UNIVERSITY OF ALBERTA
DEPARTMENT OF
RENEWABLE RESOURCES

WILDFIRE ANALYTICS

Jen Beverly

Fuel management planning – Some research insights from Alberta

Presented at the workshop "*Fuel Treatment Efficacy & Landscape Resiliency Research & Knowledge Sharing Event*"

Forest Sciences Centre, UBC Vancouver
by virtual attendance

March 1st, 2023

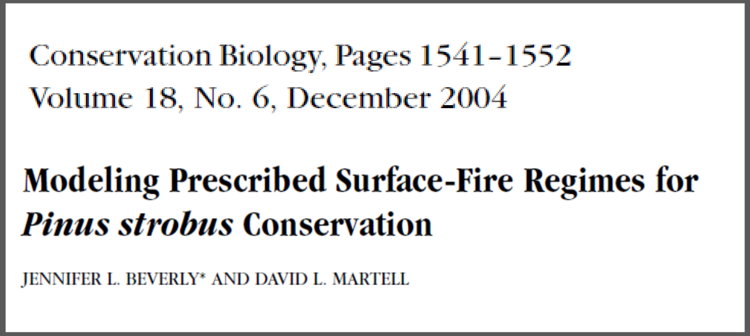
Connect

jen.beverly@ualberta.ca
wildfireanalytics.org
@fireanalytics

(Photo: J.L. Beverly)

Are we considering the broader fuel treatment regime?

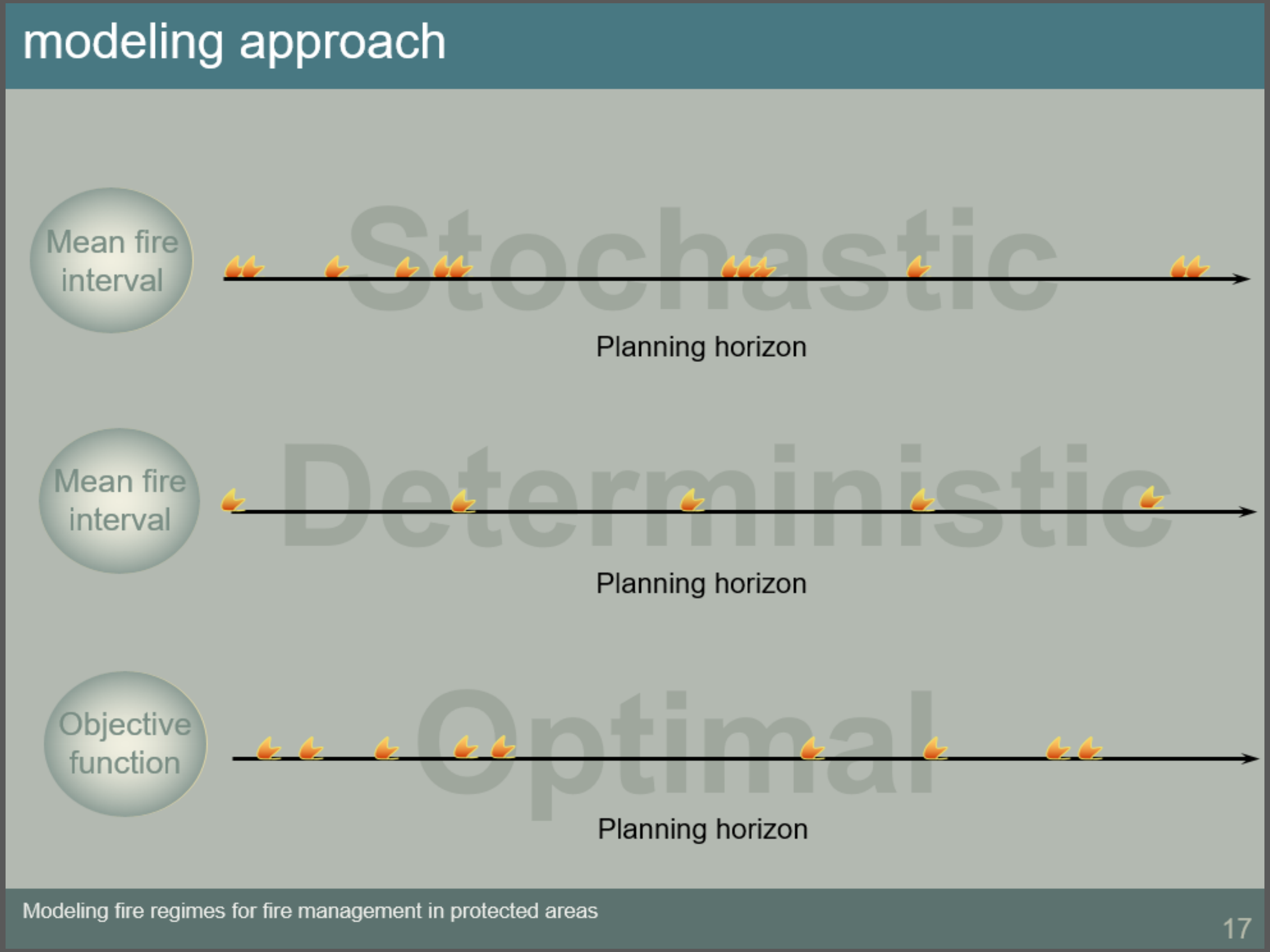
Stand dynamics model to compare impacts of different temporal arrangements of surface fires



Conservation Biology, Pages 1541–1552
Volume 18, No. 6, December 2004

Modeling Prescribed Surface-Fire Regimes for *Pinus strobus* Conservation

JENNIFER L. BEVERLY* AND DAVID L. MARTELL



Presentation slide – April 9, 2003

What is the objective exactly?

Natural

Treated

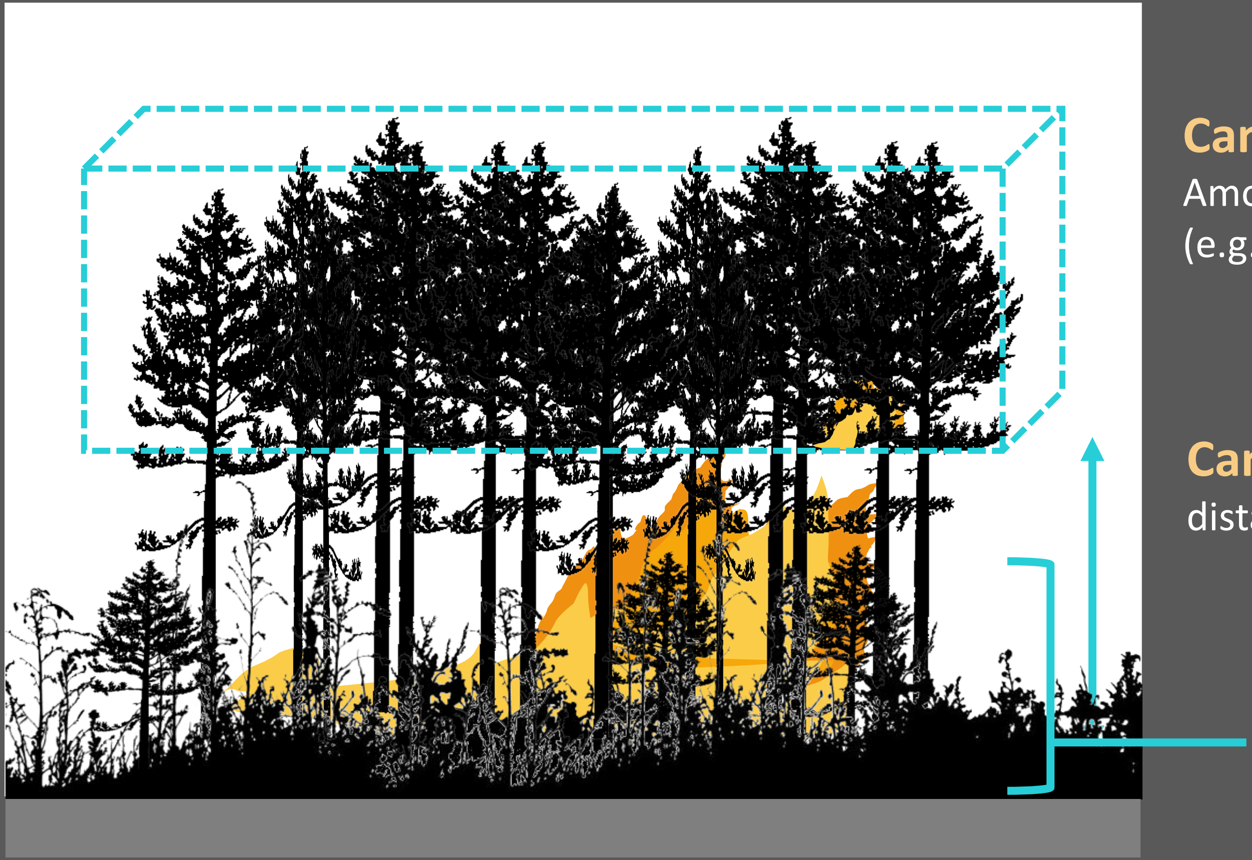
(Photos: J.L. Beverly)

Efficacy: the ability to produce a desired or intended result.

- Are we lost in minutia of measurement, statistical significance – versus achievement of meaningful outcomes
- Is this just another command and control approach to natural disturbance processes?
- Are we confident we can design and build stands and landscapes that meet our specifications?

(Photos: Alberta Wildfire

What is driving design criteria?



(Image: J.L. Beverly)

Canopy Bulk Density (CBD)
Amount and compactness of fuel in the canopy (e.g., foliage) expressed per unit volume

Canopy base height (CBH)
distance between the surface and live crowns of trees

Surface Fuel Load (SFL)
fuels such as litter, grass, forbs, understory conifer, shrubs, and mulch expressed per unit area

Design routed in crown fire behaviour modeling

Crown fire initiates when $I \geq CSI$

fire Fire 2020, 3, 35; doi:10.3390/fire3030035 MDPI

Review

Stand-Level Fuel Reduction Treatments and Fire Behaviour in Canadian Boreal Conifer Forests

Jennifer L. Beverly [1,*], Sonja E. R. Leverkus [1,2], Hilary Cameron [1] and Dave Schroeder [3]

Byram (1959)

$$I = 300 \times SFC \times ROS$$

- I: Actual surface fire intensity (kW/m)
- SFC: Surface fuel consumption (kg/m^2)
- ROS: Rate of spread (m/min)

Van Wagner (1977)

$$CSI = 0.001 \times CBH^{1.5} \times (460 + 25.9 \times FMC)^{1.5}$$

- CSI: Critical surface fire intensity (kW/m)
- CBH: Live Canopy Base Height (m)
- FMC: Foliar moisture content (%)

Van Wagner (1977)

$$ROS_{CM} = \frac{S_0}{CBD}$$

- ROS_{CM}: Critical minimum rate of spread to sustain a crown fire (m/min)
- S_0: Mass flow rate of fuel
- CBD: Canopy bulk density (kg/m^3)

What do the models tell us?

