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Wildfire loss modelling at a community-scale based on spatial post-event buildings damage data

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ÉTS Le génie pour l'industrie

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE

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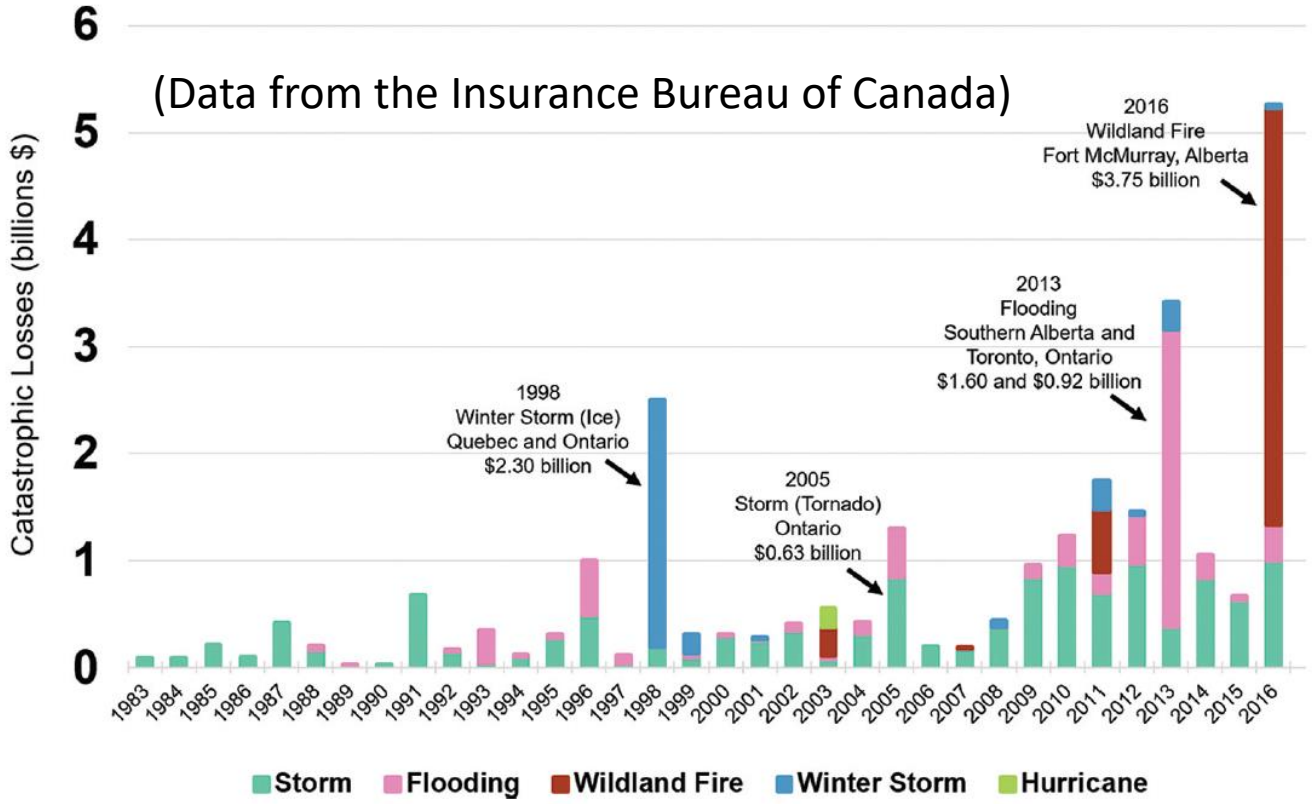
Project overview

- The project aims to develop methodologies and tools to fill the knowledge gap in the structural fire vulnerability and impact assessment of wildfires at the Wildland Urban Interface (**WUI)** communities in Canada.
- Project supported by the Canadian Forest Service, Natural Resources Canada.

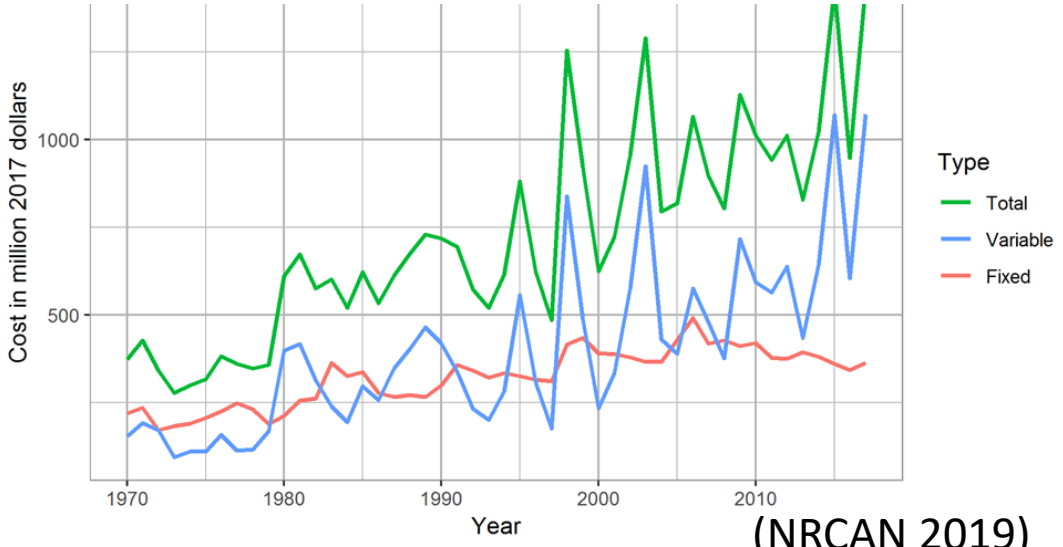
Background



(Johnston et al. 2020)

Table 1: Major WUI fire disasters recorded by P&C Insurance Industry, 2000 to present

Event	Year	Insured loss (millions, 2017 CAD)	Homes, structures lost
Kelowna, BC	2003	$254 [6]	334 homes, many businesses [7]
Slave Lake, AB	2011	$574 [8]	510 [9]
Fort McMurray, AB	2016	$3,811 [10]	1,595 structures containing 2,579 dwelling units [11]
Thompson Nicola Regional District, BC	2017	$27 [12]	215 [13]
Areas surrounding Williams Lake, BC	2017	$100 [14]	107 [15]



(NRCAN 2019)

