

Why some homes survived: Preliminary lessons from the Fort McMurray wildfire disaster

Alan Westhaver, M.Sc.
ForestWise Environmental Consulting Ltd.



Presentation objectives

1. Provide partial results of unique investigation into home survival at Fort McMurray.
2. Glimpse insights and evidence to better inform discussions and decisions about solutions.
3. Raise awareness about home ignition and wildfire loss mitigations in the wildland/urban interface.
4. Outline next steps leading to final report.

Research question:

“Why did some homes survive with little or no damage, while others did not ?”

- Led to many other questions:
 - Where did homes survive?
 - How did homes ignite? Is there evidence?
 - How did fire spread towards homes?
 - What were the circumstances?
 - Had precautions been taken? Were they effective?
 - Do current science and theories hold up?

Learning from wildfire disasters

Kelowna, British Columbia (2003)

Slave Lake, Alberta (2011)

Fort McMurray, May 03 – 05, 2016



Wildland fire

- **What is a wildland fire?**
 - A fire burning in native vegetation
- **Wildland fire environment.**



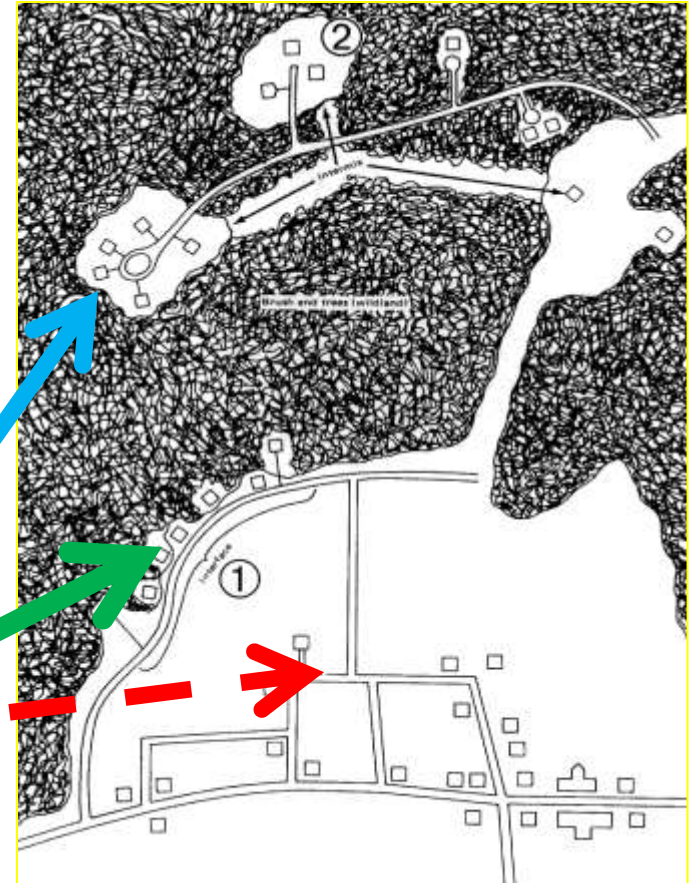
What is the wildland/urban interface?

A place: “Where forest meets homes.” (our area of interest)

A set of conditions: “That allow structures to ignite from flames or embers of a forest fire.”

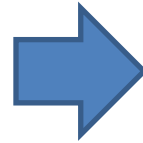
WUI

- **Urban**
- **Country Residential**

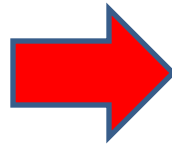


What is wildland/urban interface fire?

Where the fuel being consumed by a wildfire..



...changes from wildland fuel to urban fuel.



How do homes ignite?

3 basic ways:

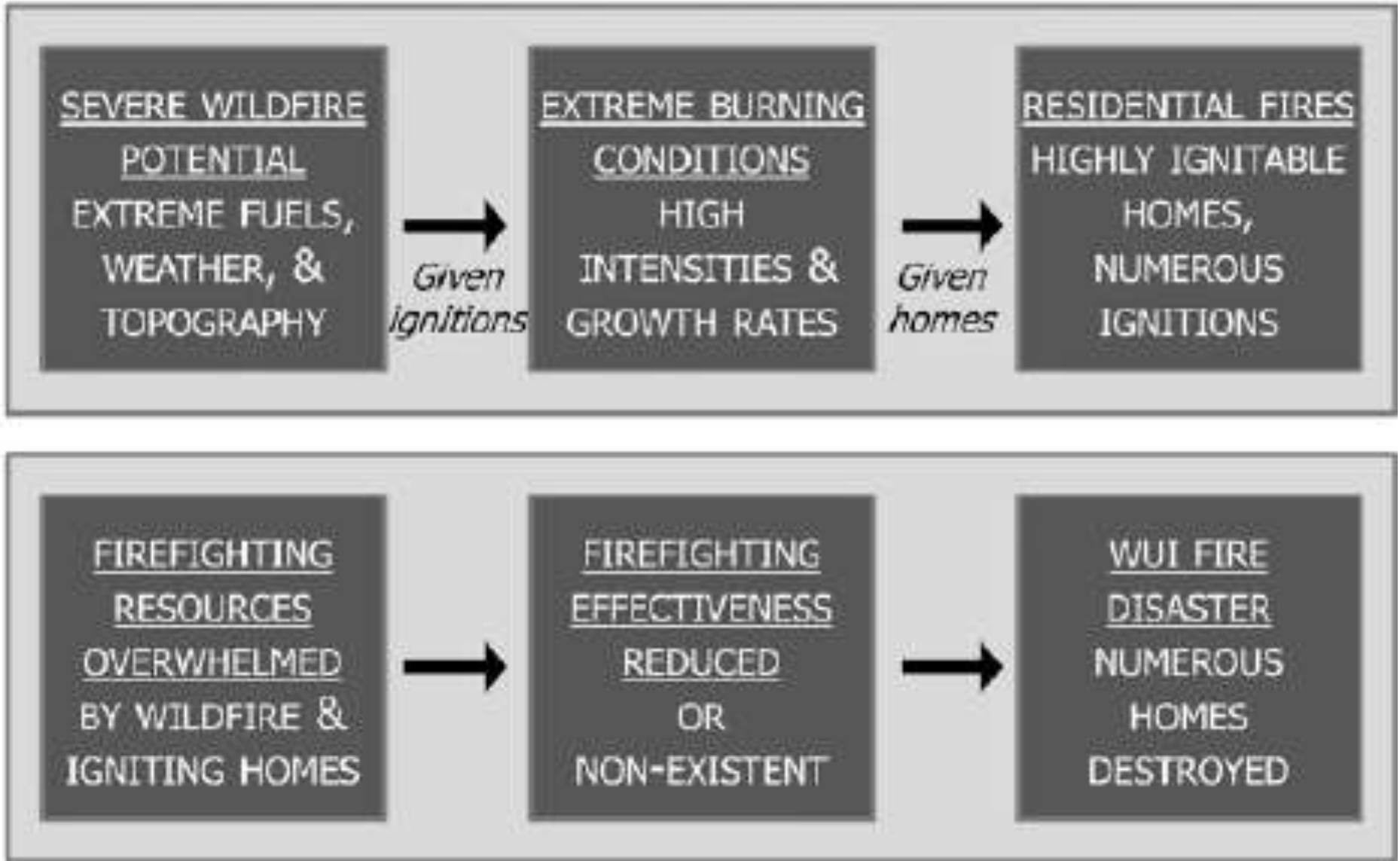
- Flames (convection).
- Radiant heat (from fire or adjacent homes).
- Embers (conduction) a.k.a. firebrands.



"It's the little things"
- Jack Cohen



The WUI disaster sequence (model)