Depends heavily on assumptions about surface fuel consumption, rates of spread (i.e., wind speeds)

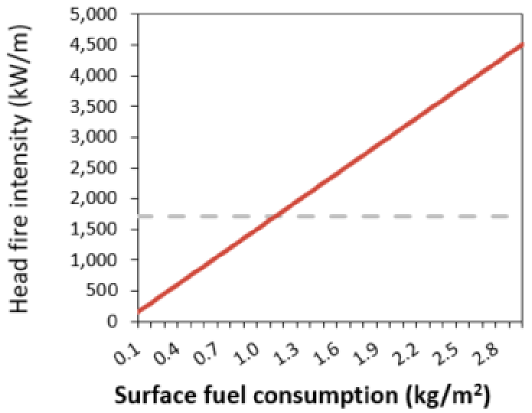
Explore how changes to ROS and SFC affect surface fire intensity
Explore how changes to CBH and FMC affect CSI (and wether or not a crown fire will initiate)

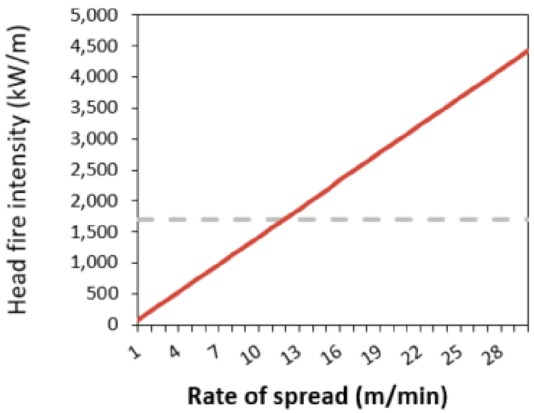
enter new values here

Rate of spread (ROS, m/min)	5	*max 100 m/min*
Canopy base height (CBH, m)	4	*1-10 m*
Foliar moisture content (FMC, %)	120	*87-120%*

enter new values here

Surface fuel consumption (SFC, kg/m^2)	0.5	*max 10 kg/m^2*
Canopy base height (CBH, m)	4	*1-10 m*
Foliar moisture content (FMC, %)	120	*87-120%*





Equation for caculating critical surface fire intensity (CSI):

$$CSI = 0.001 \times CBH^{1.5} \times (460 + 25.9 \times FMC)^{1.5}$$

Equation for caculating actual surface fire intensity (CSI):

$$I = 300 \times SFC \times ROS$$

Critical Surface Fire Intensity (CSI)
Surface head fire intensity (I)

(Photo sources: Andy Clark/Reuters; Town of Slave Lake; Twitter.com/Jerome Garot/EPA; Edith Loring-Kuhanga/Facebook)

How do these attributes vary (managed and natural stands)?

- FBP System fuel types do not account for natural variability in important stand attributes
- FireSmart treatment of stands introduces additional variability

Both photos show C-2 Boreal Spruce stands located 10 km apart

Estimated age (years):
← 72
→ 148

Trees per hectare:
← 950
→ 3090

Moisture regime:
← Mesic
→ Subhydric

(Photos: Alberta Wildfire)

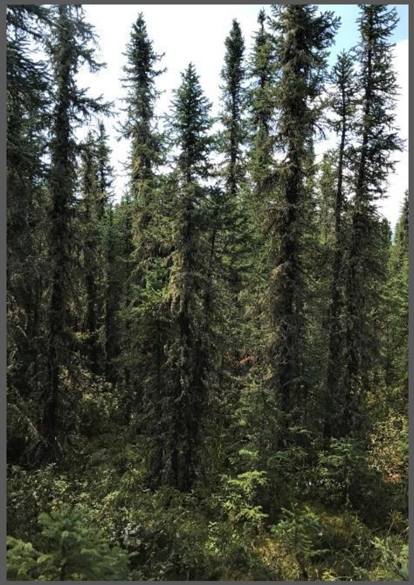
Are there other ways to classify (and prioritize) fuels?

FBP System fuel types are an example of the association method of classification – for forests

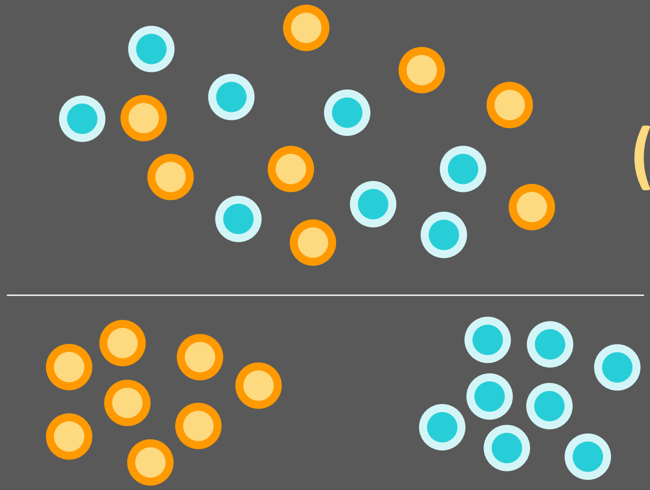
- vegetation based, primarily reflect tree species (e.g., Aspen = D-1, black spruce = C-2)

Direct classification involves learning the classes from the data using analytical methods such as clustering

D-1/2 Aspen



C-2 Boreal Spruce



Data (fuel Attributes)

Fuel Class Clusters

- Clustering is a type of machine learning
- Used to put similar observations in the same group and dissimilar observations in different groups
- Has been used to create fuel classes several times, but never in Canada

Clustering Results

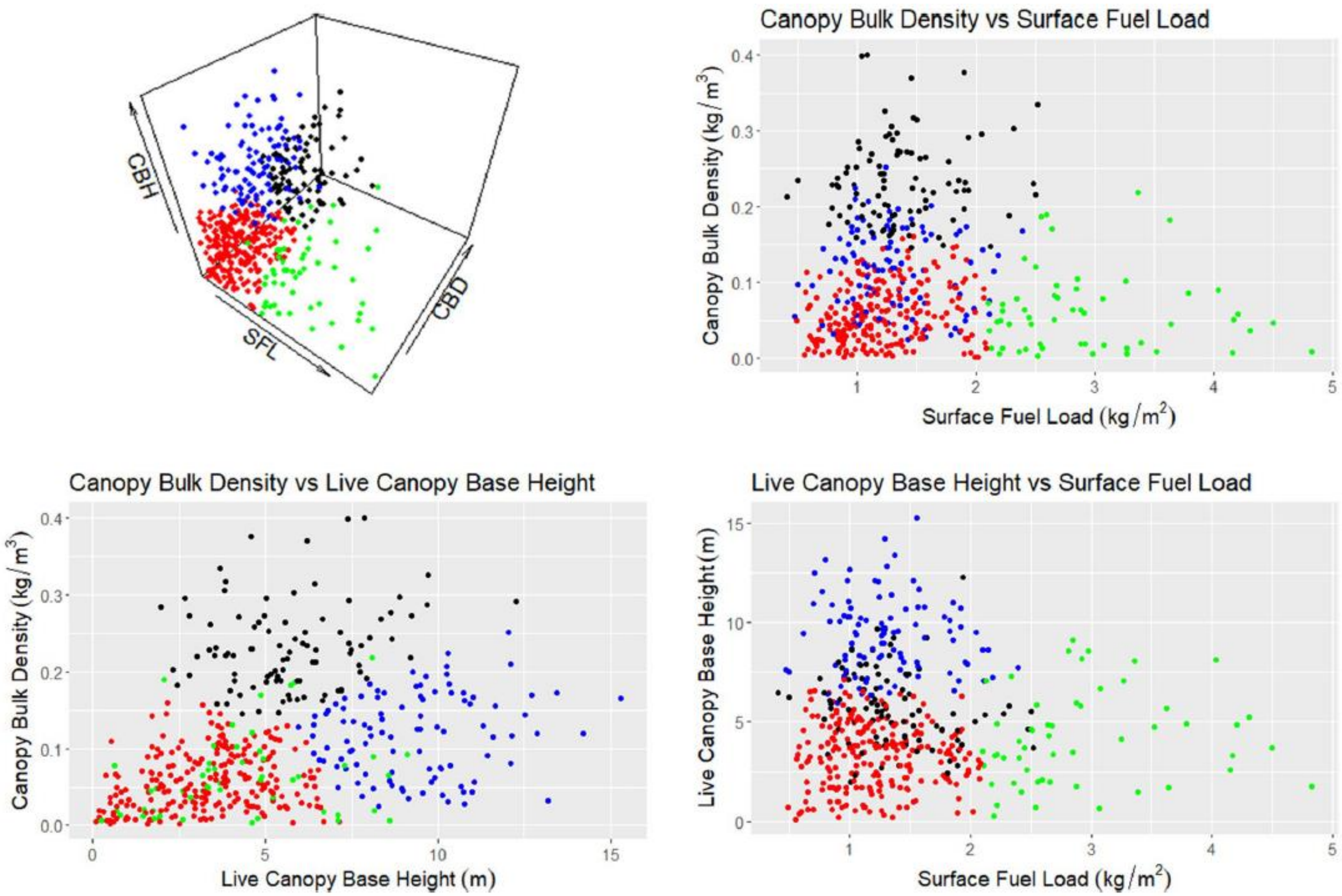
Four fuel class clusters (FCCs):

- Low SFL, CBH, CBD (n = 229)
- high SFL, low-moderate CBH, low CBD (n = 54)
- low SFL, high CBH, low-moderate CBD (n = 100)
- low SFL, moderate CBH, high CBD (n = 93)

Phelps and Beverly *Annals of Forest Science* (2022) 79:40
https://doi.org/10.1186/s13595-022-01151-x
INRAE
Annals of Forest Science
RESEARCH PAPER Open Access

Classification of forest fuels in selected fire-prone ecosystems of Alberta, Canada—implications for crown fire behaviour prediction and fuel management