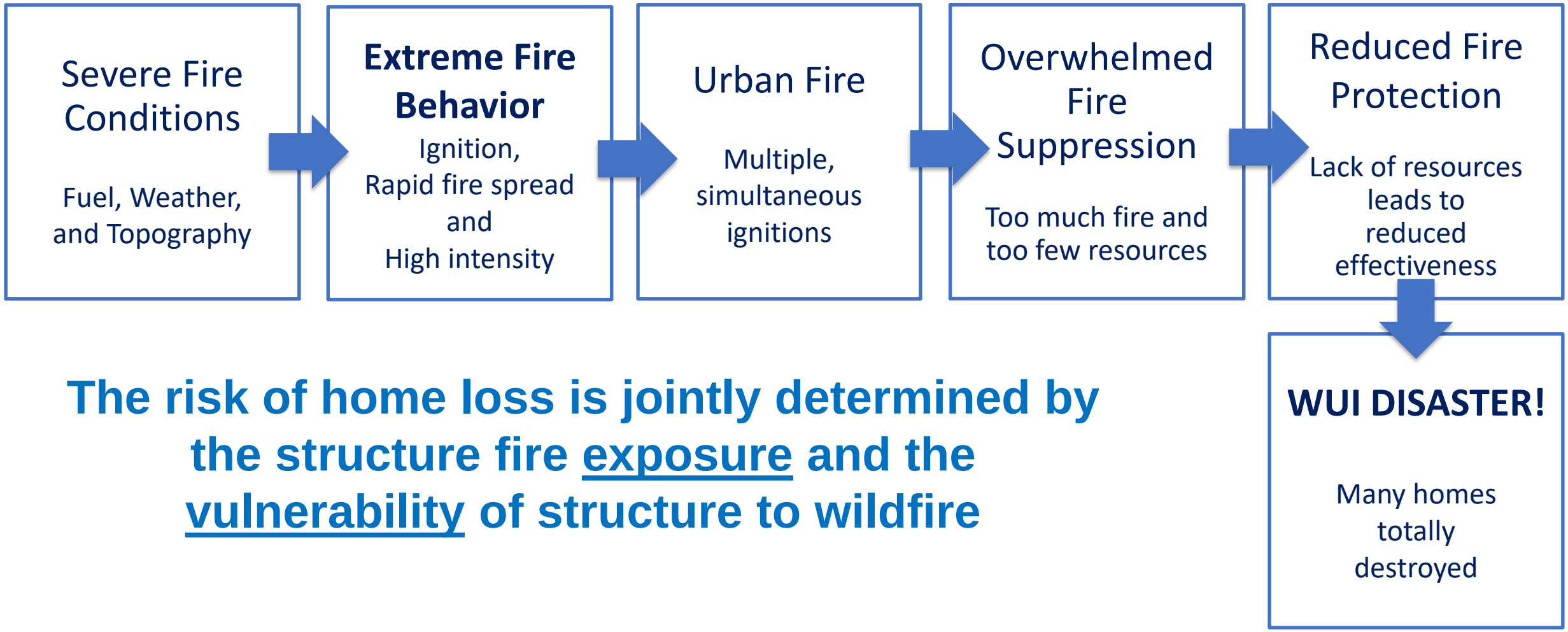
Johnston, L.M., Wang, X., Erni, S., Taylor, S.W., McFayden, C.B., Oliver, J.A., Stockdale, C., Christianson, A., Boulanger, Y., Gauthier, S. and Arseneault, D., 2020. Wildland fire risk research in Canada. *Environmental Reviews*, *28*(2), pp.164-186.

Wildfire Risk Assessment

Decisions on preparedness, mitigation measures, emergency response and recovery planning need to consider risk in terms of consequences and impacts of wildfire hazard, such as damages, as well as economic and social losses.

Source: Public Safety Canada

WUI Disaster Sequence



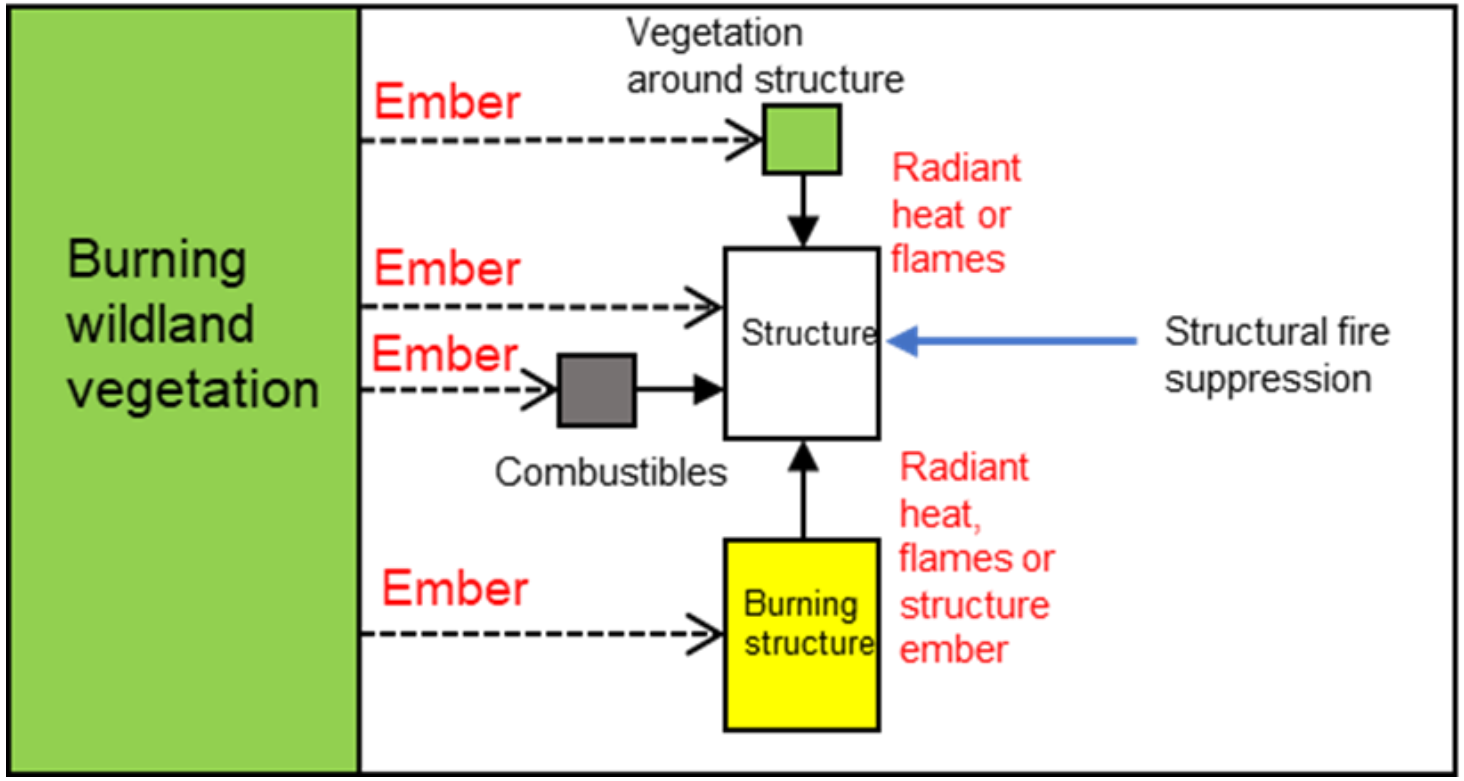
The risk of home loss is jointly determined by the structure fire exposure and the vulnerability of structure to wildfire

(Adapted from Calkin et al. 2013)

Calkin, D.E., Cohen, J.D., Finney, M.A. and Thompson, M.P., 2014. How risk management can prevent future wildfire disasters in the wildland-urban interface. Proceedings of the National Academy of Sciences, 111(2), pp.746-751.

