AWARENESS AND ADOPTION OF FIRESMART CANADA: BARRIERS AND INCENTIVES

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Abstract

Homeowners and communities in the Wildland Urban Interface (WUI) are strongly encouraged to protect their property from the risk of damage from forest fires. FireSmart Canada has been created for this purpose and is recognized as a powerful tool to mitigate losses caused by fires; however, individuals and organizations in the WUI have not fully committed to self-protection. This research aimed to identify and assess the factors that influence the awareness and adoption of FireSmart activities in Canada. I used binary logistic regression techniques to test the effects of socio-demographic and other pertinent factors on FireSmart familiarity and engagement. Results indicate that 77% of survey respondents have never heard of FireSmart Canada. Of those who had never heard of the program, the majority were females, urban residents, live east of Manitoba, and reported they had not experienced the threat of wildfire. For those who were familiar with FireSmart, results that limited knowledge and financial resources were the main deterrents from engaging in FireSmart. In addition, the research found that living in a rural setting, positive risk perception, fire damage experience, residence region, FireSmart awareness, level of education, gender, and age, all are significant predictors of FireSmart adoption. Moreover, FireSmart familiarity could be enhanced significantly by targeting education to certain professions, and using different media source for different age groups.

Findings could be used by FireSmart Canada to increase awareness of and engagement in FireSmart activities. Results suggest (1) increasing awareness of fire risk, (2) providing education/information by advertising FireSmart principles across a range of media targeted to different age groups, (3) promote lower-cost activities that require minimal effort as a start to fire protection, (4) continue to engage with and encourage the insurance industry to increase awareness of FireSmart Canada by providing education regarding FireSmart principles and developing incentives to adopt such principles.

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Chapter 1

Introduction

1.1 Background

Fire is a common phenomenon in Canada's forests, burning an average of 2.5 million hectares every year (Natural Resource Canada 2017). Canadian provinces have incurred growing financial losses as a result of increasingly extreme forest fire behaviour. Steelman (2015) described fire-related damage in the western Canadian provinces in 2015 as a tragedy given that millions of hectares burned in Saskatchewan, Alberta, and British Columbia, which was estimated to be double the historical average fire activity. The 2013 fires in British Columbia combined with the 2011 Slave Lake Fire in Alberta destroyed approximately 800 structures, resulting in insured damages over $1 billion (Stocks 2013).

The Insurance Bureau of Canada reported insurance costs for the Fort McMurray fire in 2016 to include 12,000 auto claims averaging $15,000, 27,000 personal property claims averaging $81,000, and 5,000 claims for commercial property averaging $250,000. In total, 1,820 single-family houses burned, and 600 condos and apartments were destroyed. Overall, the fire forced 90,000 residents to leave their homes and destroyed 2,400 structures, making that the costliest disaster for insurers in the country's history at approximately $3.58 billion (Cryderman 2016).

Notwithstanding the damage to human property, wildland fire has played a remarkable role in determining the health, biodiversity, and landscape attributes of forested ecosystems since the last ice age (Hirsch 2001). Furthermore, fire is a natural and necessary component of healthy ecosystem functioning, thereby making it impossible and undesirable to completely eradicate. Wildfire largely becomes problematic when it occurs within and adjacent to the Wildland Urban Interface (WUI), defined as an area with "the presence of structures in locations in which topographical features, vegetation fuel types, local weather conditions, and prevailing winds result in the potential for structure ignition from flames and firebrands of a wildland fire" (Westhaver 2016, p.4). The growth in the population moving into the WUI, combined with a

changing climate, and a long history of fire suppression have resulted in wildfires that have become costly to manage and more destructive (Stocks 2013).

Fire in the WUI has become much more problematic given a greater means of forest fire transmission from forested rural areas into populated urban zones, particularly when private property is not properly protected (Schreiber 2015). Fire in the WUI can also have profound negative consequences on communities where daily life is being disrupted by smoke and/or the need to evacuate (Bowman 2012 and Sullivan 2008).

Fire prevention can be accomplished by reducing ignitions or mitigating damages. The history of fire policy in Canada has been to reduce damage primarily through suppression. However, a century of effective suppression that largely removed fire from the landscape has resulted in ecological changes that have exacerbated the problem – with less fire on the land, flammable fuels have increased both the hazard and risk of larger and more intense wildfires (Cohen 2008). In the 1970s and '80s national and provincial fire policies shifted based on the realization that fire on the landscape is necessary and therefore, all fires should not be suppressed (Davis 2006). This shift in policy led to practices whereby fire is allowed to burn thereby performing its natural role in the ecosystem and prescribed fire and fuels treatments on public land are used to reduce fuels buildup.

A second complicating factor in wildland fire management is the desire of an increasingly greater number of individuals to live in WUI areas. The outcome has been the growth in values at risk on private property and of infrastructure such as roads, mines, power stations, communications towers, etc., as well as an increased probability of unwanted ignitions (Brenkert-Smith et al. 2012). Understanding the issue surrounding WUI fires is critical to protecting such areas. Of primary importance is raising the awareness of residents as to how homes ignite and the possible means to mitigate the risk of damage from wildfire. While it is generally believed that flame fronts along with radiant heat are responsible for home ignitions, that is not the case: embers are more likely responsible for one half to two-thirds of home ignitions on large interface fires (Cohen 2000; Cohen and Stratton 2003; Maranghides and Mell 2009; Mercer and Zipperer 2012). Home ignition occurs when embers come into contact with flammable materials outside of a structure, or the home itself (Westhaver 2015).

Researchers suggest that the growing incidence of fire in the WUI is going to overwhelm individuals, communities, and government agencies alike. The extent of the WUI is expected to increase in Canada due to the expansion of cities and as the population expands farther into forested areas. This will likely be complicated by further changes in the climate resulting in more frequent and intense wildfires (Bowman 2012; Westhaver 2015).

Given that the anticipated burnable area in North America is expected to increase 100% by 2050 and 350 - 500% by 2100 (Balshi et al. 2009), we can create buffer zones between human developments and susceptible forests as well as take steps to protect forests and private properties (Union of Concerned scientists, n.d.). To effectively reduce fire risk, it is recommended that homeowners and communities conduct risk assessments on private property as well as at the landscape level. FireSmart in Canada and Firewise in the United States are two strategies that have been practiced to successfully reduce the risk of damage and loss from wildland fire in North America (Mercer and Zipperer 2012).

Fire professionals work with homeowners to reduce the risk to private property and communities by increasing awareness of the threat of wildland fire, and by providing educational materials to adopt a range of mitigating actions and strategies. Partners in Protection (PiP), a multidisciplinary association that aims to mitigate wildfire risk within and adjacent to the WUI, was established in Alberta in the 1990s. PiP created and published the first edition of the FireSmart manual in 1999, and a second edition in 2003. Three priority zones around structures have been identified for managing trees, shrubs, debris and firewood piles in order for a home to survive (see Walkinshaw et al. 2012). Fire organizations in Canada, New Zealand and Australia have all adopted the standards provided in the FireSmart manual as strategies to mitigate wildfire risk in the WUI (Walkinshaw et al. 2012).

Targeted mitigation efforts through FireSmart focus on activities designed to treat private land and property, meaning that the private sector is responsible for actions and funding. However, individuals and communities have not been quick to adopt such practices. Limited knowledge about fire risk and mitigation methods could explain why individuals do not take action. Positive attitude and knowledge about prescribed burning was found to be a significant predictor of fuel mitigation program support. As the public become increasingly aware of the benefits generated

by fuel reduction plans such as prescribed burning and thinning, acceptance of such practices increased (Loomis et al. 2001).

Similarly, Brunson and Shindler (2004) demonstrate that public acceptability of fuel reduction programs such as prescribed fire and thinning could be enhanced through new information, whether it was obtained through formal (education, public outreach) or informal (personal experience, word of mouth) channels. They further report that knowledge and acceptability of these programs varied across geographic regions. For instance, survey respondents from Oregon were more likely to know about the positive benefits of the mechanical fuel removal whereas Utah respondents were less certain about forest fuel mitigations. They attribute differences in certainty to urbanization and exposure to wildfires and fuel mitigation strategies.

Several studies have explored factors affecting awareness, attitudes and beliefs about the environment (Klaczynski and Reese 1990; Schahn and Holzer 1990; Zelezny 2000; De La Vega 2004; Bozoglu et al. 2016). Results have shown that economic and socio-demographic factors such as gender, age, family size, income, residence (rural vs. urban), political tendencies and parents' level of education were significant. Bozoglu et al. (2016) point out that female students were more likely to be aware of environmental problems and that students from rural settings have more environmental awareness compared with urban residents. With respect to fire however, providing information and education to enhance individuals' awareness about risk does not always lead to individuals taking action to mitigate risk (Collins 2005; Brenkert-Smith et al. 2006; Martin et al. 2007; Gordon et al. 2010; Bozoglu et al. 2016).

1.2 Problem Statement and Research Objectives

While research has shown that FireSmart activities successfully mitigate damage and loss from fire to both individuals and communities, widespread adoption has not occurred. Research shows that the lack of adoption for similar programs is likely dependent upon expectations about effectiveness, and the lack of awareness regarding risk, for example (Winter et al. 2002 and 2004; Shindler and Toman 2003; Nelson 2005; Vogt et al. 2005). Studies have also investigated the relationship between homeowner awareness about specific management tools to prevent interface fires, and homeowners' lack of support for specific management measures (Loomis et al. 2001; Brunson and Shindler 2004).

My objectives for this research were to assess the public's awareness of FireSmart, to determine the factors that lead to engagement in FireSmart, and to determine methods that might lead to greater awareness of FireSmart. This research is important and will inform wildland fire management and policy regarding the protection of private property and communities. As the risk of damage to private property and human lives grows, it will be incumbent upon WUI residents to take responsibility to protect themselves and their communities. The thesis presents this research beginning with a literature review, followed by methodology, analysis, and discussion. The conclusion provides implications of the research and recommendations for future inquiry.

Chapter 2

Literature Review

FireSmart is a prevention education and damage mitigation tool that is used to reduce the susceptibility of communities and property to fire risk using a number of recommended activities including maintenance and modification of private structures, retrofitting and new construction using non-combustible building materials, landscaping and modification of fuels loads (Taylor et al. 2006). Human life and infrastructure have been increasingly threatened by wildfire due to the continued expansion of the WUI. As a result, fire agencies at the regional and local levels have increased efforts towards reducing fire risk, particularly in western Canada (Taylor et al. 2006).

The FireSmart strategy was first initiated in Alberta in the late 1990s. The purpose of FireSmart was to create awareness and workable solutions to the problem of vulnerable interface communities (Partners in Protection 2003). FireSmart could effectively lead to home survival and fire risk reduction even in extreme weather conditions and full crown fires (Walkinshaw et al. 2012) as determined in the International Crown Fire Modelling Experiment conducted between 1997 and 2000 (Alexander et al. 2010). The following literature looks at how previous research (Canadian context and elsewhere) investigates the importance and economic benefits of conducting forest fire risk mitigation in the WUI and how risk mitigation actions are affected by different factors.