Nathan Phelps and Jennifer L. Beverly*

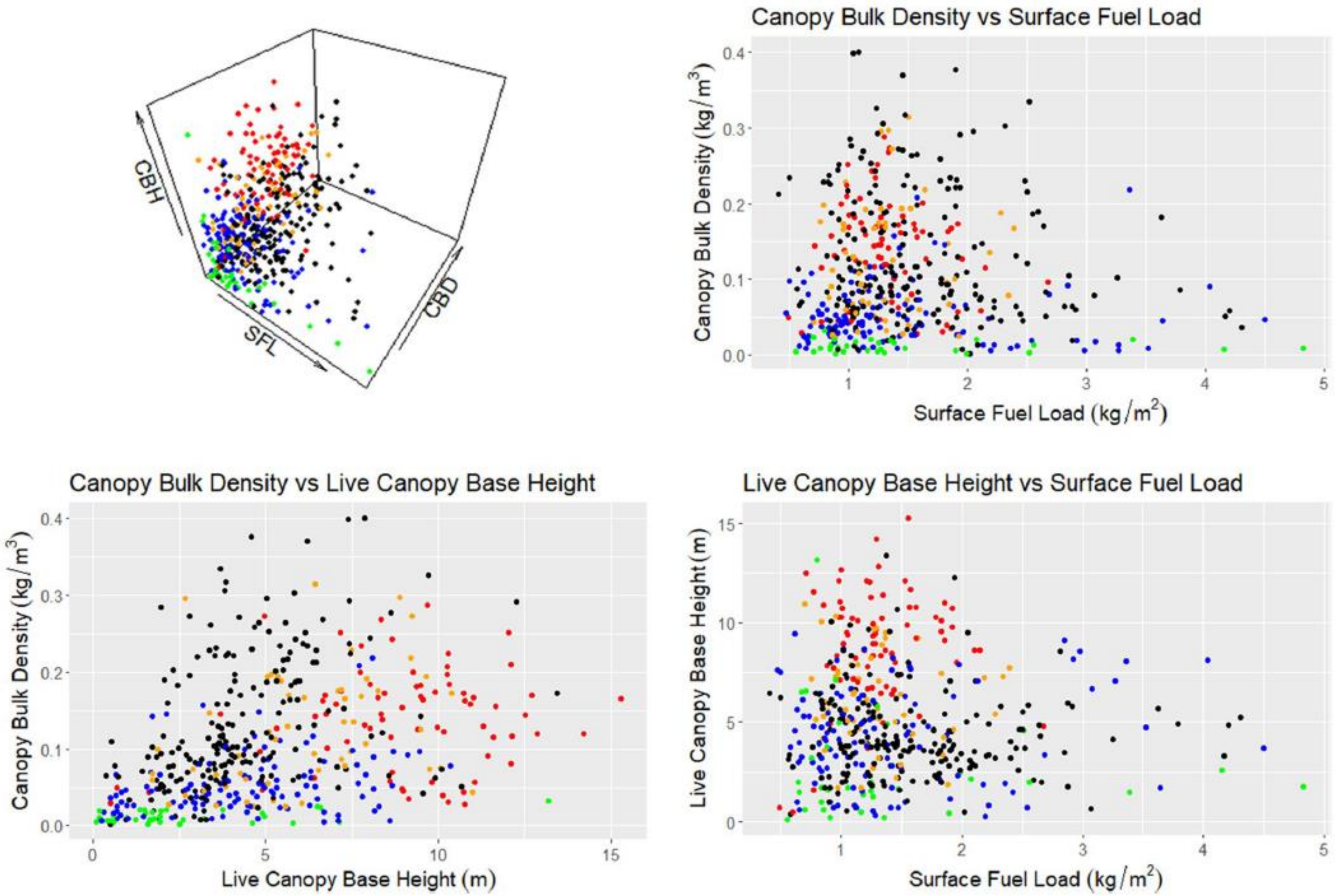


Comparing FCCs and FBP System fuel types

FBP System Fuel Types

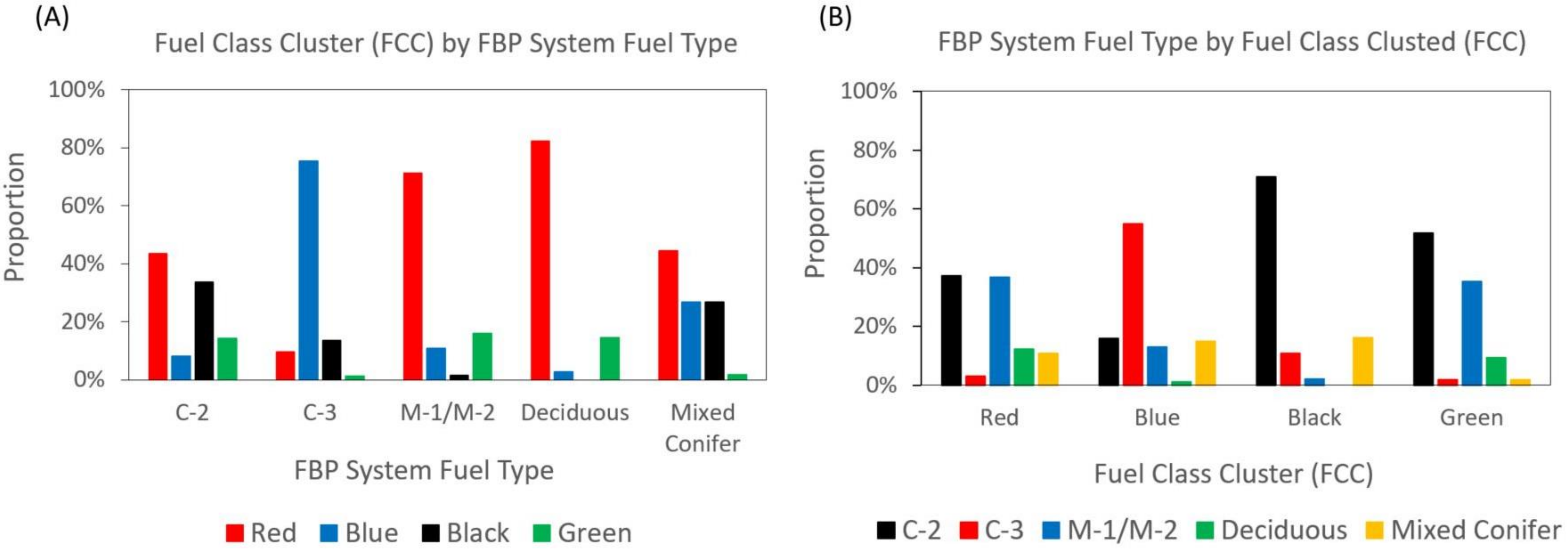
- D-1/D-2 Deciduous (n = 34)
- M-1/M-2 Boreal Mixedwood (n = 118)
- C-3 Mature Jack or Lodgepole Pine (n = 73)
- C-2 Boreal Spruce (n = 195)
- Mixed Conifer (n = 56)

Do plots of SFL, CBH, and CBD colour-coded by FBP fuel type instead of FCC reveal any patterns?



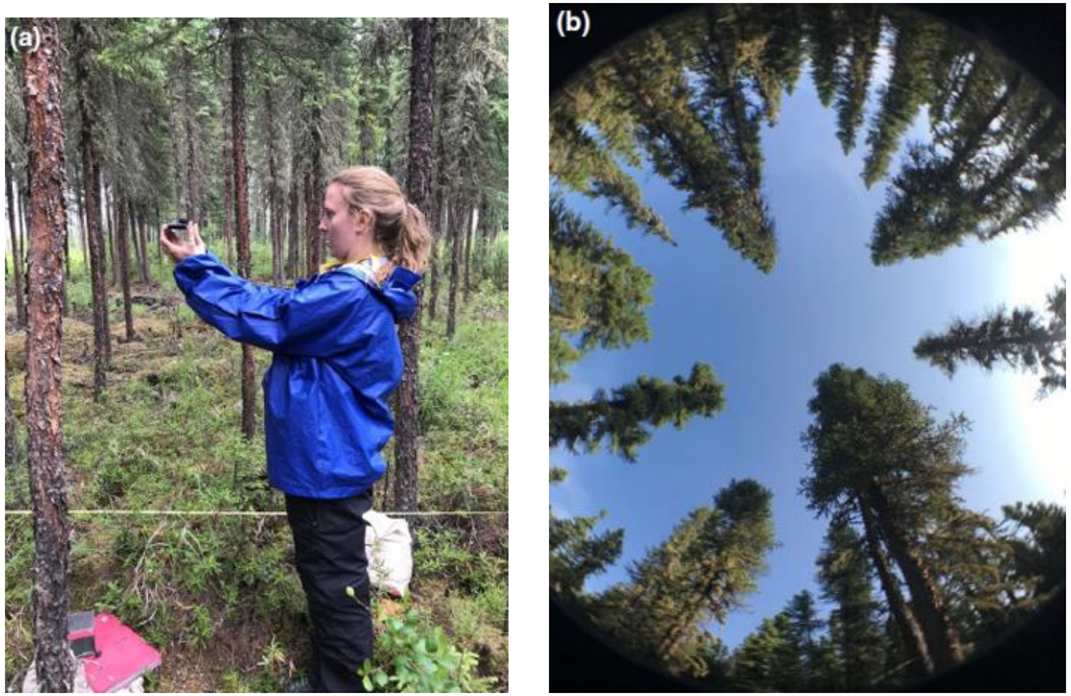
Comparing FCCs and FBP System fuel types

What is the distribution of FBP fuel types in FCCs and vice-versa?



Do I need detailed attributes to inform fuel management?

Rapid fuel assessments in-stand; airborne lidar for large regions



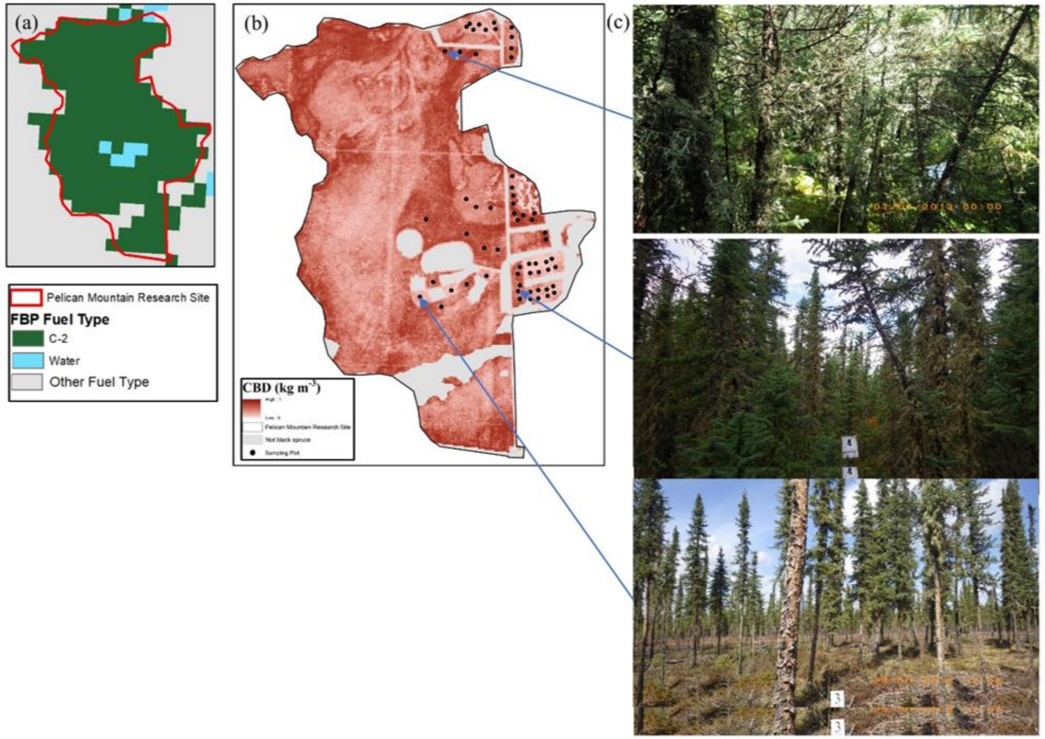
Received: 31 March 2021 | Accepted: 21 July 2021
DOI: 10.1111/2041-210X.13708