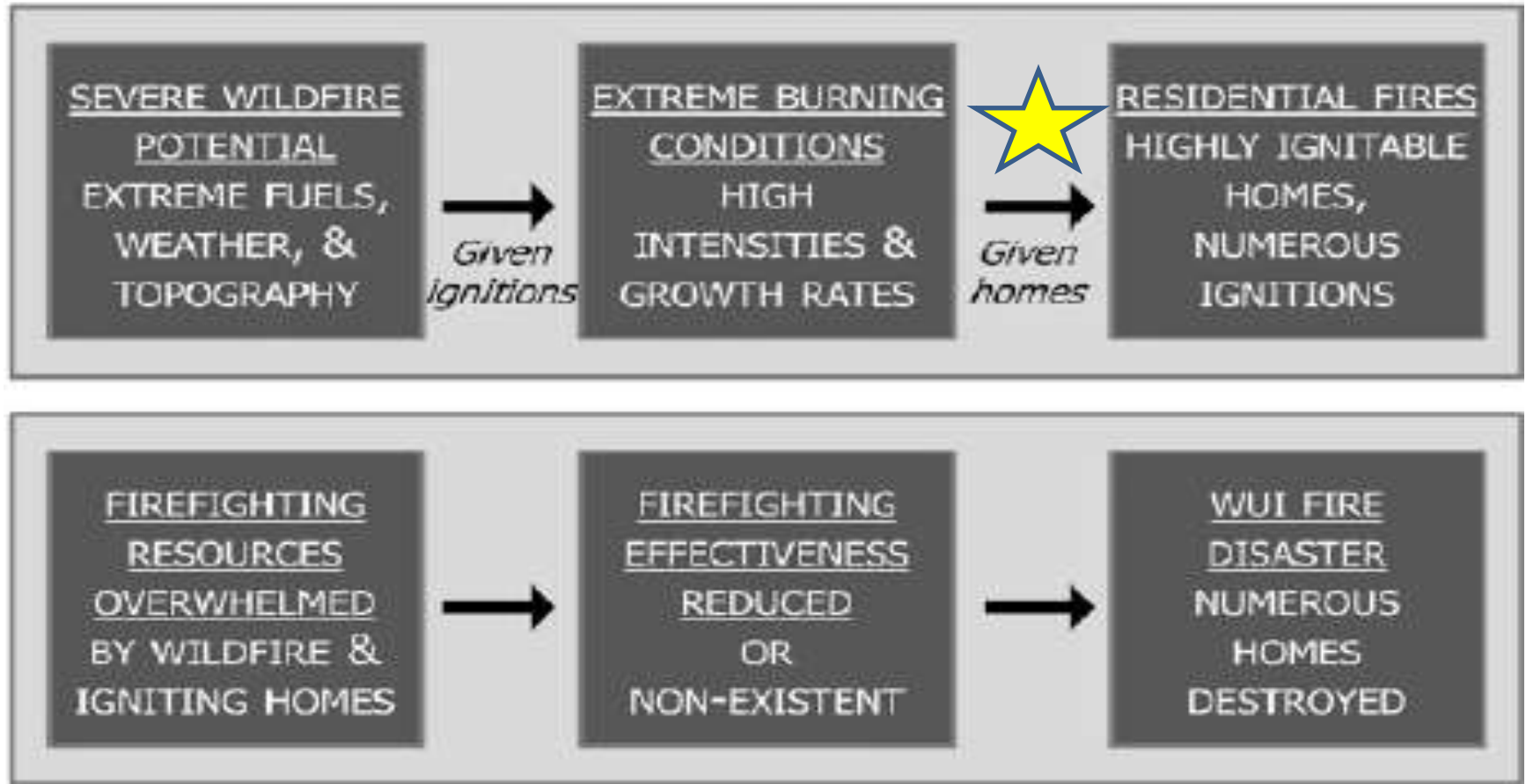
Urban conflagration fire: the “beast”

“A large, destructive fire that spreads beyond natural or artificial barriers in an urban environment, causing large monetary losses.”

No longer driven by, or feeding on, forest fuels.



Breaking the WUI disaster sequence



The key is to attack the problem at the point where a wildfire event makes the transition from forest fuel to include structural fuels

Preliminary survey: Two main scenarios.

1. Urban
2. Country Residential



Study cases: distinct situations

Concentrated on “Interface and first few rows of homes

- I: Side-by-side comparison-urban
- II: Extreme exposure – no ignition
- III: Isolated ignitions
- IV: Isolated survivors
- V: Country residential comparisons



Study Case I

- **Urban neighbourhoods sustaining heavy damage**
- **Opportunities for paired comparison of surviving and burned homes**
- **Side-by-side; similar circumstances**



Preliminary survey: Study Case II

- Urban interface neighbourhoods
- Exposure to extreme heat, ignition forces
- Home or group of homes did not ignite



Preliminary survey: Study Case III

- Isolated homes that ignited well within otherwise undamaged neighbourhoods



Preliminary survey: Study case IV

- Isolated urban homes that survived amid neighbourhoods destroyed.



Preliminary survey: Study case V

- Country residential homes in Saprae Creek Estates.
- Located S.E. of the city
- Dominated by mature black spruce forest (C-2 type)
- Large lots (1 – 5+ hectares)



Limitations and assumptions

Limitations

- Did not actually see forest fire burning, or fire behavior *
- Information obscured by intensity of burning homes
- Difficulty in distinguishing source of embers

Assumptions **

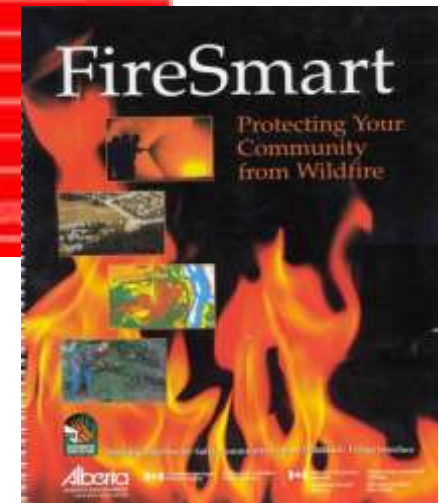
- Wind direction
- Timing of events

* Video and eye-witness reports

** Still seeking more information

Methods: Hazard Assessment

- Existing FireSmart[®] Hazard Assessment System
- Accepted Canadian standard
- Modified to include ember accumulator features.
Based on NFPA standards
- Used it retrospectively on homes destroyed by fire
 - Unique application

