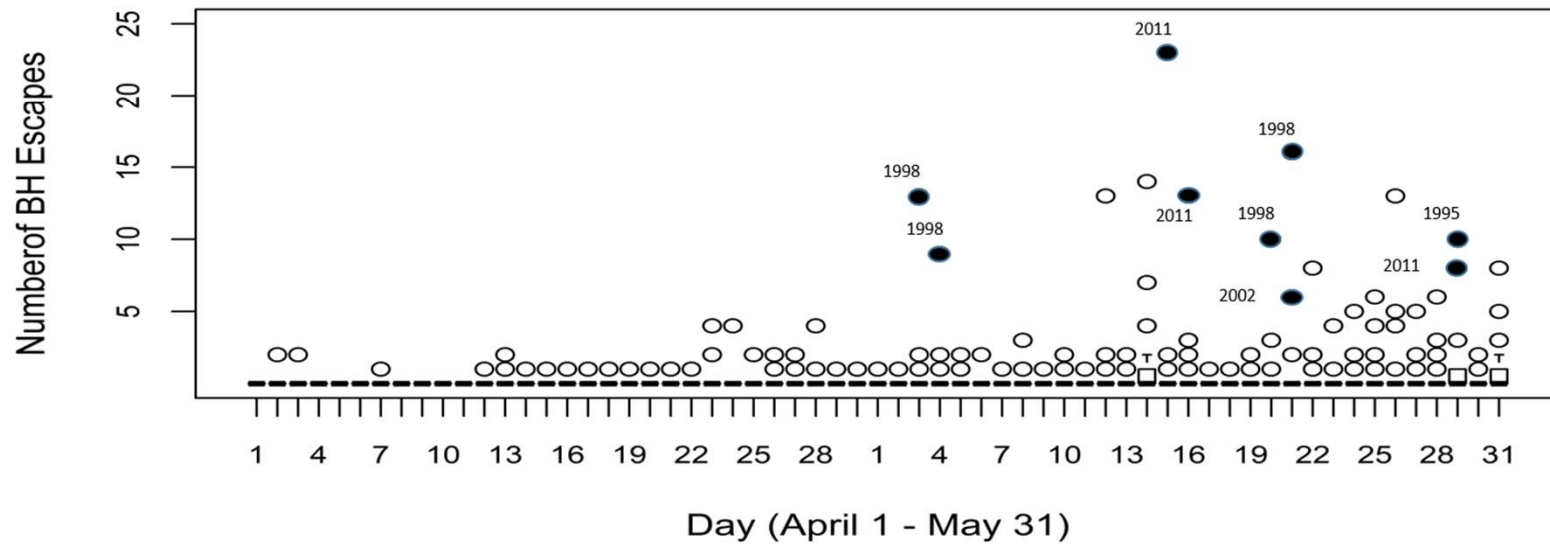


1990 – 2019: Characterization of 78 May wildfires > 1,000 ha

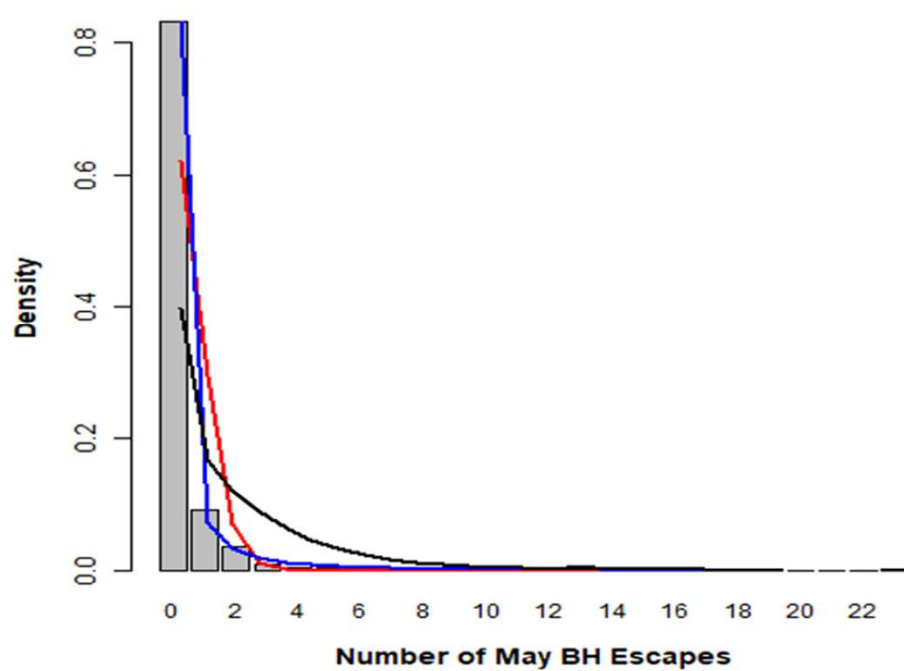