Methods in Ecology and Evolution

PRACTICAL TOOLS

Estimating canopy fuel load with hemispherical photographs: A rapid method for opportunistic fuel documentation with smartphones

Hilary A. Cameron[1] | Gastón M. Díaz[2] | Jennifer L. Beverly[1]



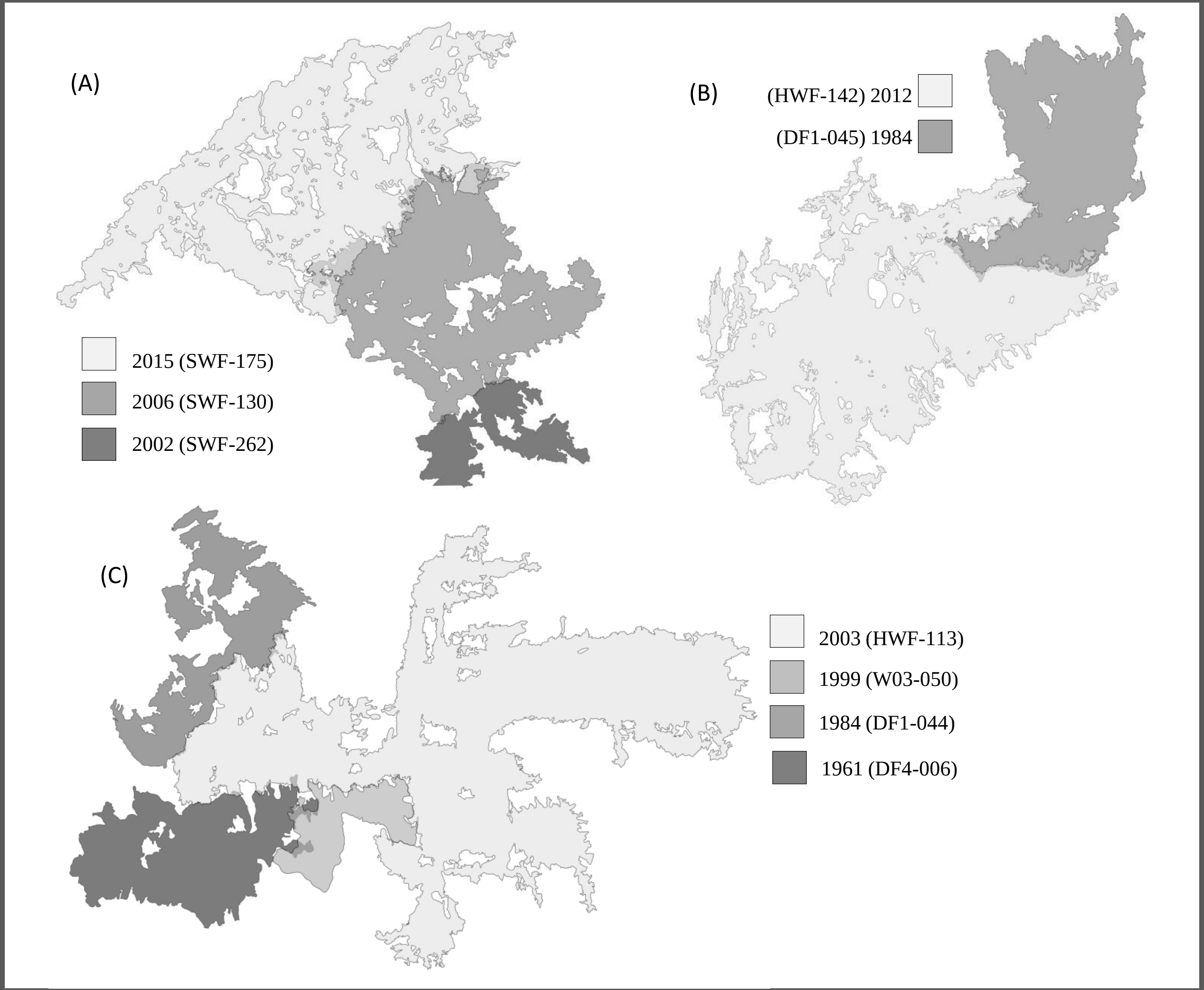
International Journal of Wildland Fire **2022**, *31*, 124–135
https://doi.org/10.1071/WF21004

Predicting black spruce fuel characteristics with Airborne Laser Scanning (ALS)

H. A. Cameron[A,C], *D. Schroeder*[B] *and J. L. Beverly*[A]

Are there other ways of informing design?

How does nature stop fires?



Forest Ecology and Management 506 (2022) 119958

Contents lists available at ScienceDirect

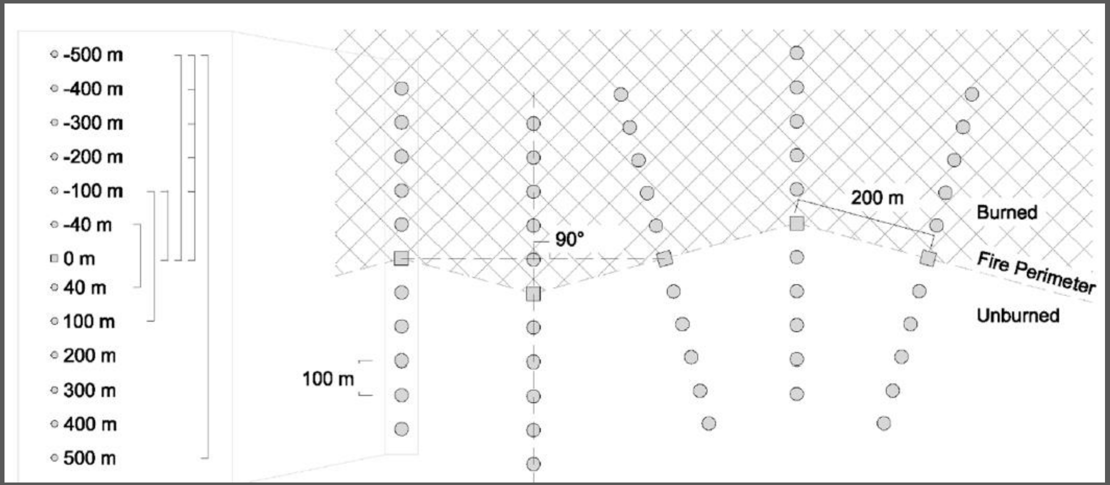
Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

ELSEVIER

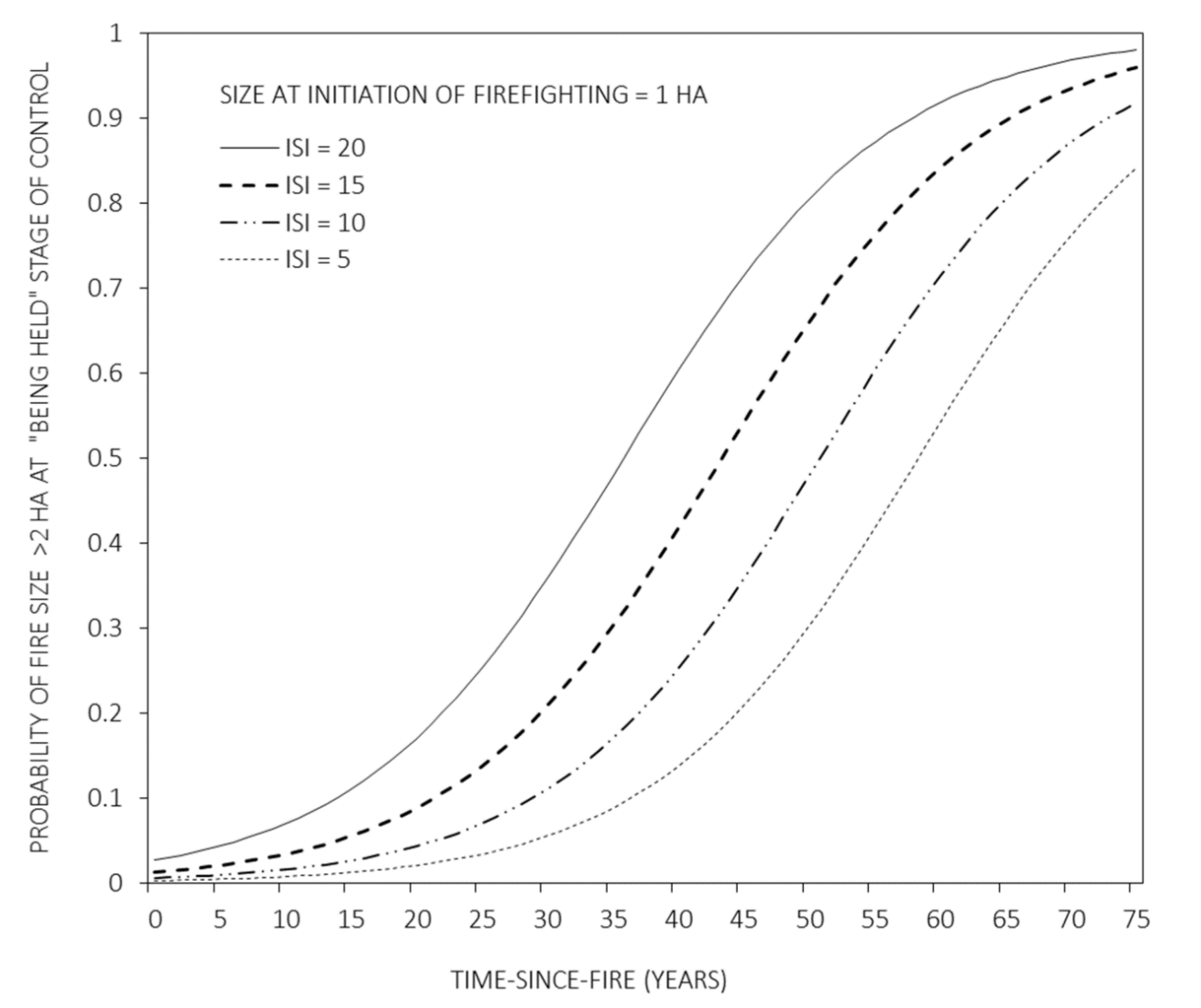
Modelling fire perimeter formation in the Canadian Rocky Mountains

Kiera A.P. Macauley [a,*], Neal McLoughlin [b], Jennifer L. Beverly [a]



Are there other ways of informing design?