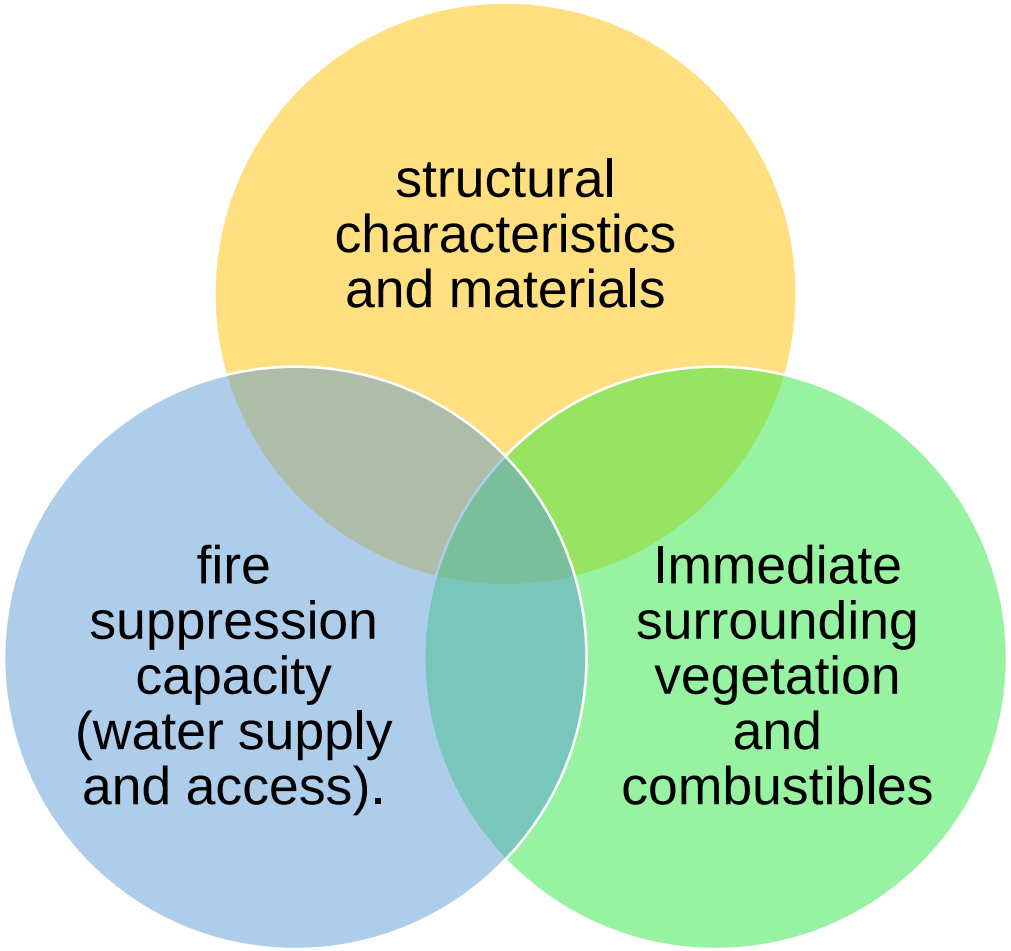
Wildfire Exposure

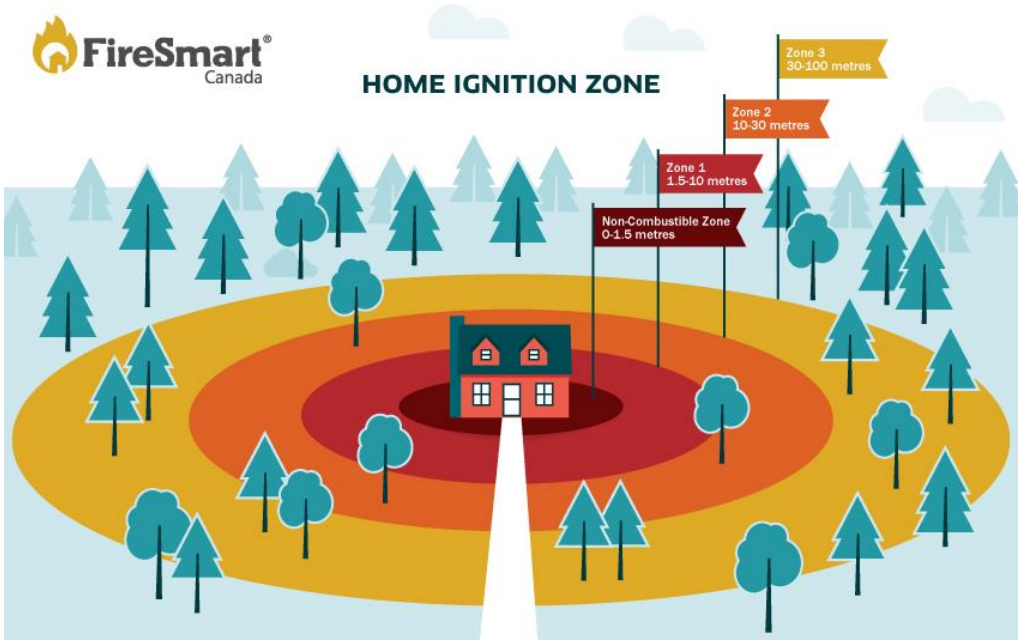
- Embers attack and ignite structures far beyond the forest burn perimeter.



Structural fire vulnerability

Structural vulnerability is a measure of a building's chance of being damaged/destroyed by a wildfire.



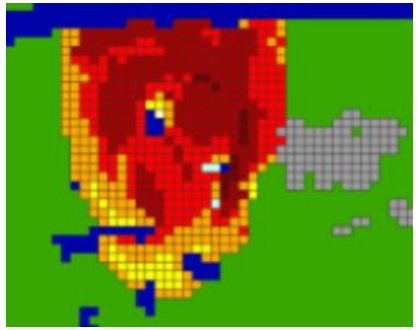


Source: FireSmart Canada

Framework for wildfire loss modelling

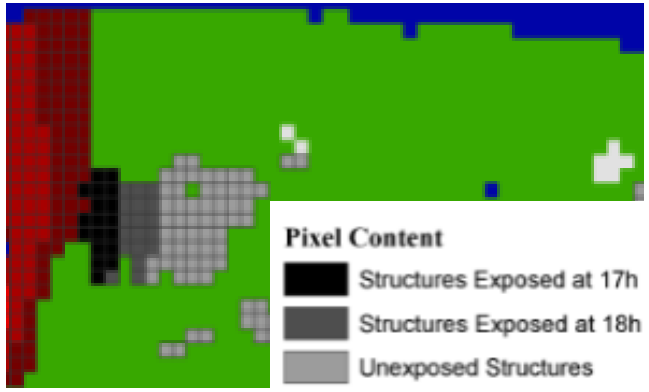
- Integration in spatial modelling of wildfire risk to communities.