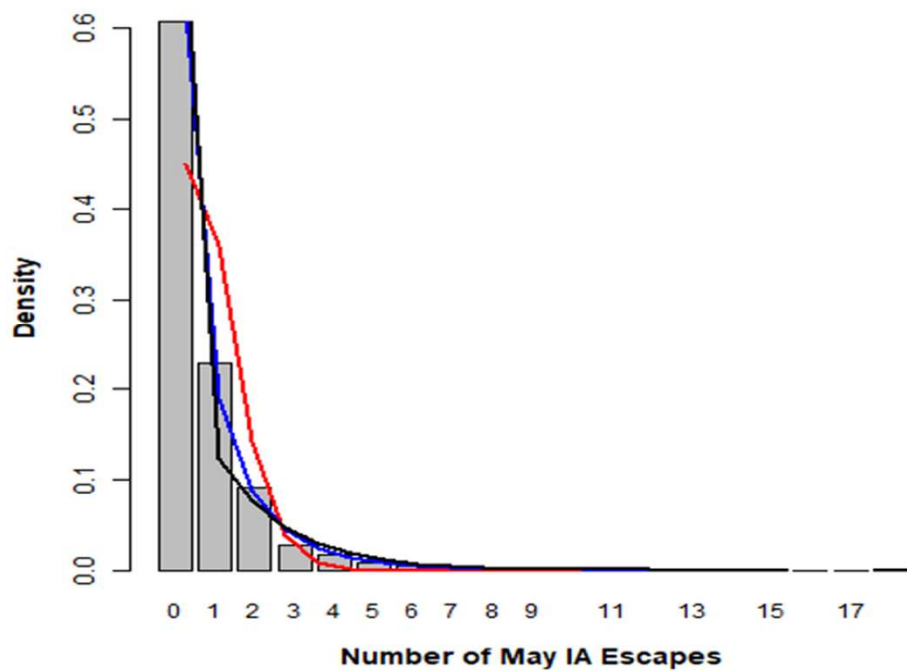
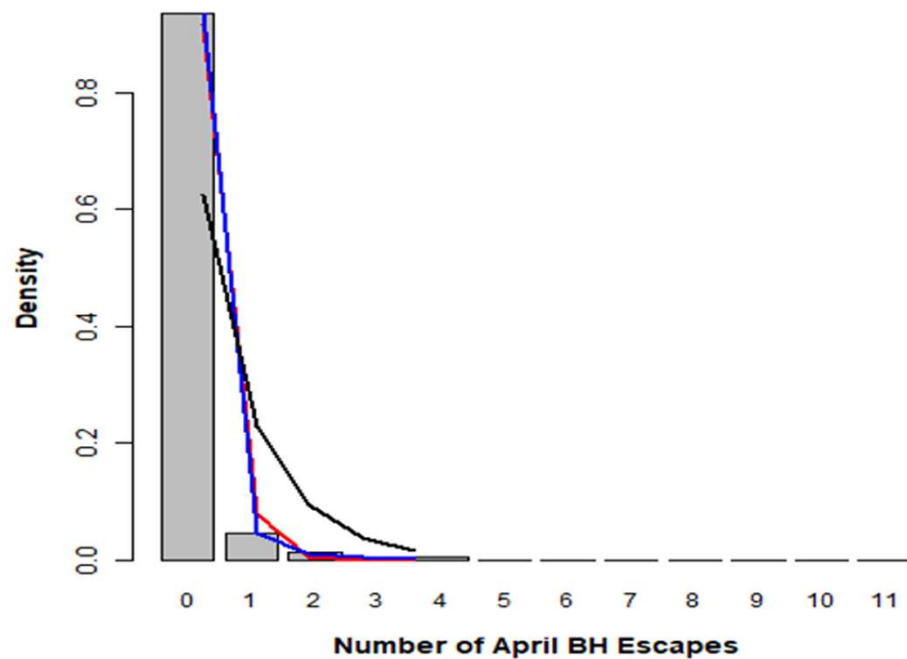
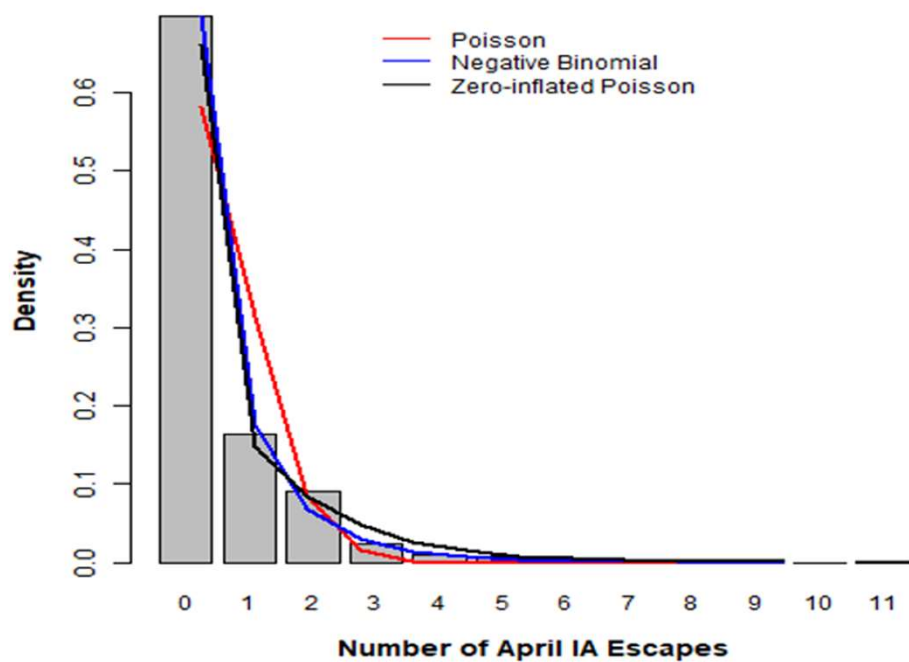
## IA Escapes