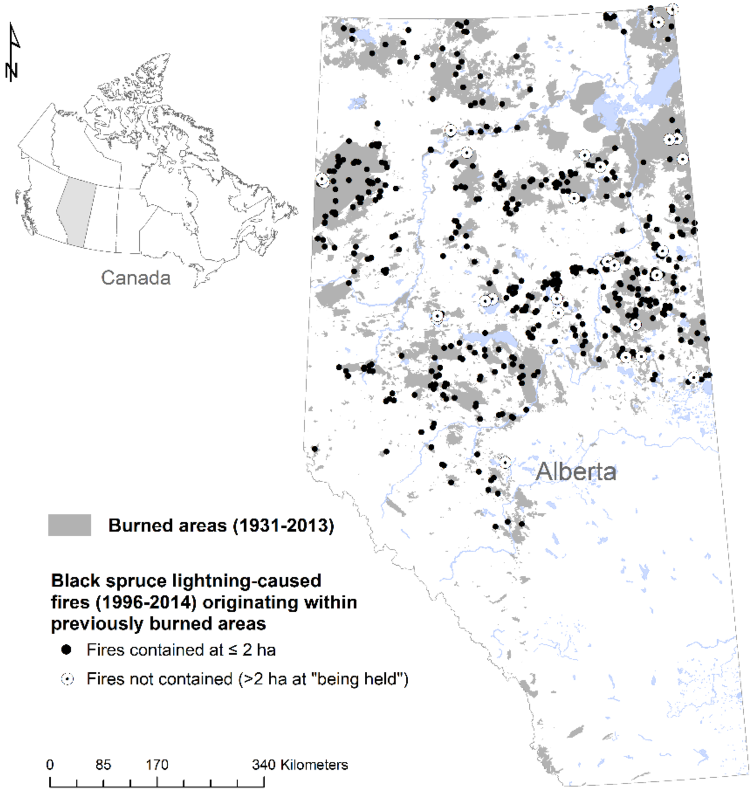
How does nature stop fires?



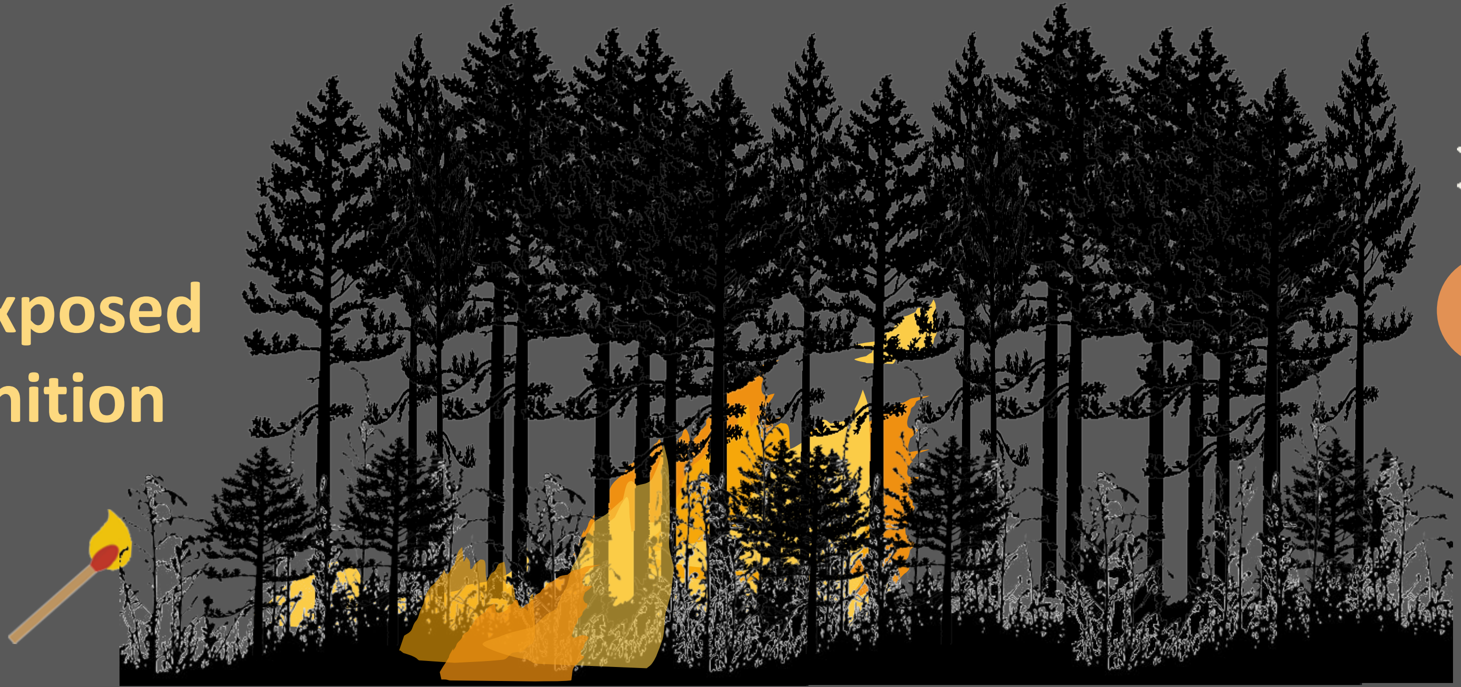
International Journal of Wildland Fire **2017**, *26*, 919–929
https://doi.org/10.1071/WF17051

Time since prior wildfire affects subsequent fire containment in black spruce

Jennifer L. Beverly



What kind of fires are we mitigating?

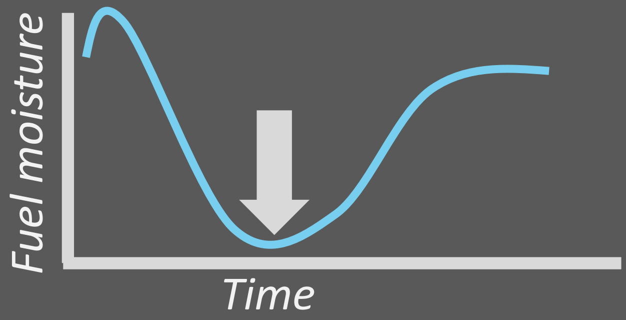


3 that's exposed to an ignition

4 Upwind of more places fire can transmit to (path)

1 a place fire can transmit to (fuel proximity)

2 at a time when its receptive (dry)



Can fuel management eliminate these kinds of fires?

Kelowna 2003

60-70 km h^{-1} winds
27,000 evacuated
239 homes destroyed
$200M in damages

Slave Lake 2011

80 km h^{-1} winds
7,000 evacuated
480 homes destroyed
$700M insured damages

Fort McMurray 2016

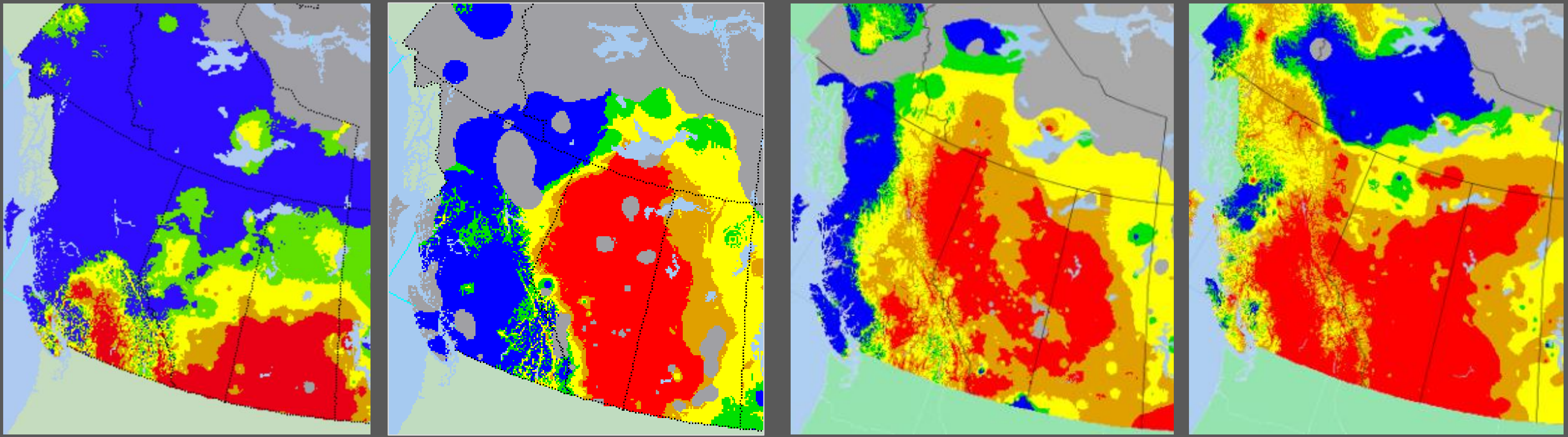
40 km h^{-1} winds
90,000 evacuated
2,500 dwelling units destroyed
$3.6B insured damages

Lytton 2021

35 km h^{-1} winds gusting at 50 km h^{-1} or greater
1,000 evacuated
Village 90% destroyed
$78M insured damages

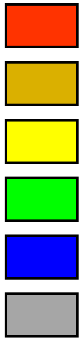
(Photo sources: Andy Clark/Reuters; Town of Slave Lake; Twitter.com/Jerome Garot/EPA; Edith Loring-Kuhanga/Facebook)

Kelowna | Slave Lake | Fort McMurray | Lytton



August 22, 2003 | May 15, 2011 | May 3, 2016 | June 30, 2021

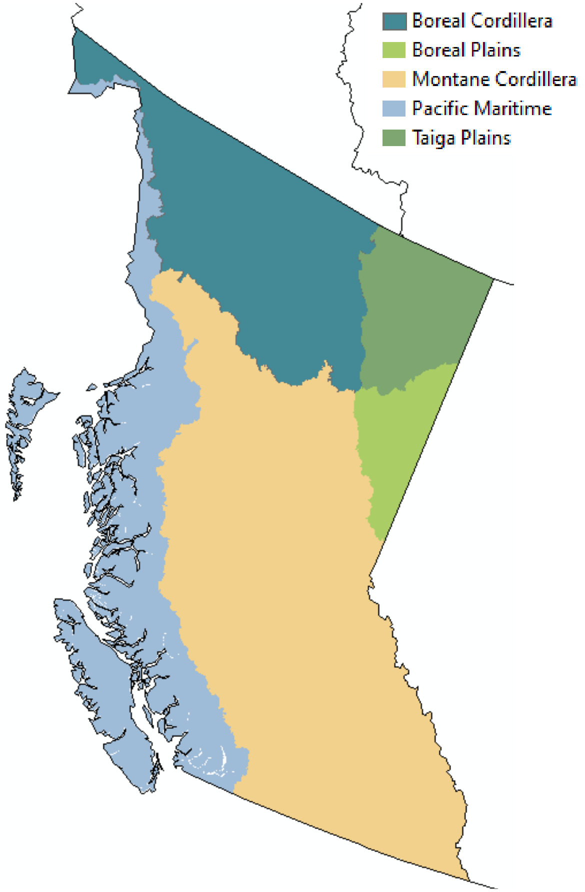
Map source: CWFIS, NRCan



Fire Weather Index (FWI)

A numeric rating of fire intensity. Used as general index of fire danger throughout the forested areas of Canada.

Can we manage fuels everywhere? Does that make sense?

