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Incentives and Barriers to Homeowners' Uptake of FireSmart® Canada's Recommended Wildfire Mitigation Activities in the City of Fort McMurray, Alberta

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Abstract: This paper presents the results of a survey that was undertaken to examine homeowners' FireSmart mitigation practices and investigate existing incentives and barriers to uptake of FireSmart Canada's recommended wildfire mitigation activities in the Urban Service Area of Fort McMurray Alberta. Single-family residential property owners, the large majority of whom were affected by the Horse River wildfire, were invited to participate in an online survey. A total of 496 surveys were completed, with a response rate of 38%. We found that most of the participants generally perceive a low to moderate wildfire risk to their properties: they felt there was a low chance of a catastrophic fire happening soon and/or 'enough' had already been done to reduce the immediate risk. Although about half of the participants searched for information about FireSmart, having information or knowledge of FireSmart did not translate into substantial adoption of recommended mitigation actions. Survey participants generally preferred and implemented more of the low-cost, low effort mitigation measures such as cutting grasses and cleaning debris, likely for reasons other than wildfire risk reduction. With regard to structural measures, we found asphalt shingles and vinyl siding were present on the majority of homes; although this was not a choice but was provided by the builder or on the home when it was purchased. Very few respondents were willing to replace their siding or roof—-the cost was the single biggest factor. In addition, we identified several other factors as negatively influencing homeowners' mitigation actions, including the tendency to shift responsibility to the municipal government and social pressure such as neighbors not being as proactive in completing FireSmart mitigation measures. Recommendations that may help promote positive wildfire mitigation behaviors are discussed.

Keywords: mitigation; FireSmart; homeowners; wildfire risk

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1. Introduction

The Horse River wildfire of May 2016 was one of the largest wildfire incidents in Canada with wide ranging social, economic, and environmental impacts. The fire (2 hectares) was first spotted on 1 May. Within three days, aggravated by the prevailing strong wind (43 KM/hr) and an unusually hot season (recorded daily temperature reaching up to 35 C), the wildfire quickly covered thousands of hectares (~157,000 ha), jumped the Athabasca River, and impacted most parts of the city. More than 88,000 residents of Fort McMurray were forced to evacuate with little notice including the evacuation of First Nations and Métis communities in the Regional Municipality of Wood Buffalo (RMWB). When the wildfire was finally under control by mid June, it had burnt an estimated area of ~ 590,000 ha (Figure 1). The damage from the wildfire was recorded as the costliest insured disaster in recent Canadian history [1]. It destroyed more than 2500 homes and damaged many more dwelling units and business establishments [2–4]. Overall, the wildfire resulted

in an estimated $3.6 billion in insurable loss [1]. Commercial and personal damages from the wildfire are estimated to be $6 billion [5].

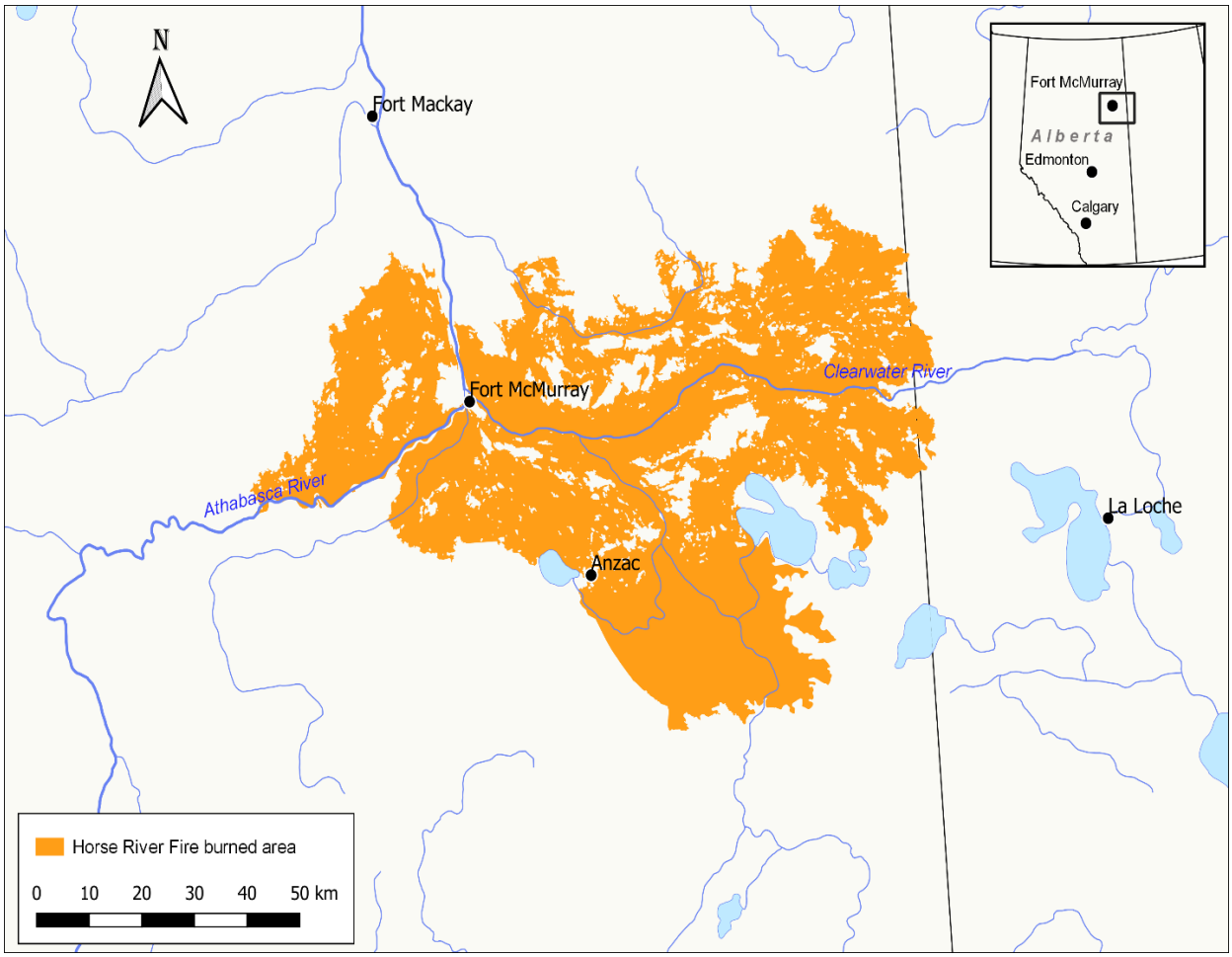

Figure 1. The May 2016 Fort McMurray Horse River Wildfire.

More than four years after the May 2016 Horse River wildfires, rebuilding and mitigation efforts in Fort McMurray are still ongoing. FireSmart education and awareness campaigns have been launched to persuade homeowners that FireSmart activities around properties can significantly reduce vulnerability of homes that are easily ignited by the inevitable showers of wind-driven embers from wildland fires. In a study completed post May 2016 fires, Walkinshaw [6] observed that the majority of home losses due to the fire were attributed to the build-up of hazardous fuels/vegetation around homes, whereas the majority that survived the fires were the ones which had followed recommended fire risk reduction measures within the home ignition zone. Although the Government of Alberta and the Municipality is committed to investing in reducing wildfire risk in the city such as by encouraging the city's residents to complete various FireSmart. FireSmart^{TM} is a comprehensive wildfire mitigation programme that has been implemented in several communities across Canada since the 1990s. The program was formulated by Partners in Protection, an Alberta-based non-profit organization dedicated to providing information and awareness to reduce wildfire risk in the WUI [7]. In USA it is known as Fire Wise [8]. recommended activities around their property, little is known whether and which recommended activities are being implemented as well as existing barriers and incentives influencing homeowners' uptake.

A significant number of empirical studies in the USA and Australia and some in Canada have examined public acceptance of fuel management practices on both private

and public lands. While crucial factors involved in the adoption of mitigation measures vary depending on ecological, social, cultural, and political context in which the hazard is situated, research findings generally noted that effective mitigation generally requires both public support for government action and engagement of private property owners in mitigating the risk to their own properties [9–12].

Recommended mitigation measures at the homeowner level can include vegetation management (i.e., clearing vegetation around the home) and/or structural changes (i.e., replacing wooden shakes with a less flammable roofing material). Research found several personal and psychological factors and situational characteristics influencing homeowners' adoption of these mitigation activities. Among the personal and psychological factors are perceived effectiveness of risk reduction activities [13,14], personal experience with wildfire [11], self-efficacy (belief in one's ability to complete treatments) [15], subjective norm or social pressure [16,17], perceived naturalness [9], and locus of control or behavioral control (e.g., limits on cost and physical capability) [9,11]. Situational characteristics including local ecological conditions [18], residency status, race, and conditions of adjacent properties [19] were also found to influence mitigation behavior.