Walkinshaw et al. (2012) examined the effectiveness of FireSmart recommendations where a sample of cabins made from non-flammable material in a boreal forest was tested for fire exposure. They showed increased survivability of houses based on modifications to protection priority zones and alternate building materials. More recently Westhaver (2016) examined home survival in the WUI in response to the Fort McMurray fire in 2016. He observed five distinct characteristics within the affected neighbourhoods and reports that traveling embers was the most significant cause for home ignitions in zones where the fire moved from the forest into urban neighbourhoods. Once a single home ignited, fire most likely spread from structure to structure becoming an urban conflagration. However, there were several homes/structures that were not

damaged or only partly damaged by fire. Westhaver states that, "the homes that survived were those more resistant to ignition by the embers and radiant heat of the wildfire through the actions and decisions of homeowners who had adopted FireSmart measures to a greater degree than the owners of adjacent homes that were destroyed" (p.22).

Prestemon et al. (2010) explored the net benefits of prevention education as it is used to mitigate wildfire risk in Florida. Specifically, the research assessed wildfire prevention education (WPE) programs and their effects on human behaviour associated with accidental and intentional fire ignitions. The researchers used panel data of preventable Florida wildfires between 2002-2007. The Poisson model was built with a lagged dependent variable in order to avoid autocorrelation issues for time-related statistics in previously burned areas. Education programs involved school presentations, home visits, and different types of media including TV and radio announcements, all of which had negative and statistically significant relationships with human-caused wildfire fires.

Results also illustrate that cost minimizing and loss avoidance, including suppression expenditures and expected economic damages from wildfire, exceed WPE program costs. The study concluded that every one-dollar increase of WPE would reduce suppression expenditures by $5.32. Prestemon et al. (2010) further state that "evaluating the expected reductions in wildfire damages given a change in wildfire prevention education efforts from current levels showed that marginal benefits exceed marginal costs statewide by an average of 35-fold. The benefits exceeded costs in the fire management regions 10 to 99-fold, depending on assumptions about how wildfire prevention education spending is allocated to these regions" (p.181). However, such ratios might not be appropriate in different contexts due to differences associated with values at risk, suppression resource allocations, and wildfire policies (Hermansen et al. 2011).

It is also equally important to better understand the underlying process that motivates individuals and communities to adopt private fire risk reduction strategies to protect themselves and their property from wildfire. Understanding this process would enable decision makers to identify factors that influence risk mitigation behaviors of various stakeholders. Research clearly demonstrates that it is possible to protect private properties to reduce potential damage from

wildland fire. However, individuals and communities are not opting to protect themselves. Individuals' awareness of programming, risk perception, wildland fire experience, program costs, level of education, income, gender, and age, have all been tested in order to evaluate their influences on the acceptance and adoption of fuel mitigation strategies and fire prevention programs.

The fire risk mitigation function (FRMF) is mainly affected by how individuals perceive risk associated with wildfire. This means that individuals might differ in terms of taking certain risk mitigation actions and beliefs about how fire threatens their properties (McCaffrey 2004; Martin et al. 2009; Champ 2013). However, the FRMF was found to be affected not only by increasing people's awareness of fire risk, but also by other factors. McCaffrey (2004) states that "once individuals have identified the full range of adjustments available to them, they engage in two types of evaluation: cost-benefit and implementation feasibility" (p.513).

Cost-benefit analysis involves the feasibility of financial returns over time. Individuals and communities might not be able to engage in risk mitigation if they have limited financial resources needed to accomplish programs such as expensive and costly retrofits including reroofing and improving driveway access, for example. Also, a poor risk mitigation commitment could be a result of the uncertainty of getting desirable outcomes. This phenomenon is known as ''pseudo-certainty,'' which means that people are more likely to take preventive actions when there is apparent certainty of fire protection (Slovic et al. 1987; McCaffrey 2004). Implementation feasibility includes investigations of the environmental and technical viability of an action: how well it fits with a specific site or the nature of land use, and the availability of necessary personal skills, tools, and equipment. Case studies show that low-cost, low-effort options such as mowing and watering grass, and moving firewood piles away from structures were more readily adopted by respondents (Brenkert-Smith et al. 2006; Bright and Burtz 2006).

Similarly, Protection Motivation Theory (PMT) also hypothesizes that hazardous fuel mitigation is not necessarily a function of a person's risk perception, but rather it is a function that can be influenced by perceived response efficacy (Rogers 1975). Furthermore, Person-Relative-to-Event (PrE) theory is built upon Protection Motivation Theory (PMT), and suggests that homeowners who judge their personal resources as valuable will engage in more extensive mitigation activities (Mulilis and Duval 1995; Reams et al. 2005).

Lindell and Perry (2000) developed the Protection Action Decision Model (PADM) to determine the hazards from earthquakes. Elements included in this model have consistent effects on risk mitigation behavior found in PrE theory. The examined variables are earthquake risk perception, homeowners' beliefs about the effectiveness of mitigation practices, and requirements of personal skills and financial needs. The PADM, however, used additional variables compared to PrE, including risk experience, effects of informal social interactions, and networks for neighbours and family members.

Residents' interactions in communities might affect the approval of adopting wildfire risk mitigation actions. This happens, for example, when household members negotiate where and how fire risk mitigation activities can be implemented (Brenkert-Smith et al. 2006). Lindell and Perry (2000) conclude that "theoretical predictions that households' adoption of earthquake hazard adjustments [applicable for forest fire risk] is correlated with their perceptions of the hazard and alternative adjustments, demographic characteristics and social influences" (p. 461).

Research sheds light on specific socio-economic and demographic factors that affect the adopting of fire risk mitigation behaviour. Carpenter et al. (1986) claimed that age and gender influenced the approval of prescribed burning, yet Shindler and Toman (2003) and McGee (2007) did not find significant relationships between support for fuel mitigation (prescribed burning), or other socio-demographic variables. Quite recently, Wolters et al. (2017) found a significant negative relationship between engaging in Firewise activities in the US and age, but they did not find a significant relationship with gender.

The level of formal education could determine the level of public support and engagement in fire prevention management. McGee (2007) and Wolters et al. (2017) state that there was a significant relationship between formal education and support for fire mitigation programs. "Formal education is not surprising since the more highly educated have been found to be significantly more likely to be informed on a variety scientific and natural resource issues, and are significantly more likely to participate in community activities" (Wolters et al. 2017, p.7-8). However, Shindler and Toman (2003) did not find a relationship between education level and support for prescribed burning. Also, employment status has no statistical association with Firewise engagement (Wolters et al. 2017).

Structure ownership/tenure is a variable also included in the Wolters et al. study. They found that temporary residents such as visitors and people who use vacation properties are significantly less likely to engage in Firewise activities when compared with permanent homeowners. Moreover, a structure owner is more likely to practice Firewise than a renter. The authors attributed such behaviour to the short time that people spend on vacation, which gives them no time or opportunity to conduct fire mitigation activities. Furthermore, they might not perceive fire to be a risk as would permanent residents/homeowners.

Factors that affect homeowners' wildfire risk mitigation adoption have been examined using elements of PMT, PrE and PADM. Hall and Slothower (2009) used constructs of PMT to predict wildland-interface homeowners' willingness to implement defensible space. They found that willingness to implement defensible space around homes increases for people who perceive that defensible space engagement is an effective tool in protecting their homes. Similarly, Martin et al. (2007) incorporated PMT components into their model to assess cognitive perceptual processes that homeowners go through when faced with decisions to protect themselves from the risk of wildfires. Results show that perceived risk severity, self-efficacy and response efficacy in different stages are correlated with decisions of completing wildfire mitigation assessments.

Brenkert-Smith et al. (2012) developed a model of wildfire risk mitigating behavior that used a set of elements prescribed in PMT, PrE and PADM including socio-demographic variables. Their results suggest that many factors were related to higher levels of wildfire risk mitigation in addition to positive wildfire risk perceptions. Older homeowners, females, those who have larger lots, those who had been evacuated, and those who talked with a neighbour about wildfire risk all had higher wildfire risk mitigation levels. Yet, limited financial resources as well as lack of specific information about risk management resulted in lower inclinations to adopt fire protection measures.

Providing education and information access for the public through different media outlets including printed and electronic materials is an important means to increase people's awareness about fire risk and mitigation strategies (McCaffrey 2004). While research shows that education is a good strategy to enhance awareness, no consistently effective source of information was found, whether radio, television or brochures (Sims and Bauman 1983; Faupel and Kartez 1996). Loomis et al. (2001) demonstrate that respondents became more tolerant towards forest fuel

mitigation applications after an educational experience. They advise resource managers to increase public support about mitigation programs through different media such as newspaper articles and direct mail.

The above literature provides guidance on the factors that could lead to greater awareness and adoption of personal and community risk mitigation measures. As such, this information was used to structure the survey instrument and informed data collection.

Chapter 3

Methodology

3.1 Data Collection and Study Area

To assess the public's perception of fire risk to their own property and their communities, awareness of FireSmart Canada, and its use and perceived effectiveness, I used data collected from an online survey, administered in French and English. The University of Saskatchewan, FireSmart Canada, CIFFC, and members of the Wildfire Prevention Working Group worked collaboratively to develop the survey questions in both languages. Additionally, the survey was pretested among group members and revised accordingly. All survey materials were reviewed and approved by the University of Saskatchewan Behavioural Ethics Research Board (BEH #17-163).

The survey was structured to capture responses by individuals, or those representing organizations including those responding as leaders in their communities, employees of wildland and structural fire organizations, a range of community associations, and government representatives for example. It was important to assess organizations' responses because FireSmart activities aimed at communities are different from those aimed at individuals. Also, the authority to conduct FireSmart activities differs between private homes and organizations. Depending on each respondent's perspective, they got a series of questions representing FireSmart activities recommended for individuals (modifications to private property) or activities commonly carried out by organizations at the community level.

Variables were selected based on the literature review and effectiveness in predicting awareness and adoption. Variables used in this project are as following: property ownership, rural/urban location, FireSmart awareness, media and information sources, risk perceptions, damage experience, and range of demographic variables including age, gender, education, etc.

Survey data were collected via two sources simultaneously. Panel data were collected by Probit, a Canadian survey research company; and by provincial and federal agencies using social media.

Probit panellists were emailed a request and unique link to complete the survey. Probit panellists were also sent one reminder email if they had not completed the survey in the allotted time. The target panel was approximately 1,500 respondents reflective of the Canadian public.

Unique survey links were developed for each fire management agency to test and compare public engagement in each region. The survey was launched on June 12th, 2017 and remained active until the end of Labour Day, September 4th, 2017. An English version of the survey is included in Appendix A.

Summary statistics are reported and binary logistic regressions are used to assess the relationships between individual and organizational characteristics and FireSmart awareness and adoption.

3.2 Methodology

Logistic regression is an appropriate method for use when the response variable is dichotomous (binary). It provides a predictive analysis to describe data and explain relationships between one (binary) response variable and one or more ordinal, nominal, interval, or ratio-level explanatory variable (Statistic Solutions 2018). According to Liu (2017) "logistic regression generates the coefficients (and its standard errors and significance levels) of a formula to predict a logit transformation of the probability of a presence of the characteristic of interest" (p.81). The relationship between the probability (p) of an outcome and the predictors is not linear in a logistic regression, but rather the logit probability log odds is created to have a linear relationship between the outcome of interest and the explanatory variables (Field 2009; Statistical Solutions 2017). Thus, the formulated equation for the logit model can be written as (3.1):

$$Logit(p)\ OR\ Log\ odds = ln\ (p/1\text{-}p) = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots + b_kX_k + e \qquad (3.1)$$

Where $ln\ (p/1\text{-}p)$ is the log likelihood, p is the probability of the characteristic of interest being present $(p=1)$, and e is the error term.

