Strategic Infrastructure Planning: Wildfire Evacuation, Transportation, and Human Behaviour

Project Co-PIs

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Funder for Project

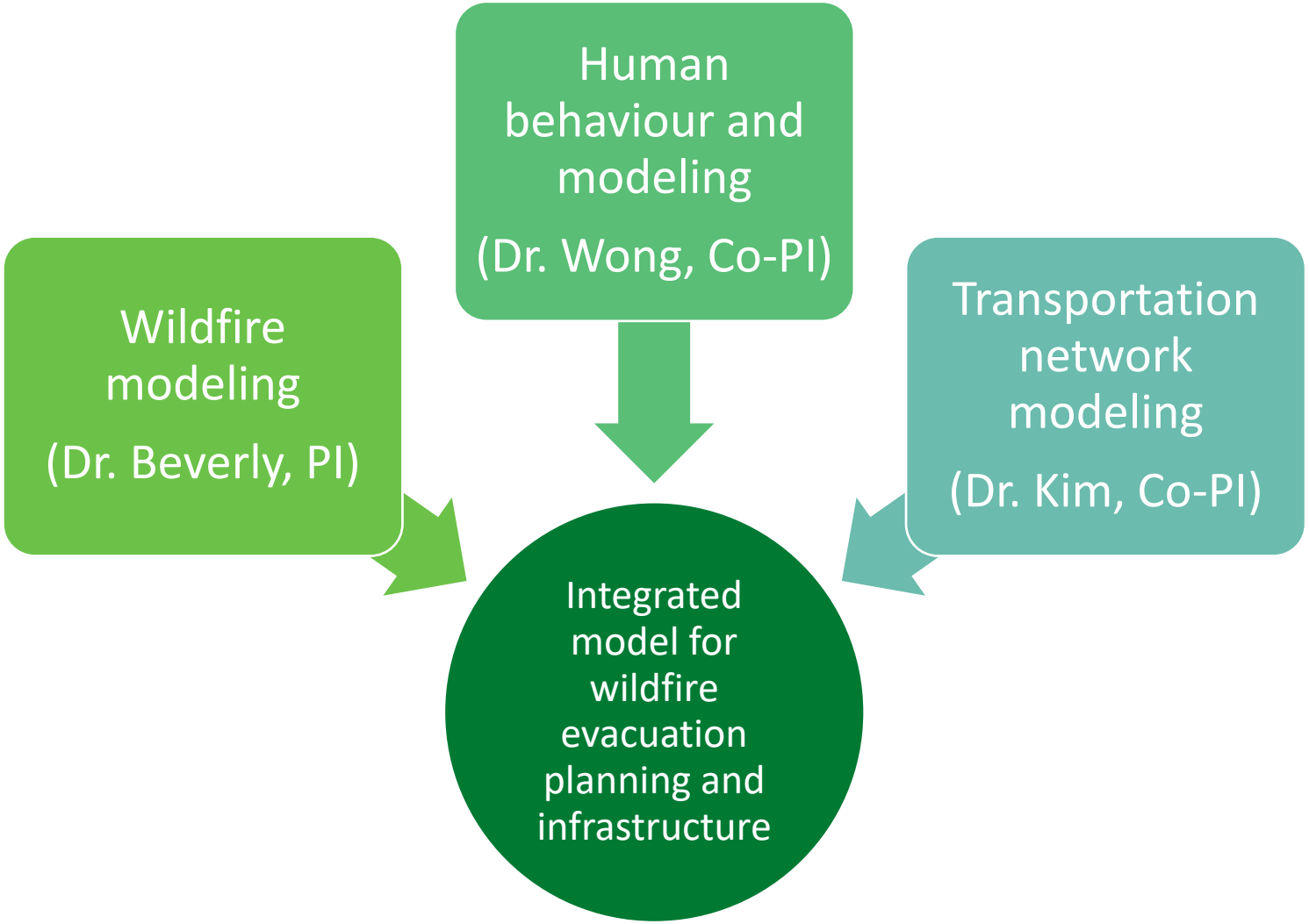
Housing, Infrastructure and Communities Canada

Research and Knowledge Initiative

- The purpose of the Research and Knowledge Initiative is to advance the understanding of public infrastructure needs, challenges, and opportunities relevant to Canadians.

Housing, Infrastructure and Communities Canada
Logement, Infrastructures et Collectivités Canada

Big Picture – Interdisciplinary Project



Wildfire Evacuation Analysis and Planning in Canada

- Modeling for five small communities in Canada (between 10,000 and 25,000 people)
- Canmore, Whitecourt, Salmon Arm, Nelson, Quesnel
- Results can help inform small town and rural evacuation planning in Canada and beyond

2021 Lytton Fire

Source: Darryl Dyck / The Canadian Press

WILDFIRE ANALYTICS

Jen Beverly
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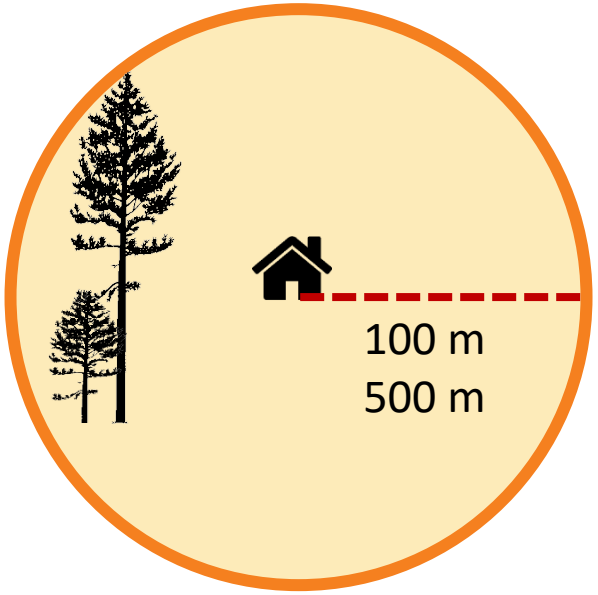
Patrick Mahler

UNIVERSITY OF ALBERTA

Wildfire Modelling

Overview of methods
Highlight results

Canmore
Nelson
Quesnel
Salmon Arm
Whitecourt

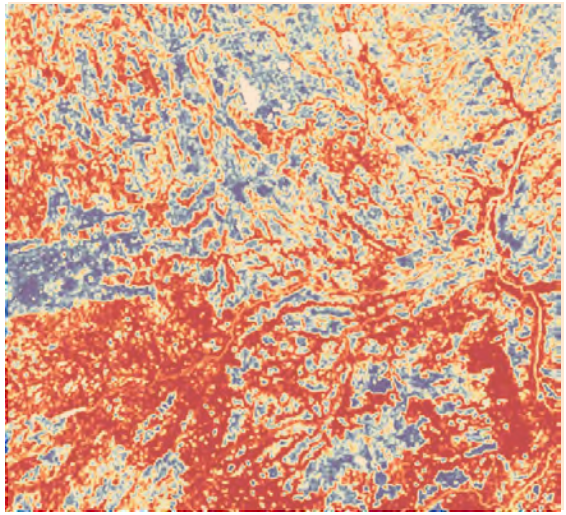


Wildfire exposure and directional vulnerability

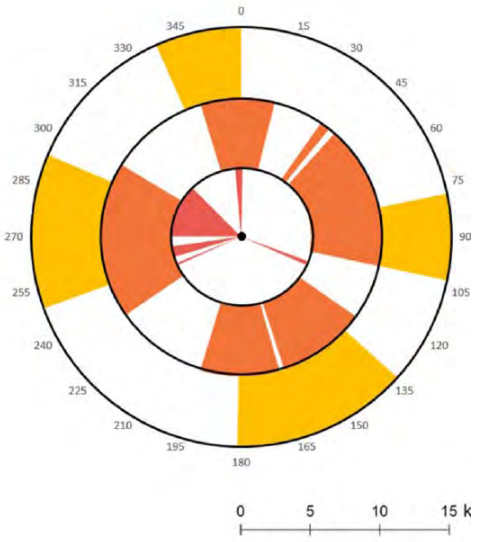
Three Assessments:

1. Landscape Scale Exposure
2. Community Scale Exposure
   - Longer range embers (500 m)
   - Short range embers (100 m)
3. Directional Vulnerability