At the community level, public acceptance of community level mitigation (such as prescribed burning, neighborhood work-bee, fire break, and mechanized thinning) were also found to be influenced by factors such as citizen trust in fire management agencies [10] and knowledge of and familiarity with the practice [20]. Limited research completed in Canada's wildland urban interface (WUI) context have noted that while residents in fire-prone communities are generally aware of their fire risk, not all recommended activities are uniformly adopted or accepted as necessary [11,21,22]. For example, a 2009 study completed in WUI communities in Alberta (e.g., Edson, Grande Cache, High Level, Hinton, Peace River, and Whitecourt) has found that homeowners tend to focus more on low-cost, low effort mitigation measures [21]. A survey completed in 2018 by the Municipality of Wood Buffalo, three years after the Fort McMurray wildfire, to assess public awareness of the FireSmart program post fire, found low levels of FireSmart implementation among residents [23]. The main objective of this research was, therefore, to examine residents' (focusing on homeowners) FireSmart mitigation practices and investigate the incentives and barriers to homeowners' uptake of FireSmart Canada's recommended activities for wildfire mitigation. Given the limited research available on the human dimensions of wildfire management in Canada's WUI context, this study attempted to bring a much-needed examination of individual, social, and institutional factors influencing residents' wildfire mitigation practice after a wildfire event.

The specific objectives included:

- Assess perceptions and attitudes of Fort McMurray residents of wildfire risk and mitigation following the Horse River wildfire.
- Examine the extent to which FireSmart activities are known, understood, and applied by homeowners.
- Explore the factors affecting homeowners' uptake of FireSmart Canada.

2. Literature Review

Research completed in the WUI (mainly in USA and Australia and Canada to some extent) has shown crucial factors involved in the adoption of mitigation measures vary depending on the ecological, social, cultural, and political context in which the hazard is situated [10,12,15,24]. Nevertheless, research evidence has generally established that effective mitigation generally requires both public support for government action and engagement of private property owners in mitigating the risk to their own properties [9–12,25–28].

Some of the major factors influencing the adoption of mitigation measures at the individual homeowners' level include personal and behavioral factors such as risk perception [29–36], past experience with wildfires [21,27,29,37,38], self-efficacy (belief in one's ability to complete treatments), subjective norm or social pressure [17,30,31], place attachment/place dependency [16,17,20], and locus of control or behavioral control (e.g.,

limits on cost and physical capability) [35,36]. Among personal and behavioral factors, although existing research frequently identified risk perception as the most important factor influencing homeowners' mitigation measures, other researchers have also found that higher risk perception alone does not always explain individuals' decisions and actions in completing mitigation measures [35,37]. Instead, they pointed to other factors such as how severe the event is perceived instead of the likelihood of its occurrence to sufficiently stimulating preparedness behavior [31,35]. A survey study completed in Perth, Australia, by McNeil et al. [31] found that residents who reported a higher risk perception (especially risk severity) have shown to have a higher level of wildfire preparedness. Similarly, researchers found differing findings with regards to the influence of prior hazard experience on mitigation behavior. For example, survey research conducted in fire-prone Central Oregon from 2011 to 2013 found that residents who experienced a wildfire event in the past were significantly more likely to engage in Firewise behaviors [27]. In contrast, a study by McGee et al. [38] following the 2003 Lost Creek and McLure wildfires in western Canada found a mixed result. While participants who had experienced previous wildfires and evacuation were motivated to implement protection action on their properties due to heightened concern, participants who lost their homes to wildfires, despite the increase in their risk perception, were not motivated to implement mitigation measures due to the perceived ineffectiveness of such measures to make a difference.

Situational characteristics including local social context such as length of residency, age, race, socioeconomic status [19] and ecological context such as conditions of adjacent properties [33] were also found to influence mitigation behavior. For example, studies, in general, have found that newcomers are more likely to have low-risk perceptions and are less inclined to complete wildfire mitigation measures compared to longtime residents [33]. Research has also brought insight into the factors influencing the implementation of mitigation measures beyond the individual homeowner's level such as at the neighborhood and or community level. For example, public acceptance of community-level mitigation (such as prescribed burning, neighborhood work-bee, fire break, and mechanized thinning) are found to be influenced by such factors as citizen trust in fire-management agencies [10] and knowledge of and familiarity with the practice [20].

Over the past years, several municipalities in Alberta and other parts of Canada have been embarking on wildfire risk reduction activities guided by FireSmart principles mitigation [21,39]. FireSmart manual and brochure were created, and a FireSmart Grant Program was developed to provide grants for municipalities, municipal districts, Métis Settlements, and registered non-profit societies to develop their own wildfire mitigation [21,39]. Limited research completed in the past with communities in Alberta has noted that while residents in fire-prone communities are generally aware of their fire risk, not all recommended activities are uniformly adopted [21,37,39]. For example, in their 2009 study completed in WUI communities in Alberta (e.g., Edson, Grande Cache, High Level, Hinton, Peace River, and Whitecourt), McGee et al. [21] found that homeowners tend to focus more on low-cost, low effort mitigation measures [21].

Efforts to make Fort McMurray an example of a FireSmart community started as early as 1997 when the Alberta Environment, Land, and Forest Service identified Fort McMurray as one of three pilot communities to engage in a multi-faceted interface fire planning process [7]. At the individual level, efforts included education and awareness campaigns to encourage homeowners to complete FireSmart activities on their property and around the Home Ignition Zone where the risk can be effectively reduced. According to FireSmart Canada, this ignition zone includes "the condition of the house and its immediate surroundings within 30 to 100 m and other structures such as garages, decks, porches, or fences that come in contact with the house" [7]. FireSmart standards require completing a list of vegetation management and structural measures around the Home Ignition Zone. Some of the vegetation management measures include cleaning up fallen branches, dry grass, and needles from within 10 m of the home, keeping rain gutters and roof free of leaves, needles, and branches; keeping tree limbs pruned at least 2 m from the ground

and spaced 3 m apart and moving woodpiles or other combustible materials more than 10 m from their home [7]. Structural measures include installing fire-rated roofing material known to offer strong protection to embers such as asphalt shingles and replacing and or retrofitting sidings with a higher fire-rated material such as stucco, brick, and fiber cement [7].

Despite the fact that the 2016 Horse River wildfire removed a majority of the hazardous wildland fuel types surrounding Fort McMurray, ignitions of wildfire, whether natural or human-induced, can result in a high level of threat as many residents in the city have not implemented the recommended FireSmart measures [23]. In a study completed post-fire 2016 wildfires, Westhaver [40] observed that the majority of home losses due to the fire were attributed to the build-up of hazardous fuels/vegetation around homes, whereas the majority that survived the fires were the ones which had followed recommended measures within the home ignition zone. The author also found that the use of combustible exterior structure materials (including roofing, siding, and decking materials), the existence of combustible materials within 10 m of structures (including fences and outbuildings), and dense flammable vegetation around homes are still identified as posing a high risk to wildfires in the city [40]. Since the 2016 wildfires, homeowners have also been encouraged to do vegetation management on their property since the 2016 firs with the aim of creating a fuel-reduced buffer between structures and flammable vegetation. However, it is not yet known whether homeowners are implementing such measures and what factors influence their actions.

3. Research Methods

This section outlines sampling, design of the survey instrument, data collection, and analysis. The survey research was conducted in collaboration with FireSmart Canada and RMWB. FireSmart Canada generously provided advice, support, and funding for this project while RMWB provided useful comments on the survey questions and assisted us in promoting the survey for residents during data collection.

3.1. Sampling

This study was conducted based on a cross-sectional household survey involving a sample of single-family residential property owners residing within the urban service areas of Fort McMurray, the Regional Municipality of Wood Buffalo (RMWB), Alberta. Single-family residential property owners who were identified via telephone solicitation (see Section 3.3) were invited to complete the survey. Other residential types were excluded from the sample because they are less likely to complete recommended wildfire mitigation measures as they are restricted in the types of mitigation activities that can be done on their properties [11,35].

Based on the 2018 RMWB Municipal Census, the total population of RMWB was 111,687, which shows a 10.67% decrease from one year prior to the Horse River wildfire [41]. The decline in the municipal population was attributed to two major factors: the downturn in the region's economy over this period and the Horse River wildfire [41]. Fort McMurray is the city located at the heart of the municipality and classified as an urban service area. The rest of the municipality constitutes nine rural communities and several temporary workers' camps. According to the 2018 municipal census, the Urban Service Area of Fort McMurray has a population size of 75,615 (67.7%). In contrast to the total municipal population, the urban population shows a slight increase up from 66.2% in 2015. Out of the total population in the Urban Service area, 72,056 (95.3%) are permanent residents while 3559 (4.7%) constitute temporary residents defined as "shadow population". The total number of dwelling units in Fort McMurray in 2018 was 27,072, which showed an 8.4% decrease from the 2015 due to home losses because of the Horse River wildfire. Data on the distribution of occupied dwellings in the city in 2018 showed that single-detached residential property (also called single-family residential property) continues to be the

dominant form of housing (47.2%), showing a 2.2% increase from 2015. In 2018, more than half of the city's population resided in single-detached dwellings [26].

A total of 496 single-detached residential property owners completed the survey, out of a total of 10,816 in the city. Following statistical sampling theory, a sample of this size is representative of the true population 19 times out of 20 (95% confidence level, +/− 5%). This assumes there is no error from non-response, measurement, or coverage [42].

3.2. The Survey Instruments

The survey included a wide range of questions organized under topics including experience with the May 2016 wildfires, risk perception, FireSmart mitigation awareness, FireSmart mitigation practices, and demographic characteristics.