Hazard model

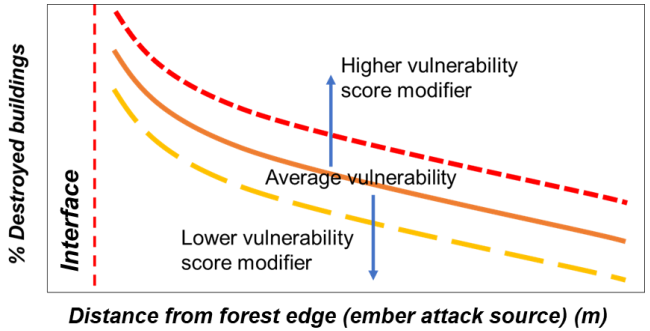


Inventory data

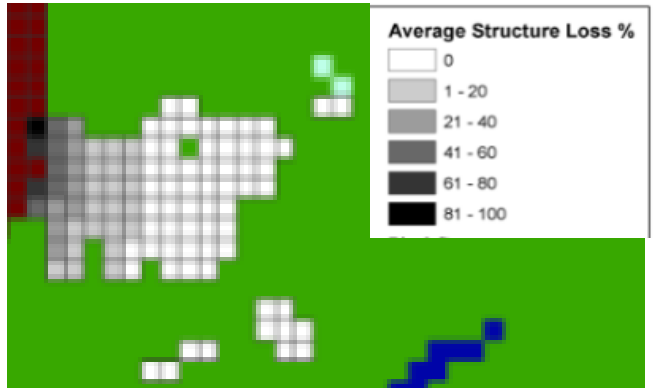
Exposure model



Vulnerability model



Impact Simulation

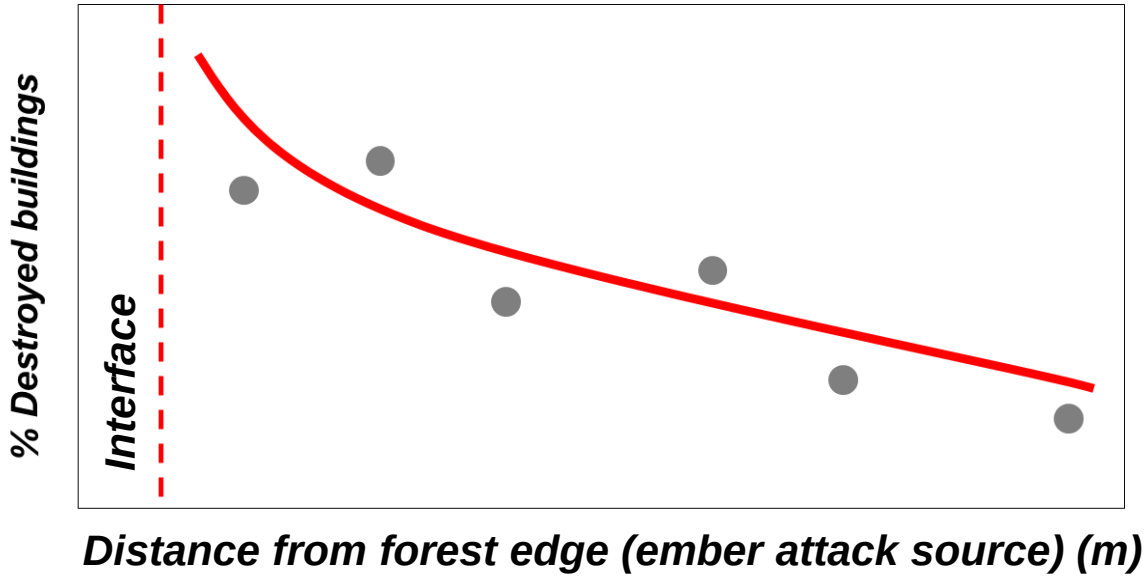


(Adapted from Abo El Ezz et al. 2022)

Abo El Ezz, A.A., Boucher, J., Cotton-Gagnon, A. and Godbout, A., 2022. Framework for spatial incident-level wildfire risk modelling to residential structures at the wildland urban interface. *Fire Safety Journal*, p.103625.

Community scale empirical vulnerability functions

- Development of empirical vulnerability (damage) functions applicable for community scale risk assessment based on post-fire surveys and mapping of survived and destroyed buildings in WUI events in Canada.