The logit transformation of the probability is known as the odds ratio $(p/1\text{-}p)$, which is equal to the probability of the presence of a characteristic divided by the probability of an absence of a

characteristic as per equation 3.2.

Odds of an outcome of interest = $(e^{a}) * (e^{b1X1}) * (e^{b2X2}) * \ldots * (e^{bkXk})$ *(3.2)*

The probability of an event occurring is expressed by equation (3.3),

$p = e^{a+b1X+b2X2\ldots+bkXk} / 1+e^{a+b1X1+b2X2\ldots+bkXk}$, *(3.3)*

were $0 < p < 1$.

The logistic regression is a nonlinear transformation for the linear regression and the logistic distribution is an S-shaped function. The cumulative density function (CDF) of a logistic distribution is written as equation 3.4,

$P(y=1|z) = p = 1/(1+exp^{-Z})$ *(3.4)*

where $z = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_kX_k$, and it can take any value, and p is confined to a value between 0 and 1 (Liu 2017).

The fitted line for the probability is S-shaped because the outcome is dichotomous. The difference between the shape of regression line for the linear probability model and the logistic regression model is presented in Fig. 3.1 (Liu 2017).

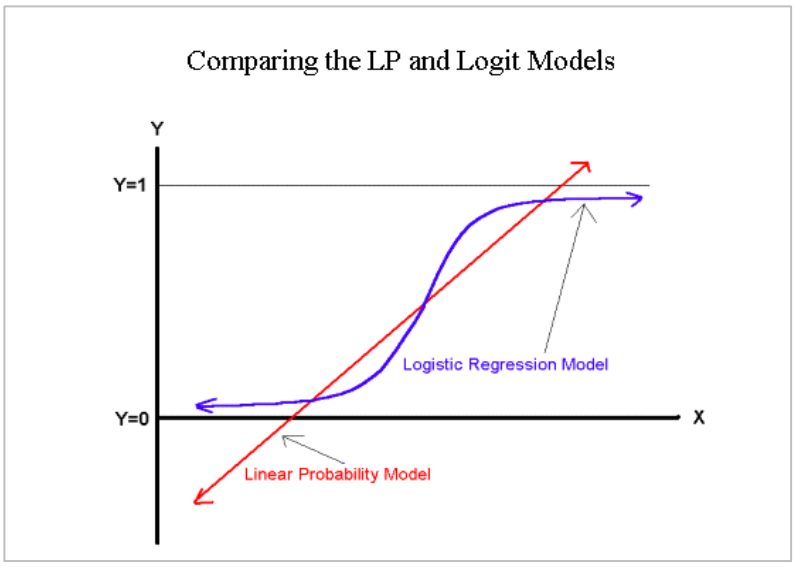

Figure 3.1: Linear and logistic regression models from Liu (2017)

The coefficients in the logistic model have no direct substantive meaning because of the nonlinearity of the model. Only the signs of coefficients matter for interpreting the effect of x on the probability of y=1. Therefore, the logistic regression outputs are commonly interpreted using odds ratios for the associated variables, which is the exponential of the coefficient *EXP(b)* (Field 2009).

3.3 Test Statistics for Binary Logistic Regression Using SPSS

3.3.1 Omnibus Tests of Model Coefficients

The Omnibus test uses a Chi-square (χ^2) p-value to show if a new model (a model with explanatory variables included) is an improvement compared to a baseline model. A p-value smaller than 0.05 implies that the model is statistically significant at predicting the outcome of interest. It can also be used to see if there is a significant difference between the Log-likelihoods (specifically the -2Log likelihoods) of the baseline model and the new model, and to compare different models with explanatory variables included. The -2log likelihood is often called the deviance, which is an indicator of how much unexplained information there is after the model has been fitted.

Large values of the -2log likelihood indicate that the model is poorly fitting the data. A new model with a significant reduction in -2Log likelihoods compared to the baseline model suggests that a new model is explaining more of the variance in the outcome and is an improvement. It is worth mentioning that the larger the number of predictors (sample size) for the logit model, the more likely the model will be good at predicting the probability of a characteristic of interest. This is because the maximum likelihood estimates in logistic regression are less powerful than that for the ordinary least squares (Statistics Solutions 2017).

3.3.2 Wald Statistics Test

The Wald statistic test plays an analogical role to the t-test performed on coefficients in the linear regression. The Wald statistic test is used to examine whether the variable is making a significant contribution to the prediction of the outcome, specifically whether the explanatory variable's coefficient is significantly different from zero. The null hypothesis for this test is that the explanatory variable does not have a significant relationship with the response. Failing to reject the null occurs when the Wald test p-value is < 0.05 meaning that there is not a statistical relationship between the predictor and the outcome.

3.3.3 Hosmer-Lemeshow (H&L) test

The Hosmer and Lemeshow is a statistical test that uses the Chi-square (χ^2) test to measure goodness of fit for the logit model. The null hypothesis for this test suggests that the model is a good fit. Therefore, a model will be considered as a good fit if $p > 0.05$. This test divides the data into about ten groups (g=10) defined as "deciles of risk." Calculations of observed and expected number of cases in each group is completed, and then the Chi-squared statistic is calculated as:

$$X^2_{HL} = \sum_{g=1}^{G} (O_g - E_g)^2 / E_g\,(1 - E_g/ n_g) \qquad (3.5)$$

with O_g, E_g and n_g, expected events, number of observations for the g^{th} (risk decile group), and G number of groups. The test statistic asymptotically follows a Chi-squared distribution with $G-2$ degrees of freedom. A small p-value (< 0.05) indicates that the estimated model has a poor fit while a p-value > 0.05 implies that the model fits the data well (Hosmer et al. 2013).

3.3.4 Cox ad Snell R^2

The Cox and Snell R^2 is a test given by SPSS default output as a measure of how much variation in the outcome is explained by the model (similar for linear regression analysis). The Cox and Snell R^2 equation is defined as

$$R^2_{C\&S} = 1 - (L_M / L_0)^{2/n} \qquad (3.6)$$

where n is the sample size, L_M is the log-likelihood for a model with predictors, and L_0 is the log-likelihood for a base model. This statistic has some attractive properties such as consistency with the classical R^2 that is used for OLS regression, and also with the maximum likelihood as an estimation method. It is also asymptotically independent of the sample size n (Cox and Snell 1989). However, the Cox and Snell R^2 has a maximum value less than one, which can be a means of underestimated variance of an outcome (Nagelkerke 1991).

3.3.5 Nagelkerke R^2

The Nagelkerke R^2 adjusts the Cox and Snell R^2 to extend the range of a possible value to one towards the analogical property of the OLS R^2. Usually this statistic is defined as "pseudo" R^2. The formula of Nagelkerke R^2 is written as:

$$R^2 \text{ Nagelkerke} = 1 - (L_{(0)} / L_{(M)})^{2/n} / 1 - (L_{(0)2/n}) \qquad .(3.7)$$

where, $L_{(0)}$ is the likelihood for the intercept-only model, $L_{(M)}$ is the likelihood of the specified model, and n is number of observations.

It is worth mentioning that the R^2 definition is different between OLS and logit models. "OLS attempts to minimize the error sum of squares, maximum likelihood logistic regression seeks to minimize the -2log-likelihood statistic (or equivalently, to maximize the likelihood function)" (Menard 2000, p.20). Just as the R^2 in OLS can be interpreted as the proportion of reducing the sum squared residuals, R^2 in the logit model can be interpreted as the proportion of reducing the -2log-likelihood statistic.

Therefore, a good predictor and indicator of a model with good fit is the with the following criteria:

- Large sample size
- Low –2log likelihoods compared with the base model
- Omnibus tests Chi-square (p-value < 0.05), and
- Hosmer and Lemeshow test with the Chi-square (p-value > 0.05). (Field 2000; Strand and Winston 2008).

Chapter 4

Results

4.1 Demographic

Respondents were invited to take the survey as accessed on various provincial and federal agency websites as well as by direct invitation by Probit. Overall, 62,848 individuals opened the survey link. Of those individuals, 3,201people began the survey, and 2,427 completed the survey for an overall response rate of 3.9%.

Survey respondents were 55.6% male (n=1,302) and 44.3% female (n=1,039) meaning that males are slightly overrepresented in this sample. Statistics Canada (2017b) reports slightly over half the Canadian population to be female (50.4%).

The majority of respondents identified as Canadian, non-Aboriginal (91.6%, n=2,173). Aboriginal Canadian respondents represented 6.0% (n=143) of the total. Fifty-eight people chose not to declare (2.4%). This result is also reflective of the Canadian population. Statistics Canada reported in 2011 that the Aboriginal population in Canada was 4.3% and expected to grow in proportion.

The survey asked respondents to provide the first three characters of their postal code. Results were mapped by Natural Resources Canada to show the distribution of responses across Canada (Fig. 4.1.1).

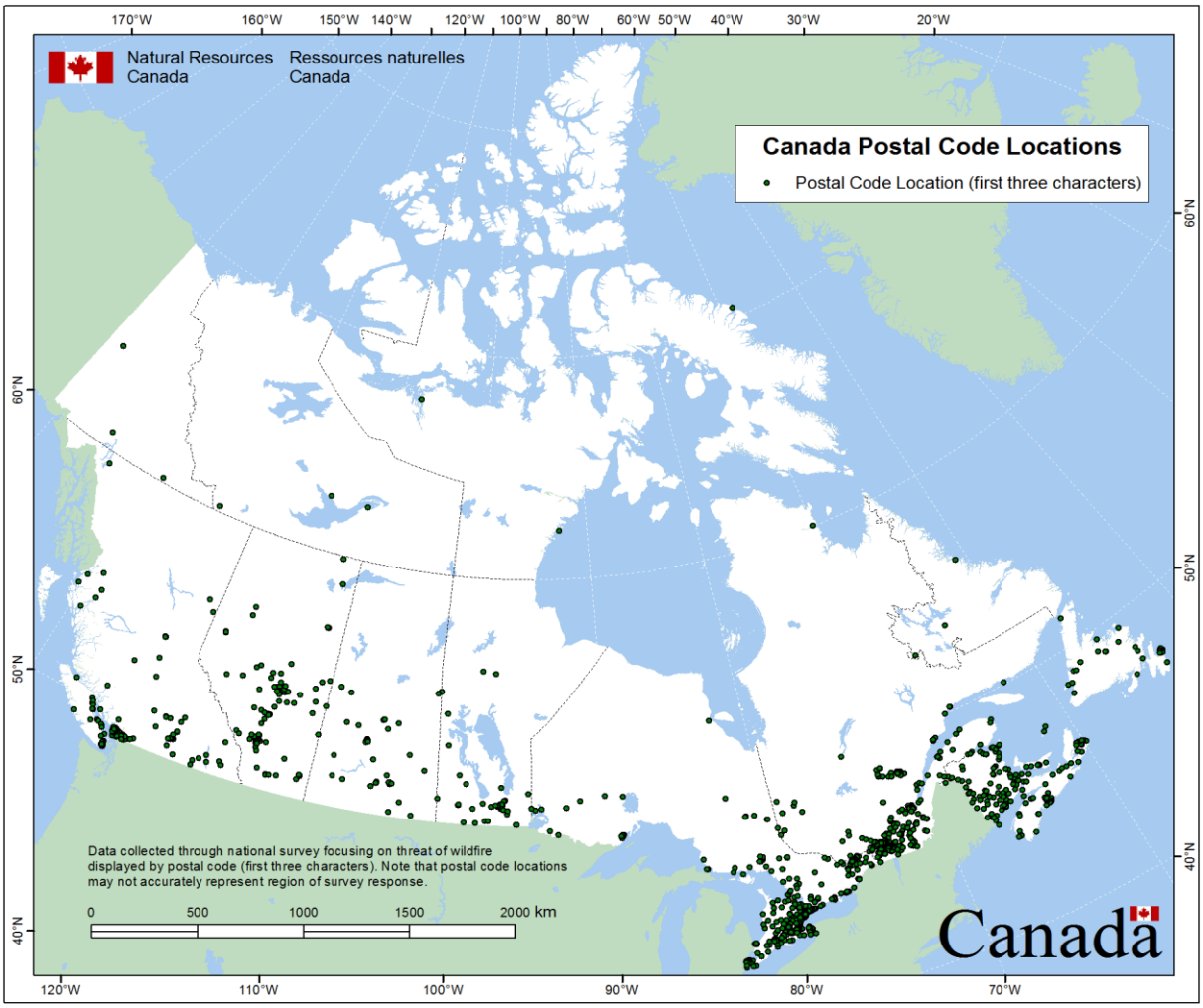

Figure 4.1.1: Distribution of survey respondents based on postal code (first three characters)