Survey participants were asked if they had any experience with the May 2016 Fort McMurray wildfire by asking whether they (or someone close to them) had lost homes or property or had been evacuated. In order to capture risk perception, survey participants were asked to rate how likely they think they will experience damage to their property from wildfires within in the next five years using a scale of no risk (1) to very high risk (7). Similarly, survey participants' perception regarding the controllability of wildfire impacts to their property was measured using a scale ranging from not at all controllable (1) to very controllable (7); whereas the likelihood that firefighters would protect their home if it were threatened by a wildfire was measured through (1) very unlikely to (5) very likely. To understand survey participants' perception of the threat from wildfires in relation the adoption of mitigation measure, they were asked to rate the statements "threat is not significant enough to warrant mitigation" and "wildfires are too destructive to bother preparing for" using a five scale Likert question: (1) strongly disagree to (5) strongly agree. In order to assess FireSmart awareness, survey participants were asked if they had searched for information about FireSmart to learn about how to reduce wildfire risk around their property. To assess whether homeowners had completed recommended FireSmart™ mitigation actions post May 2016 Fort McMurray wildfires, the survey utilized the list of FireSmart™ Canada's recommended mitigation activities (first proposed by Partners in Protection 2003) [43]. The activities were classified and included in the survey into two broad categories: vegetation management and fuel-reduction activities and structural mitigation measures. Questions were also included to understand survey participants' attribution of responsibilities to wildfire risk reduction activities and the influence of social pressure. The final section of the survey presented questions related to some background and demographic characteristics of the respondents.

3.3. Data Collection

The survey was administered online. We hired a survey administration company (Advanis) to recruit participants, coordinate, and manage the survey. In order to recruit participants, Advanis generated a list of random phone numbers, both landline and mobile, from the local telephone directory. Residents were contacted through a live telephone operator. Potential participants were identified and screened through the operator. Using a pre-defined script, the head of the household was asked questions to determine if the person fulfilled the criteria set. The screening criteria to be included in the study were being a resident of Fort McMurray, owning and living in a single-detached property, and being 18 years of age or older. If the person qualified, and agreed to answer the survey, the person was asked if s/he would prefer a text message or an email with the link to the online survey. This helped to ensure the participant could fill out the survey at their convenience, whether on their smartphone, tablet, or computer. A toll-free phone number was provided for questions, comments, and/or concerns participants may have had regarding the survey. This toll-free phone number went to a voicemail, where participants could leave questions and contact details. Recruitment of participants continued until a sufficient sample size was completed. A total of 1288 was found to satisfy the recruitment criteria. Out of these, 496 homeowners successfully completed and submitted the online survey (Table 1), with

a response rate of 38%. A follow up was made for the recruits that did not respond (this would include leaving a message, email reminder, and sending the SMS link to those we received voicemails for).

Table 1. Background of the sample participants and the population.

	Sample * *N* = 496		**Population ** *N* = 71,590**	
Background of the participants	Freq.	%	Freq.	%
Gender *n* = 480				
Male	244	50	38,555	54
Female	236	48	33,040	46
Other	2	0.4		
Age groups *n* = 465				
<25	3	0.65	22,215	31
25–34	70	15	16,555	23
35–44	146	31	13,110	18
45–54	130	28	10,855	15
55–64	81	17	6930	10
65–74	32	7	1470	2
>75	3	0.6	480	0.6
Education *n* = 487				
Some grade school or high school education	5	1	3470	7
High school graduate	59	12	12,810	27
Some post-secondary education	57	12	***	
College or trades certificate or diploma	180	37	21,770	46
University or post-graduate certificate, diploma or degree	186	38	10,305	22
Employment status *n* = 496				
Full-time paid employment	317	64	31,005	54
Part-time paid employment	34	7	15,470	27
Self-employed	39	8	2260	10
Unemployed	20	4	3115	6
Retired	59	12	1955	3
Domestic parenting duties	35	7	***	
Household Income *n* = 441				
Less than $40,000	11	3	2010	8
$40,001–$60,000	13	3	1015	4
$60,001–$80,000	12	3	1150	4
$80,001–$100,000	34	8	1230	5
More than $10,000	371	84	20,255	79

* The sample (*n* = 496) only constitutes single-detached residential property owners drawn from a total (*n* = 10,816) of single-detached residential property owners residing in the city. ** Represents some background characteristics of the municipal population (*n* = 71,590) based on the 2016 statistics Canada census report. Ideally, the comparison should have been made with the total single-detached homeowners in the city in which the sample is taken but unfortunately, the municipal survey does not have the detailed socio-demographic data segregated by dwelling units. Looking at the comparison made with the 2016 Stastics Canada census, however, still gives good evidence that our sample is a good representation. *** Census data for this category is unavailable.

3.4. Data Analysis

The survey data analysis was conducted using SAS 9.4 and Advanis' online reporting tool. We begin with a discussion of the socio-economic and demographic background of the survey participants. Survey participants' experiences with the 2016 Fort McMurray wildfire, their risk perception, and mitigation practices were analyzed statistical techniques.

4. Result

We begin with a discussion of the socio-economic and demographic backgrounds of the participants. We then discuss participants' experiences with the recent wildfire, risk perception, mitigation practices, sense of responsibility, social pressure, and fuel management preferences using descriptive statistics. Factors influencing the adoption and implementation of FireSmart mitigation activities post-fire are further explored and discussed.

4.1. Socio-Economic and Demographic Background of the Participants

All participants were homeowners above the age of 18 and currently living in the urban service area of Fort McMurray. Men and women were more or less equally represented in the sample, as 49.6% of the participants were female, 48.1% male, and 0.4% had other responses. Forty-six percent (46%) were between the ages of 25–44; 45% were between the ages of 45–64, and 7% were above 65 age (Table 2). Participants under the age of 25 constitute only 0.6% (three participants) of the sample. Thirty-eight percent (38%) had obtained a university degree/diploma, a college or trade certificate (37%), some form of post-secondary education (12%), and high school completion (12%). Only 1% of the participants reported having only some grade school or high school education. Sixty-four percent (64%) of the participants stated they were employed full-time, 7% were in part-time paid employment, and 12% stated they were retired. Eight percent (8%) stated that they were self-employed, while 7% stated that they had domestic parenting duties. Only 4% stated they were unemployed.

Table 2. Perception of wildfire risk.

Perception of Risk Variables	Mean	Standard Deviation
[a] How likely is it you will experience damage to your property from wildfires within in the next 5 years	3.3	1.6
[b] How likely is it there will be a wildfire near by/in surrounding city's environ within the next 5 years	4.1	1.5
[c] How controllable are wildfires in terms of people's ability to control the effects	4.6	1.7
[d] How likely is it firefighters could protect your home if it were threatened by a wildfire	3.7	1.1
[e] Threat is not significant enough to warrant mitigation	2.7	1.0
[f] Wildfires are too destructive to bother preparing for	2.0	0.8

[a,b] Rated on a scale from 1 = no risk, 7 = very high risk. [c] Rated on a scale from 1 = not at all controllable, 7 = controllable. [d] Rated on a scale from 1 = very unlikely, 5 = very likely. [e,f] Rated on a scale from 1 = strongly disagree, 5 = strongly agree.

Seventy percent (70%) earned a total household income of more than $120,000 (Table 1). The income distribution data appear to be more or less in line with Statistics Canada census data. The 2016 Census showed more than 75% of private households in RMWB earn a total

annual income of $100,000 CAD and over [44], which is much higher than the Canadian average. All of the other demographic data correspond to census information.

Participants had lived on their property and in Fort McMurray for varying periods of time, with many being long-term residents. The majority (73%) of the participants reported living in the city for more than 10 years—-the average length of residency for all participants was 16 years. Only 3% reported living in the city for less than five years. In terms of length of residency in their current home, 40% of the participants had lived on their property between six and 10 years, 26% had lived 11 to 20 years, and 14% had lived for more than 20 years. The remaining 21% had lived on their property for less than five years. The average length of participants' residency on their property was 11 years.

4.2. Experience with the Horse River Wildfire

The majority of study participants had gone through a direct fire experience during the Horse River wildfire. Eighty-nine percent (89%) of the respondents were evacuated, 8% lost their home, and 10% reported they had lost other structures on their property because of the wildfire. Even if they had not experienced any property damage due to the wildfires, close to 2/3 of the study participants reported someone close to them lost their house because of the wildfire. Out of the 496 study participants, only 5% reported they did not directly experience the Horse River wildfire (Figure 2).