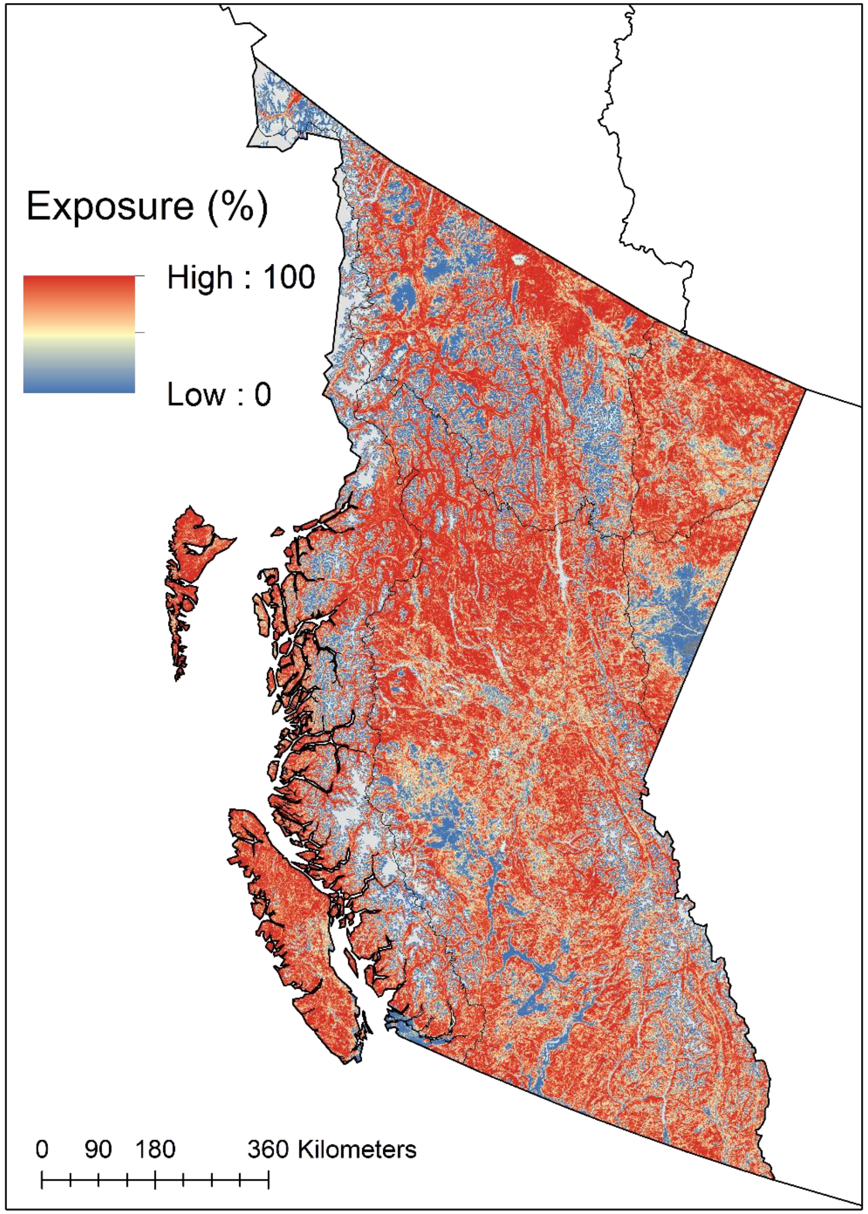


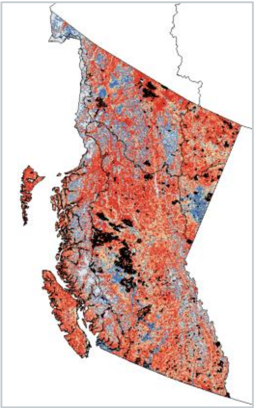
Landscape Ecol (2021) 36:785–801
https://doi.org/10.1007/s10980-020-01173-8

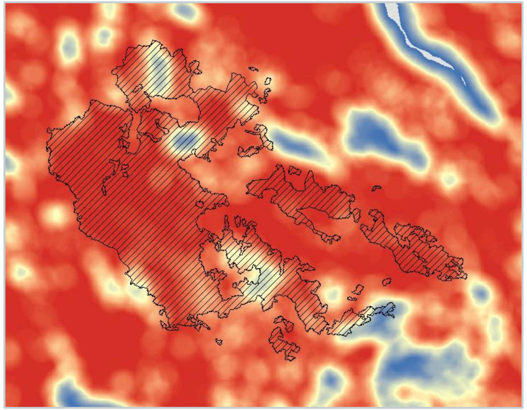
RESEARCH ARTICLE

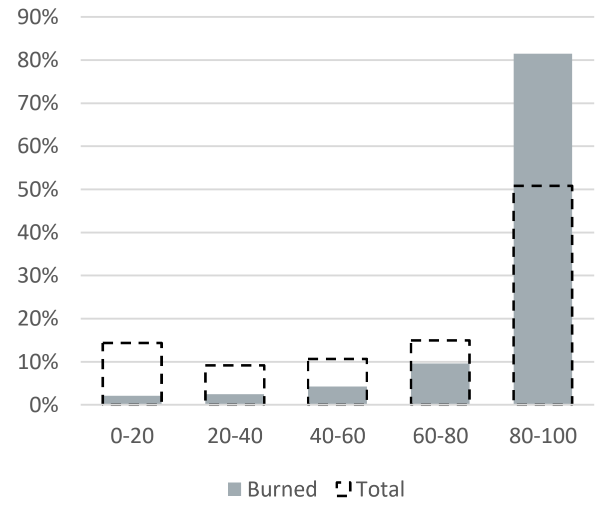
A simple metric of landscape fire exposure