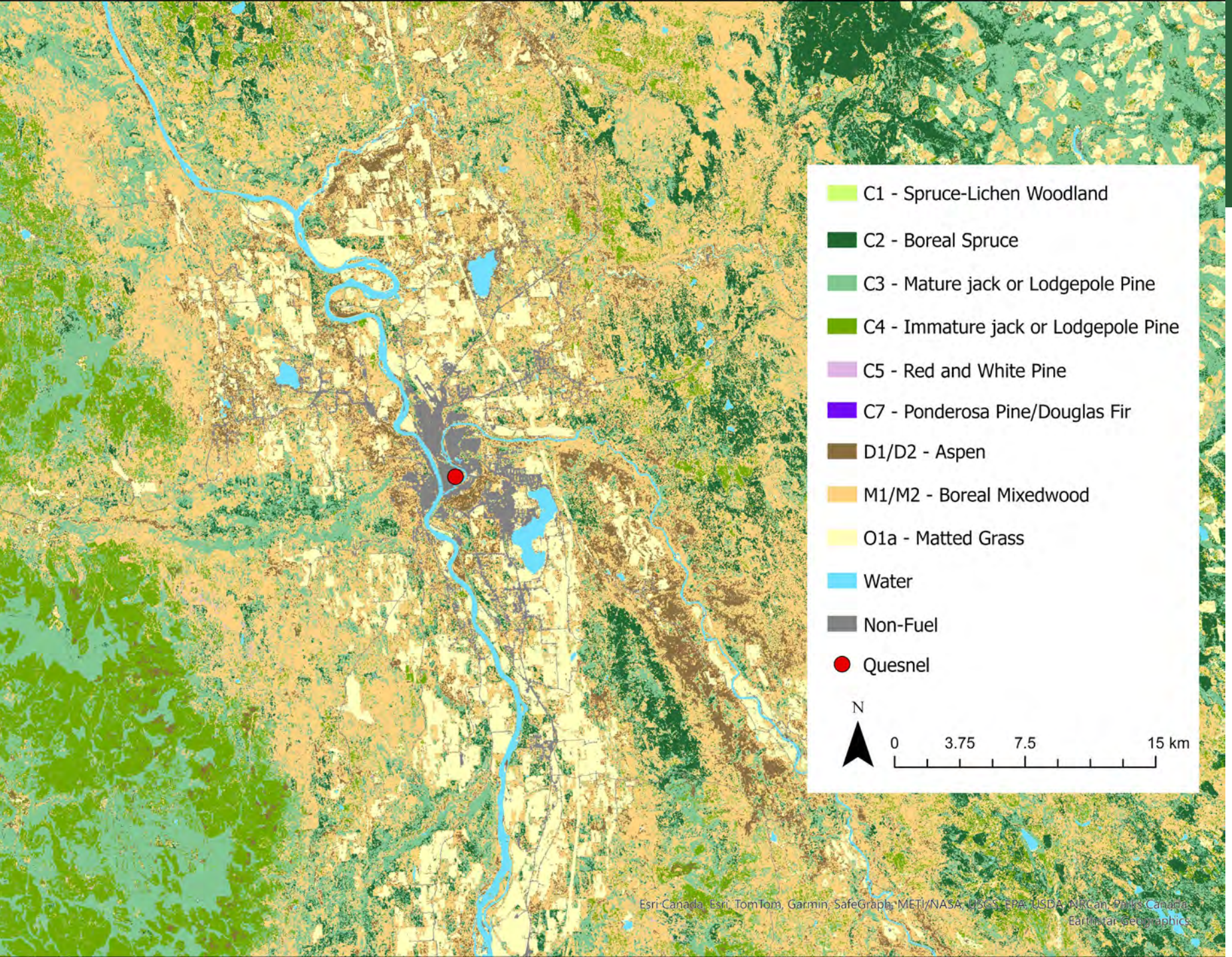
Landscape Exposure



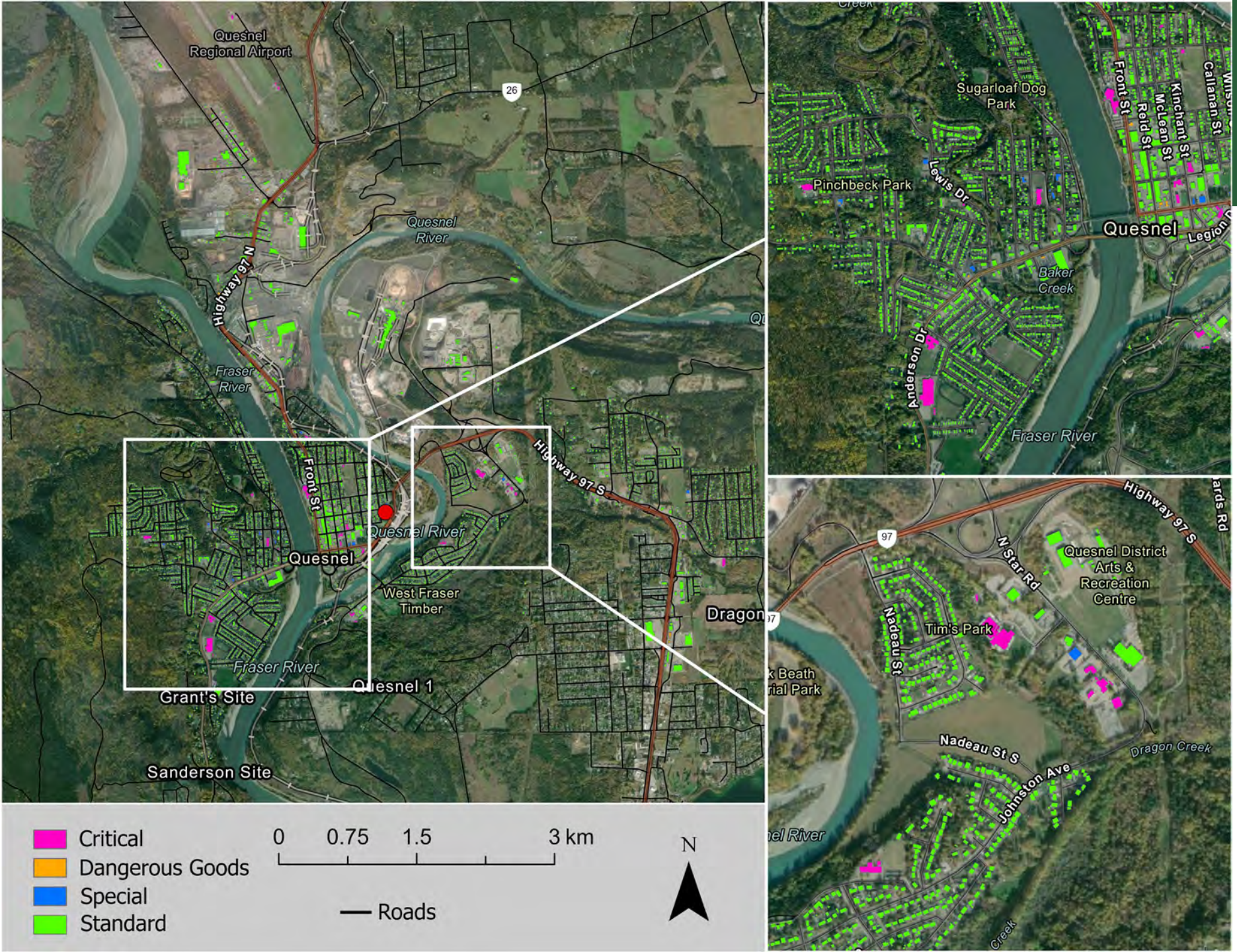
Fire pathways
(vulnerable directions)



Fuel


C1 - Spruce-Lichen Woodland
C2 - Boreal Spruce
C3 - Mature jack or Lodgepole Pine
C4 - Immature jack or Lodgepole Pine
C5 - Red and White Pine
C7 - Ponderosa Pine/Douglas Fir
D1/D2 - Aspen
M1/M2 - Boreal Mixedwood
O1a - Matted Grass
Water
Non-Fuel
Quesnel
N
0
3.75
7.5
15 km
Esri Canada, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, EPA, USDA, NRCan, Parks Canada, Earthstar Geographics