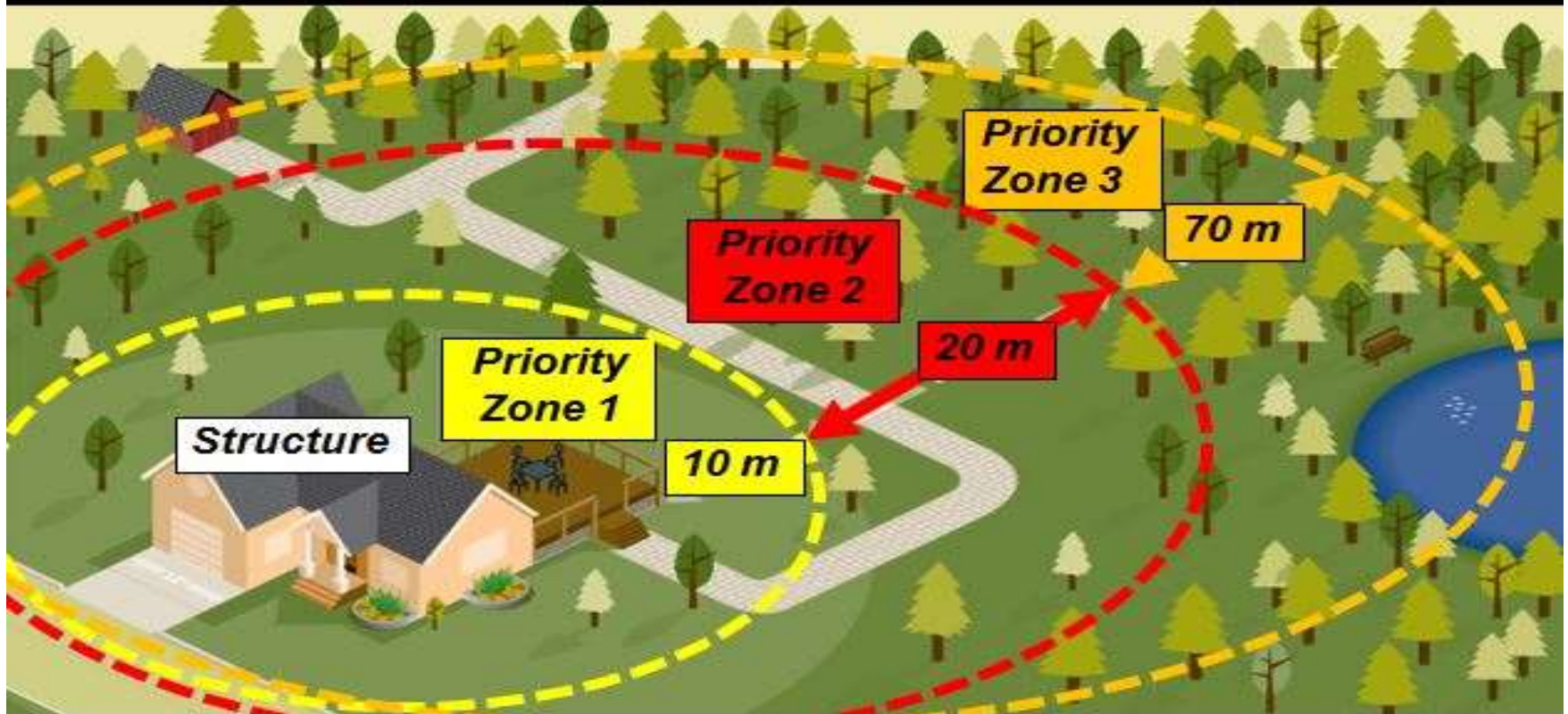


FireSmart: Principles and programs for reducing wildfire losses.

Where are FireSmart guidelines applicable? “Home Ignition Zone”

Home Ignition Zone

Structure + Priority Zones 1 - 2 - 3



Methods: Data collection format



Measuring conformity with FireSmart guidelines

- 3 main categories of hazard
- ~16 individual hazard factors
- Golf-style point scoring
 - High points = high hazard
 - Low – Mod – High – Extreme
 - Low – Mod = “FireSmart”