## BH Escapes



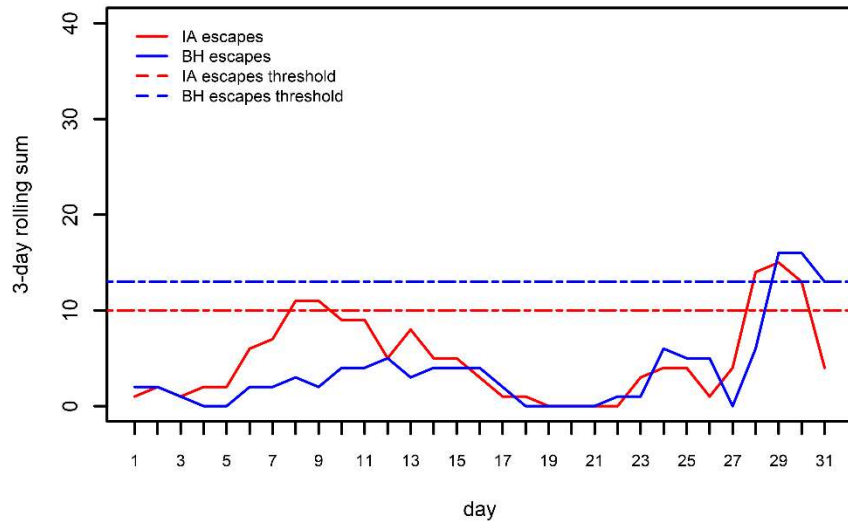




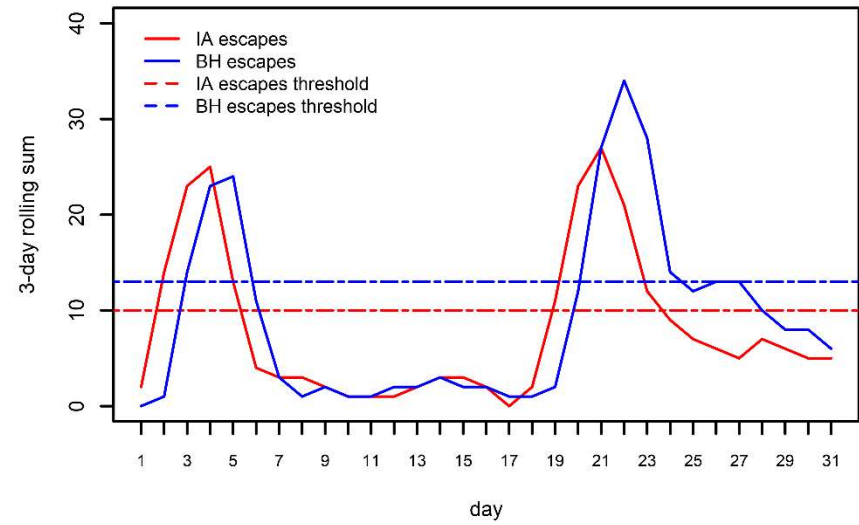
- We applied univariate EVT and the Pareto Principle using the peak over threshold (POT) approach to model IA and BH escape risk.
- POT technique models exceedances (peaks) of high pre-determined thresholds and approximates the distribution of the right-tail outliers using the generalized Pareto distribution.