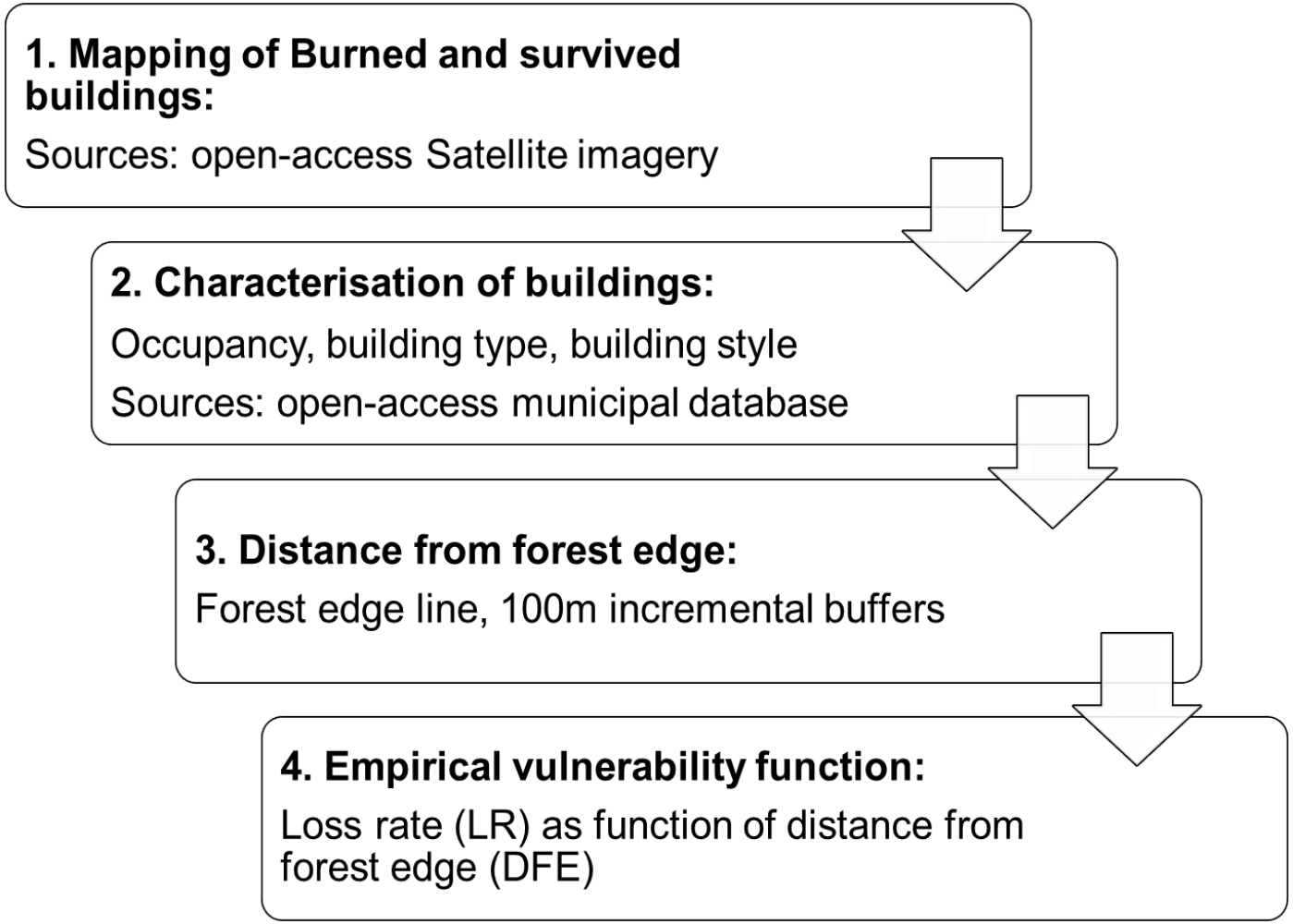


Community scale empirical vulnerability functions

- Communities and wildfire events:
  1. Kelowna (Okanagan Mountain Park Fire), 2003.
  2. Slave Lake (Flat Top Complex Fire), 2011.
  3. Fort MacMurray (Horse River Fire), 2016.
  4. Lytton (Lytton Creek Fire), 2021.

- The post-fire scene represents the final product of the interaction among (1) the ignition vulnerability of buildings, (2) fire exposure (heat and ember intensity), (3) defensive and suppression actions.

Community scale empirical vulnerability functions



Post-fire damage databases

- Attributes, data sources and processing

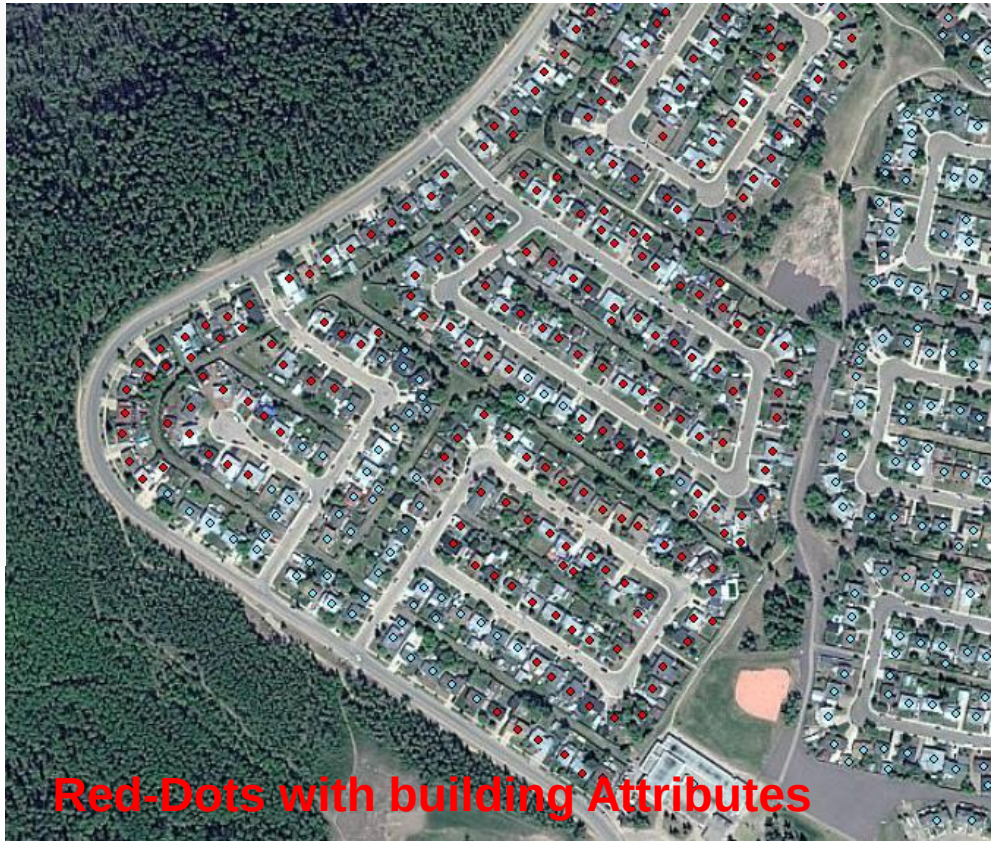
Attribute name	Attribute parameters	Data sources and processing
Building location	Long. , Lat., footprint	Digitized and Georeferencing from Google maps images
Building occupancy	Residential, other (e.g., commercial, industrial, government)	Municipal databases, OpenStreet maps
Building type	Main building, outbuilding (e.g., garage, shed).	Municipal databases, Google maps
Building style	Detached single building, attached townhouse, multi-story apartment building	Municipal databases, Google maps
Post fire status	Destroyed, survived.	Google maps (before and after fire), news images and drone videos
Burn scar	Raster image (burned or not burned).	Georeferencing from NASA satellite images
Distance from burned vegetation	Distance in meters.	ArcGIS spatial analysis
HFI	Head fire intensity (KW/m)	CWFIS hotspots database
Burned vegetation type	Burned vegetation FBP Fuel Types	CWFIS Fuel types database

Post-fire damage databases

Digitized buildings (survived, destroyed), Fort McMurray 2016

Before Fire (2015)