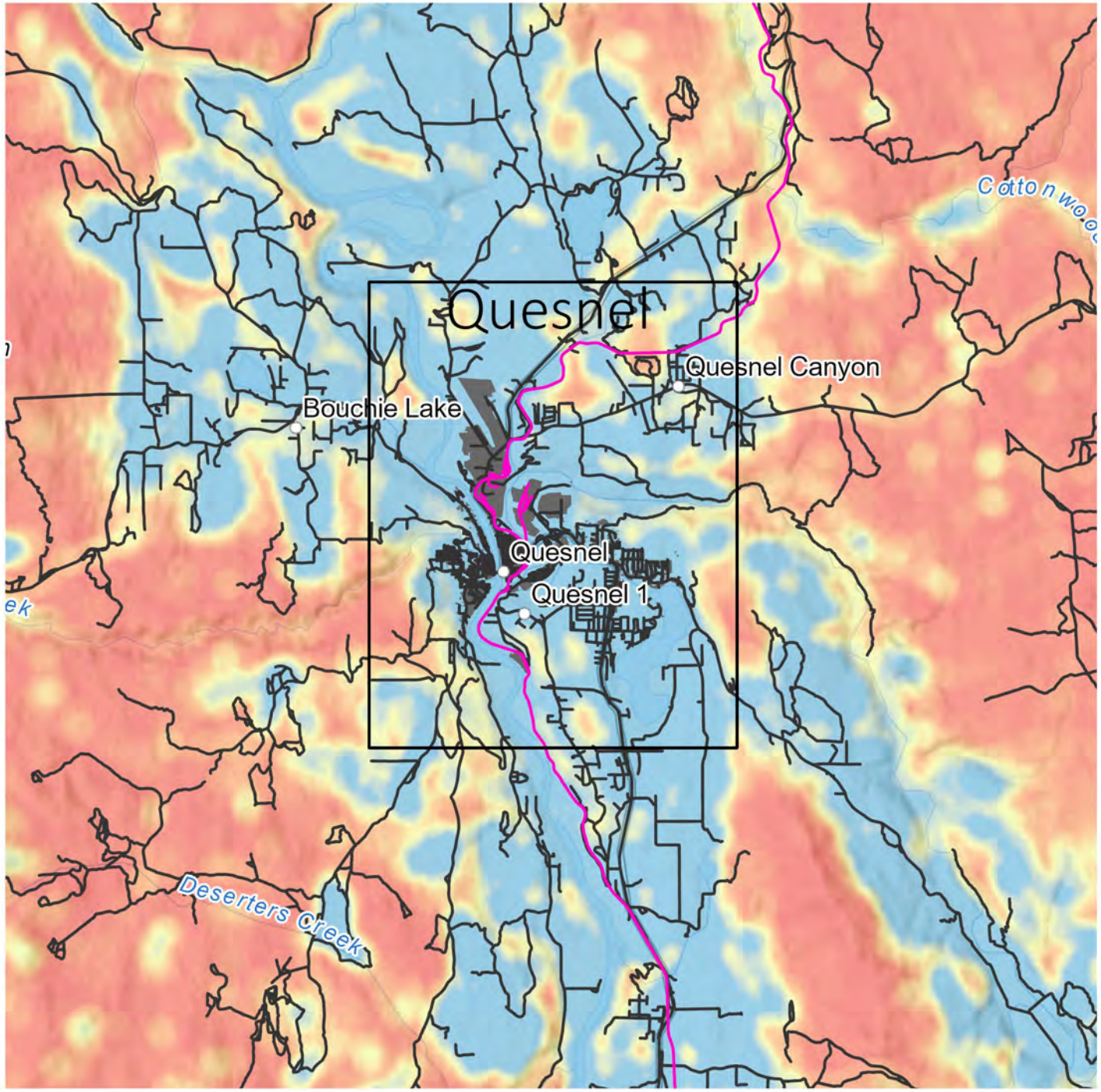
Structures

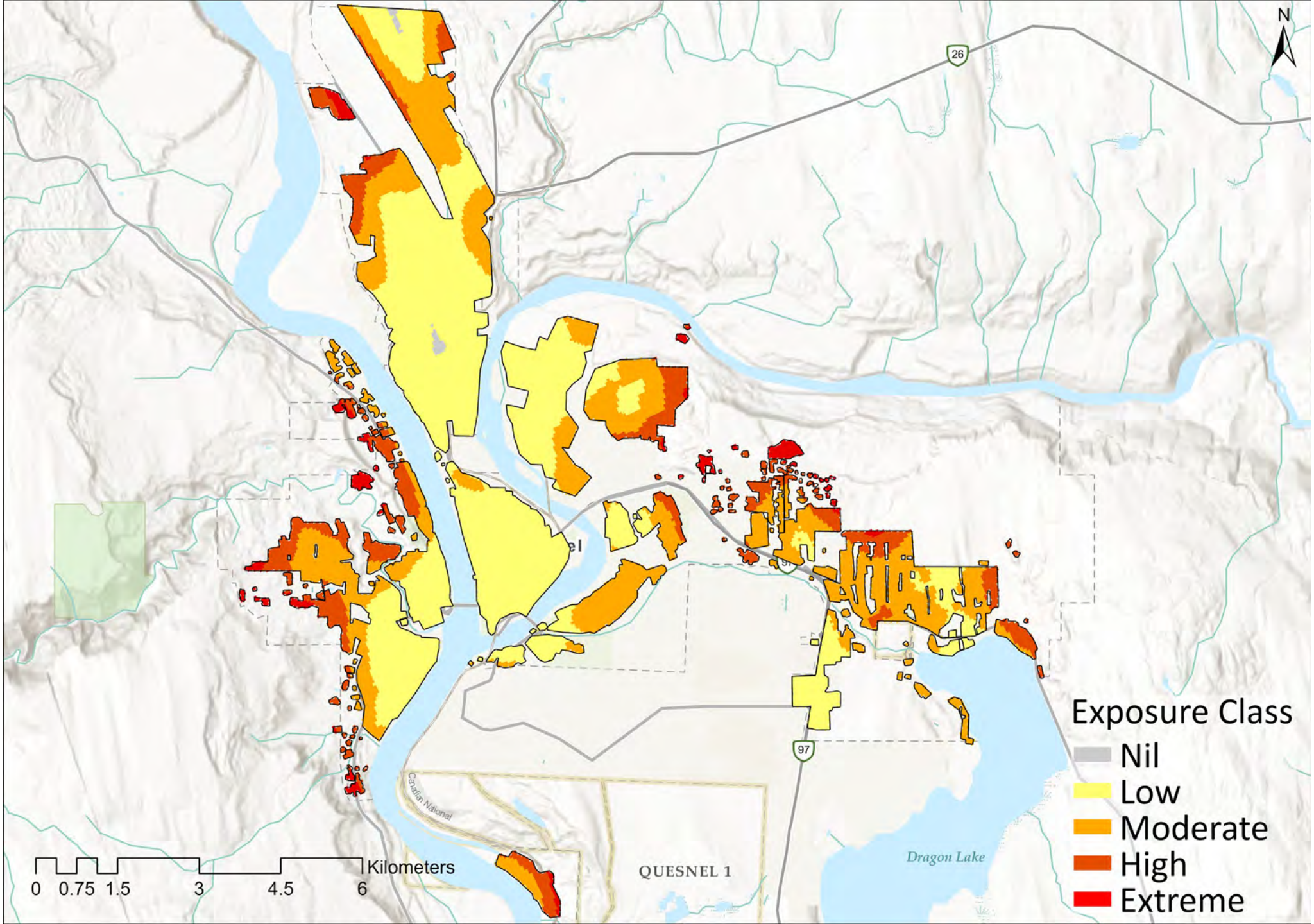

Quesnel Regional Airport
26
Quesnel River
Highway 97 N
Fraser River
Front St
Quesnel River
Quesnel
West Fraser Timber
Highway 97 S
Dragon
Fraser River
Quesnel 1
Grant's Site
Sanderson Site
Critical
Dangerous Goods
Special
Standard
0 0.75 1.5 3 km
Roads
N