BH Escapes	68 Percentile Threshold: Exceedances		95 Percentile Threshold: Exceedances		99.7 Percentile Threshold: Exceedances		BH Objective (97 Percentile) Threshold: Exceedances		Kurtosis Method Threshold: Exceedances	
	April	May	April	May	April	May	April	May	April	May
BH escapes with zeros	0: 48	1: 135	1: 13	2: 33	3: 3	14: 2	1: 13	4: 22	NaN	NaN
BH escapes with no zeros	1: 13	2: 33	3: 3	13: 3	4: 0	20: 1	4: 0	13: 3	3: 3	4: 22
3-day rolling sum BH escapes with zeros	0: 119	0: 257	2: 16	8: 36	5: 2	32: 3	2: 16	13: 23	NaN	3: 68
3-day rolling sum BH escapes with no zeros	2: 16	3: 68	4: 4	16: 13	6: 0	36: 1	4: 4	23: 7	5: 2	7: 41
2-day rolling sum BH escapes with zeros	0: 86	0: 206	1: 28	5: 35	4: 1	24: 2	2: 1	8: 24	NaN	NaN
2-day rolling sum BH escapes with no zeros	2: 9	2: 62	4: 1	15: 9	5: 1	30: 1	4: 1	17: 6	4: 1	7: 26