**VISUAL OBSERVATIONS ONLY
NO PROBING, COLLECTING, DIGGING
INFORMATION ON SURFACE,
OR NOT AT ALL**

Date: Form#:		I.C.L.R. HOME SURVIVAL ASSESSMENT PROJECT					
		FIRESMART: RAPID RESIDENTIAL HAZARD ASSESSMENT FORM.					
District:		Street Name:			House #:		
FACTOR		CHARACTERISTICS AND POINT RATINGS				CASE:	
STRUCTURE							
1	Roofing material	Metal, tile, asphalt, ULC rated shingles: non-combustible		Unretired wood shakes			
		0		30			
2	Roof cleanliness	No combustible material	Scattered material <1cm	Gagged >1cm deep			
		0	2	3			
3	Building exterior	Non-combust.	Log, heavy timber	Wood, vinyl, shingles			
		0	1	6			
4	Eaves, vents and openings	Closed, screened	Closed, not screened	Open, unscreened: debris			
		0	1	6			
5	Balcony, deck or porch	Non-combustible/closed	Combustible/closed in	Combustible: not closed			
		0	2	6			
6	Window and door glazing	Tempered	Double pane		Single pane		
		0	Sm/med	Large	Sm/med	Large	
			1	2	2	4	
7	Location of combustibles	None or >10m from structure		<10m from structures			
		0		6			
8	Setback from edge of slope	Adequate		Inadequate			
		0		6			
8a	Ember accumulators*	None to few		Moderate	Abundant		
		0		3	10		
PRIORITY ZONE 1 (0 – 10m) and PRIORITY ZONE 2 (10 – 30m)							
9	Forest Overstory	Deciduous	Mixedwood	Coniferous			
		0	30	Separated	Continuous		
	P2-1			30	30		
	P2-2			10	30		
10	Surface Vegetation	Lawn: non-combust.	Wild grass or shrubs	Dead/down woody			
		0	30	Scattered	Abundant		
	P2-1			30	30		
	P2-2			5	30		
11	Ladder Fuel	Absent	Scattered	Abundant			
		0	10	20			
	P2-2			5	10		
SUM							
PRIORITY ZONE 3 (30+m)							
12	Forest Overstory	Deciduous	Mixedwood	Conifer			
		0	15	Separated	Continuous		
				15	30		
13	Surface Vegetation	Lawn: non-combust.	Wild grass or shrubs	Dead/down woody			
		0	5	Scattered	Abundant		
				5	15		
14	Ladder fuel	Absent	Scattered	Abundant			
		0	5	10			
15	Slope	0-10%	10-25%	>25%			
		0	Even	Gullied	Even	Gullied	
			4	5	8	10	
16	Slope position	Low/sloping	Mid-slope	Upper slope			
		0	3	5			
Hazard Levels: LOW = 0-42 MOD = 43-58 HIGH = 59-70 EXTREME = 70+							

“Hazard Categories” ?

1. Structural features
2. Ignition sites
3. Vegetation/fuel



Structural factors: explained

Top to bottom:

- Roof
- Vents and openings
- Exterior walls
- Windows and glazing



Ignition sites: explained

Miscellaneous Combustibles:

1. Roof cleanliness
2. Balcony, deck, porches
3. Nearby combustibles (fences, trash, firewood, ATVs, 100+ others)

Ember accumulators:

- Inside corners
- Base of walls
- Wood chip mulch beds
- Eddies, “dead” zones
- “Nooks and crannies”



Vegetation/fuel factors: explained

Hazard is assessed according to:

- How much?
- How combustible? (evergreen vs. deciduous)
- How close to the home is it?
- Vertical layers - continuity?
 - Natural vegetation
 - Landscaped/ vegetation



Office confirmation

Regional Municipality of Wood Buffalo “Mapping Tool”.

- Before and after air photos of each home



Results and conclusions

Caveat

- Interim nature of results and conclusions
- Results are incomplete:
 - More detailed analysis to be done
 - More areas to be explored
- Range from very clear, to trends, to insights
- At this point – these are all important

Results: Proximal source of ignition

- Flames?
- Radiant heat?
- Embers?



Average FireSmart Rating for Paired Homes (Urban and Country Residential)

Pooled FireSmart hazard ratings for pairs of homes		
	SURVIVING HOMES	DESTROYED HOMES
Suburban Homes (N=13)		
Average hazard points	30	56
Range of hazard point values	10 - 65	12 - 103
Average hazard level	Low	Moderate/High*
Avg. difference between surviving and destroyed homes	31 points**	
Frequency surviving homes rated < destroyed homes	11/13	(85%)
Frequency surviving homes rated = destroyed homes	1/13	(7.5%)
Frequency surviving homes rated > destroyed homes	1/13	(7.5%)
Country Residential homes (N=5)		
Average hazard points	47	87
Range of hazard point values	26 – 63	56 – 120
Average hazard level	Moderate	Extreme
Avg. difference between surviving and destroyed homes	40 points	
Frequency surviving homes rated < destroyed homes	5/5	(100%)

Table 4-1: FS rating of homes surviving versus homes destroyed

Interim results: Average FireSmart rating for paired homes (Urban and Country Residential)

1. Urban survivors rated LOW Hazard; burned homes border line HIGH.
2. Rural survivors rated MODERATE (just); burned homes EXTREME.
3. Large point difference between surviving and burned homes:
 - 31 points in the URBAN areas
 - 40 points in the Country Residential
4. In 16 of 18 pairs, the surviving home rated with fewer points.