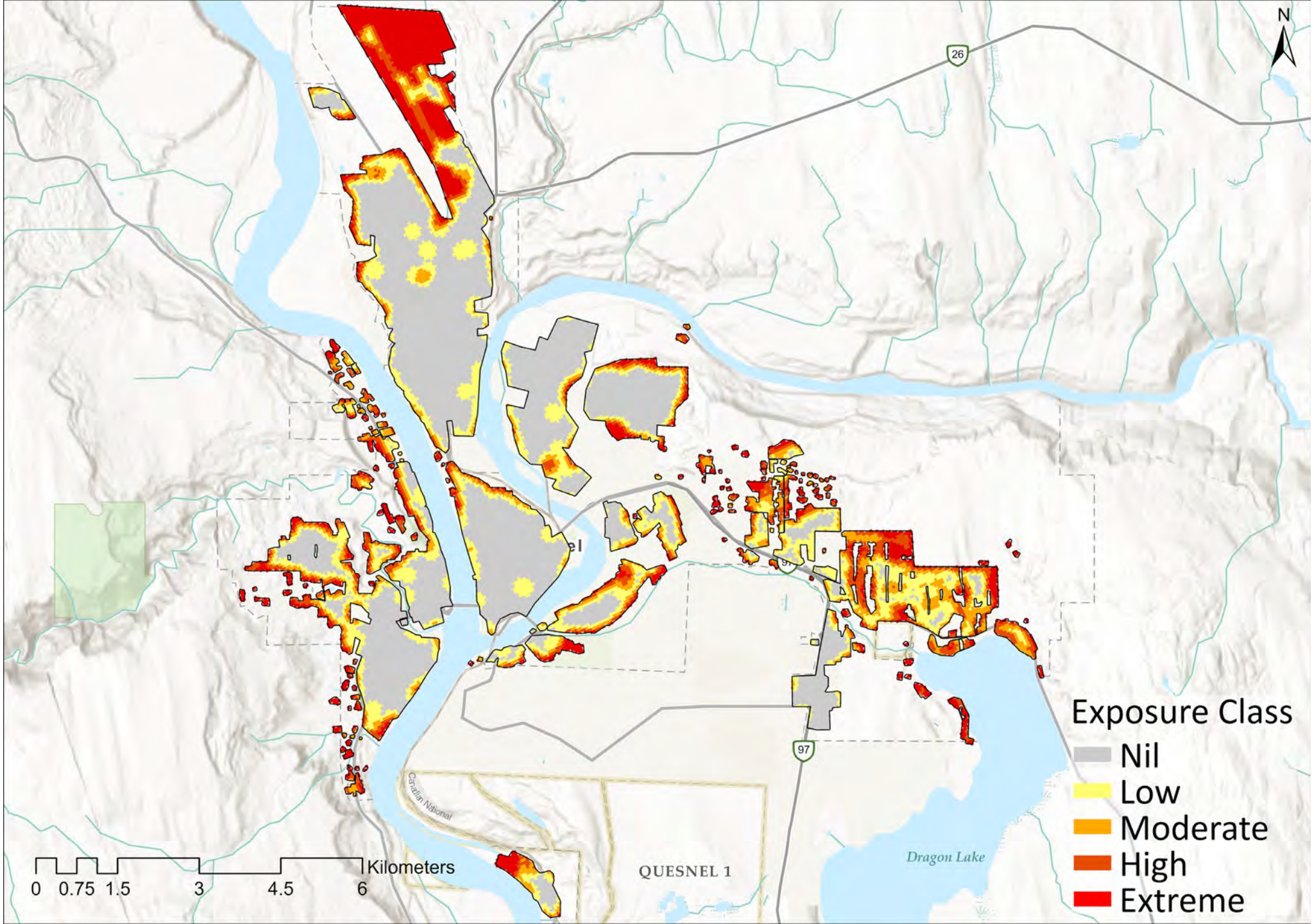
Sugarloaf Dog Park
Front St
Reid St
McLean St
Kinchant St
Callanan St
Pinchbeck Park
Lewis Dr
Quesnel
Baker Creek
Anderson Dr
Fraser River

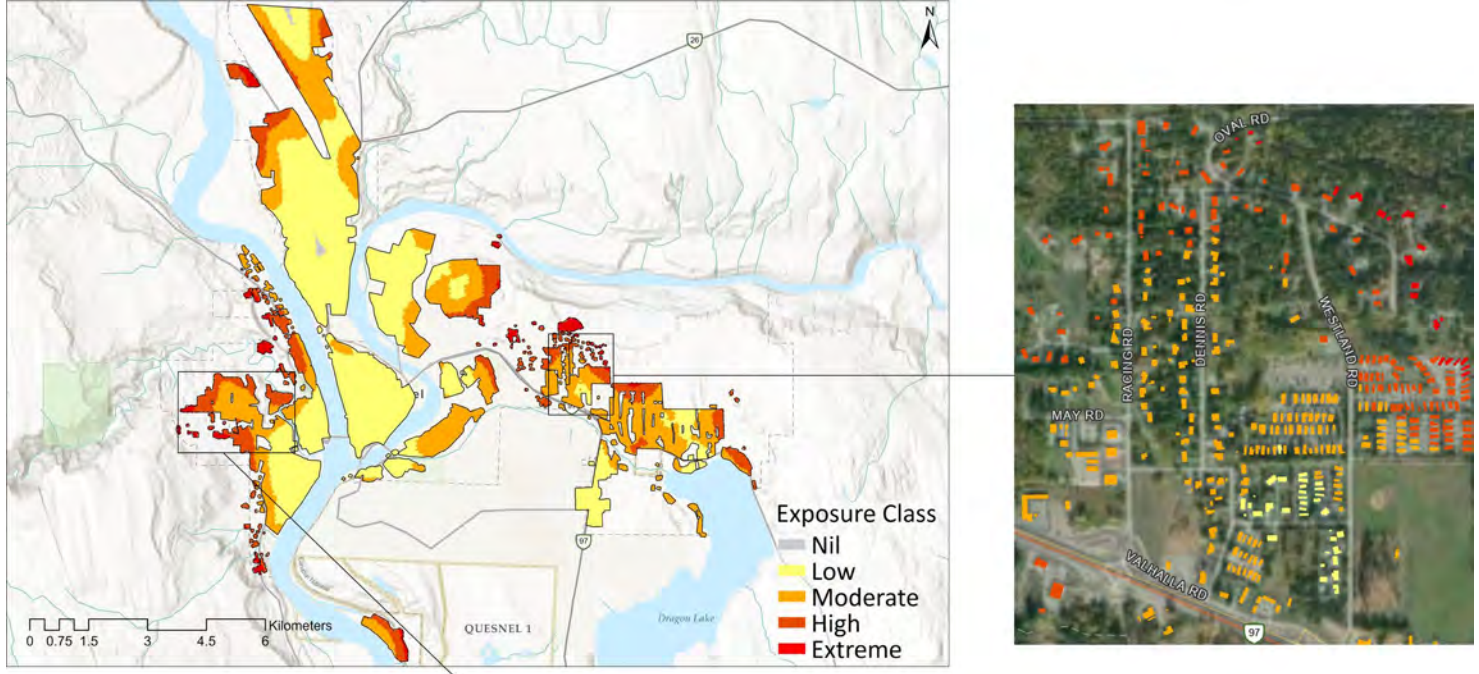
Highway 97 S
97
N Star Rd
Quesnel District Arts & Recreation Centre
Nadeau St
Tim's Park
Nadeau St S
Dragon Creek
Johnston Ave