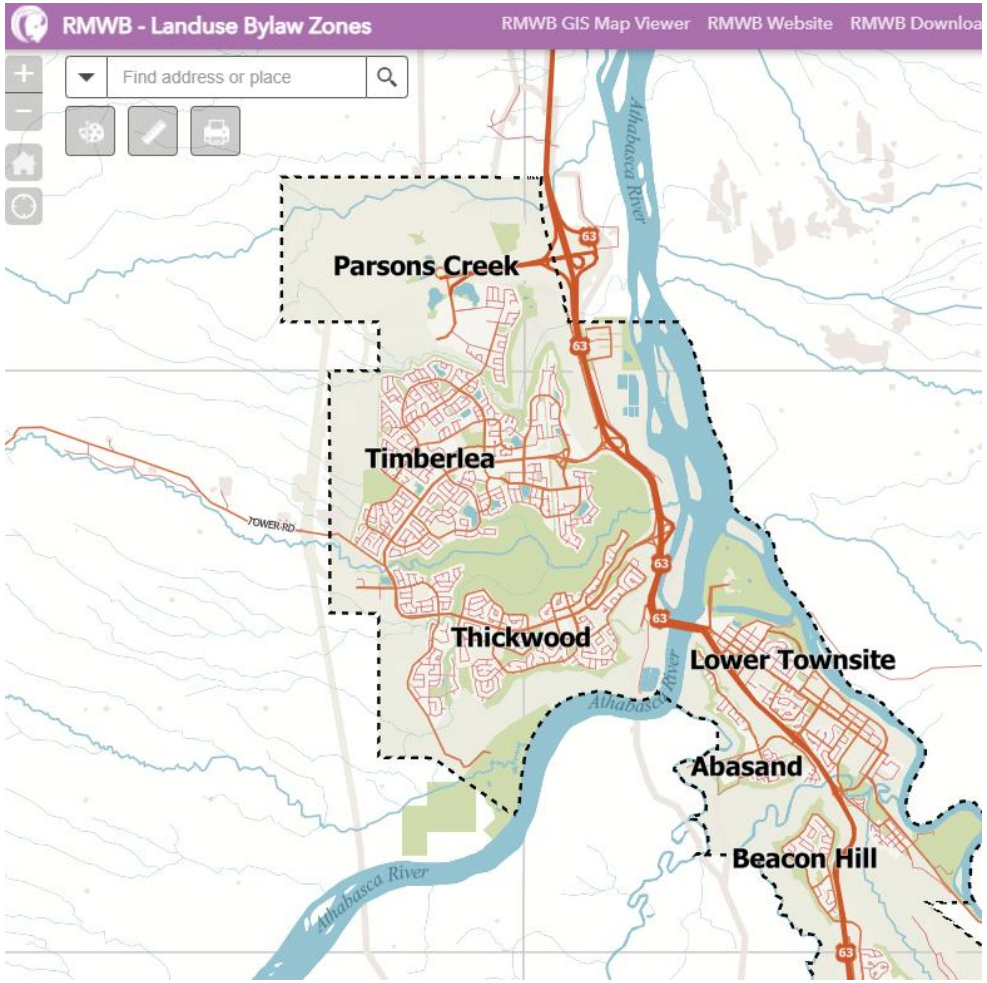
After Fire (2016)



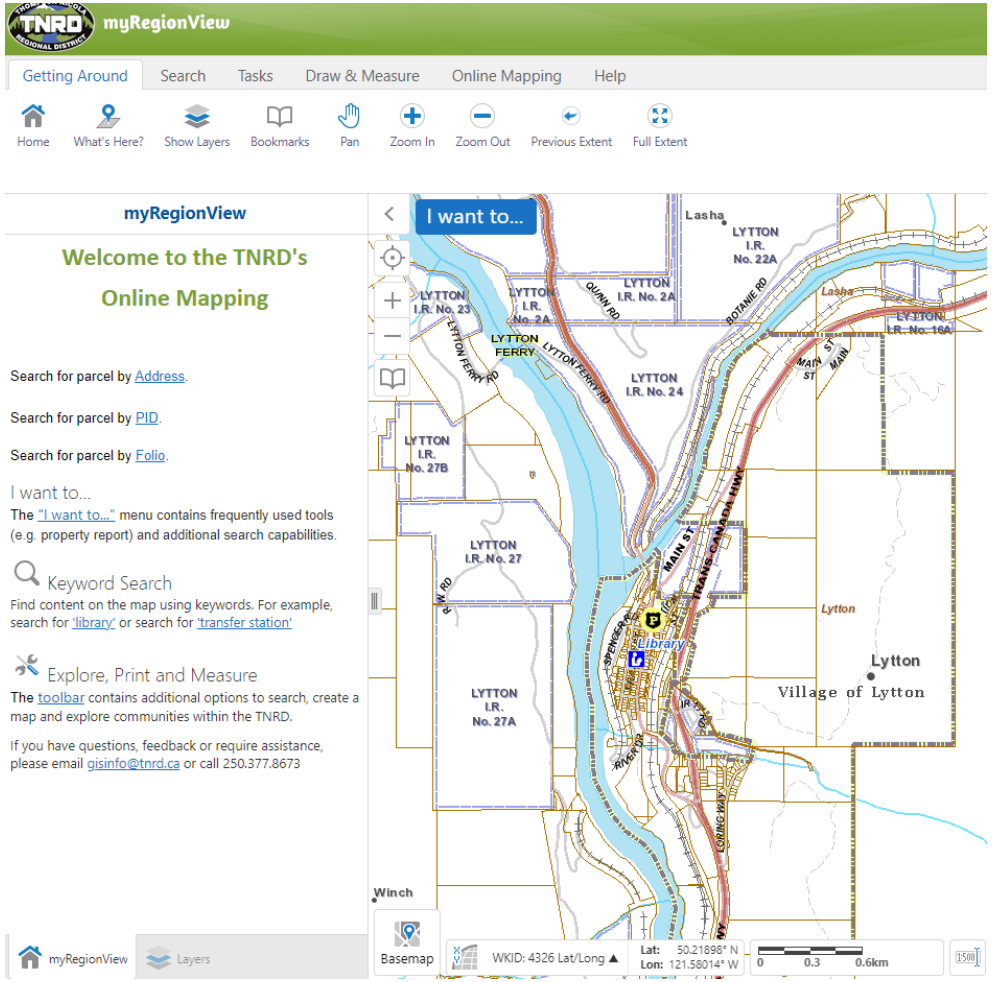
Post-fire damage databases

Building's occupancy data

Fort McMurray (Regional Municipality of Wood Buffalo web maps)