Net FS Hazard Rating – All Homes

FireSmart Hazard Level for all Homes Assessed in all Cases								
Study case	Low (0-42 points)		Moderate (43-58 points)		High (59-70 points)		Extreme (71+ points)	
	#	%	#	%	#	%	#	%
Case I: Paired Urban Homes – Survived	10	77	2	15	1	8	0	0
Case I: Paired Urban Homes – Destroyed	4	31	4	31	1	7	4	31
Case II: High Heat Exposure - Survived	3	100	0	0	0	0	0	0
Case III: Isolated Urban Ignitions	n/a	-	n/a	-	n/a	-	n/a	-
Case IV: Isolated Urban Survivors	2	40	0	0	2	40	1	20
Case V: Paired C. R. Homes – Survived	1	20	3	60	1	20	0	0
Case V: Paired C. R. Homes ² – Destroyed	0	0	0	0	2	40	3	60
Total # of Surviving Homes by Haz. Level	16	62	5	19	4	15	1	4
Total # of Homes Destroyed by Haz Level	4	22	4	22	3	17	7	39

Table 4.2: Hazard Level of all homes in all cases – Surviving and Destroyed

Interim results: Net FireSmart rating

- I. 90% survivors rated L- M; 1/3 burned homes in L, M, EXTR
- II. 100% of homes surviving extreme exposure rated LOW
- III. Ember caused; ratings variable; all with vital weaknesses
- IV. Mixed results here; structure + PZ1 rated excellent in all
- V. 4 of 5 homes rated L-M FireSmart ; 1 “edged” into HIGH

Overall:

- 81% of surviving homes were rated L – M (i.e. FireSmart)
- 2/3 of burned homes rated EXTREME.

Hazard by Categories - Urban

Hazard Points by Major Hazard Categories for Urban Homes			
	STRUCTURAL	VEGETATION/ FUEL	IGNITION SITES
Surviving Homes			
Average Value for Surviving Homes	10	14	5
Range of Values for Surviving Homes	5 - 16	0 - 47	1 - 8
% of Total Hazard by Category at Surviving Homes	34%	48%	17%
Homes Destroyed			
Average Value for Homes Destroyed	13	37	10
Range of Values for Homes Destroyed	2 - 23	0 - 84	6 - 14
% of Total Hazard by Category at Homes Destroyed	22%	62%	16%
Avg. Difference between Surviving and Burned Homes	3.5	24	4
Frequency Surviving Home Rated > Burned Home	3	0	2
Avg. Difference when Surviving Home > Burned Home	2	n/a	3
N = 13			

Table 4-3: Hazard Point Distribution by Category for homes surviving versus homes destroyed

Interim results: Hazard by major categories (all study cases)



1. Largest contributor to hazard was vegetation:
 - In both urban and CR areas; on average ~50% and 60%
 - 48% for urban survivors, 62% for homes destroyed
 - Average 24 – 29 less points awarded survivors than burned homes
2. Structural factors were the 2nd largest contributor to hazard; small difference in points to surviving versus destroyed homes.
3. Ignition sites were smallest contributor in both areas; but 2x and 5x more points awarded to burned homes than to survivors

Vegetation/Fuel Hazard by Priority Zone

Hazard Distribution by Vegetation/Fuel Priority Zones - Urban			
	Priority Zone 1	Priority Zone 2	Priority Zone 3
Surviving Homes			
Average Value for Surviving Homes	2	3	10
Range of Values for Surviving Homes	0 - 22	0 – 11	0 - 35
% of Vegetation/Fuel Hazard by Priority Zone	16%	17%	67%
Homes Destroyed			
Average Value for Homes Destroyed	12	12	12
Range of Values for Homes Destroyed	0-50	0 - 47	0 - 37
% of Vegetation/Fuel Hazard by Priority Zone	35%	32%	33%
Avg. Difference between Surviving and Burned Homes	10	9	2
Frequency: Hz @ Surviving Home Rated > Burned Home	2	2	2
Avg. Difference when Surviving Home Rated > Burned Home	3	3	7
N = 13			

Table 4.6: Hazard point distribution by Priority Zone – Urban

Interim results: Hazard distribution by priority zones (all study cases)

1. Urban areas/Surviving homes: 2/3 of hazard was located in PZ-3, balance evenly in PZ-1 and PZ-2; largest point differential between burned and surviving homes was in PZ-1.
2. Rural paired homes: no surviving homes had veg hazard in PZ-1; 80% located in PZ-3, 20% in PZ-2; major point differences found between surviving and burned homes in PZ-1 and PZ-2.
3. Overall: < 30% of all vegetation hazard found in PZ-1 of surviving homes but >60% of total vegetation hazard was located in PZ-1 of homes destroyed.