Landscape Exposure and Directionality



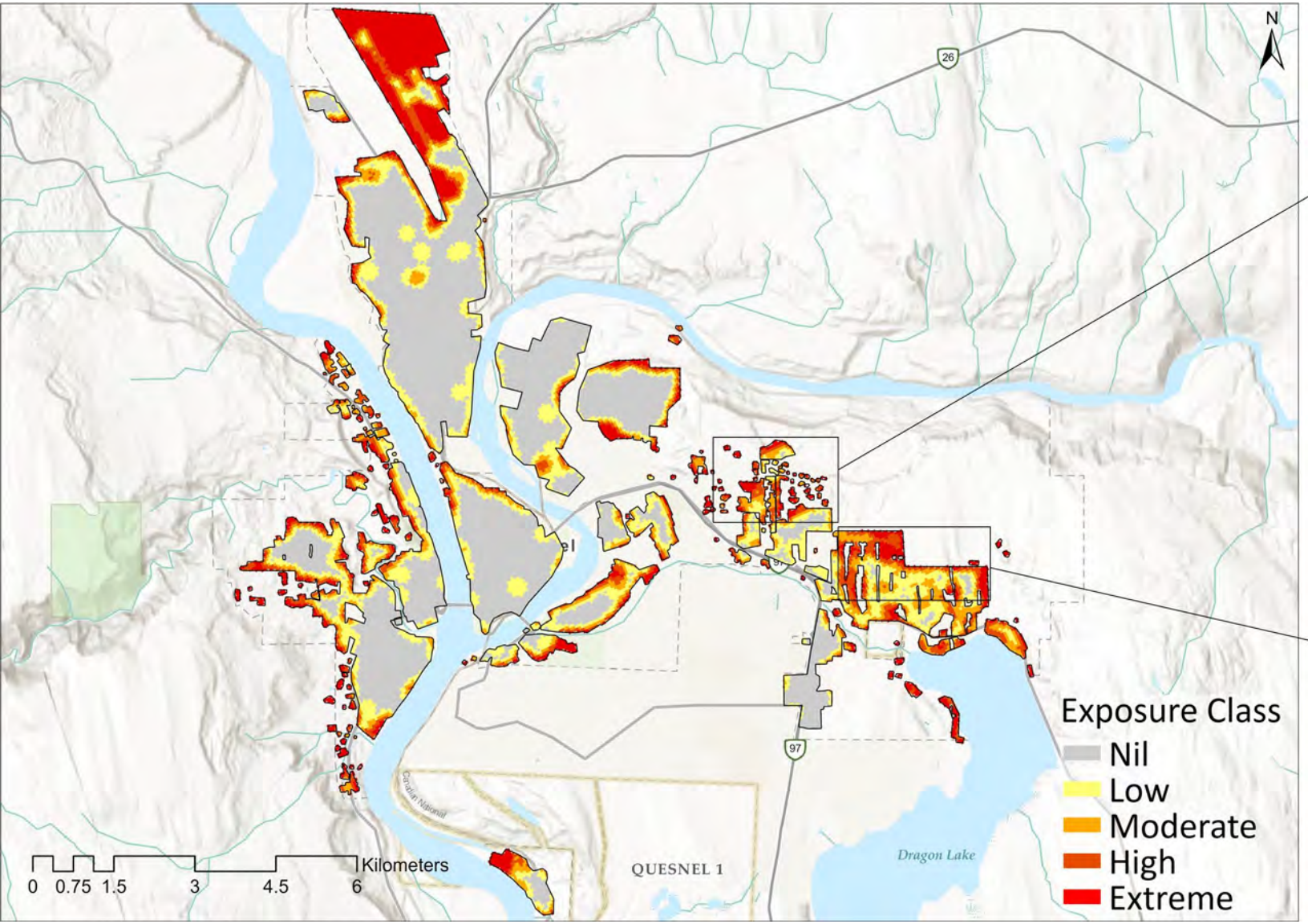

N
26
97
Exposure Class
Nil
Low
Moderate
High
Extreme
Kilometers
0 0.75 1.5 3 4.5 6
QUESNEL 1
Dragon Lake
Canadian National

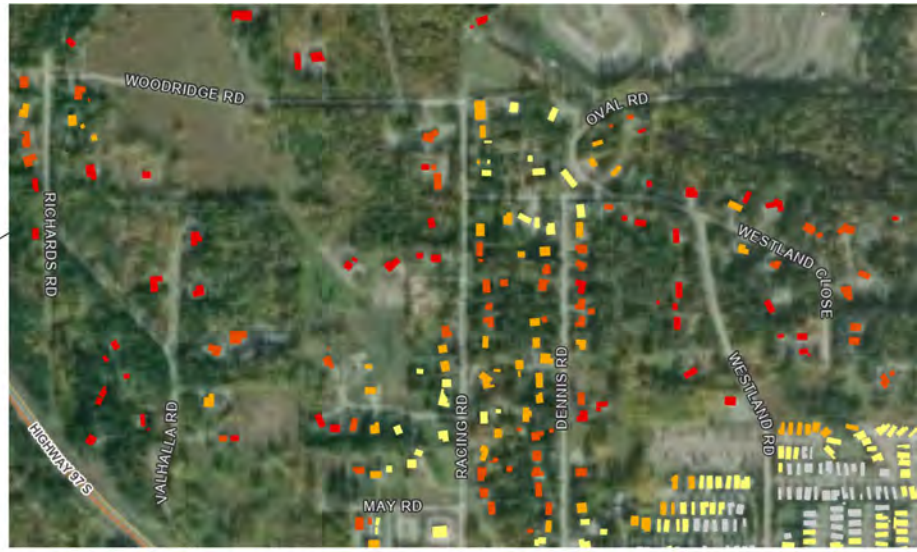

N
26
97
Exposure Class
Nil
Low
Moderate
High
Extreme
Kilometers
0 0.75 1.5 3 4.5 6
QUESNEL 1
Dragon Lake
Canadian National


N
Exposure Class
Nil
Low
Moderate
High
Extreme
0 0.75 1.5 3 4.5 6
Kilometers
QUESNEL 1
Dragon Lake

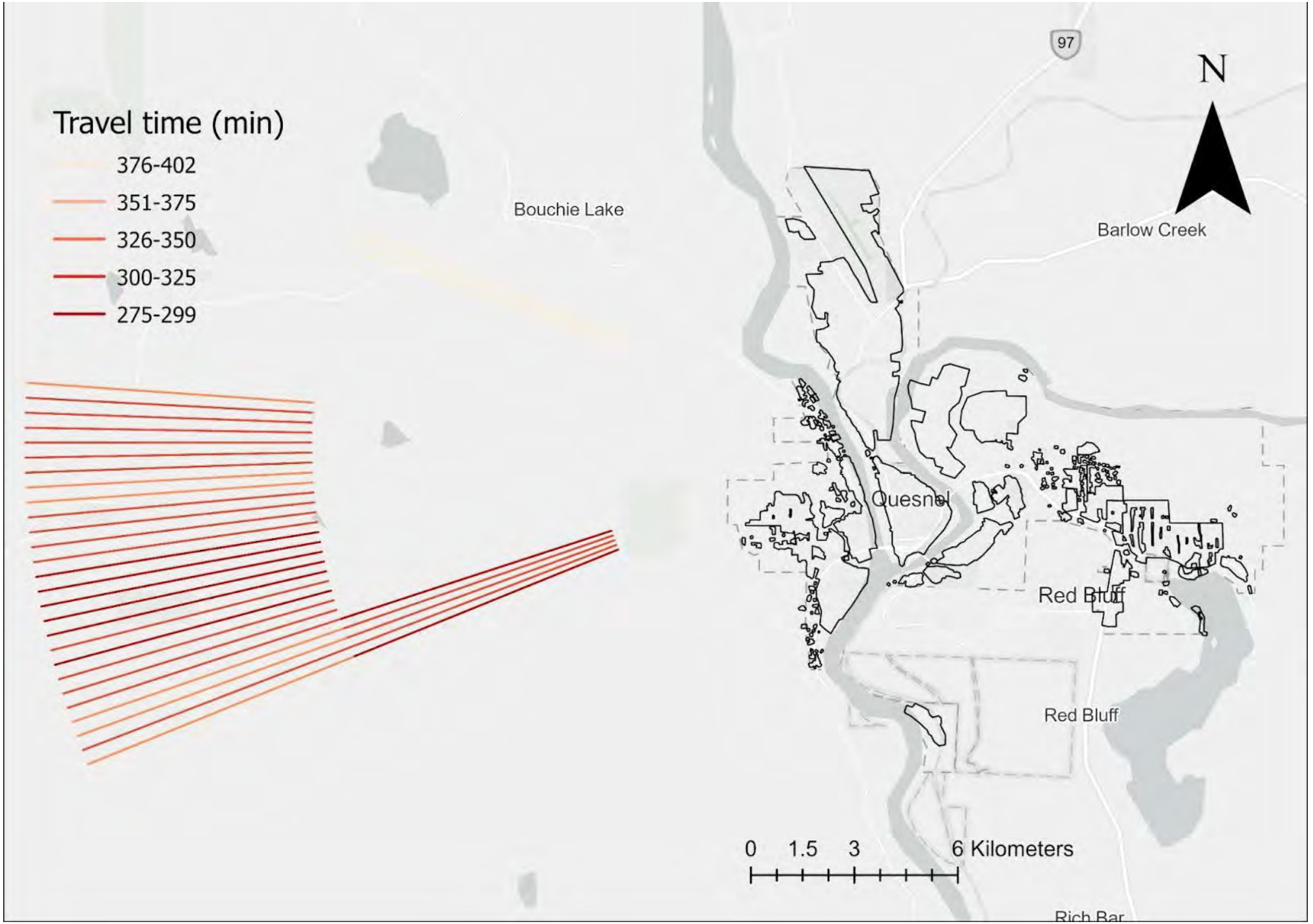
OVAL RD
RACING RD
DENNIS RD
WESTLAND RD
MAY RD
VALHALLA RD
97