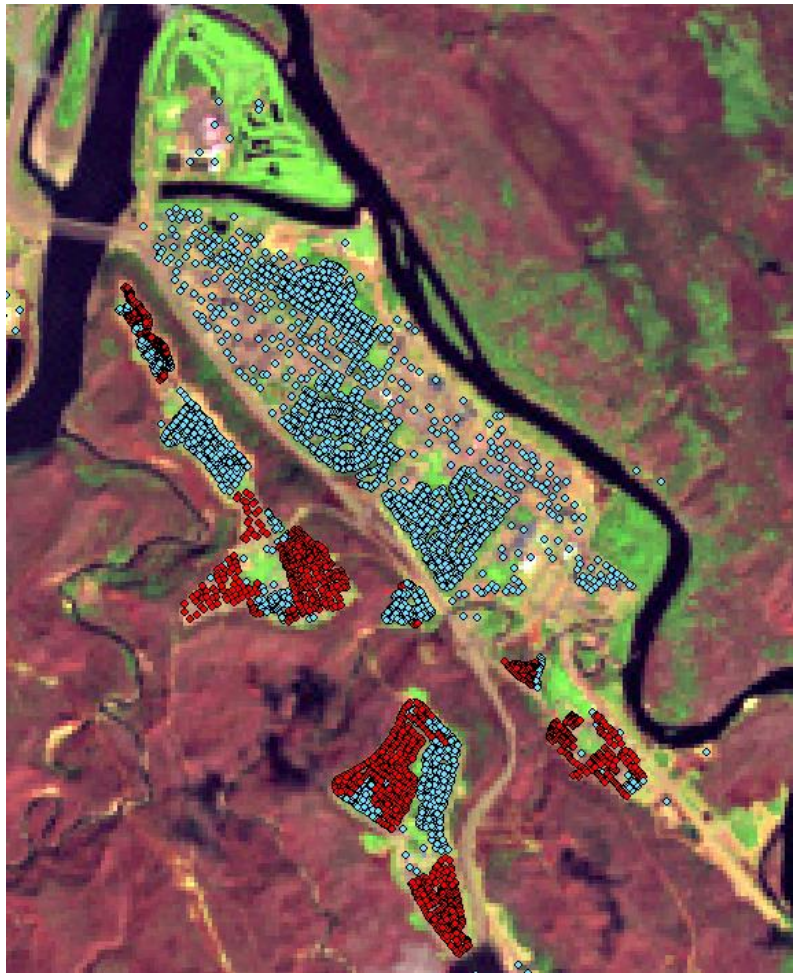


Lytton (Thomson Nicholas Regional District web maps)



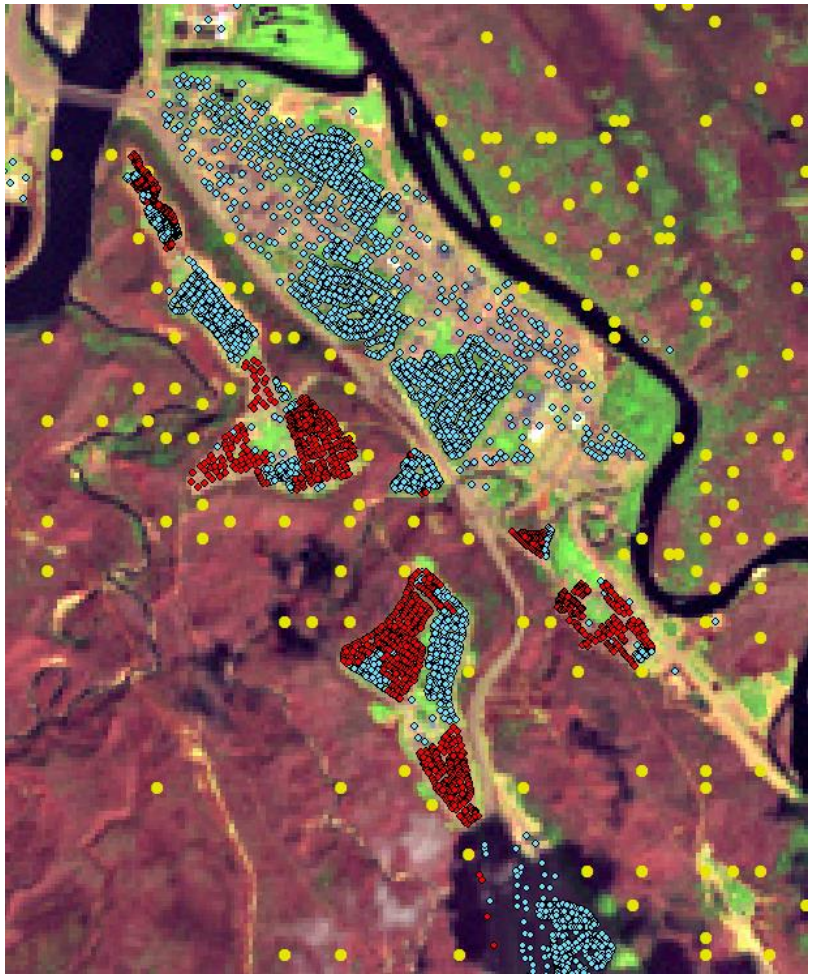
Task 2: Post-fire damage databases

Burn scar image (NASA)