Individual hazard factors: Strengths

In general:

1. Combustible roofs and vents/opening no longer an issue.
2. 90+% of all homes vinyl-sided, including many survivors
3. Attributes of wood decks may increase ember resistance
4. Vinyl, 2-glazed windows appear highly resistant to failure
5. Early season lawn care and litter clean-up = big advantage
6. FireSmart landscaping options positively linked to survival
7. Neat and tidy properties (fewer combustibles and ember accumulators) also are positively associated with survival

Individual hazard factors: Weaknesses



In general:

1. Leaf litter and tall grass are an effective “carrier.”
2. Wood chip and bark mulch beds played frequent and prominent roles in home ignition pathways; about 50% of the time they burned completely, partially in remaining cases.
3. Decorative juniper/cedars present extreme danger and are believed to be a main element of many fire pathways leading to home ignition (i.e. potentially hundreds).
4. Wood fences and landscaping timbers are highly persistent and effective “wicks” that carry fire to attached home or structures.
5. Outbuildings seemed highly susceptible to ignition, were large fuel sources, and often a potential ignitor of homes.

Conclusions: Scope & caveats

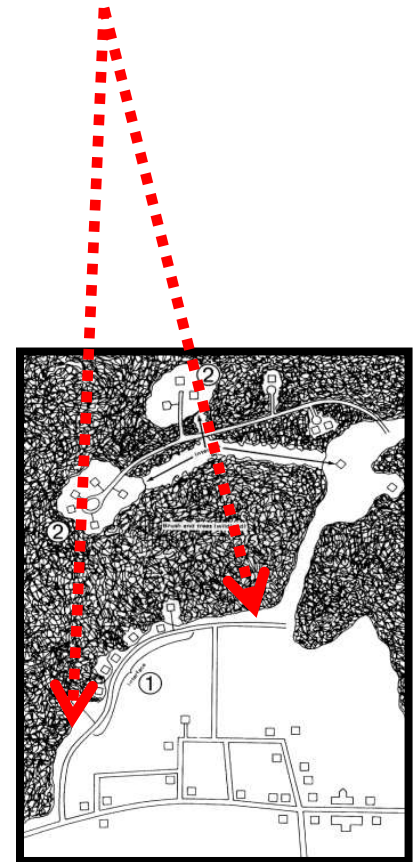
Only talking about homes in critical transition zone:
“Interface: Where forest meets homes”.

Conclusions do not apply to homes in the
“urban conflagration zone”

but have obvious implications for their
survival.

Preliminary conclusions and recommendations:

- More data to come
- Further analysis to be done
- More connections to other literature to be made



Proximate and secondary causes of home ignitions

Proximate cause:

1. Wind driven embers (flaming and smoldering)

Secondary causes:

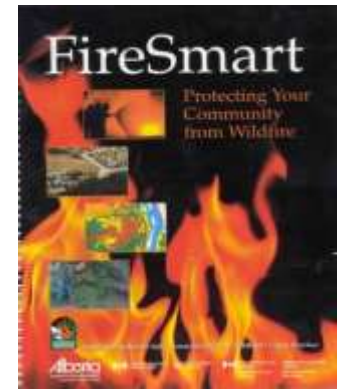
2. Radiant heat
3. Direct flame contact



“It’s the little things”

- Alan Westhaver

Conclusions:



1. FireSmart guidelines seem to be validated, in every study case.
2. Consistently, surviving homes are those who's owners have adopted FireSmart practices within their home ignition zones.
3. It appears that, if fewer homes had ignited in the interface, then many fewer structures would have been destroyed in the urban core, and overall, by the ensuing urban conflagration.

Conclusions:



1. 81% of all surviving homes assessed were “FireSmart”; $\frac{3}{4}$ in the “low” hazard category.
2. For matched pairs, the surviving home was rated “FireSmart” 89% of the time.
3. Isolated survivors avoided ignition by diligent attention to FireSmart guidelines; not due to random events, or luck.

Conclusions:



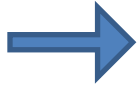
1. Compliance with guidelines pertaining to the condition of surrounding vegetation is a strong controlling factor of home survival.
2. Low compliance with vegetation + ignition site guidelines also correlate strongly with home destruction.
3. Vegetation management in PZ-1 and PZ-2 appears to be more critical than in PZ-3 (>30m from homes)

Conclusions: “Other”



1. Many homes were placed at risk due to hazards on adjacent properties, within their PZ-1.
2. Requirement for fire resistant ply-board beneath side vinyl siding on side exposures should be extended to all exposures in wildland/urban interface areas.
3. Last-minute risk mitigations by residents prior to evacuation were sometimes effective, if property was already “compliant” with FireSmart guidelines – better evacuation instructions are needed.