The greatest number of responses was from Quebec and Ontario (Table 4.1). Compared to the Canadian population,[1] the sample under represents Ontario by 14.7%. The greatest anomaly is Nova Scotia with the third highest number of responses at 15.1% of the sample, and with only 2.6% of the Canadian population. This is likely indicative of fire managers' efforts in Nova Scotia to increase participation in this research. Note that the map in Figure 4.1.1 indicates three respondents from Nunavut as given by the postal codes, yet none has listed their province of residence as Nunavut. All other distributions closely reflect Canadian demographics.

[1] The Canadian population is based on 2017 statistics

Table 4.1: Survey responses and Canadian population distribution

	Survey sample		(Canada)	
Province	#	%	# (‘000s)	%
Alberta	194	8.1	4286.1	11.7
British Columbia	259	10.8	4817.2	13.1
Manitoba	80	3.3	1338.1	3.6
New Brunswick	163	6.8	759.7	2.1
Newfoundland and Labrador	68	2.8	528.8	1.4
Northwest Territories	5	0.2	44.5	0.1
Nova Scotia	364	15.1	953.9	2.6
Nunavut	0	0.0	38	0.1
Ontario	578	24.0	14193.4	38.7
Prince Edward Island	10	0.4	152	0.4
Quebec	603	25.0	8,364	22.8
Saskatchewan	71	2.9	1163.9	3.2
Yukon	14	0.6	38.5	0.1
Total	2409	100	36708	99.9

For analysis purposes, respondents were also grouped by region (n=2,409):

- North (NWT, YT, NU) – 1.4%
- East (ON, QC, NB, PE, NL, NS) – 73.0%
- West (BC, AB, SK, MB) - 25.6%

Respondents 18 years and older were invited to participate in the survey and asked to identify their age by category (Fig. 4.1.2). The total number of responses (n=2,904), and the highest percentage of respondents fell into the 45-54 year-old category at 25.2%.

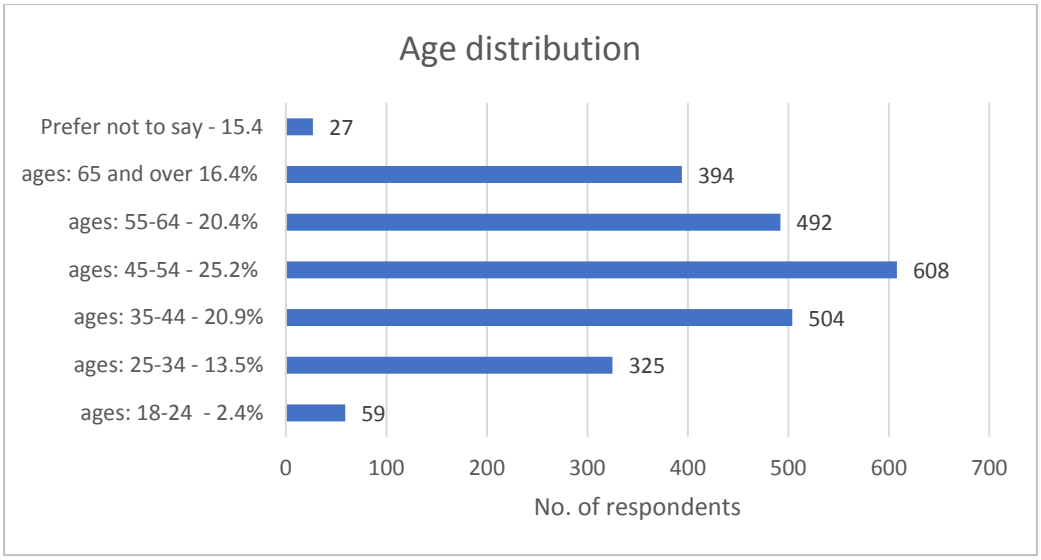

Figure 4.1.2: Age distribution for survey respondents

Respondents provided employment information, with most (40.1%) selecting "other," and specifying the industry. The results for "other" were categorized as the private sector (46.2%), retired (30.4%), and the public sector (23.4%). Industries of interest potentially affected by fire are listed in (Fig. 4.1.3).

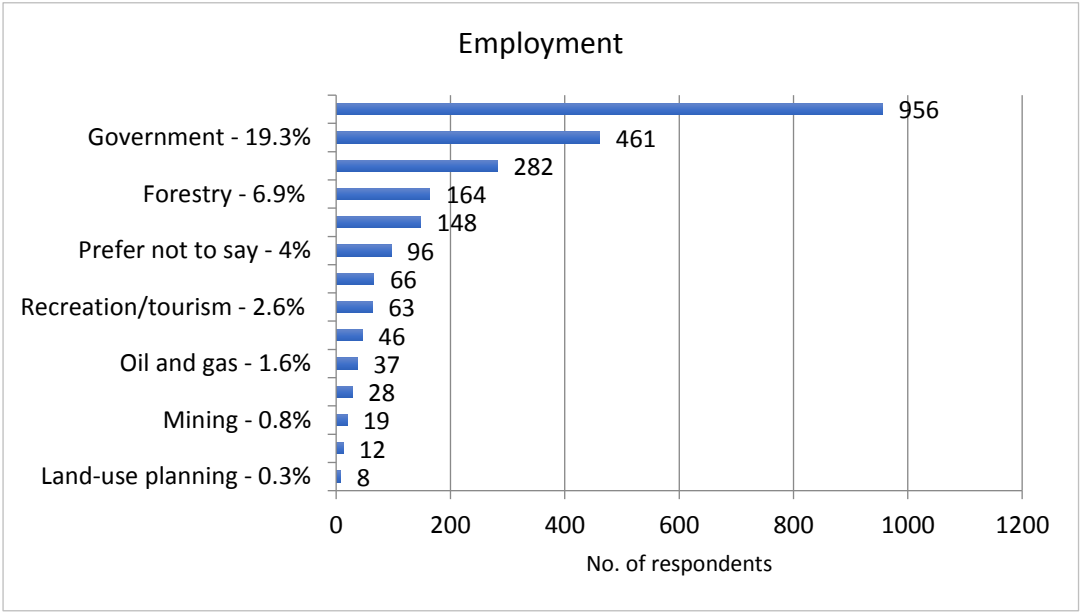

Figure 1.1.3: Employment by sector for survey respondents

Respondents also provided education levels with the majority (45.8%) reporting having completed college, university, or trade school (Fig. 4.1.4). The second highest education category was graduate degree at 24.4%, which is higher than the population average, but not unsurprising given that online surveys tend to attract more highly-educated respondents (Szolnoki and Hoffmann 2013).

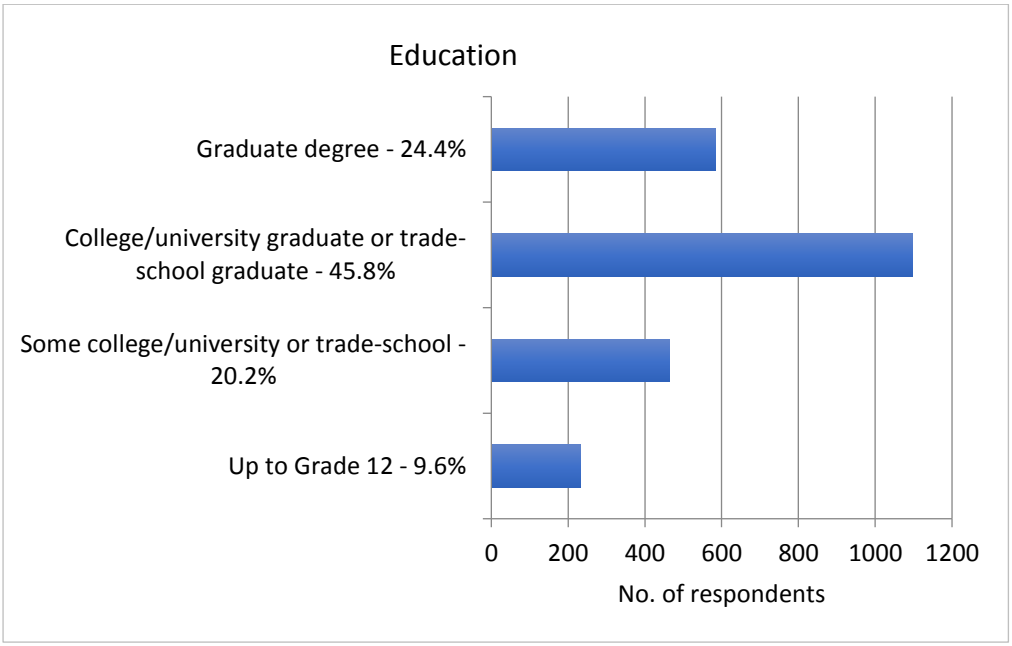

Figure 4.1.4: Educational distribution for survey respondents

Respondents were asked to select income categories (Fig. 4.1.5). The top two income ranges selected were between $40,000 and $80,000 making up 35.5% of the total. Although survey responses were anonymous, 15.4% of people chose not to select a category.