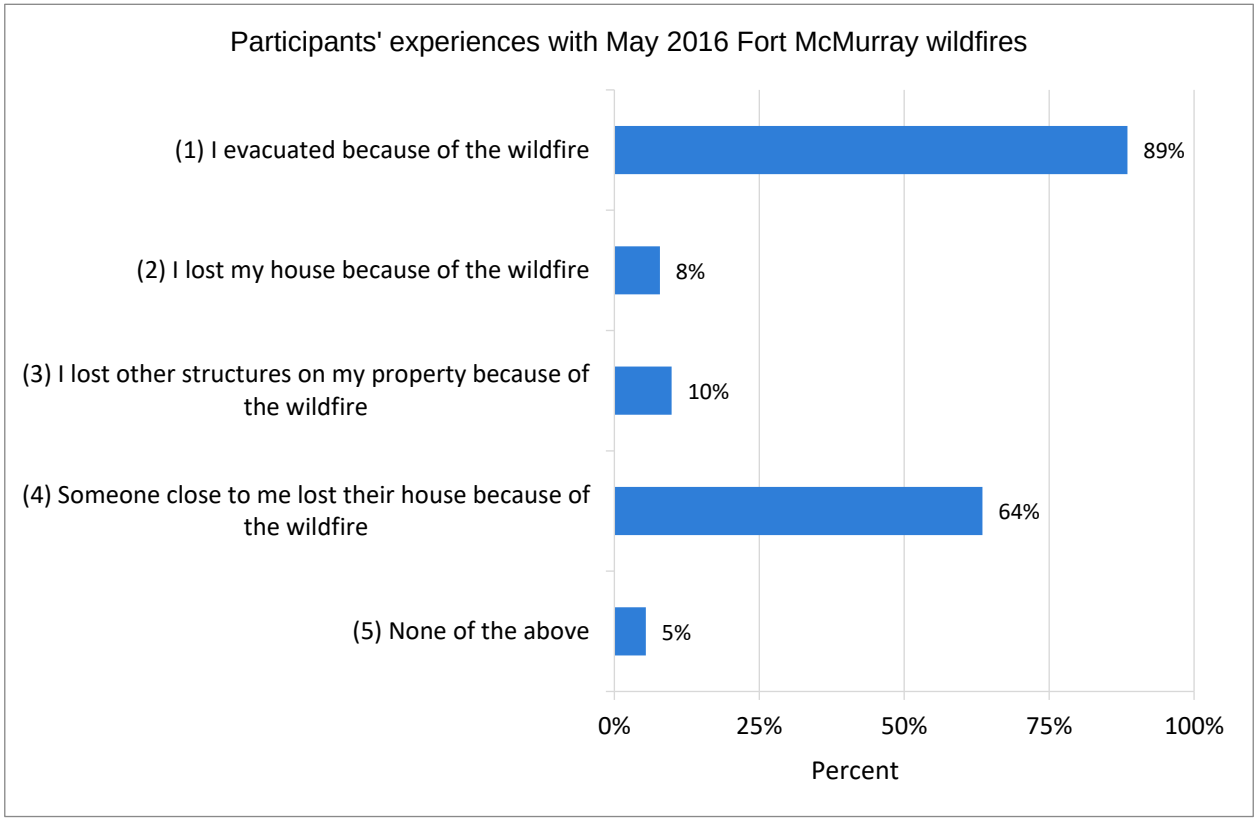

Figure 2. Participant homeowners' experiences with the May 2016 Fort McMurray wildfires (participants were able to select multiple responses).

4.3. Perceived Risk

Homeowners' perceptions of risk from wildfires varied considerably depending on the nature of risk, the experience they had with the recent wildfire, and how they perceived the likelihood of the wildfire threat to their property and the city's surroundings (Table 2). We examined the wildfire risk perception of the participants by asking them to rate how much of a risk they believe wildfire poses to their property and to the city's surrounding

area over the next five years using a scale of no risk (1) to great risk (7). We found the majority of the participants rated the risk to their property over the next five years as low to moderate (mean = 3.3). In contrast, they perceived the risk to the city and the surrounding environment as moderate (mean 4.1), indicating many believe there is a higher chance a wildfire would pose a risk to the city than to their individual property.

Respondents were also asked about their ability to control the effects of wildfires on a scale of 1 (not at all controllable) to 7 (very controllable). Interestingly, more than half of the participants perceived wildfire as generally controllable (M = 4.6). When respondents were asked, "how likely it is firefighters could protect your home if it were threatened by a wildfire?" about 2/3 of the participants felt it was likely that firefighters could protect their home. Only 13% stated it was unlikely fire fighters could protect their home and 21% stated they were not sure. Although there is a low to moderate level of risk perception to property, many disagreed with the statement that the "threat is not significant enough to warrant mitigation" (mean = 2.0). While most respondents (67%) disagreed with the statement "wildfires are too destructive to bother preparing for", some participants (19%) maintained the view that wildfires are too catastrophic and any FireSmart measures they would perform around their property would do little to protect them from damage. As will be discussed later, such views, among others, seem to have negatively influenced participants' FireSmart mitigation actions around their property.

Further, we also examined if there was a variation in participants' wildfire risk perception by gender, experience with the Horse River wildfire, and length of residence in Fort McMurray. Although the majority of the participants rated the risk to their property over the next five years as low to moderate, we found a slightly higher wildfire risk perception among female participants as compared to their male counter parts (Table 3). However, we found no significant relationship between risk perceptions, experience with the 2016 Fort McMurray wildfire and length of residency in Fort McMurray (Table 3).

Table 3. Risk perception by gender, wildfire experience, and length of residency.

Variables	* Perception of Risk to Property from Wildfires Over the Next Five Years		t-Value
	Mean	Standard Deviation	
Gender			0.007 ***
Male	3.1	1.5	
Female	3.6	1.6	
Experience with the 2016 Fort McMurray wildfire			0.7
Direct experience **	3.3	1.5	
No experience	3.4	1.9	
Length of residency			0.1
<10 years	3.5	1.6	
>10 years	3.3	1.6	

* Rated on a scale from 1 = no risk, 7 = very high risk. ** Direct experience with the fire included those who were evacuated, lost homes or other structures on their property. *** Significance is indicated by $p < 0.05$.

4.4. FireSmart Mitigation Awareness

Out of the 496 study participants, 213 (43%) of the respondents indicated they had searched for information about FireSmart to learn about how to reduce wildfire risk around their property. The study participants used a variety of sources. The most common information sources included the internet, the municipality's website, social media, a local FireSmart representative, and word of mouth (Figure 3). Other information sources less frequently used include billboard and signage, provincial government's information sources, friends and relatives, and neighbors.

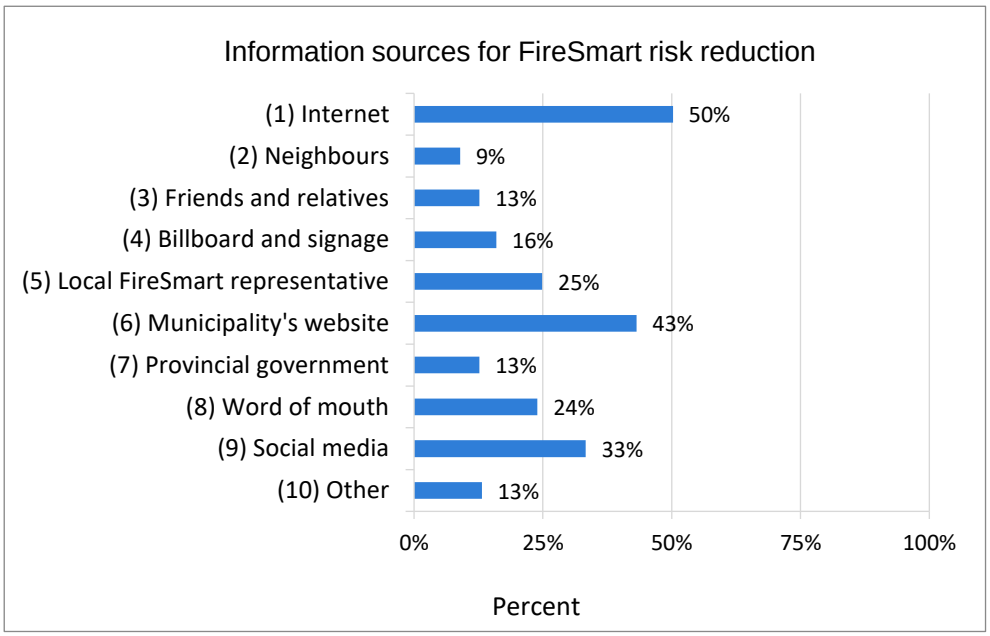

Figure 3. Homeowners' sources of information for FireSmart risk reduction (participants were able to select multiple responses).

4.5. FireSmart Mitigation Activities Known and Implemented in Post-Fire Recovery

We also assessed whether homeowners had completed recommended FireSmart mitigation actions after the Horse River wildfire. Following FireSmart Canada's recommended mitigation activities (first proposed by Partners in Protection (2003)), we broadly classified the actions into two broad categories: (1) vegetation management and fuel-reduction activities and (2) structural mitigation measures.

4.5.1. Vegetation Management and Fuel-Reduction Activities

Vegetation management and fuel-reduction activities constitute several FireSmart mitigation actions homeowners are recommended to complete to reduce the risk of wildfire around the area known as the "Home Ignition Zone". These activities included vegetation management activities specifically for wildfire risk reduction (such as thinning and removing trees, moving a woodpile, etc.) and other activities completed as part of general property maintenance (such as mowing and watering lawns, and removing debris from roofs and gutters). We asked participants whether they had completed such actions over the last year for reasons that included protecting their home from wildfires. We found that although participants had completed several recommended vegetation management mitigation measures, not all the measures were equally implemented.

From the list of vegetation management measures presented to the participants, the two most widely implemented activities were cleaning up of fallen branches, dry grass, and needles from within 10 m of home (81%) and keeping rain gutters and roof free of leaves, needles, and branches (78%). Sixty percent (60%) of the participants in our study further stated they kept tree limbs pruned at least 2 m from the ground and spaced trees 3 m apart. Sixty percent (60%) of the participants also stated they had moved woodpiles or other combustible materials more than 10 m from their home. While 56% of the participants stated that they cleared the area within 10 m of their house of flammable trees, the rest of the participants stated they did not (Table 4). Therefore, the least popular homeowners' vegetation management activities were those that involved cutting trees. However, it is important to note that the majority of participants still undertook these activities.