Wildland/urban interface disaster sequence



I interpret what I saw at Fort McMurray as being in close agreement with the prevailing science:

1. “Front row” homes acted as “points of ignition” for structure to structure spread of fire into the urban core.
2. Heat, flames, embers from these added to the ember train from nearby forest, igniting homes downwind.
3. The process grows exponentially as more “front row” homes ignite; and urban conflagration develops.

“Community as the fire break”

It's time for a 180°



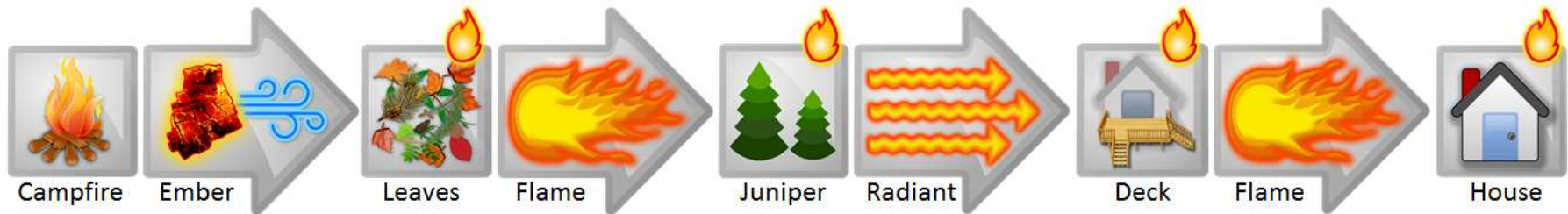
I observed a number of locations where homes at the interface did NOT ignite, survived, and so did adjacent homes located downwind and closer to the urban core:

- Groups of homes.
- Heavily exposed to radiant heat and embers.
- Were rated as FireSmart
- Suffered damage but did not ignite.
- This theory has now turned into practice in USA, it's our turn.

Getting our message across: “Showing” instead of “telling”



Prototype “fire pathway”: Putting it all together.



Repeating patterns: Myriad pathways for fire to spread to a home.

- Many begin with embers.
- Then pass through multiple fuels,
- and terminate with ignition of a home,
- ... unless interrupted by mitigation actions.

Interim recommendations

- Do not pertain specifically to the Fort McMurray fire.
- View WUI fire disasters as a national issue.
- Are strategic in nature.
- Addressed primarily to Federal and Provincial authorities with jurisdiction.
- Aimed at preventing similar disasters in the future.

Recommendations: Mandate and goal setting

Preliminary recommendations of this study are that:

1. Breaking the wildland/urban interface disaster sequence needs to become the fundamental goal of all future wildfire risk mitigation programs.
2. A strong, presumably Federal, mandated role be established to ensure effective wildland/urban interface loss reduction practices become the norm among Canadian property owners living in wildfire-prone areas across the nation.

Recommendations: Action on the ground

3. That the Federal Government act with urgency to allocate funding and restore momentum to the 2005 Canadian Wildland Fire Strategy and its four main initiatives including:
 - a) The Canadian FireSmart Initiative for enabling programs that empower individuals and communities to directly reduce wildfire risks within home ignition zones and to reduce fire intensity in the immediate interface fringe.

Recommendations: Strategic investing

- 4. An increased proportion of existing investments in emergency management, public safety and municipal infrastructure be expended towards preventive wildfire risk/loss mitigations in order to achieve reductions in disaster response and recovery costs.**
- 5. The insurance industry explore the potential for incorporating the “building back better” concept into current and future wildfire loss recovery efforts.**

Recommendations: Building and planning

- 6. National, provincial and other building codes be strengthened to increase the resistance of homes, outbuildings and other structures to ignition by embers and radiant heat during wildfire events.**
- 7. Authorities having jurisdiction over land planning and development policy consider adjustments to decrease the potential for structure-to-structure fire spread within urban areas.**

Recommendations: Regulatory

8. Wildfire-prone jurisdictions consider legislative or regulatory approaches to making wildfire risk mitigation mandatory to avoid or reduce the socio-economic impacts wildland/urban interface fire disasters.

Recommendations: Research

9. A consistent nation-wide system to adequately identify, quantify, and prioritize wildland/urban interface areas and associated threats should be developed and operationalized to inform land use planning, risk mitigation, public safety, and other relevant disciplines.

Next steps for this study?

1. Interim report
2. Media session
3. Final Report



Summing Up:



WHERE is the problem?

Home ignition zones = private property

WHO is responsible?

Homeowners, property owners, business owners

WHAT is the solution to this problem?

Getting owners to take effective risk mitigation actions

Questions and Comments are Welcome Now



**Alan Westhaver, M.Sc.
ForestWise Environmental
Consulting Ltd.**

Fernie, British Columbia

(250) 423-4818

alan.westhaver@shaw.ca