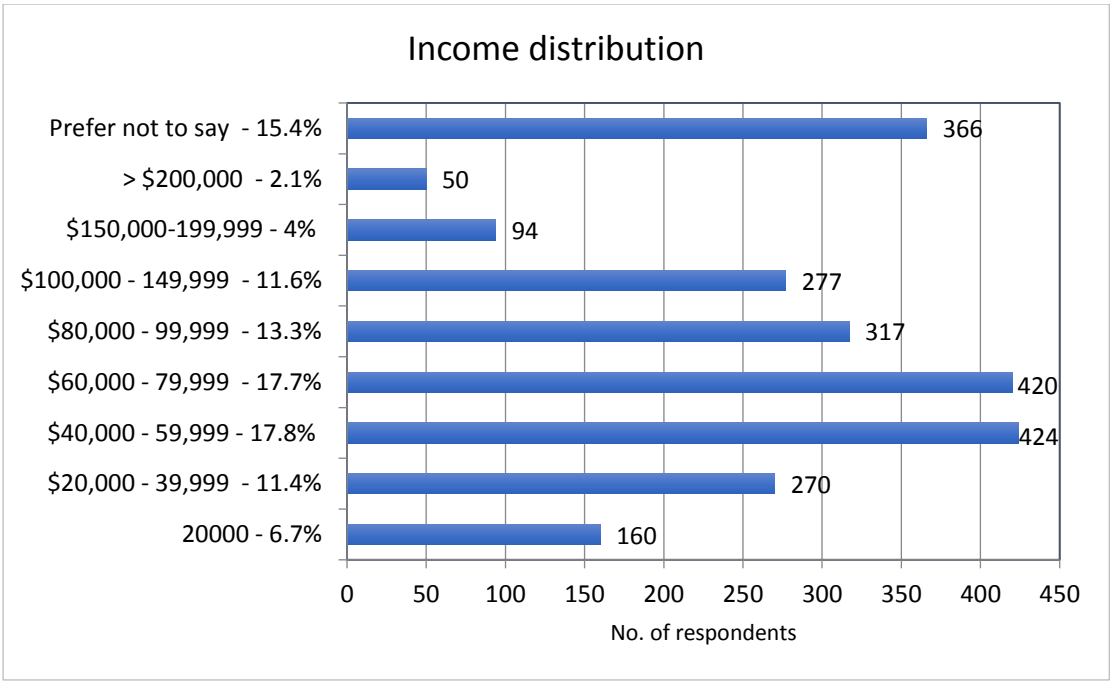

Figure 4.1.5: Income distribution by category for survey respondents

The survey began by asking respondents to identify as an individual or as representing an organization (Fig. 4.1.6). The majority of respondents self-identified as urban homeowners (41%), followed by rural homeowners (27%). Renters made up only 17% of respondents. Respondents that self-identified as "individual" made up 85% of the total. Those representing organizations made up 15.6% of respondents. Of the 2,036 individuals who responded to this question, 1,624 owned their properties (~80%).

If respondents self-identified as individuals, they were directed to questions that assessed their perceptions of FireSmart activities and programs aimed at individuals. Those responding on behalf of an organization were presented with FireSmart activities and programs for communities.

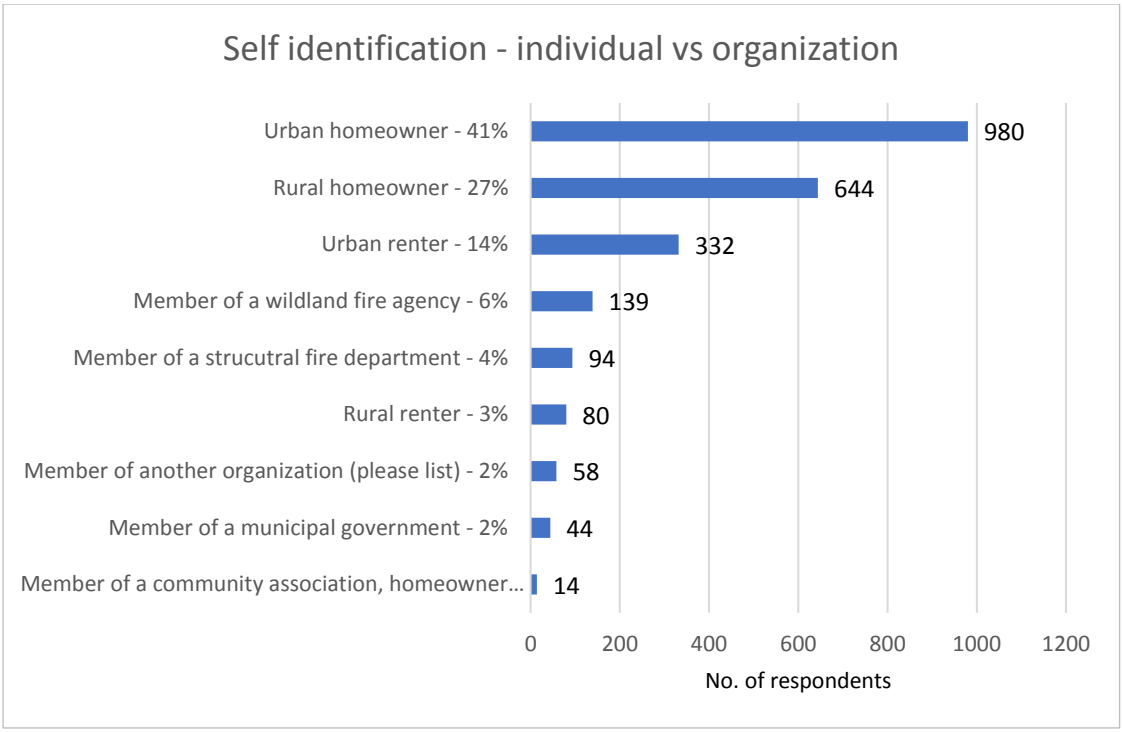

Figure 4.1.6: Survey respondent self-identification as individual vs. organization

Those responding as other organizations selected local government (n=10), provincial government (n=36), and federal government (n=4). Other categories were volunteer fire department (n=8), police and military (n=2), and other (n=11).

The second question assessed respondents' level of awareness of FireSmart Canada. The majority of respondents had never heard of FireSmart Canada (77%), which precluded them from answering questions about the effectiveness of the program. Respondents who were either familiar (17%) or very familiar (6%) with the program and services made up 23% of the total.

Results were tabulated by province to provide insight into awareness of FireSmart by jurisdiction (see Table 4.2).

Table 4.1: Familiarity with FireSmart by province

Province	No. Respondents	No. familiar with FireSmart	%
AB	209	73	34.9
BC	272	104	38.2
MB	85	32	37.6
NB	171	43	25.1
NF	69	34	49.2
NT	5	4	80.0
NS	378	136	35.9
NU	2	1	50.0
ON	602	51	8.4
PEI	12	2	16.6
QC	626	80	12.7
SK	80	15	18.7
YK	15	14	93.3

In an attempt to identify the characteristics of respondents who had never heard of FireSmart, I ran cross tabulation analysis using SPSS. I tested relations between FireSmart awareness and factors including gender, fire risk experience, damage experience, residence location (urban and rural), ethnicity, region of residence, and age. "Crosstab, or Cross Tabulation is used to aggregate and jointly display the distribution of two or more variables by tabulating their results one against the other in 2-dimensional grids. The process creates contingency tables from the multivariate frequency distribution of variables presented in a matrix format. Crosstab is widely used in survey results to find interrelationships and interactions between variables". (Research Optimus 2018, n.p).

Gender was statistically significant with females (n=1,334) representing 57.5% of total responses that never heard of FireSmart. While males represent a lower proportion of those who never heard about the program, they represent 56.2% of total respondents who were very familiar.

Of the respondents who had never heard of FireSmart, about 90% reported they were not threatened by fire. This result is intuitive and supported by others' findings given that an individual's level of awareness is related to experience with fire hazards (McCaffrey, 2004, p.510). Similarly, 63% of the respondents that were not familiar with FireSmart self-identified as urban ($p < 0.003$). Respondents were identified by region (East, West, and North) and indicate different levels of awareness. Respondents living in the East represent the largest percentage (76.7%) of people who have never heard about the program, with western respondents at 22.7%, and northerners at 0.6%. Finally, relationship of awareness with age was inconclusive.

Only those who had heard of FireSmart were asked to select all media sources by which they had heard of the program (Fig. 4.1.7).

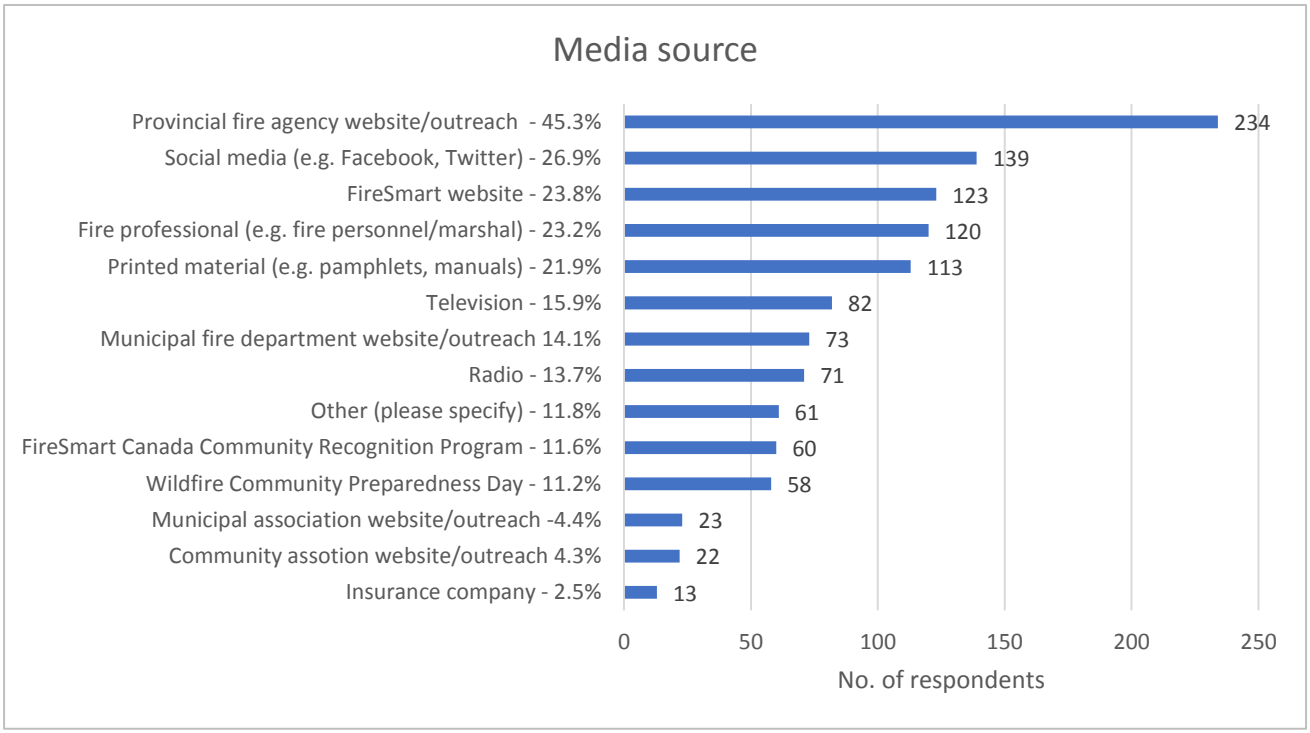

Figure 4.1.7: Awareness of FireSmart - media source (select all that apply)

Provincial agency websites were the most frequently cited at 45.3%.[2] Social media sources were second (26.9%). Third were the FireSmart website (23.8%), fire professionals (23.2%), and

[2] Note, percentages add to more 100% in some instances due to rounding.

printed material (21.9%). Ranking in the 10-20% category were television (15.9%), municipal fire departments website/outreach (14.1%), radio (13.7%), FireSmart Community Recognition (11.6%), Wildfire Community Preparedness Day (11.2%) and other (11.8%).

If respondents selected "other" they were asked to identify the source using a comment box. The majority of respondents selected:

- Work (30%),
- Government (17.9%), and
- Word of mouth/personal contacts (10.4%).

Other comments also listed choice items already presented such as social media (n=5), signs and print material (n=10), and the FireSmart website (n=6). The remainder were not sure where they had heard of FireSmart.