Jennifer L. Beverly · Neal McLoughlin · Elizabeth Chapman

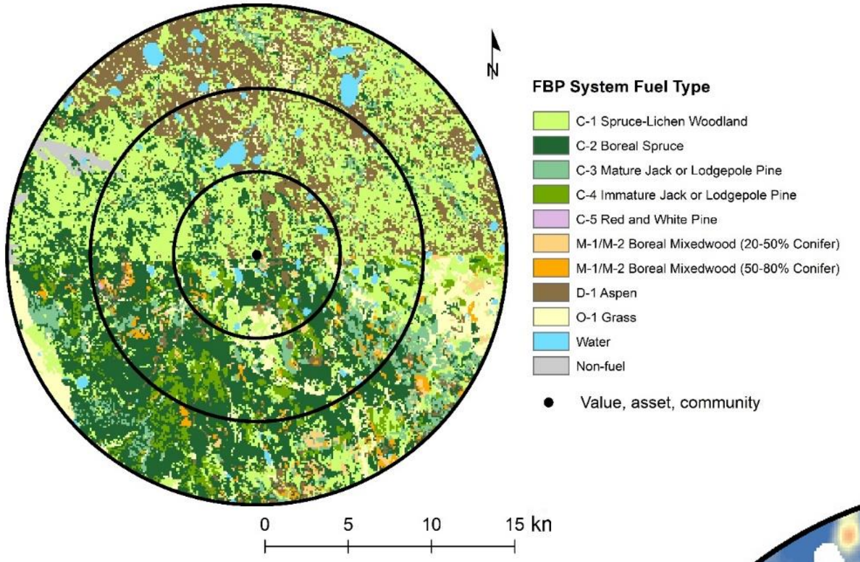


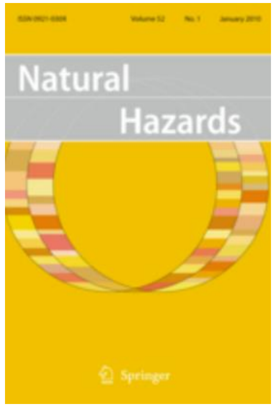






Boreal Cordillera



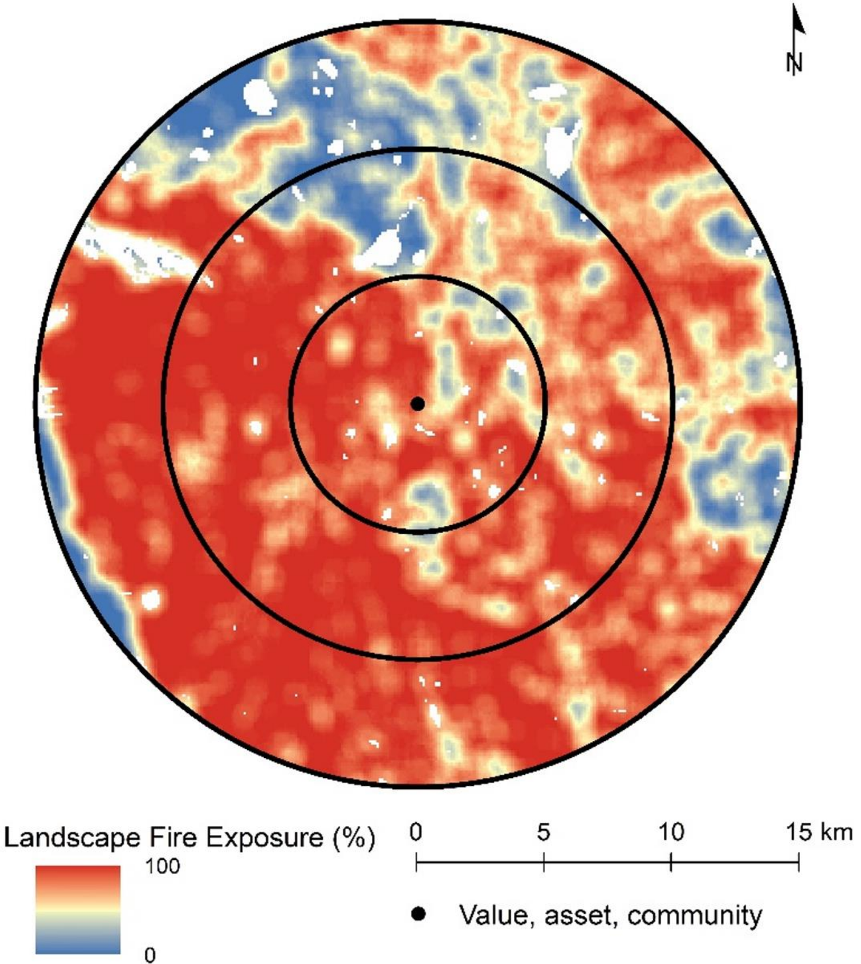


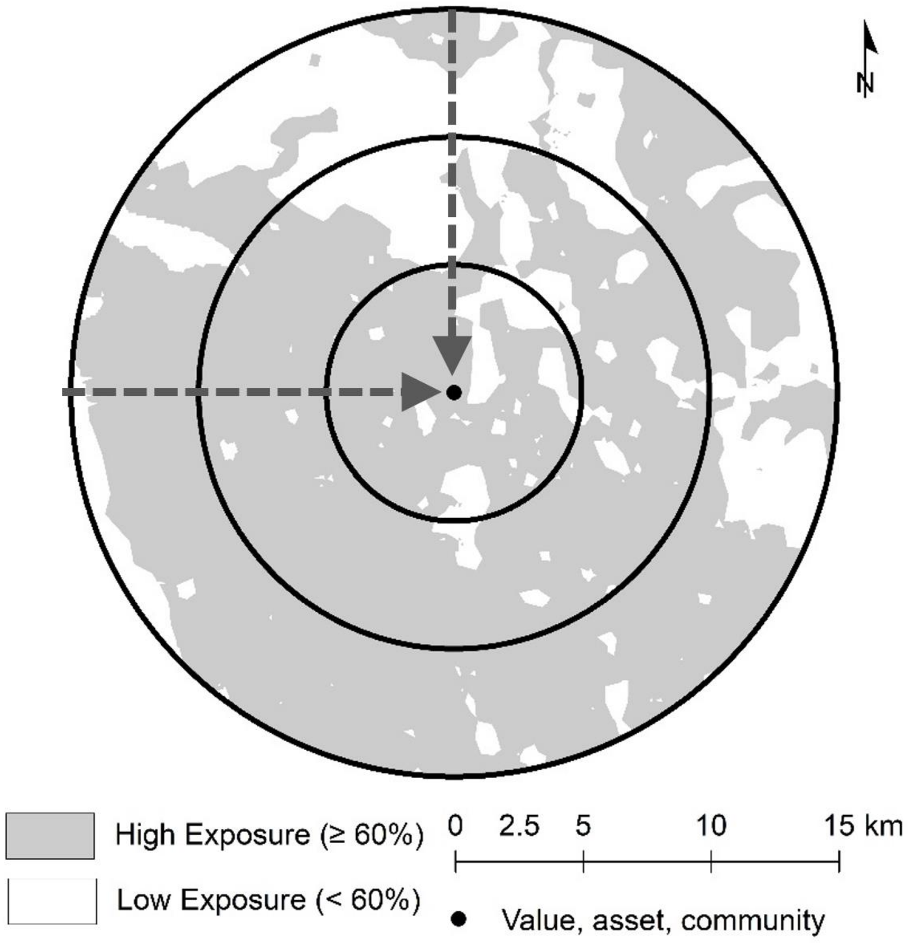
Research Article

Assessing directional vulnerability to wildfire

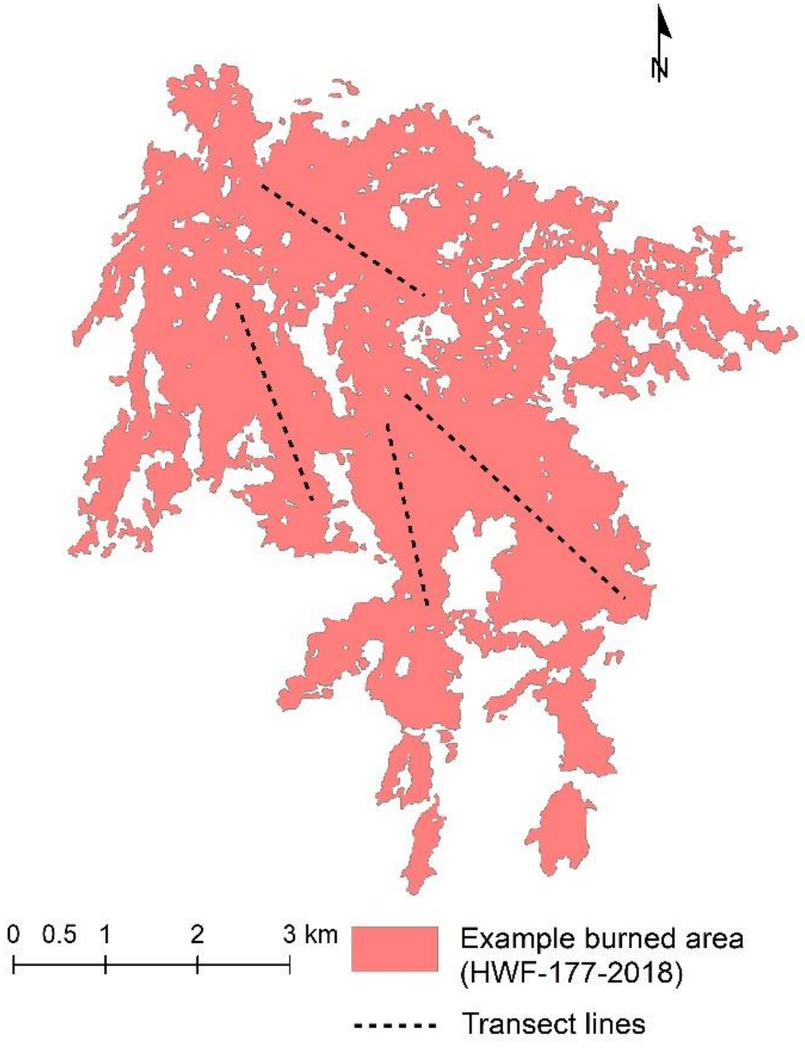
Accepted for publication February 17, 2023