Table 4. Percentage of homeowners who had adopted vegetation management and fuel-reduction activities.

Vegetation Management and Fuel-Reduction Activities	**Yes**		**No**		
	Frequency	**%**	**Frequency**	**%**	**N**
In the past year, I have kept my rain gutters and roof free of leaves, needles, and branches *for reasons that include protecting my home from wildfires.*	385	78%	107	22%	492
In the past year, I have cleared the area within 10 m of my house of flammable trees, other vegetation, and combustible materials *for reasons that include protecting my home from wildfires.*	277	56%	218	44%	495
In the past year, I have kept my tree limbs pruned at least 2 m from the ground and have spaced my trees 3 m apart *for reasons that include protecting my home from wildfires.*	293	60%	203	41%	496
In the past year, I have moved woodpiles or other combustible materials more than 10 m from my home *for reasons that include protecting my home from wildfires.*	291	60%	202	40%	493
In the past year, I have cleaned up fallen branches, dry grass, and needles from within 10 m of my home *for reasons that include protecting my home from wildfires.*	401	81%	94	19%	495
In the past year, I have done something not listed above *in order to protect my home from wildfires.* (Please list other wildfire protection measures you have taken in the past year.)	129	26%	363	74%	492

Some participants also reported completing other activities not listed above, including removing wooden walkways around the perimeter of the house and replacing it with gravel, replacing and planting less flammable vegetation around the home, landscaping using rocks, and replacing wood decking with composite materials. While most participants completed the vegetation management and fuel-reduction activities to protect their homes from wildfires, other reasons were also mentioned including aesthetic reasons/to make the property look nicer, to minimize other risks (e.g., falling trees, flooding), and to increase property value. Participants who have not completed some of the FireSmart recommended mitigation measures had several reasons for not doing so despite 41% saying that it was a priority to implement the activities. The most commonly cited reasons for not completing such activities were that they required information before they could complete these actions (28%), and they did not consider the threat of wildfire significant enough to warrant doing some of these activities (24%) (Table 5). Importantly, 37% of participants said their family or neighbors would like the changes and 69% felt that completing FireSmart activities would make firefighters' job easier when responding to future fires.

Some of the study participants also mentioned lack of skills (19%), lack of financial capacity (19%), physical inability (18%), and a preference to natural connectedness over tree cutting/vegetation removal (16%). Five of the respondents also mentioned their lots were too small to adhere to some of the recommended measures such as moving woodpiles 10 m from a house. Still others maintained the view that vegetation removal and tree cutting around their house would do little in protecting them from approaching wildfires; rather they left this responsibility for the municipality to maintain a firebreak around the city. Respondents were given the opportunity to provide comments in addition to the structured questions and these comments provided additional insights on the respondents' views and opinions towards FireSmart recommended mitigation measures.

Table 5. Attitude towards FireSmart vegetation management and fuel-reduction measures.

	Mean [a]	SD	Agree [b]	Disagree [c]
I need more information before I can complete some of these activities.	2.8	0.9	28%	40%
If I made all or some of the suggested changes, my family or neighbors would like it.	3.3	0.8	37%	16%
I do not have the financial capacity to make these changes.	2.6	1.1	19%	51%
Implementing these activities is a priority for me.	3.3	0.8	41%	16%
For physical reasons I am unable to complete some of these activities without assistance.	2.3	1.1	18%	68%
I do not have the skills to complete some of these recommended activities.	2.5	1.0	19%	62%
If I made those changes I would not feel as connected to nature.	2.4	1.0	16%	62%
I do not consider the threat of wildfire significant enough to warrant doing some of these activities.	2.6	1.0	24%	48%
Wildfires are too destructive to bother preparing for.	2.0	0.8	8%	80%
If I made these changes, it would make firefighters' jobs easier when responding to future wildfires.	3.7	0.9	69%	10%

[a] Rated on a scale from 1 = strongly disagree, 5 = strongly agree. [b] 1 and 2 on 5-point scale. [c] 4 and 5 on 5-point scale.

4.5.2. Structural Mitigation Measures

Roofing Material

We found that an overwhelming majority of the participants have asphalt shingles (94%) and metal roofing (2%) (Figure 4). These are fire-rated roofing material known to offer strong protection to ember fire starts [7]). An earlier study by [11] similarly noted the use of asphalt shingles becoming common in new-house construction in Alberta. Only 3% of the participants reported having untreated wood shakes—-a roofing material rated as flammable and more vulnerable to sparks and burning embers from a wildfire [43]. The remaining 1% had other materials such as recycled plastic, rubber, and treated wood shakes.

The majority (59%) of the participants stated they had asphalt shingles because it was on their roof when they bought their house, and it is the most common roofing material (41%). Some of the other reasons cited included aesthetic reasons or for improving the appearance of a property (17%), it being less expensive (13%), and easy to install (10%) (Figure 5). Only 11% of the participants stated they had asphalt shingles because the shingles could significantly reduce damage to their house should a wildfire occur.

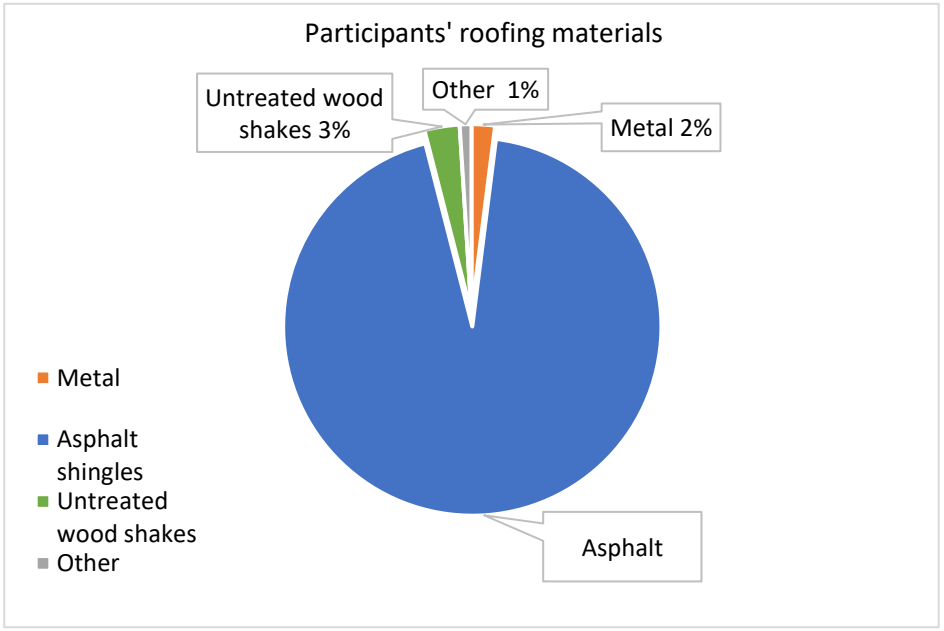

Figure 4. Participants' roofing materials.

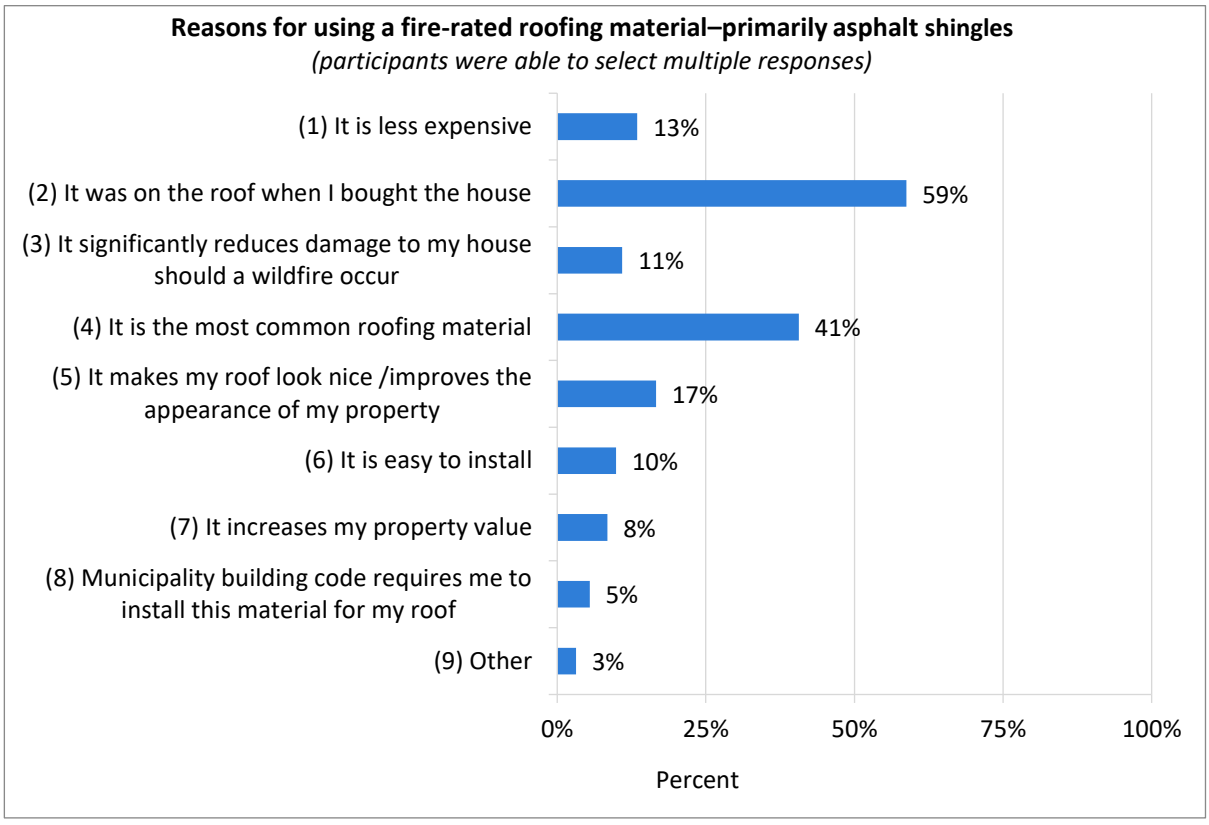

Figure 5. Reasons for using a fire-rated roofing material (participants were able to select multiple responses).