All respondents were asked whether they believed wildfire would be a threat to their community or personal property. Responses were relatively evenly divided:

- Yes 49.3% (n=1,184)
- No 50.7% (n=1,217)

Additionally, respondents were asked whether they had experienced damage from wildfire, or were threatened:

- 4.4% (n=104) – experienced damage from wildfire,
- 13% (n=305) – have been threatened by wildfire.
- 82.6% (n=2000) – either never experienced fire risk or did not respond.

Natural Resources Canada used postal code information to map respondents' reports of both threats from wildfire (yellow dots) and actual damage from wildfire (red dots). The greater the number of reports, the larger the dots (Fig. 4.1.8).

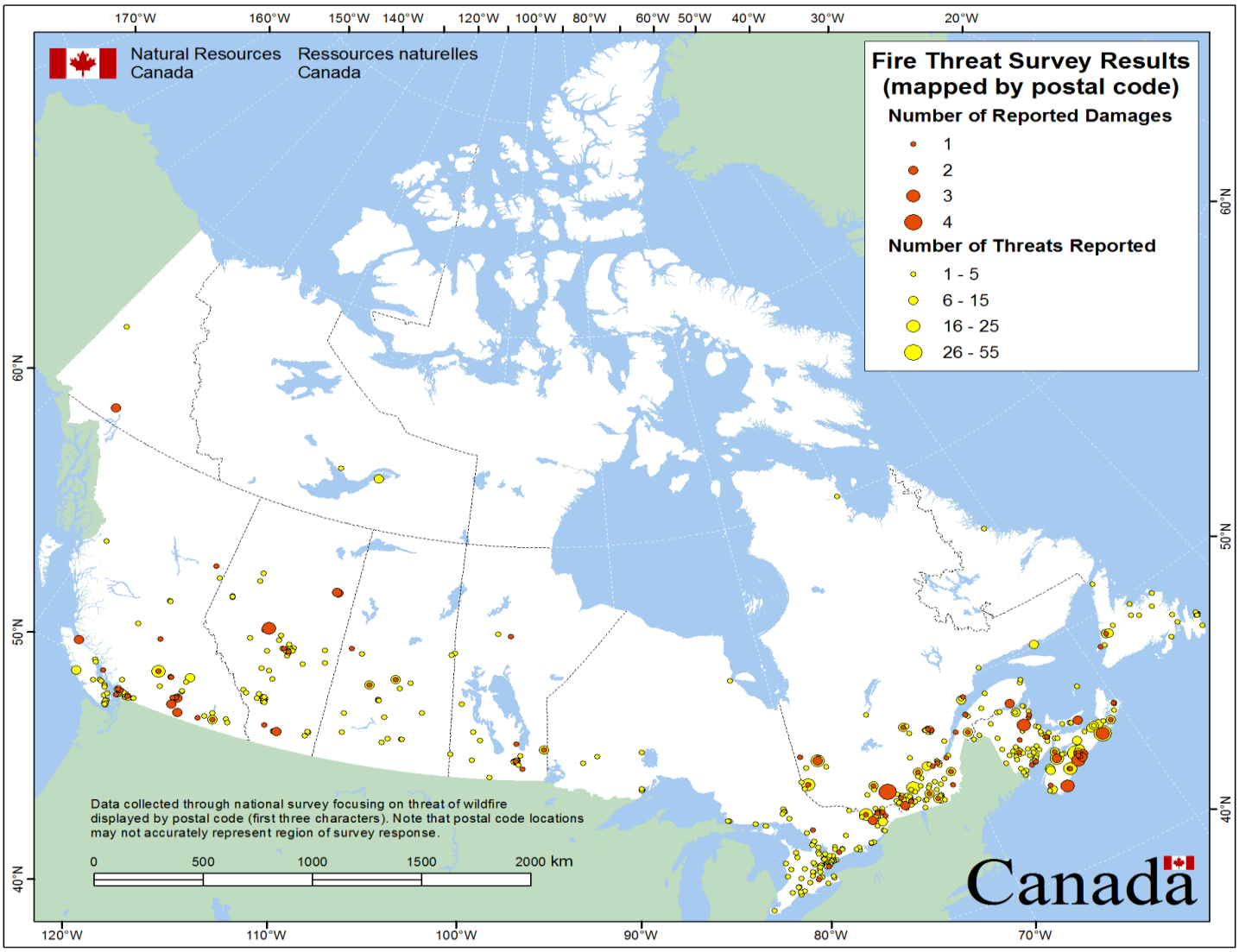

Figure 4.1.8: Threat and damage from wildland fire - respondent reports

4.2. Survey Responses

4.2.1 Individual Responses

Because FireSmart recommends activities for both individual homeowners and community organizations, I evaluated engagement separately. Individuals were first asked whether they had conducted FireSmart activities on their properties: slightly less than half (45.1%) had (n=412). Those who answered yes were asked to select all activities in which they had engaged (Fig. 4.2.1). Because many respondents selected more than one activity, percentages add to more than 100%.

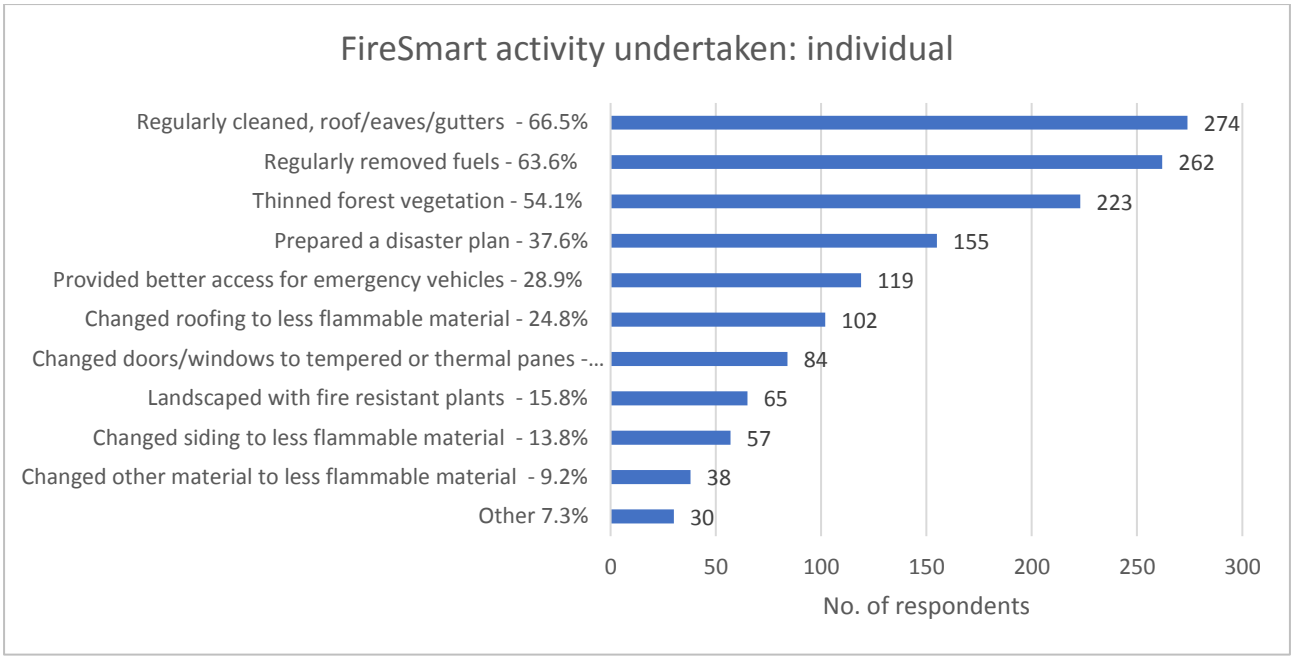

Figure 4.2.1: Individual FireSmart activity undertaken (select all that apply)

Results suggested that respondents engaged mostly in activities that did not result in significant structural modifications or renovation. Rather, the most cited activities focused on cleaning and maintenance including roof cleaning (66.5%), fuels removal (63.6%), and thinning (54.1%). Preparing a disaster plan ranked fourth (37.6%), followed by providing better access for emergency vehicles (28.9%). Retrofitting roofing, and installing fire-resistant doors and windows was selected 24.8% and 20.4% of the time. Changes to siding and other flammable materials was selected 13.8% and 9.2%. It is likely that these changes were selected less frequently given the greater cost and amount of effort necessary.

Respondents were also given a chance to comment on other activities in which they engaged to mitigate potential damage from wildland fire. Thirty individuals listed the following activities:

- Increased water availability – 40% (n=12)
- Changed behavior – 23.3% (n=7)
- Yard maintenance – 23.3% (n=7)
- Built new with fire-resistant materials – 13.3% (n=4)

Respondents who had not already taken action were asked to select the top three reasons why they had not (Fig. 4.2.2). The most commonly cited was "not knowing what action to take" (52.6%), followed by "lack of financial resources" (34.5%). These findings are consistent with open comments.

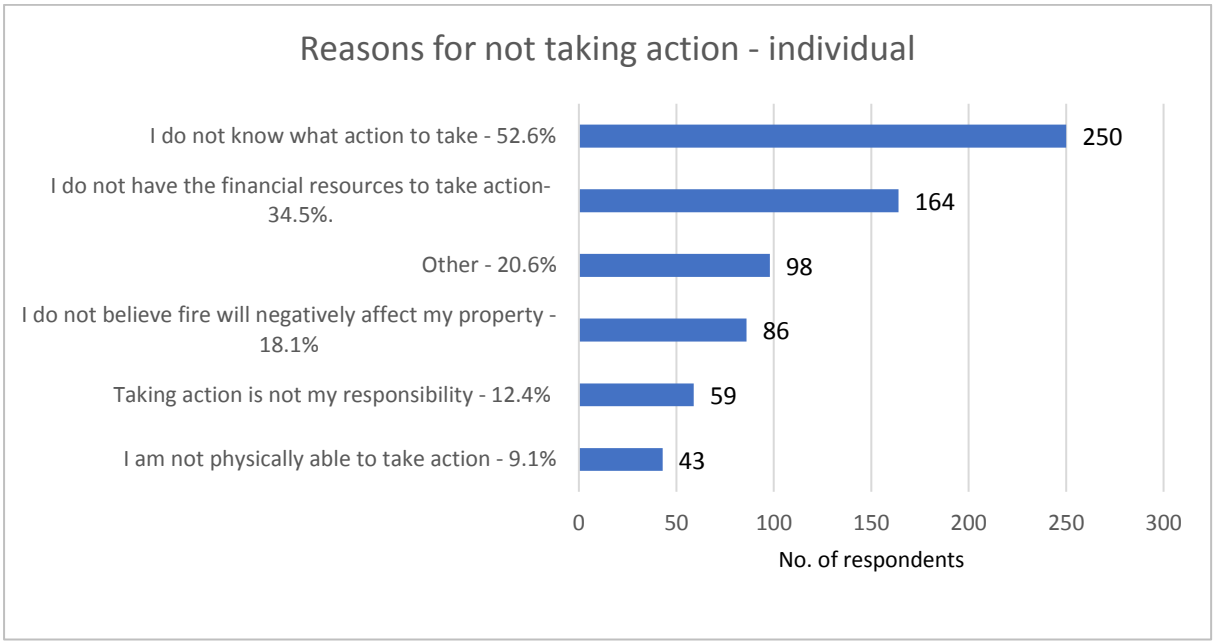

Figure 4.2.2: Top reasons for not taking action - individual (select the top three)

The three top reasons from those who responded "other," were the lack of time (34%, n=17), that the property was not theirs (22%, n=11), and that it would not matter in terms of effectiveness (20%, n=10).