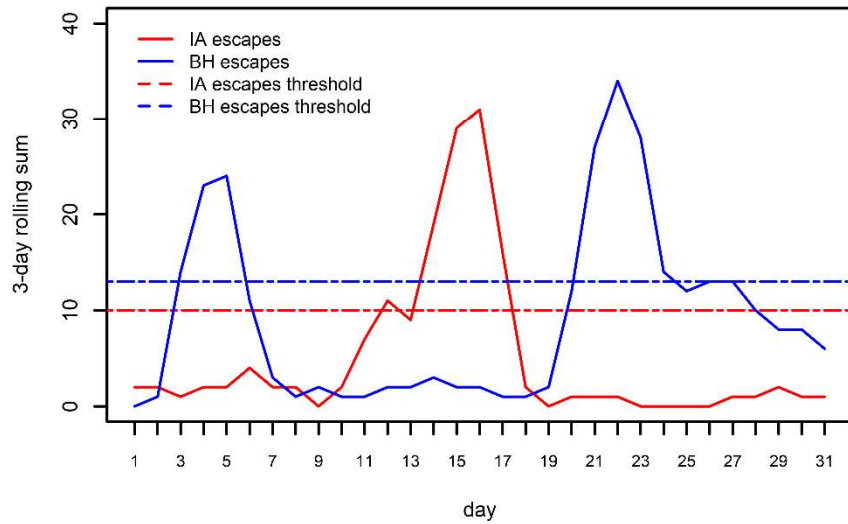
May 1995 IA and BH Escapes



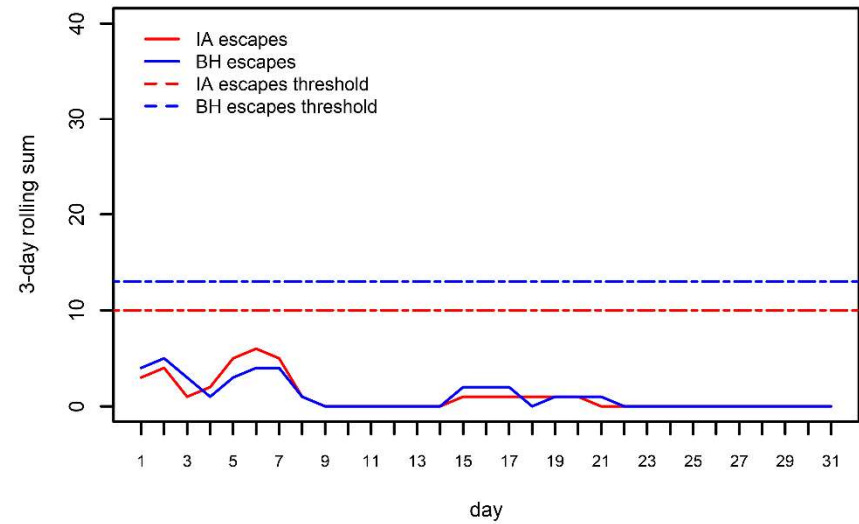
May 1998 IA and BH Escapes

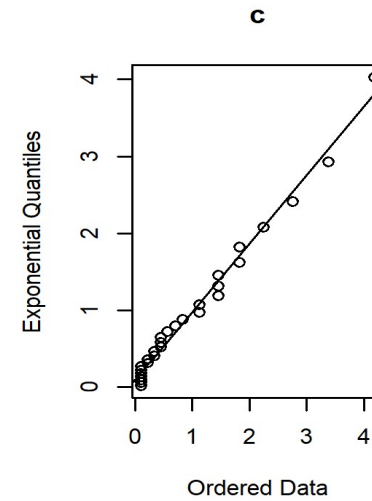
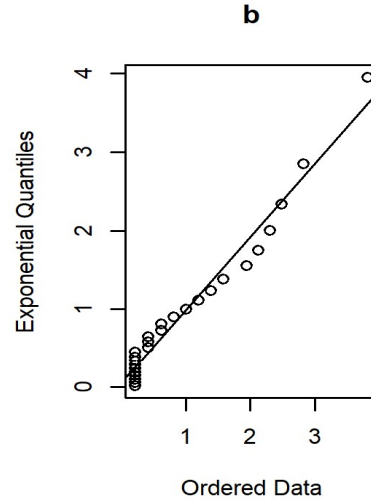
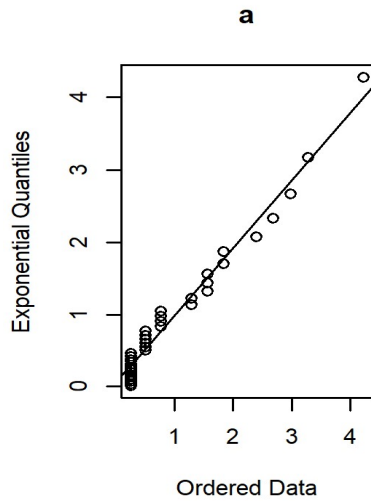


May 2011 IA and BH Escapes

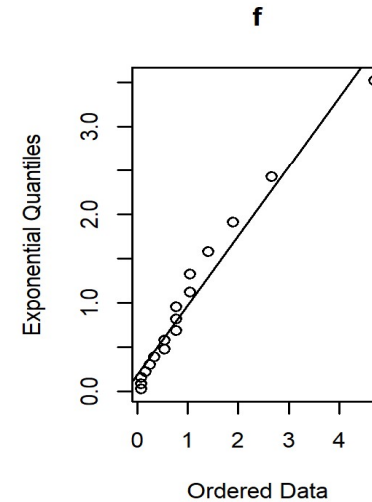
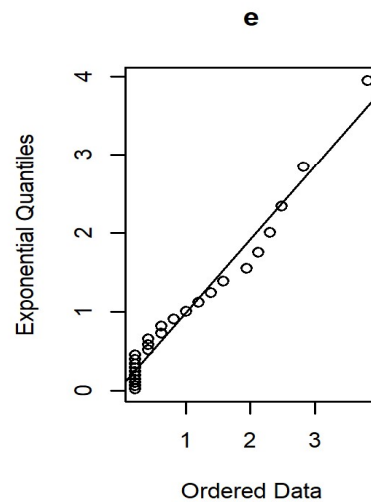
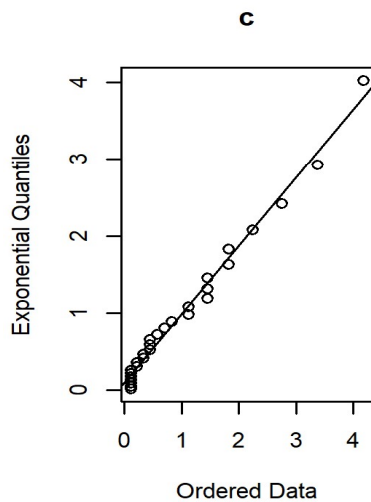


May 2016 IA and BH Escapes





IA



BH

**IA May Escapes (3-day rolling sum) 0.98 quantile point estimate:  
17.48 (16.01 – 20.87)**

**BH May Escapes (3.day rolling sum) 0.97 quantile point estimate:  
22.99 (19.68 – 28.25)**



A photograph of a forest at dusk or dawn. The sky is filled with a large, dramatic, golden-brown cloud formation that looks like a massive plume of smoke or a large fire. The trees in the foreground are dark and silhouetted against the lighter sky. A street lamp is visible on the left side of the image.

**There is a need to create an environment that is more understanding and accepting of risk.**

**This requires innovative and integrated approaches to manage a future world with more wildfire.**

**This includes the application of advanced statistical approaches.**