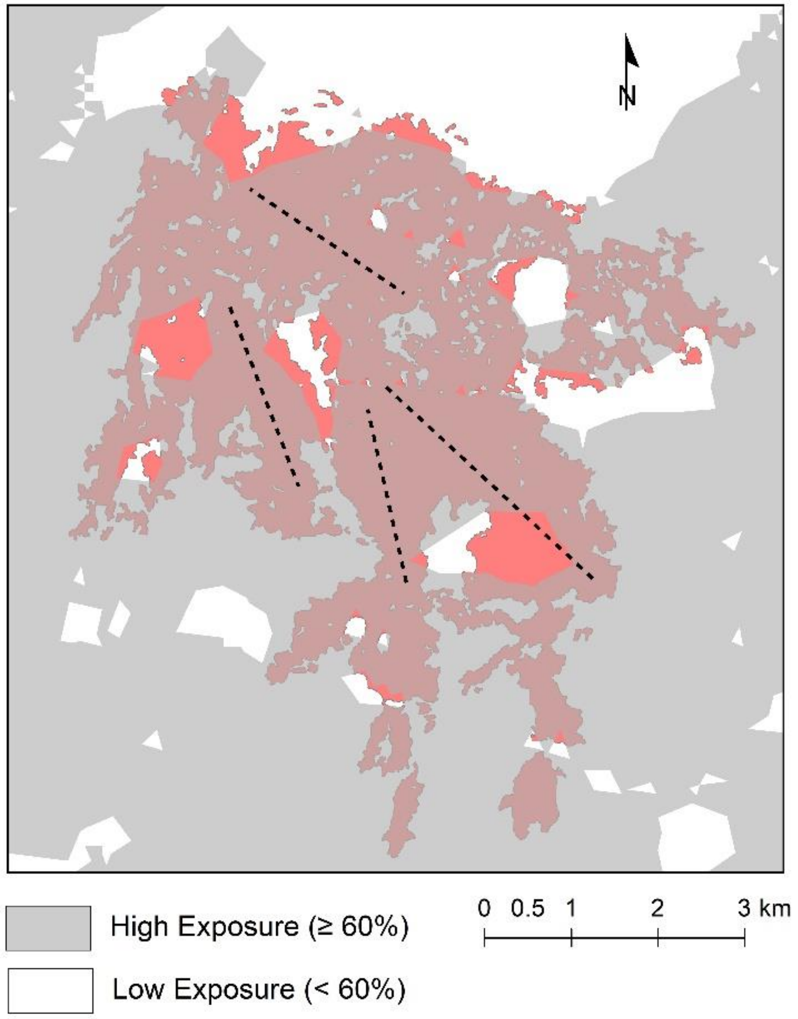
Jennifer Beverly, Air M. Forbes

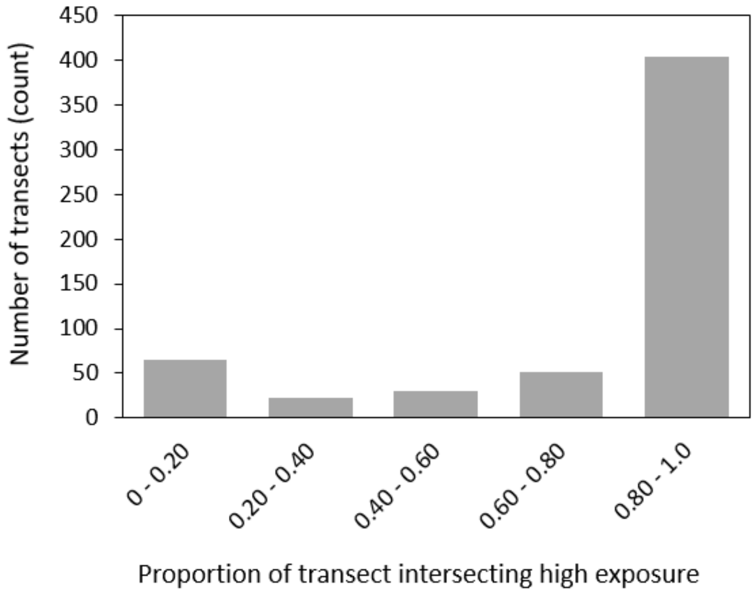


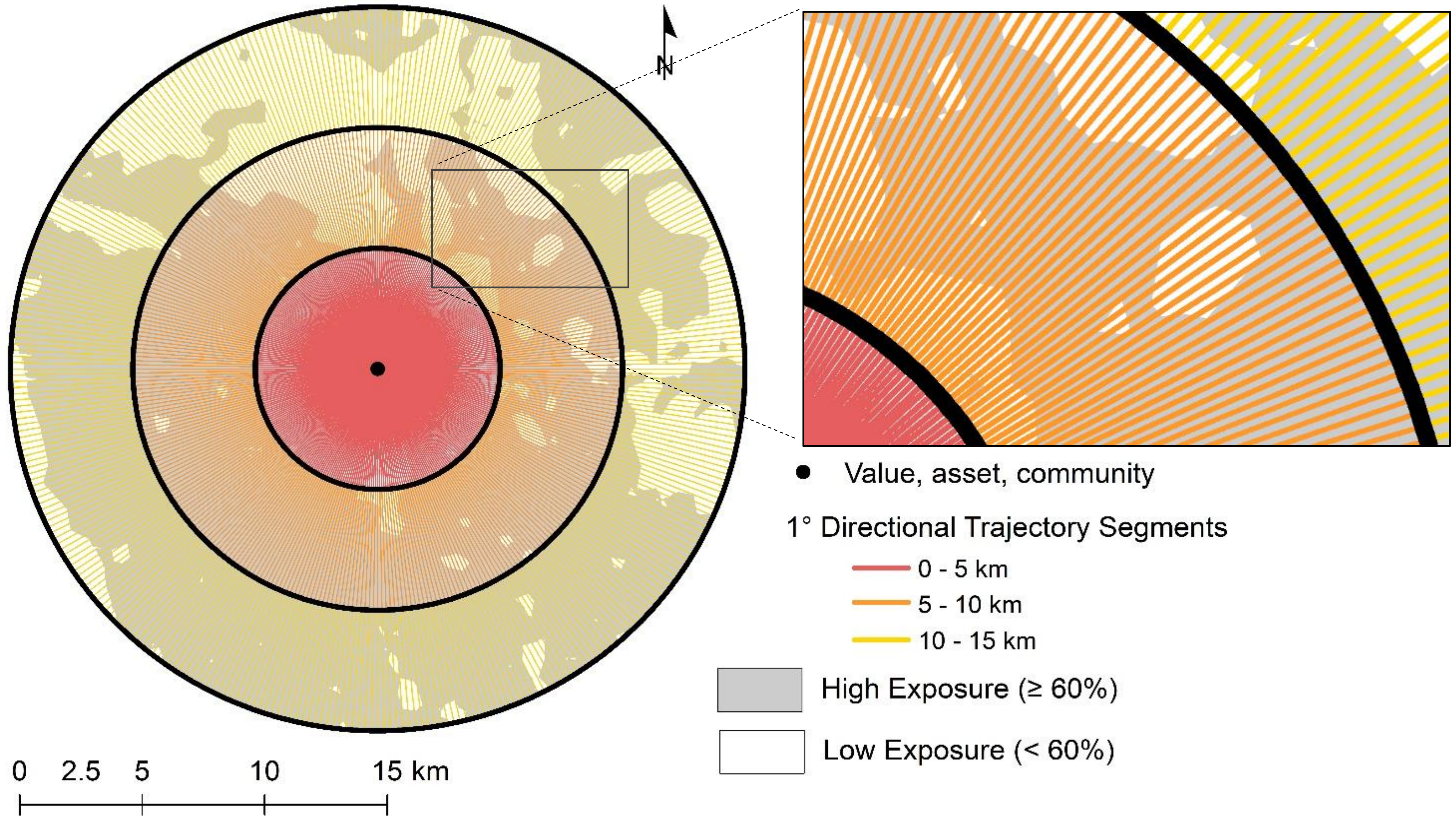


Can we define a viable fire trajectory based on exposure?

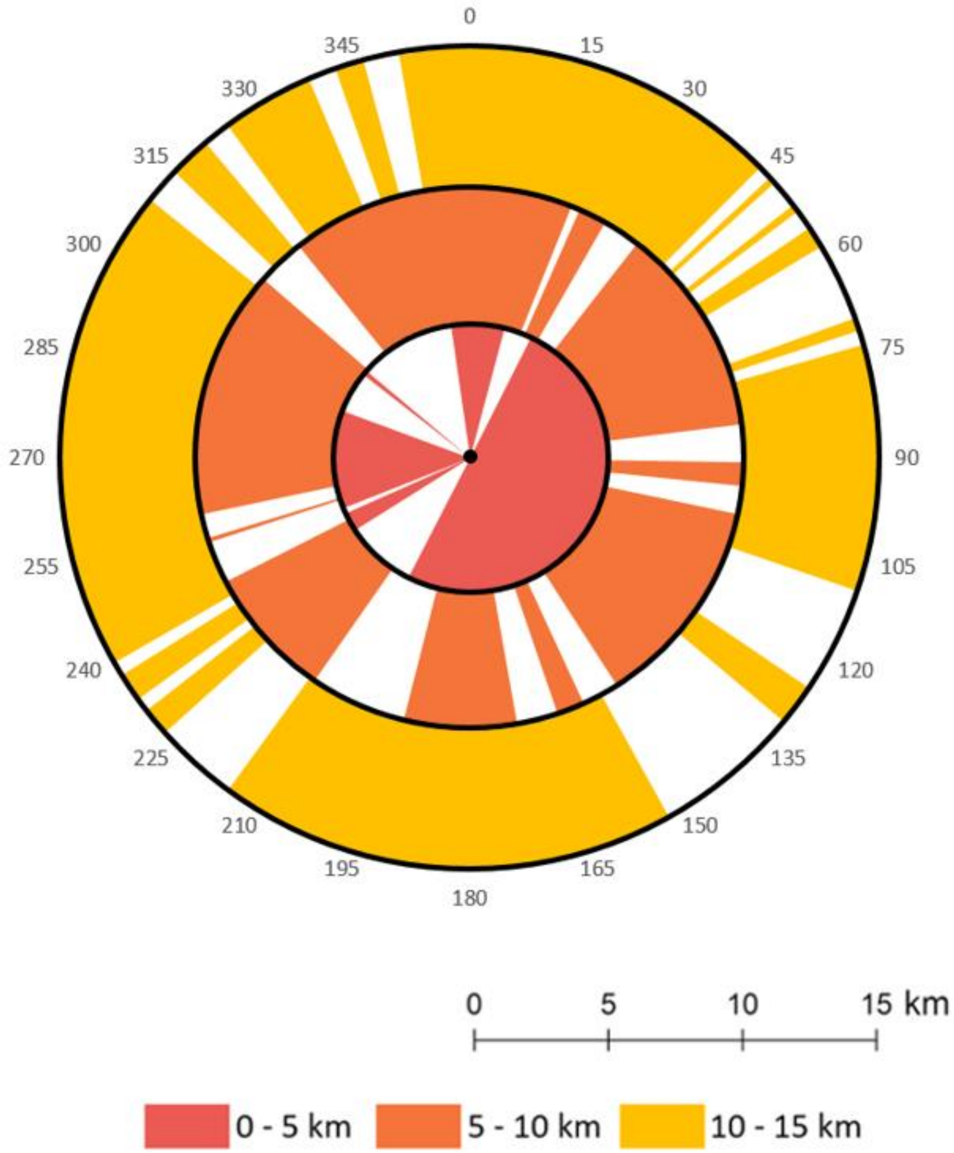




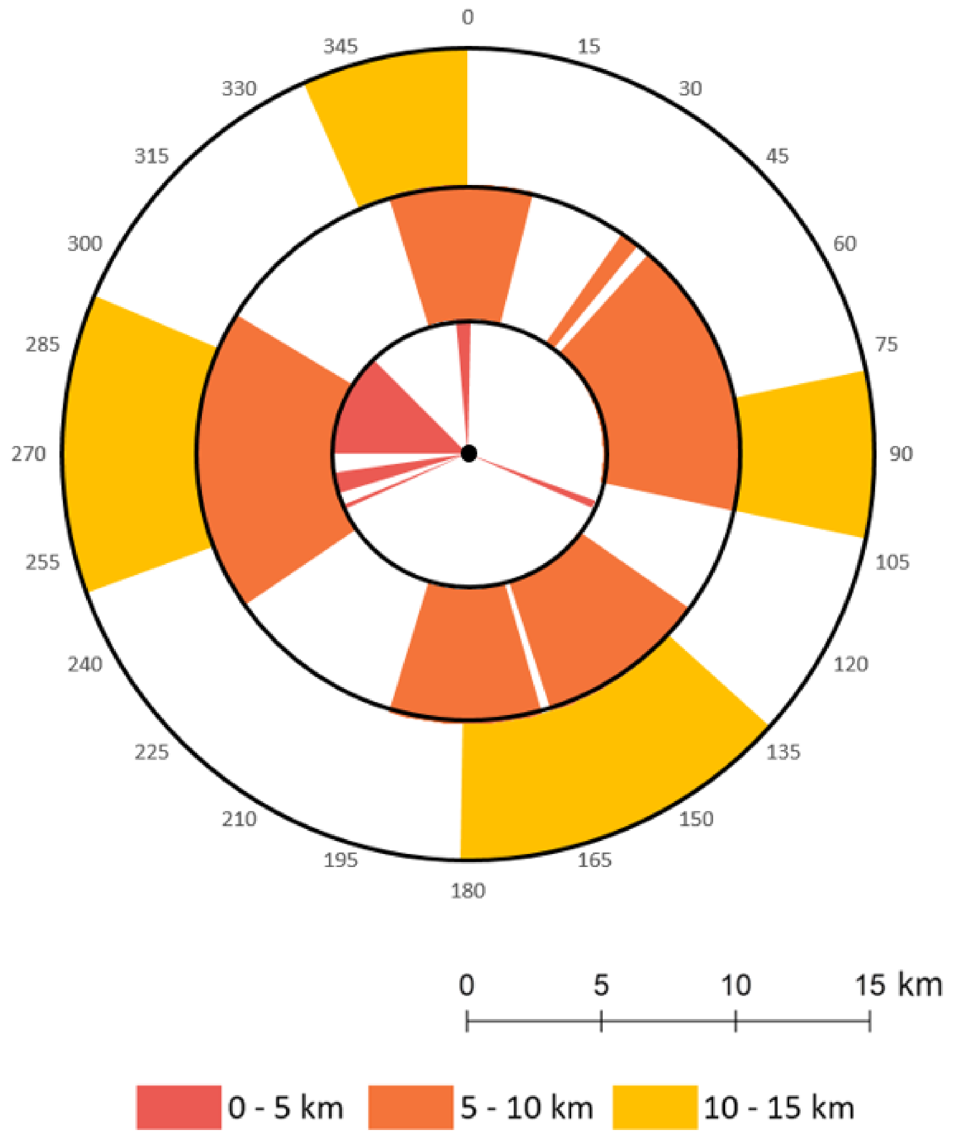



N
Value, asset, community
1° Directional Trajectory Segments
0 - 5 km
5 - 10 km
10 - 15 km
High Exposure (≥ 60%)
Low Exposure (< 60%)
0 2.5 5 10 15 km

Nordegg



Jasper



Some key insights…

- **Consider fuel treatment regimes –** beyond treatments as individual events: temporal sequencing, interactions across landscapes
- **Question our command control fuel management ideology –** are we capable of designing functioning ecosystems based on our limited understanding? Human societies have a long track record of getting that wrong (precautionary approach is called for)
- **Step back, look up, look forward –** are we lost in the details? Need to include big-picture, integrated landscape scale strategies to prioritize actions (response, mitigation, recovery – post-fire management)
- **Question efforts to telegraph solutions –** confront group think, consider alternatives that don't fit the current business model
- **Question efforts to limit perspectives, approaches –** innovative thinking needed to overcome stagnation in methods, move beyond antiquated models, question one-size-fits all approaches

(Photos: J.L. Beverly)

Supporters, contributors, influencers

Funding

Alberta Wildfire Management Branch

Forest Resource Improvement Association of Alberta (FRIAA)

Institute for Catastrophic Loss Reduction

NRC · CNRC

National Research Council

People

Alberta Wildfire

Dave Schroeder
Neal McLoughlin
Liz Chapman
AWFIP field crews
…and many others

ALBERTA FireSmart™

Laura Stewart
…and many others in Laura's vast network

WILDFIRE ANALYTICS

Hilary Cameron
Air Forbes
Sonja Leverkus
Kiera Macauley
Nathan Phelps
Jared Randall
Ashwat Sharma
Andrew Stack

UNIVERSITY OF ALBERTA
DEPARTMENT OF
RENEWABLE RESOURCES

WILDFIRE ANALYTICS

Jen Beverly

Thank you for listening, questions?

Connect

jen.beverly@ualberta.ca
wildfireanalytics.org
@fireanalytics

(Photo: J.L. Beverly)