PALEY AVE
PICARD AVE
LEWIS DR
BAKER DR
DIXON ST
PATCHETT ST
PINCHBECK ST
DAWSON ST
FINDLAY RD
ABBOTT DR
FLAMINGO ST
BETTCHER ST
BLAIR ST
STORK AVE
BOYD ST


N
26
97
Exposure Class
Nil
Low
Moderate
High
Extreme
0 0.75 1.5 3 4.5 6
Kilometers
QUESNEL 1
Dragon Lake


WOODRIDGE RD
OVAL RD
RICHARDS RD
WESTLAND CLOSE
HIGHWAY 97 S
VALHALLA RD
RACING RD
DENNIS RD
WESTLAND RD
MAY RD


BRITTON RD
BRITTON RD
COACH RD N
GROSZ RD N
BREARS RD N
PHILLIPS RD N
ENEMARK RD N
GAVLIN RD
GAVLIN RD
PEDERSEN RD
GROSZ RD S
BREARS RD
PHILLIPS RD S
ENEMARK RD S
CRAWFORD RD
FIEGER RD
REDDEN RD
TAITCHELL RD
NEIGHBOUR RD
QUESNEL-HYDRAULIC RD
SANDERSON RD
VIKER RD


Travel time (min)
376-402
351-375
326-350
300-325
275-299
Bouchie Lake
97
N
Barlow Creek
Quesnel
Red Bluff
Red Bluff
0 1.5 3 6 Kilometers
Rich Bar

Source: City of Quesnel / Used with Permission

Human Behaviour and Modelling

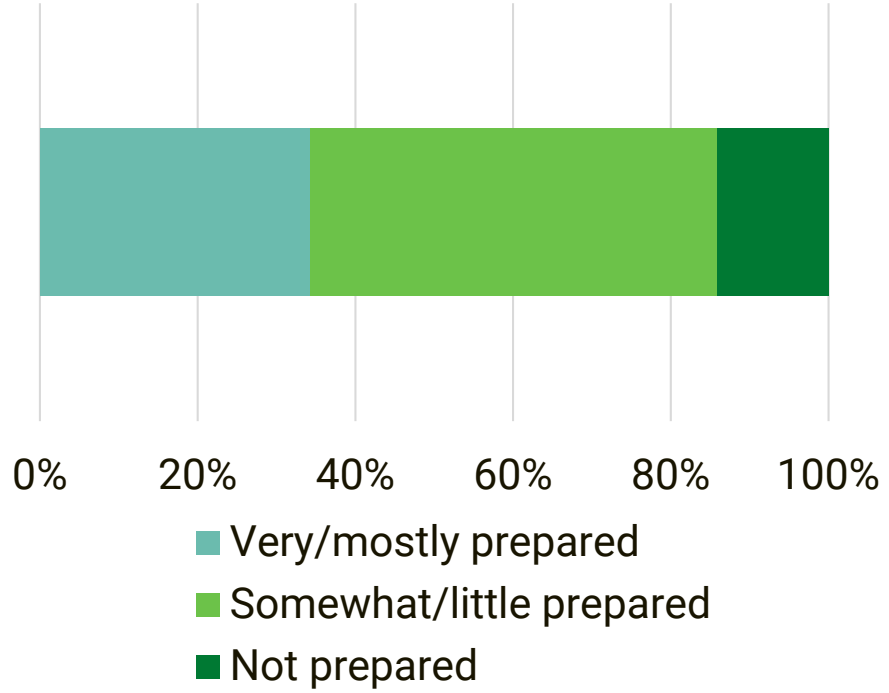
Data Collection

- Panel Sample
  - Alberta and British Columbia residents (n=1,371)
  - Self-report high/moderate fire risk
- Convenience Sample
  - Residents in five communities (n=1,497)
  - Quesnel (n=187)

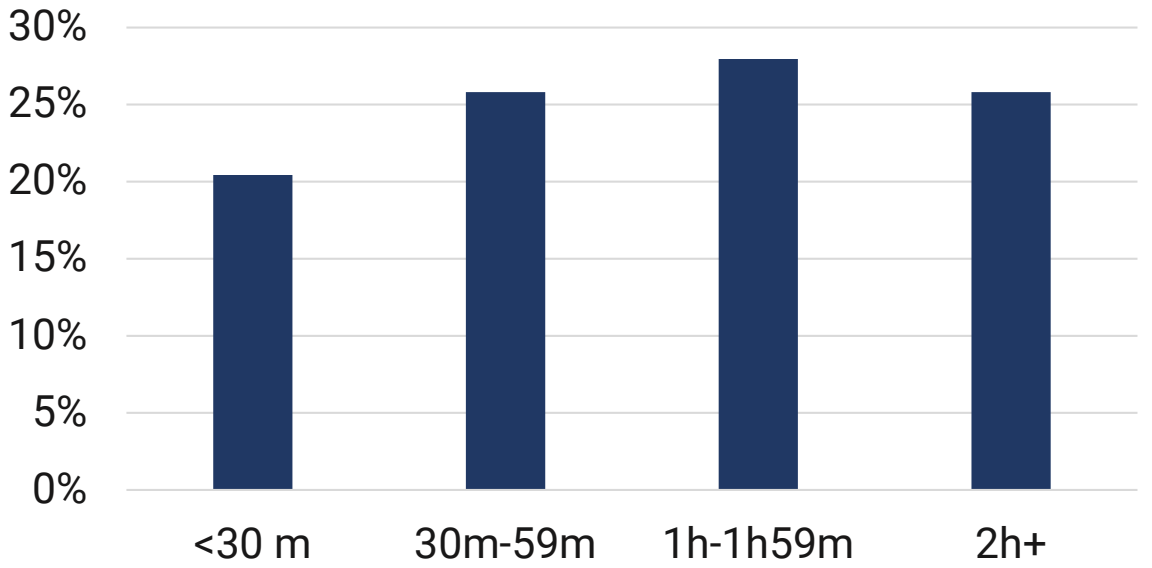
Source: Province of British Columbia

Key Results for Quesnel

Preparation Level for an Evacuation (n=184)