4.2.2 Organization Responses

Community respondents were asked whether FireSmart activities had been undertaken in their communities. The results indicate that the majority of respondents did not take action (65%, n=225). The respondents who answered "yes," were asked to identify all the activities in which their organizations had engaged (Fig. 4.2.3). The top two were fuels removals (51.7%), and ensuring an adequate water supply (49.1%). The category least selected involved retrofitting

buildings (6.9%). It appears that the more expensive and involved an activity, the less likely it is to be adopted.

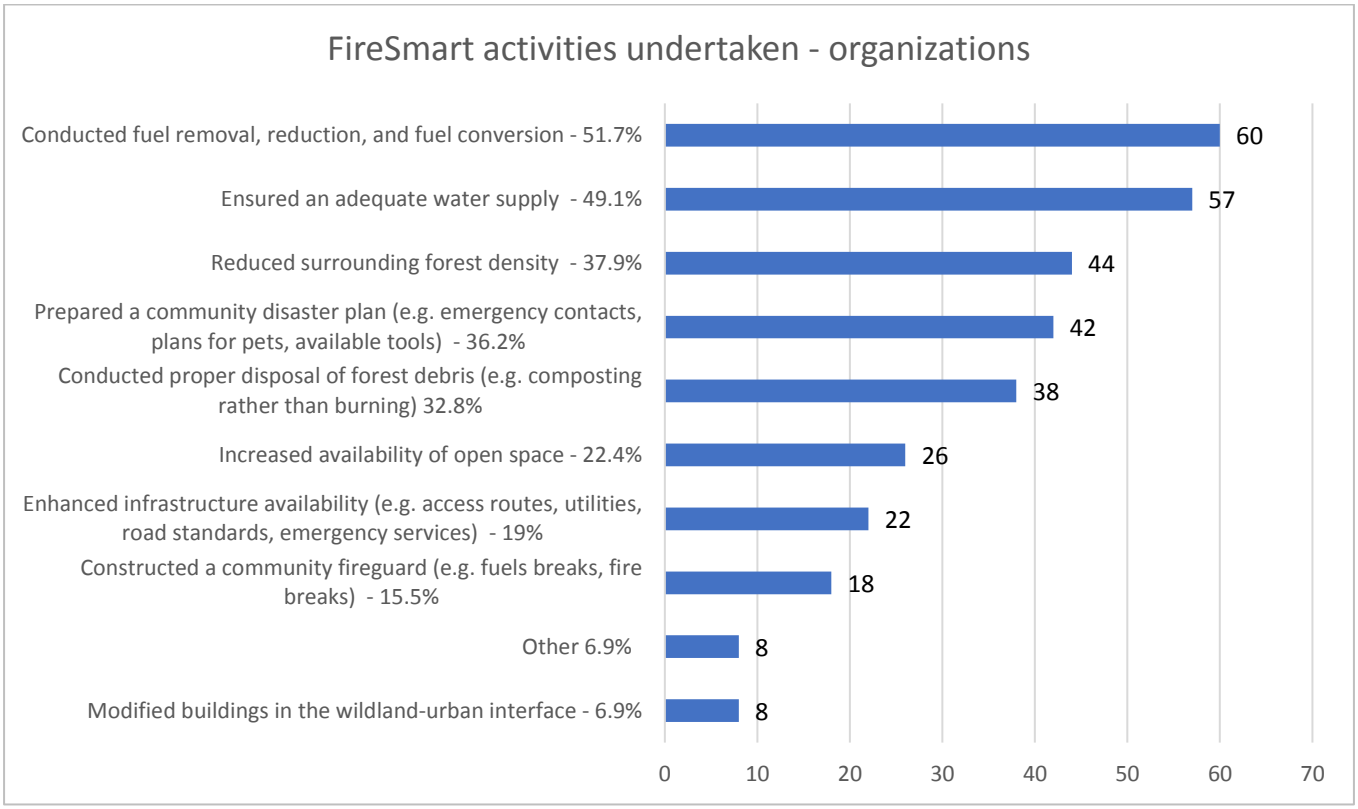

Figure 4.2.3: FireSmart activities undertaken by organization (select all that apply)

There were only eight comments indicating "other" activity, which included increasing awareness (n=4), implementing a fire ban (n=1), and using education to increase awareness (n=1). Two comment sections were left blank.

When asked why FireSmart activities had not been undertaken (Fig. 4.2.4), the most cited reason was the lack of financial resources (41.1%, n=53). Lack of responsibility was selected by 27.9% of respondents, and not knowing what action to take was selected by 24.8%. Both results are consistent with open comments. Only 14% believed fire would not affect their community negatively. There were 13 comments that indicated other reasons including a lack of leadership (n=4), lack of awareness of risk (n=4), that FireSmart was not a priority (n=3), and that regulations would be required to conduct any activity (n=2).

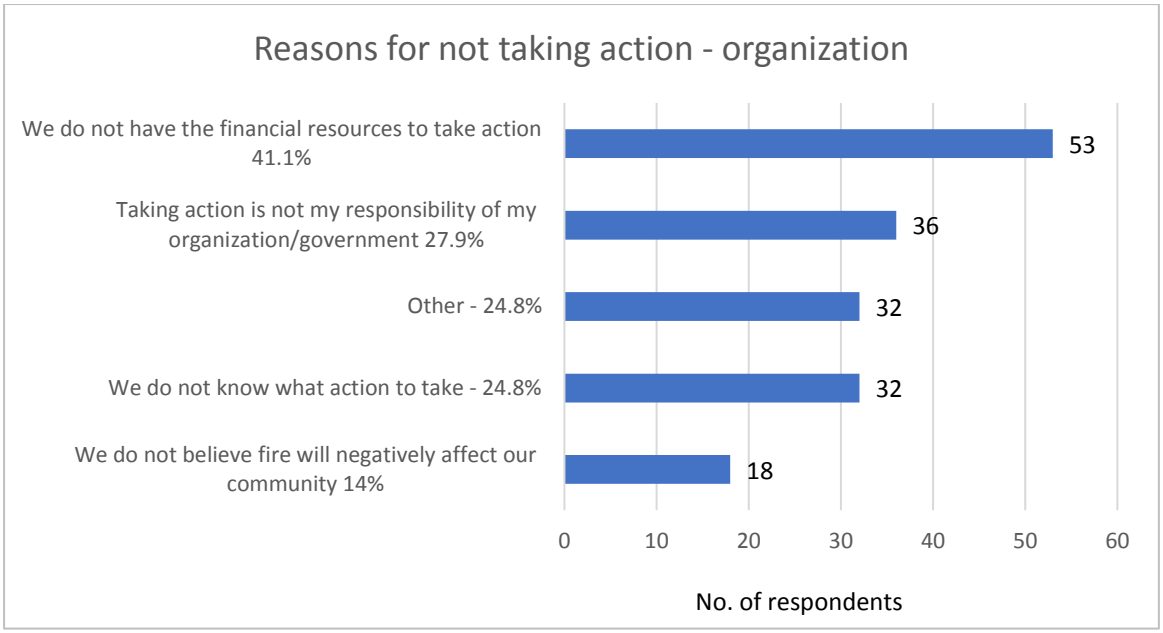

Figure 4.2.4: Top reasons for not taking action - organization (select the top three)

4.3 Compliance

All respondents were asked what would encourage them to take action on their property or in their community to reduce the risk of damage from wildfire. Respondents were presented sequentially with eight options and asked to mark their level of support on a sliding scale from no support, to strong support. The question numbers correspond to the numbered circles in Fig. 4.3.1. Responses were normalized to reflect relative support among choices. The shaded area around each response indicates the standard deviation. Results are displayed for organizations (left) and individuals (right).

Questions were designed to reflect both monetary and non-monetary measures that were positive (e.g., reductions in insurance premiums, and assistance), as well as measures that were negative or punitive (e.g., fines and regulations). The most supported method to encourage respondents to implement FireSmart recommendations would be a reduction in insurance premiums for those who implemented FireSmart recommendations (4). This outcome was supported by both organizations and individuals. Alternatively, the least supported option by both groups was the refusal of insurance for failing to implement FireSmart recommendations (6).

What would encourage you to take action on your property or in your community to reduce wildfire risk?

Please indicate your level of support.

1. *Monetary fines for non-compliance with FireSmart standards*
2. *Peer pressure from community members to engage in FireSmart activities.*
3. *Mandatory building codes (legislation)*
4. *Reduction in insurance premiums for compliance with FireSmart standards*
5. *Land use/zoning policies*
6. *Refusal of home insurance unless in compliance with FireSmart standards*
7. *Refusal of fire suppression engagement due to fire responder safety concerns*
8. *Technical assistance from FireSmart personnel*

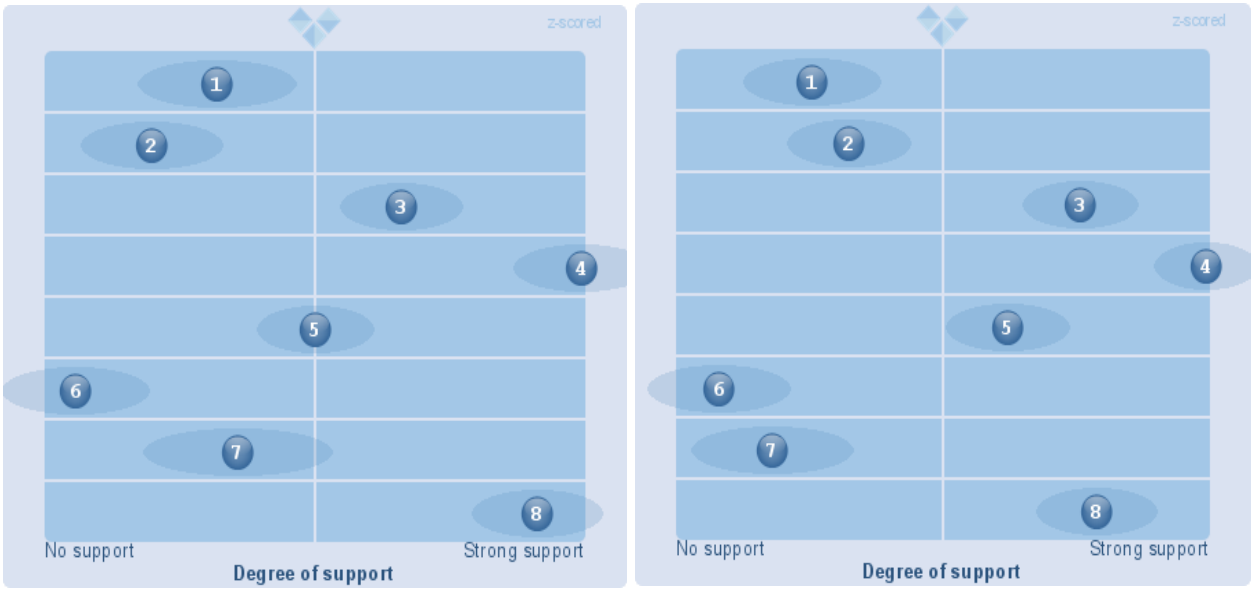

Figure 4.3.1: Degree of support by organizations (left) and individuals (right)

There was also support for technical assistance (8), and mandatory building codes (3). Land use/zoning policies (5) received slightly more support from individuals than organizations. There was significantly less support for other negative approaches as indicated by results for peer pressure (2), monetary fines (1), and refusal of fire suppression (7). While both groups indicated less support these four options, the ordering was slightly different – organizations ranked peer

pressure seventh, whereas individuals ranked it fifth. Similarly, refusal of fire suppression was ranked fifth by organizations, whereas individuals ranked it seventh.