The few survey respondents (19 out of 496) who had not installed a fire-rated roofing material were also asked if they were willing to replace it with a higher fire-rated material. Of these, only three respondents expressed their willingness to replace it with a higher fire-rated material and two of them expected they could make this change within the next five years. The rest of the respondents were either unwilling (seven respondents) or

were not yet sure if they needed to replace it or not (nine respondents). Sixteen of the respondents cited lack of financial capacity and not having a plan to replace it unless it gets old and needs repair. Three respondents indicated they did not consider the threat of wildfire significant enough to warrant this change.

Siding Material

We found that the majority of the study participants had vinyl as a siding material (78%) (Figure 6). The use of vinyl siding can decrease the likelihood of a house surviving a wildfire as this material can melt when exposed to high temperatures, allowing the fire to reach the underlying wall components and penetrate the interior of the building (FireSmart Canada 2019). Only a third of the participants reported having siding materials with higher fire resistance including stucco (19%), brick (9%), and fiber cement, e.g., Hardie board (4%) (Figure 6). About 3% reported using wood and another 3% had other materials such as aluminum, metal, and cement.

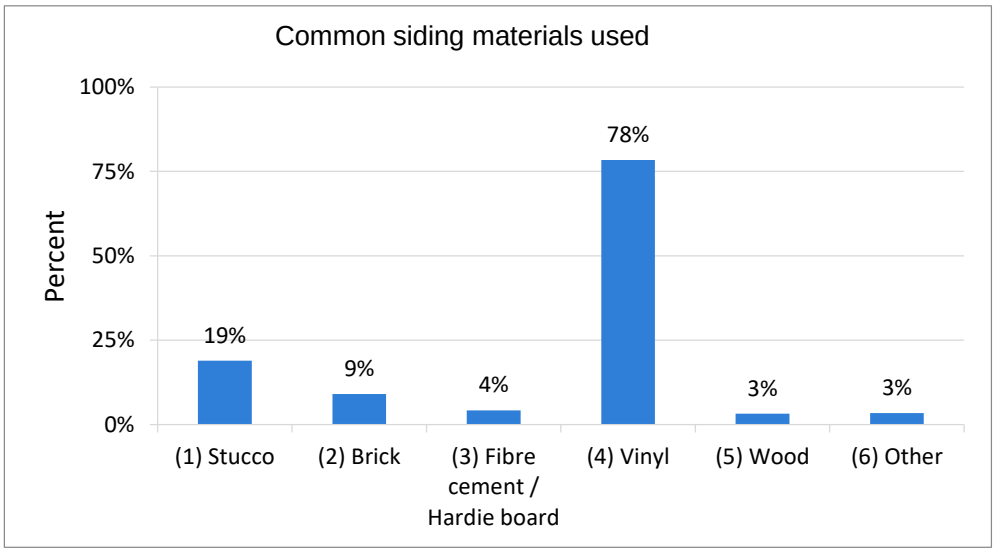

Figure 6. Participants' siding materials.

When asked the primary reason for using the siding material currently installed on their homes, the majority (70%) stated it was already in place when they bought the house. Again, of those using a fire-rated siding, only a small number (16%) stated that they used the material for home construction believing it significantly reduced potential damage to their house should a wildfire occur.

Respondents who had lower fire rated siding material like vinyl were also asked if they were willing to replace their siding with more fire-resistant materials (such as stucco, brick, fiber cement boards, and/or poured concrete). Of the 389 participants who had vinyl as siding material, more than half (52%) said that they were unwilling to replace their siding, and 25% stated they were not sure. Only 19% (76 respondents) expressed their willingness. The remaining 6% had no opinion. Out of the 76 respondents who were willing, 33% (25 respondents) expect they can make this change within the next five years and 15% were yet unsure.

Respondents who were unwilling to replacing their sidings with a higher fire rated material cited several reasons. Among these, two of the most frequently cited reasons were lack of financial capacity (57%) and not having a plan to replace current siding unless it gets old and needs repair (47%). Interestingly, 26% (102) of the participants stated they do not consider the threat of wildfire significant enough to warrant doing this change. Some of the other cited reasons included that it was not a priority, lack of time, aesthetic reasons, and lack of support from family (Figure 7).

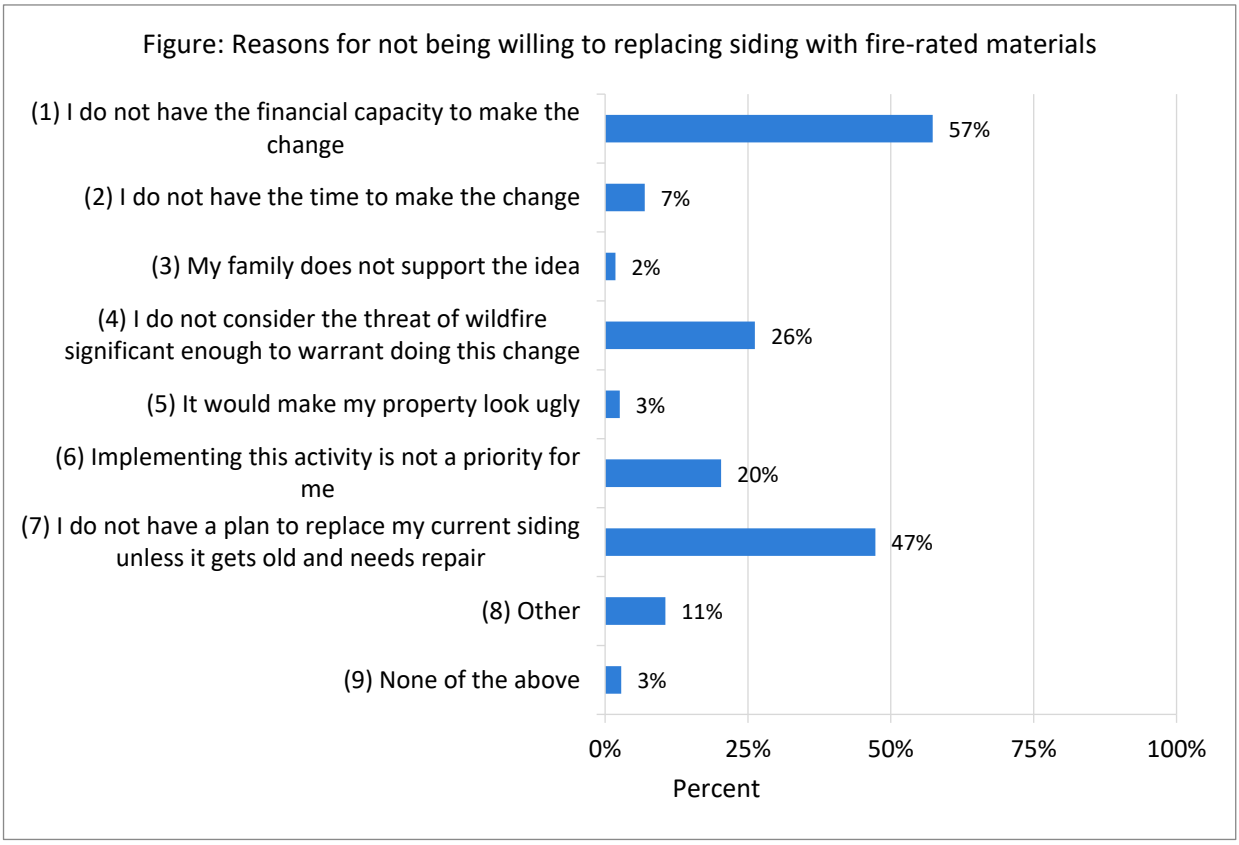

Figure 7. Reasons for not being willing to replacing siding with fire-rated materials (participants were able to select multiple responses).