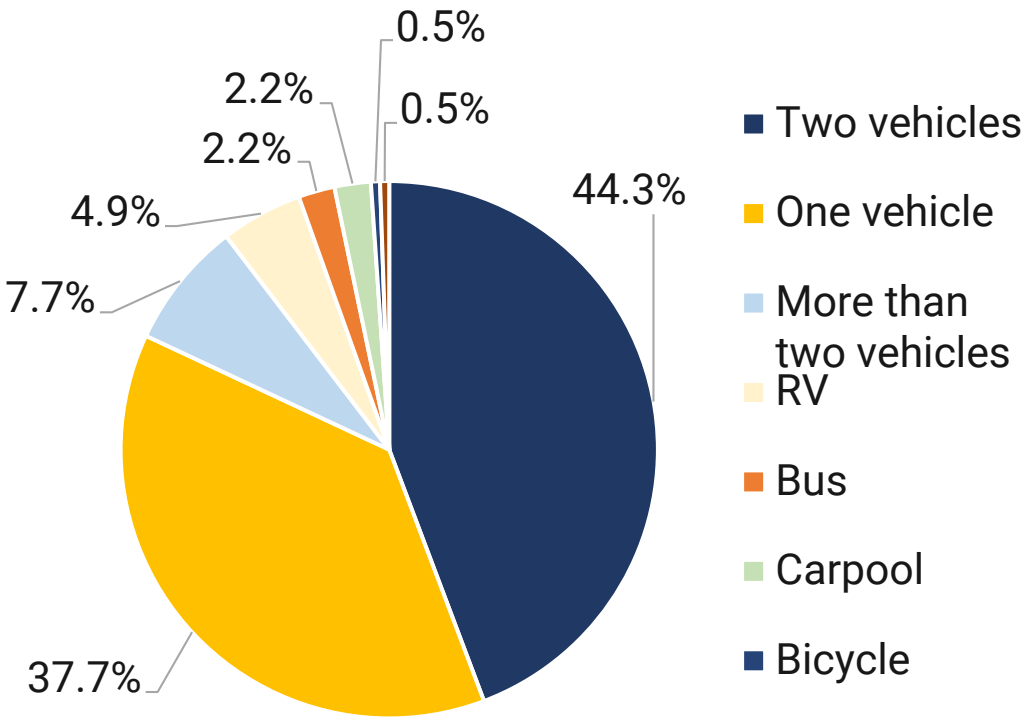


Preparation Time Before Evacuating (n=186)

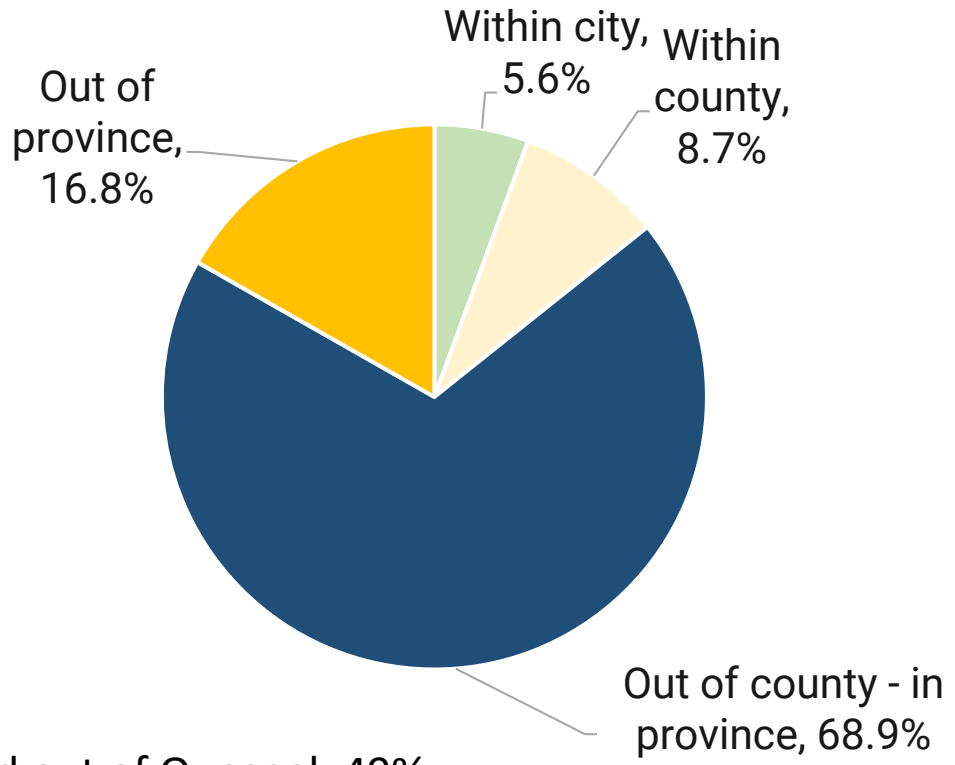


Key Results for Quesnel

Mode Choice for Evacuation (n=183)



Evacuation Destination (n=161)



Of those evacuating within Canada and out of Quesnel, 49% would likely evacuate north and 51% would evacuate south

Key Results for Quesnel

Expected Evacuation Information Sources (select all that apply) (n=187)

	Family/friends	Neighbours	Government
Text	51%	34%	82%
Phone call	50%	29%	45%
Conversation	50%	51%	32%
Social media	43%	22%	72%

	Government	News outlet
Television	61%	66%
Radio	58%	62%
Website	72%	53%
Social media	67%	53%
Smartphone application	76%	43%
Billboard or road message sign	57%	24%

Quesnel Takeaways

- Over 50% of the population will take 1+ hours to prepare
  - A fast-moving fire may catch some people off guard.
- Significant use of multiple vehicles and high towing rates
  - Congestion will likely arise, especially at intersections.
- Balanced directionality of evacuation travel

  Transportation/shelter strategies are needed both north and south.
- High expectations of evacuation information from the government
  - Multiple communication channels will need to share consistent information.

Source: Quesnel Cariboo Observer

Overall Behaviour Modeling Recommendations

General Population Assessment

- 1) Evacuation route improvements
- 2) Diverse communication strategies
- 3) Tailored evacuation plans to the local context and household needs

Vulnerable Population Assessment

- 1) Multimodal evacuation plans with transit and shared mobility considerations
- 2) Public shelters with amenities to accommodate diverse needs
- 3) Targeted support for those with intersecting vulnerabilities

2024 Jasper Complex Wildfire

Source: Global News

Photo by Cole Freeman on Unsplash

Evacuation Simulation Model

Simulation Model Inputs

Wildfire Exposure

- Community fire entry scenario(s) of concern

Human Behaviour

- Survey respondents' evacuation intentions and preparedness

Evacuation Simulation Model

Insights for evacuation traffic management and planning, and infrastructure design

Open-source Multi-Agent Transport Simulation Platform

MATSim
Multi-Agent Transport Simulation

Inputs for our models:

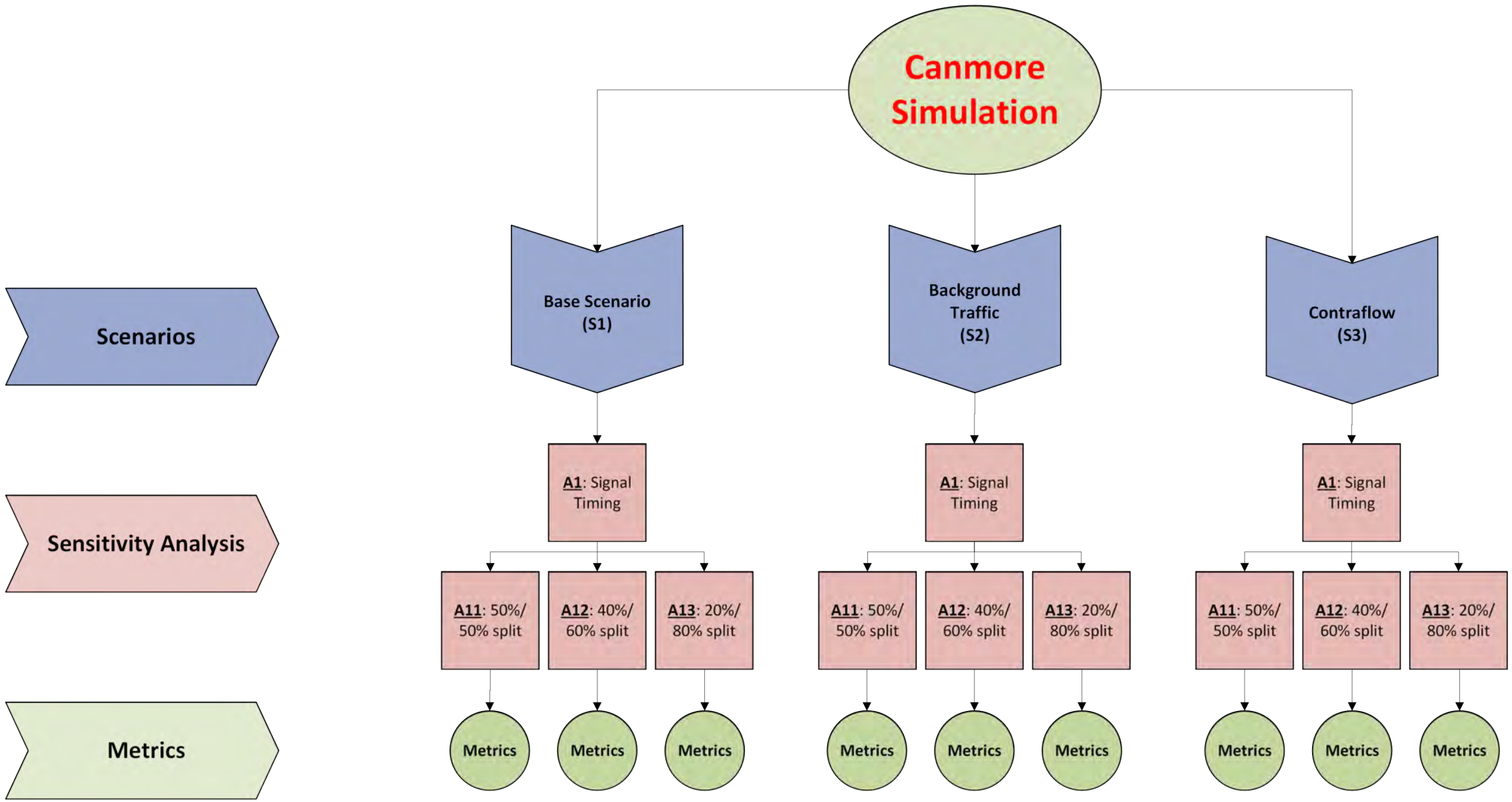
- **Transportation network:** Open Street Map (OSM) data
- **Population / transportation demand:** Canada Census 2021 dataset, neighborhood footprints, behavioural survey
- **Traffic control devices:** Signal timings/configuration from community or BC MoTT, or in absence, basic assumptions