Hot spots (CWFIS), locations and attributes

Canadian Wildland Fire Information System



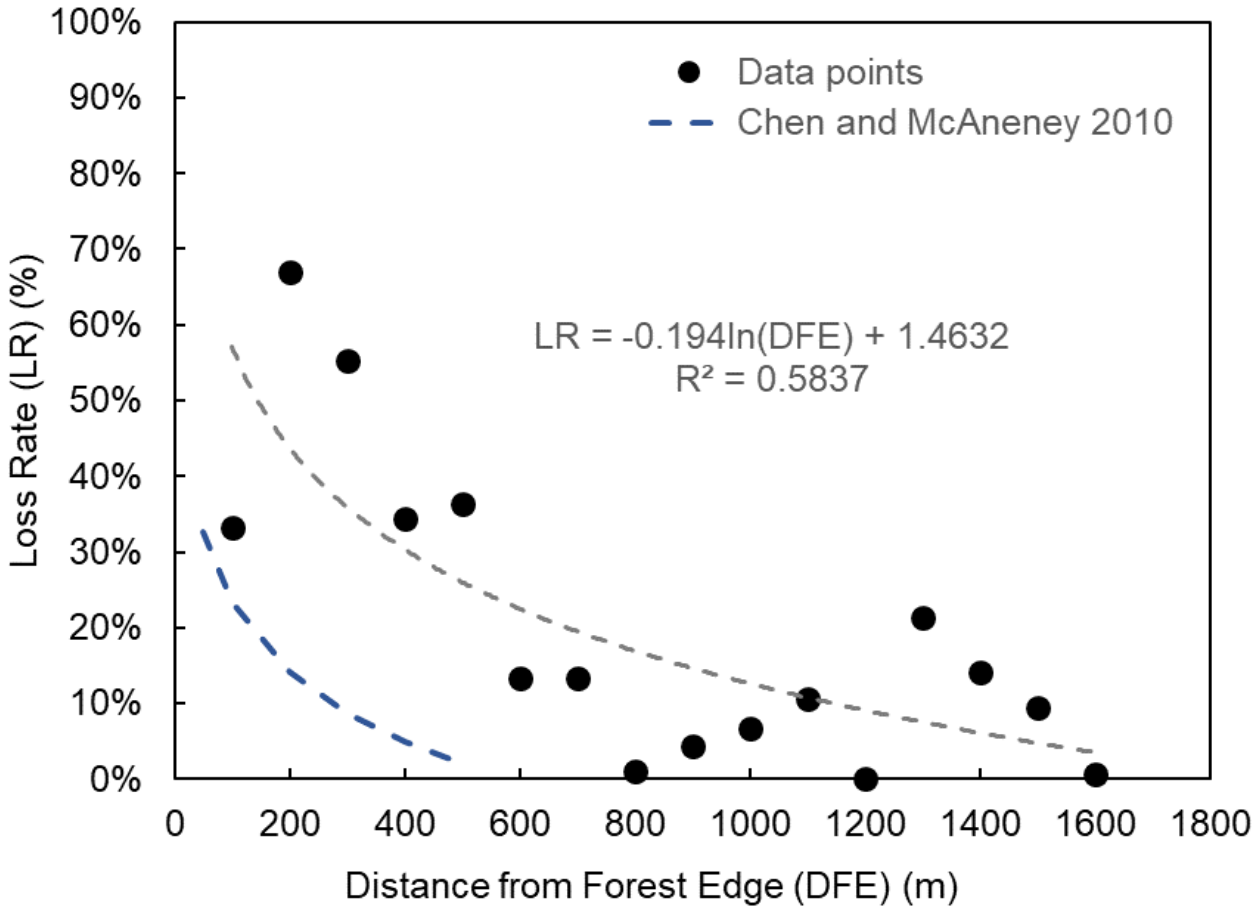
Case Study

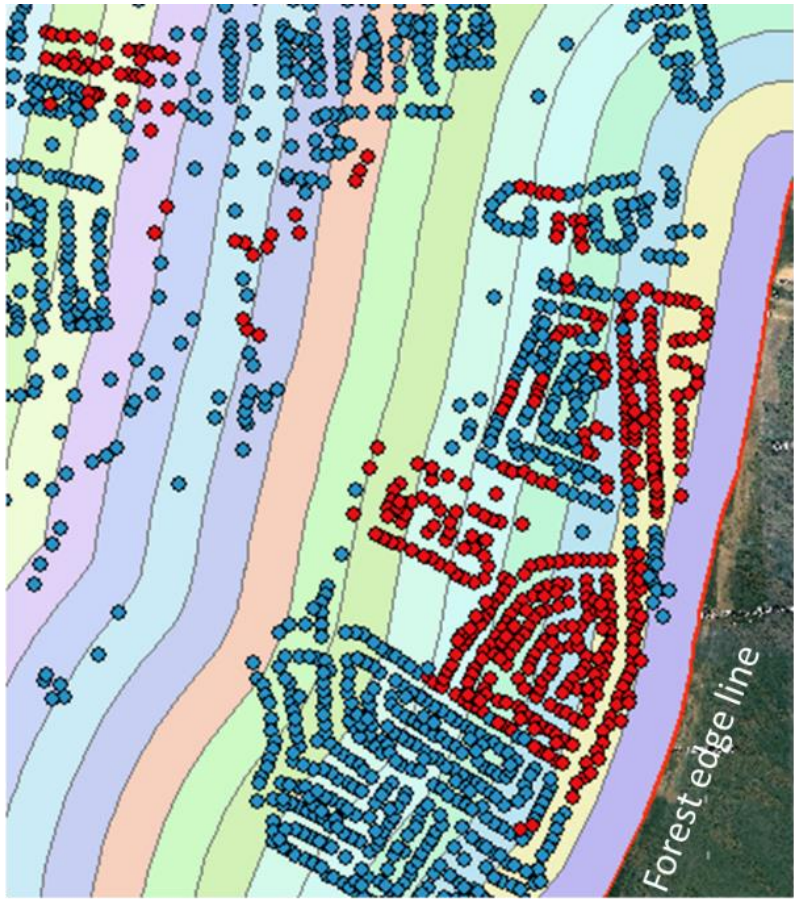
Town of Slave Lake, Alberta
(Flat Top Complex Fire), 2011

- The fire forced the complete evacuation of the town 7,000 residents.
- The fire destroyed more than 400 buildings including the town hall and the library buildings.
- Insurable damage was estimated at C$750 million.

Satellite image (Google earth pro©.) and georeferenced destroyed (in **red**) and survived (in **blue**) buildings

Empirical vulnerability function

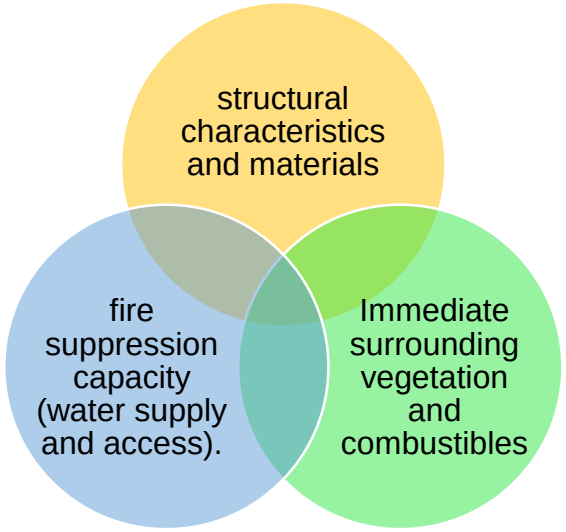


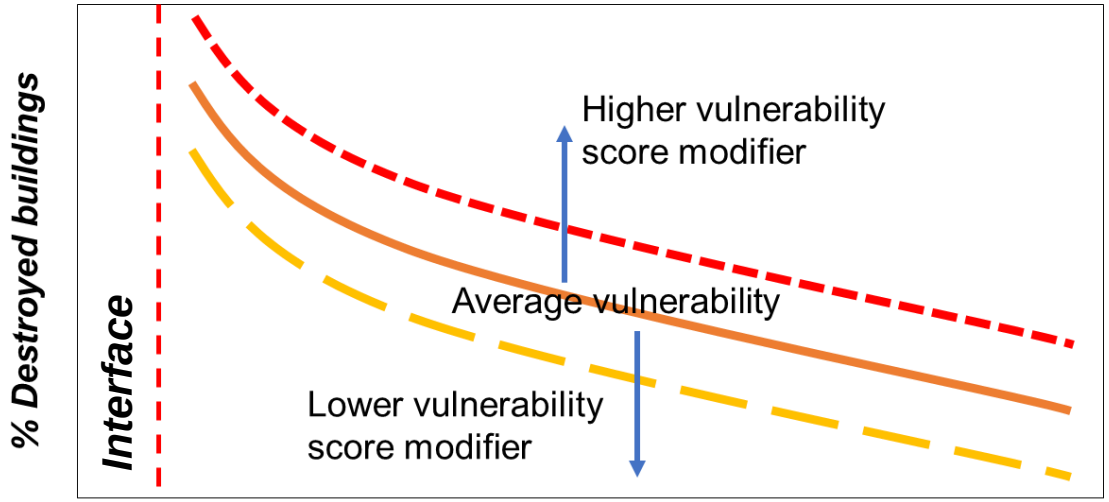


Loss Rate (LR) : proportion of buildings that were damaged to the total number of buildings at each distance increment from the forest edge

Outlook

- Future research in the framework of this project will include the assessment of the influence of building specific vulnerability parameters such as construction materials of roofs, walls, windows, vegetation conditions and combustibles near the building and fire suppression capacity.





Thank you!
Merci!

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