From those who selected 'other', two of the participants stated they had already spent enough money on their house and were not willing to spend any more money. Another participant mentioned insurance was more complicated when a house was partially damaged as opposed to completely burned down. Another participant stated that he was selling his property soon. Some strongly opposed the idea of making it a requirement for homeowners to make such changes. In the words of one of the participants:

> *"I strongly disliked the suggestion of being forced to do anything to my home at my expense. I owned this home before the fire. According to all current and previous laws my home is fine the way it is. I'd leave Fort McMurray if I had to replace my siding for a more "preferable and fire smart exterior". If they want to impose such laws on new builds be my guest."*

4.6. Sense of Responsibility

Participants were asked whom they thought should be responsible for reducing wildfire risk on their property: themselves and their households, municipal/city fire department, the municipal government, the provincial government, and/or the federal government. A considerable number of respondents attributed responsibility to themselves as well as the government at different levels. Overall, most (78%) of the participants indicated that homeowners have responsibility for reducing the risk of wildfires to their properties, followed by the municipal government (77%), themselves and homeowners living in their neighborhood (75%), and the provincial government (74%) (Figure 8). A relatively lower proportion (64%) viewed mitigation as a federal government responsibility.

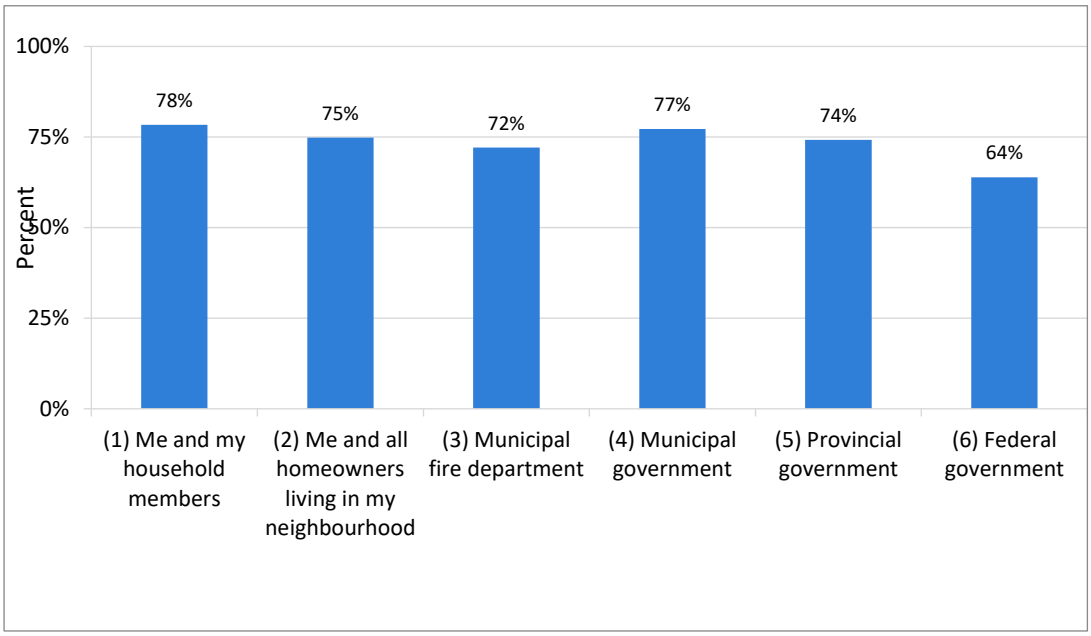

Figure 8. Participants' attribution of responsibilities to wildfire risk reduction activities (participants were able to select multiple responses).

4.7. Social Pressure

We asked participants about their neighbors' actions on mitigation. We found that while 39% of the participants agreed most people in their neighborhood had taken mitigation measures (such as those listed in Section 4.5), 24% disagree and the rest maintained a neutral view (Table 6).

Table 6. Participants' views towards their neighbors' mitigation activities.

	Mean [a]	SD	Agree [b]	Disagree [c]
Most people in my neighborhood take measures such as those listed above in order to protect their homes from wildfires.	3.2	0.8	39%	24%
Residents in my neighborhood work together to solve local problems.	3.1	0.9	32%	25%
Those who own rental properties in my neighborhood are equally interested in mitigating wildfire risk as other residents.	2.7	1.0	20%	11%
Seasonal residents in my neighborhood are equally interested in mitigating wildfire risk as other residents.	2.7	0.9	15%	37%

[a] 1 = Rated on a scale from 1= strongly disagree, 5= strongly agree. [b] 1 and 2 on 5-point scale. [c] 4 and 5 on 5-point scale.

While 32% of the participants agreed with the statement that "residents in my neighborhood work together to solve local problems", 25% disagreed and the rest (43%) maintained a neutral view. Some participants expressed their views that their neighbors were not as proactive as themselves in completing FireSmart mitigation measures on their properties, which they found negatively influenced their motivation towards completing the same. In the words of one of the participants:

> *"I live on a small property with only one tree on my property that has been trimmed to remove all dead branches. Neighbours have trees that are dead and/or have dead branches that require removal but that hasn't happened. We all have to work together to mitigate this ever happening again."*

Participants were asked if they thought those who owned rental properties and seasonal residents in their neighborhood were equally interested in mitigating wildfire risk as other residents. As shown in Table 6, we found 20% agreed, 11% disagreed, and 69% were neutral. Two of the participants expressed their concerns about the limited FireSmart actions taken by their neighbors who own rental homes and absentee homeowners in the comments section:

> *"I find efforts on my property is limited by the numerous rental homes in my area that are never maintained. For example, there are yards that have not been maintained since the homes were built ten or more years ago. The homes are built close together and I worry that during a wildfire there would not be adequate resources to prevent structure fires from spreading."*

5. Discussion

We found, although many of the participants had gone through a direct experience, most of the participants generally perceived a low to moderate wildfire risk to their properties. Experience with hazard has long been identified by researchers as one of the many factors influencing residents' risk perception and the adoption of mitigation measures [11,12,32,35]. However, the relationship is complicated. In some cases, experience can increase risk perception and help stimulate mitigation behavior; in other cases, it can decrease risk perception by creating a feeling that "lightning does not strike twice" ([45], p. 19). Research completed in communities in southern Alberta found that residents' lower risk perception could be attributed to the large area already burnt; the infrequency of large fires; the infrequency of hot, dry summers; or a combination of these factors [38]. It is also possible that residents could perceive a higher risk in their area or region but could downplay the risk to their particular homes [46], which was also found in this study.

Hazard experience can also increase risk perception so much that residents develop a feeling of fatalism, where they believe no steps can be taken to effectively reduce risk and that we are at the mercy of nature [35]. Our results support these previous findings as a few participants felt they lived in an area at extremely high risk to wildfires and felt risk reduction efforts were futile—-it is important to note that this was a minority viewpoint. Such conflicting views held by the residents regarding the likelihood of wildfire risk and its potential impacts could have a negative implication on homeowners' FireSmart mitigation behavior. Informing the residents of the potential risk and the likely response action they could do at their disposal is a necessary first step in mitigation [21,25,29].

We also examined if risk perception was influenced by other factors such as gender, income, and length of residency in the city. Concerns about wildfires remained the same for long-term residents and newcomers alike; we found female participants tend to have slightly higher risk perceptions compared to their male counterparts. The latter is consistent with research conducted elsewhere (e.g., in Australia), which found that women tend to have a higher risk perception and, thus, are more likely to want to evacuate when confronted by wildfires [47,48]. Women are often ignored or missed when communicating about wildfires. Some communication efforts could, therefore. be targeted at women or targeted to events where a high proportion of women attend (craft sales, farmers markets, school activities, women-only gyms, etc.) instead of generic 'head of household', which often means men. Past studies have shown a relation between income level and wildfire mitigation activity, which we did not. The likely reason is the very high level of income of the majority of residents of Fort McMurray, and our sample. We simply did not have enough stratification of income levels to determine any correlation. Another study on uptake of FireWise actions in the USA found that income becomes important around incomes of $80k and upwards, but with low significance [33].

Our finding suggests homeowners had a moderate level of knowledge regarding FireSmart mitigation. In the National FireSmart survey, only 26% said they had ever heard of FireSmart [49], so the level of awareness of FireSmart in the RMWB is much higher. However, having information or knowledge of FireSmart did not translate into substantial

adoption of recommended mitigation actions. Other studies have found the reliance on increasing name recognition of a program does not translate well for programs that require behavioral change [50]. In the National FireSmart survey, 42% cited a lack of knowledge for why they have not implemented FireSmart recommendations. The next highest was lack of money at about 25% [49].

We found that the majority of participating homeowners were not interested in completing a FireSmart assessment of their home and property. As discussed below, when asked what policies would help mitigation in their community, 77% were favourable to the provision of free Firesmart assessment, and 79% favoured better public education. Our questions do not permit analysis of these conflicting views between desire for their property, and desire for the community as a whole. The dissonance in these findings could suggest that participants do not see themselves at risk, and only see others as needing help. The most frequently cited reason for not wanting a personal assessment was that they did not consider the threat of wildfire significant enough.

These findings have important implications on the need to do more education, support, and follow up on FireSmart to ensure homeowners understand, are motivated and encouraged to implement the recommended mitigations actions. As evidenced in previous research [12,13,21,46], however, the issue of how best to communicate with residents of the WUI and persuading them to perform mitigation remains problematic. Although a number of factors determines the success of public education, the method of communication is a vital component in successful risk reduction initiatives [15,16,35,51]. Christianson et al. [39] examined 13 case studies of wildfire mitigation in Alberta and found the most successful programs with the highest rates of adoption and community support relied on a risk communication approach; this is when focus was put on two-way communication between residents and a trusted risk manager. There were similar findings in the USA, where Shindler [51] found that successful programs could be traced to one individual with strong communication skills who was respected in the community.