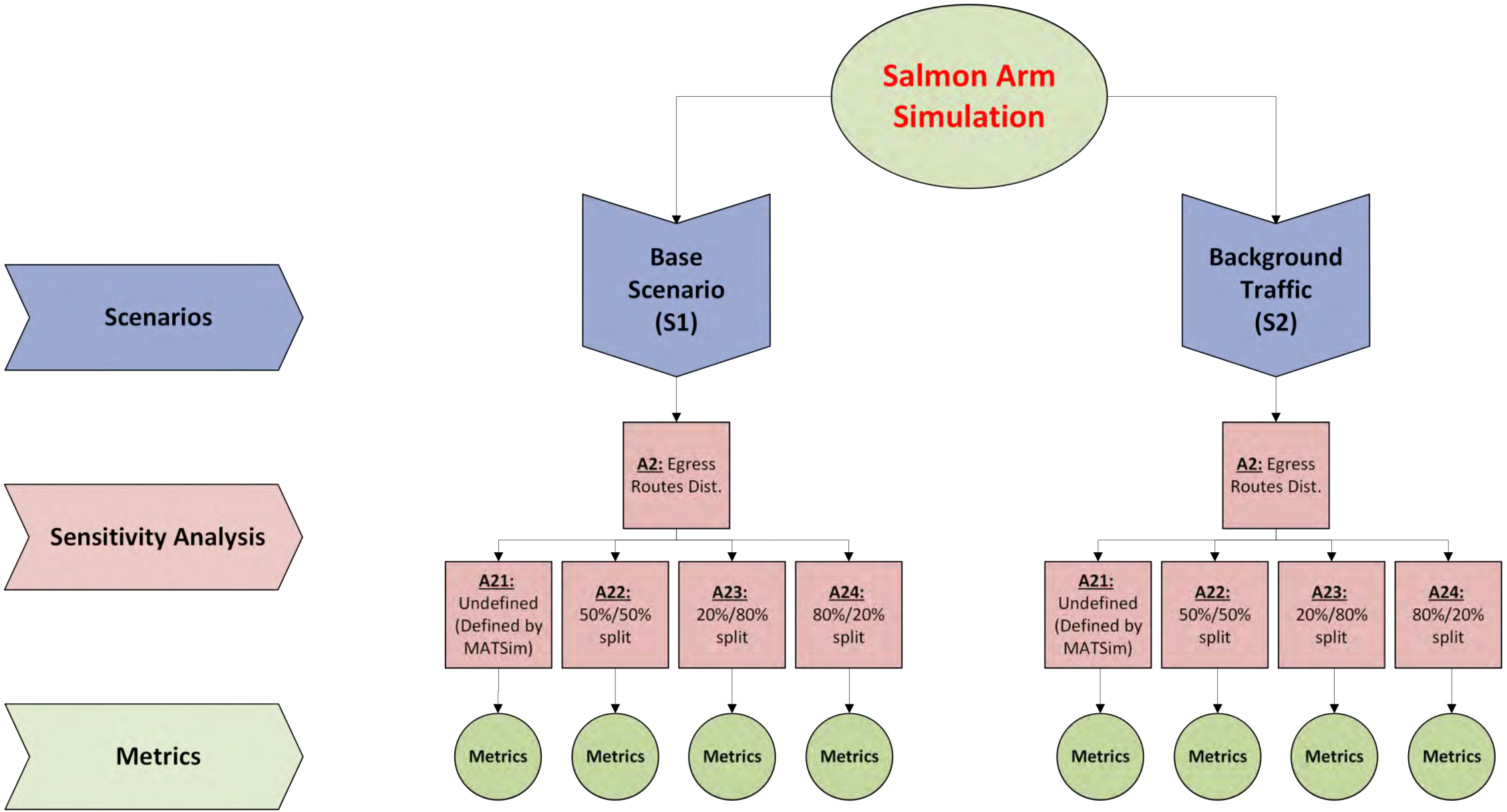
Household departure times from the survey data

Two elements, of many we investigated, had the clearest influence on departure times:

1. Having children in the household
2. Respondent have had prior direct experience with wildfire

Option
'Attended a public meeting about wildfire management'
'Learned about wildfire in a class, from TV/video, a book or newspaper, an expert, or family/friends
'Saw the flames of a wildfire'
'Experienced discomfort from or saw the smoke of a wildfire'
'Had my work/job/livelihood affected by a wildfire'
'Saw parts of an area that had recently burned.'
'My job is related to wildfires'
'Had personal property destroyed or damaged due to a wildfire'
'Been evacuated from my house due to a wildfire'
'Been injured as a result of a wildfire'


Scenarios
Sensitivity Analysis
Metrics
Canmore Simulation
Base Scenario (S1)
Background Traffic (S2)
Contraflow (S3)
A1: Signal Timing
A11: 50%/ 50% split
A12: 40%/ 60% split
A13: 20%/ 80% split
Metrics


Scenarios
Sensitivity Analysis
Metrics
Salmon Arm Simulation
Base Scenario (S1)
Background Traffic (S2)
A2: Egress Routes Dist.
A2: Egress Routes Dist.
A21: Undefined (Defined by MATSim)
A22: 50%/50% split
A23: 20%/80% split
A24: 80%/20% split
A21: Undefined (Defined by MATSim)
A22: 50%/50% split
A23: 20%/80% split
A24: 80%/20% split
Metrics
Metrics
Metrics
Metrics
Metrics
Metrics
Metrics
Metrics

Key Results – Measures

Output measures include:

- Travel time histograms
- Total evacuation time
- 95th percentile departure time
- Total congestion time over length (km) of roadways (km-hr)
- Average speed (VDT/VHT) (km/hr)

Key Takeaways

1. A lot of congestion both in town and on highways out during evacuation period – start evacuation earlier
2. Favoring major movements at intersections may create more localized congestion but improves overall evacuation measures
3. Match evacuee egress routes with roadway capacity as much as possible
    - Evacuation staging by neighborhood
    - Egress direction recommendations by neighborhood
    - Designation of reception centres

Next Steps

Source: Prince George Citizen

Next Steps

- Website with all project deliverables
- Documentation of MATSim model
- Open-access journal articles
- Continued presentations
- Opportunities to conduct scenario analysis in future grants

2003 Okanagan Mountain Park Wildfire

Source: Province of British Columbia / Flickr