For vegetation management and fuel reduction measures, the two most widely implemented activities were cleaning up of fallen branches, dry grass, and needles from within 10 metres of home and keeping rain gutters and roof free of leaves, needles, and branches. The finding that a higher proportion of participants are engaged in these vegetation management activities starkly relates to those found by Faulkner et al. [52] in other municipalities in Alberta. In their study, the authors found that while 79.6% had removed shrubs, trees, or fallen branches close to their house, 79.4% had cleaned needles, leaves, and overhanging branches from the roof and gutters. It appears that of the suite of possible recommended vegetation management activities, the least popular were those that involved the cutting of trees, although the majority of participants were still doing it. The National FireSmart survey had very similar results [49]. Providing expert advice on the type of trees and vegetation that could be planted as a more FireSmart alternative during in-person FireSmart home assessments may encourage homeowners who are reluctant to replace higher risk trees on their properties. Municipal FireSmart engagement plans need to incorporate local expertise from a range of professionals, such as landscape architects, who would be able to provide local expert advice on residential landscaping for promoting FireSmart properties without compromising homeowner values.

As was found in other WUI communities in Alberta (e.g., Edson, Grande Cache, High Level, Hinton, Peace River, and Whitecourt), homeowners tend to focus more on low-cost, low effort mitigation measures [21,52]. As further noted in the result section, participants gave multiple reasons for not undertaking risk reduction activities: (1) it was a low priority, (2) they needed for more information, (3) low fire risk perception, (4) a lack of skills, (5) a lack of money, (6) physical inability, and (7) a preference to natural connectedness over tree cutting/vegetation removal. Research completed mainly in the USA has had similar findings. Despite higher risk perceptions associated with dense vegetation, residents were not willing to engage in vegetation management to minimize their hazard exposure because

of environmental preferences or preferences for the 'natural' aesthetics offered by dense forest environments [9,13,53,54].

On a positive note, participants did indicate that conducting mitigation activities would make firefighters' job easier. The continued involvement of the local fire department in FireSmart activities, promotional materials, and home assessments could further entrench the fact that conducting these activities is helpful for fire crews, perhaps making it more likely for homeowners to be willing to undertake such measures. Some participants felt on-going municipal level FireSmart activities (e.g., maintenance of city firebreak) would be enough to protect them from future risk.

We also examined homeowners' acceptance and implementation of structural mitigation measures focusing on roofing and siding. With regard to roofing, we found an overwhelming majority of the participants had asphalt shingles, mostly because it was on their roof when they bought their house.

Of the participants who had vinyl as a siding material, very few said they were willing to replace their sidings, and out of those, only a third of the respondents stated they expected to make this change within the next five years. Most residents viewed recommended structural risk reduction measures such as changing roofing and siding as expensive. The finding that cost is the most important barrier for completing the structural mitigation measures is not new. Our research confirms previous research findings which indicated costly home construction measures such as roof and siding replacement are least likely to be undertaken by homeowners [11,13]. For example, a recent study conducted to examine barriers to implementing mitigation behaviors in 12 Colorado counties in the USA found that out of the 863 survey participants, over two-thirds (69%) indicated cost as moderate to extreme barrier [25]. The researchers pointed out a mix of suggestions including local construction codes, insurance, and some community programs or policies, such as retrofitting assistance [25] Part of it also has to do with how much uncertainty is involved in homeowners' cost-benefit calculation surrounding its adoption. In discussing factors that play role in the adoption of a new practice, Rogers [55] noted that perceived relative advantage is a key predictor to adoption rates suggesting on the need to work more on the cohesiveness and styles of communication among residents.

Some participants felt the municipality should focus on city level mitigation activities such as the creation of firebreak and defensible space around the perimeter of the city. This is consistent with other research findings, which suggested municipal level risk reduction activities (e.g., fuel management, fireguard) and firefighting resources can provide a false sense of security among homeowners, making them believe those actions and resources would be enough [15]. Several participants felt their neighbors were not as proactive as they were in completing FireSmart mitigation measures on their properties and expressed their concerns about the limited FireSmart actions taken by their neighbors who own rental homes and absentee homeowners, which influenced their willingness to undertake mitigation. Past research has suggested that conditions on adjacent lands could be a consideration for homeowners' mitigation decision. Studies relate this factor to subjective norms (also known as social pressure) to denote the influence of neighbors on residents' mitigation behavior [15,56]. For example, homeowners' may feel discouraged to perform mitigation works around their property if they think their neighborhoods are doing nothing to reduce risk [57]. It is, therefore, important to understand that there may not be a simple pattern in the implementation of FireSmart recommended mitigation measures among homeowners; and such differences are driven by psychological, socioeconomic, and situational influences. The task of FireSmart engagement officials is to consider the diversity of views and tailor messages to specific groups of homeowners/neighborhoods.

Although the above factors appeared to influence homeowners' implementation of residential mitigation measures in varying degrees, most survey respondents viewed mitigation as a shared responsibility. These findings of homeowners' attribution of wildfire mitigation responsibilities are consistent with the findings of other similar studies completed with five WUI communities in Alberta [52] and WUI communities in the USA such

as in California [25] and Texas [56]. Such perception of who is responsible for wildfire mitigation might influence homeowners' implementation of FireSmart [38]. Hesseln and Ergibi [49] found in the National FireSmart Survey that respondents who perceived a fire risk to their homes were five times more likely to undertake mitigation activity. Showing the usefulness of mitigation could be highlighted by showing the results of Westhaver [40] who noted that among the homes that survived the Horse River wildfires, most had completed recommended FireSmart guidelines.

6. Conclusions

Using a survey research method, this study examined homeowners' FireSmart™ mitigation practices and investigated existing incentives and barriers to uptake of FireSmart™ Canada's recommended wildfire mitigation activities in the Urban Service Area of Fort McMurray, Regional Municipality of Wood Buffalo, Alberta.

More than three years after the Fort McMurray wildfires, the risk reduction measures that homeowners' reported completing is still limited to a few of the possible FireSmart recommended mitigation measures. Our result showed that although many of the survey participants had gone through a direct experience, we found that most of the participant homeowners generally perceive a low to moderate wildfire risk to their properties. Some participating residents even perceived a very low risk of wildfire to their property within the next five years, which appears to be influenced by their observation of the infrequency of large wildfires, the area burnt, and the large-scale municipal tree cutting mitigation works commenced following the May 2016 wildfires. Although participant residents appeared to have a higher level of awareness of FireSmart recommended risk reduction activities, the proportion of sampled homeowners who consulted the appropriate FireSmart guidelines and implemented them was still lower. We found that the most frequently cited reason for lacking interest to completing FireSmart assessment was related to having a lower risk perception or not considering the threat of wildfire significant enough. Having the information or knowledge of FireSmart did not translate into substantial adoption of recommended FireSmart mitigation actions. These findings suggest the need for fire managers to work more persuading residents on the imminent fire risk. One idea would be to make fire history maps of the region available to residents on the RMWB website, to show residents they live in an area frequently impacted by wildfire. Another idea is to showcase other communities that had been threatened by large wildfires but where community and homeowner mitigation activities reduced the effects. Documented American examples include Circle Oaks, Napa, California; Thomas Fire, Montecito, California; and High Park Fire, Redstone Canyon, Colorado. More recently, a case study with community of Montecito, California, also documented how pre-fire mitigation activities played a clear, central role in minimizing property loss from the 2017 Thomas Fire [26].

Our research further highlighted several key factors inhibiting homeowners in completing recommended mitigation measures. The most common included not being a priority, requiring more information before completing some of these actions, not considering the threat of wildfire significant enough to warrant doing some of these activities, the cost of mitigation, physical inability, and conflicting values due to a preference to natural connectedness over tree cutting/vegetation removal. Other factors that appeared to influence homeowners' implementation of vegetation measures included having too little acreage to adopt some the recommended measures, subjective norms, and shifting responsibility away to firefighters, the city, or the municipal government. These findings suggest the need for continued involvement and engagement of the local fire department in providing expert advice, promotional materials, and free or low cost FireSmart home assessments to further entrench the fact that conducting these activities is helpful for fire crews, perhaps making it more likely for homeowners to be willing to undertake such measures. In addition to personal contact, there should be regular neighborhood meetings, where the importance of participation by all is highlighted as mitigation is a shared responsibility. Homeowners need to perceive that it is worth investing in mitigation actions. This may mean investing

resources in communicating about the measure that are most likely to be adopted that will have the largest impact on fire risk reduction. Providing financial incentives for those homeowners who are willing to retrofit their house with fire rated materials and enforcing new codes for developers to use fire-rated building materials can go a long way in promoting FireSmart home construction in the city.

This study is unique in the sense that it focused on homeowners' mitigation preferences in an urban setting after experiencing an extreme wildfire event that resulted in a mass evacuation event and widespread destruction of homes and infrastructure. Future longitudinal studies (for example, returning to the community 10 years post-fire) might be useful to examine the changes in perceptions or the extent of adoption of recommended mitigation measures. Although this study is limited to homeowners' mitigation actions on private property and did not conduct a thorough examination of community-level mitigation activities, it does, however, provide some insight into the need for mobilizing neighborhood or community level mitigation works. Future study could focus on better understanding the effectiveness of community or city level mitigation activities (such as tree cutting, fire breaks, vegetation cleaning on public lands, etc.) and their relationship to homeowners' FireSmart behaviors.

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