Respondents were also invited to provide suggestions that they believed would encourage people to take action individually or by their organizations. Eighty-one people chose to comment suggesting largely positive actions:

- Education and outreach – 27.1% (n=22)
- Financial incentives (subsidies, tax breaks, loans) – 26% (n=21)
- Resources and assistance – 12.3% (n=10)
- Regulations – 12.3% (n=10)
- Prevention – 10% (n=8)

Very few respondents suggested punitive measures (fines – 6.1%, n=5), and several suggested being left alone to manage private property as they saw fit (no more regulation/no interference – 13.6%, n=11).

4.4 Responsibility

4.4.1 Private Homes/property Protection

Respondents were asked to specify who they believed was most responsible for protecting private homes and property. The survey included a list to choose from and respondents were also invited to submit their own answer. Results are presented in (Fig. 4.4.1).

The majority of respondents believe that homeowners are responsible for their own protection (45.6%, n=1084). Local and provincial government and the community ranked similarly between 14.8 and 16%, and collectively at 30.8%. The two entities believed to be least responsible were neighborhoods (2.8%) and the federal government (2.6%), which is not surprising given that wildland fire management is largely a provincial responsibility.

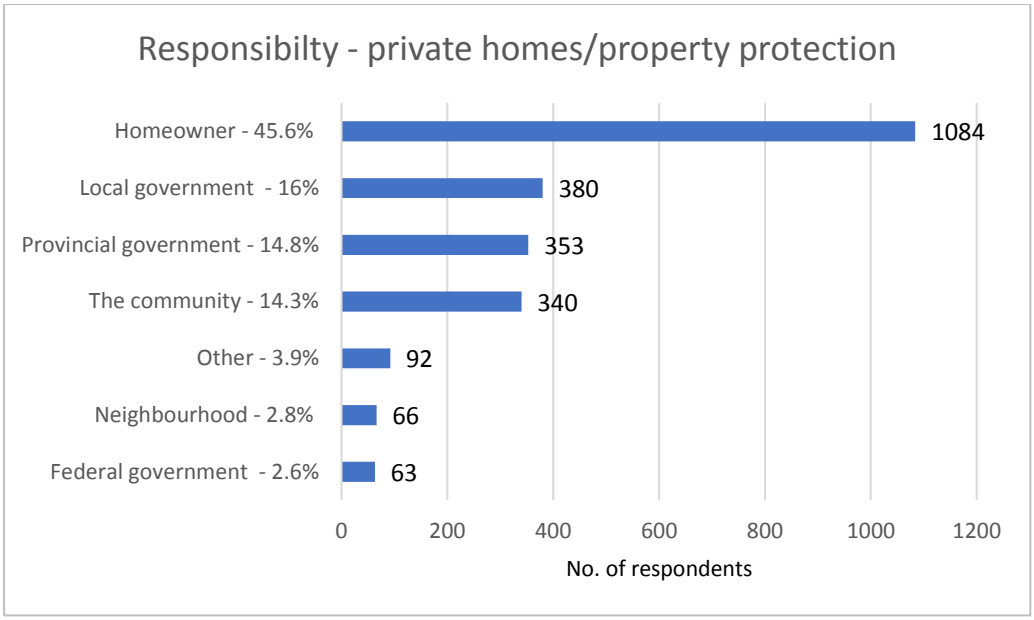

Figure 4.4.1: Perceived responsibility for private home/property protection

The majority (70%) of those who selected "other" (n=97) suggested that everyone is responsible for protection: that protecting private property should be a collaborative effort. The remainder (30%) selected a combination of one or two entities from the list presented.

4.4.2 Community Protection

All respondents were asked who they believe is responsible for community protection from wildfire, the results of which are captured in (Fig. 4.4.2). Local government was the first choice at 33.8% followed by the community (23.7%) and provincial government (22.2%). Only 10.5% of respondents selected homeowners. Those selecting "other" (n=82) also suggested that responsibility was a joint effort and that fire prevention activities were the responsibility of all parties (62%). The remainder selected different combinations of one or two parties listed (38%).

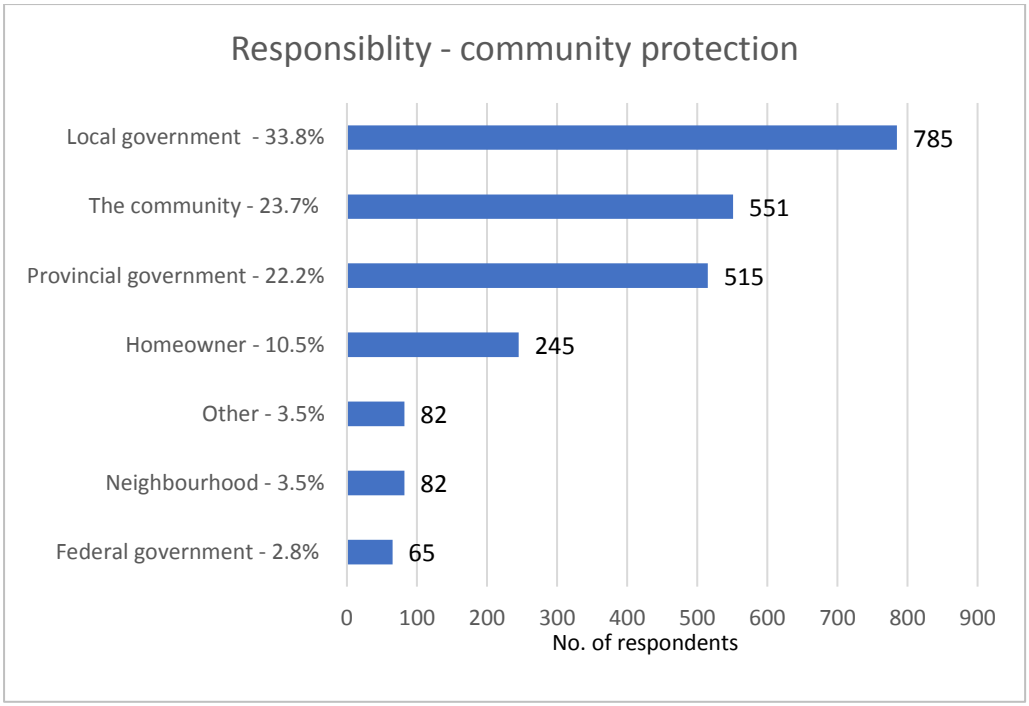

Figure 4.4.2: Perceived responsibility for community protection

4.5 Increased FireSmart Participation

The final question asked respondents their opinion on how to increase participation in the FireSmart program (Fig. 4.5.1). Suggestions were provided by 406 respondents, and were sorted and presented by category. The top four suggestions all involve continuous learning, communication, and collaboration and make up 70% of the total.

The first category – suggestions to increase education and information – focused largely on educating communities and individuals of the dangers to private property, and to communities in general (24%, n=98). Twenty percent (n=81) of respondents suggested increasing awareness of FireSmart, and 26% (n=55) suggested doing so through community engagement and outreach specifically.

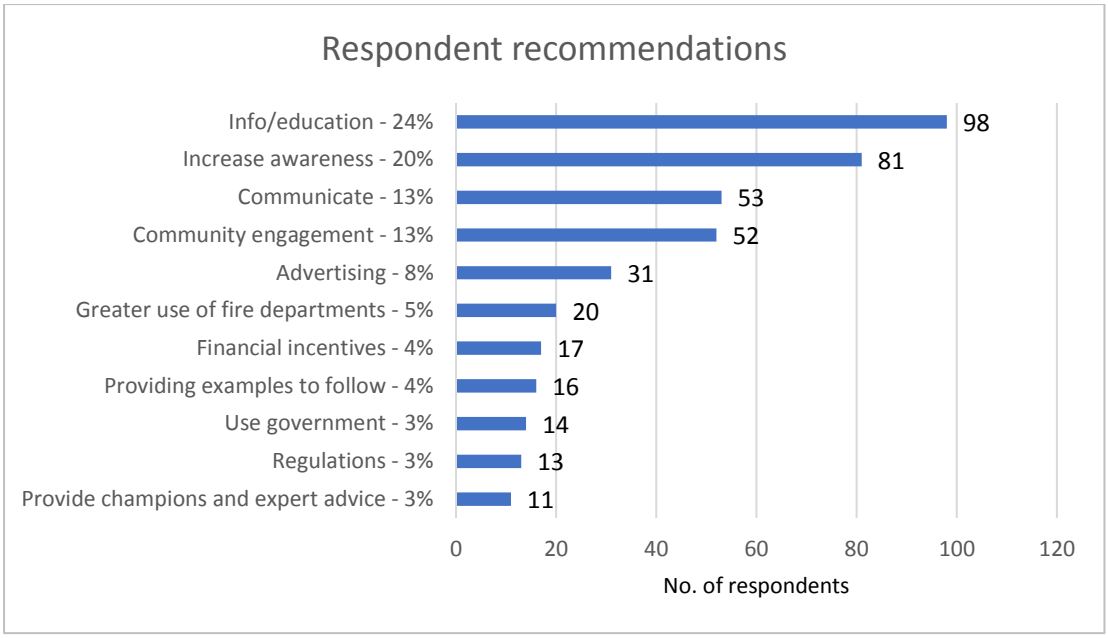

Figure 4.5.1: Suggestions for increasing FireSmart participation (open comments by category)

4.6 Statistical Analysis

FireSmart is a powerful tool, however, people in the WUI have not fully committed to protecting themselves and their communities. Results showed that the majority of survey respondents had not heard of the program (77%) and only a fraction who had, had engaged in FireSmart activities.

I developed models to determine (1) the factors that influence individual engagement in FireSmart activities, (2) factors that influence organizational engagement in FireSmart activities, and (3) factors that influence the awareness of FireSmart Canada.

4.6.1 Individual FireSmart Engagement

The research question for this model is: *is FireSmart engagement for individuals affected by socio-demographic and other pertinent factors?*

> H_0: there is no significant relationship between the response (individual FireSmart engagement) and the explanatory variables.

$H_{1:}$ there is a significant relationship between individual FireSmart engagement and one of the explanatory variables.

Note, the model also attempts to show if there are significant differences between groups and their base categories such as ethnicity, age, and employment, etc.

I ran a binary logistic regression to determine the characteristics that indicate whether individuals had engaged in FireSmart (yes = 1) or not (no =0). Independent variables tested in the model include:

RURAL – rural respondents – (rural = 1, otherwise = 0)

RENT – renters (renter=1, otherwise = 0)

RISK-PERC – risk perception (believe their property is at risk = 1, otherwise = 0)

DAMAGE-EXP – experienced damage by wildfire (yes = 1, otherwise = 0).

EMPL – employment category (unemployed = 1, otherwise = 0)

CAN-AB – Ethnicity (Canadian Aboriginal = 1, otherwise = 0)

NON-CAN – nationality (non-Canadian=1, otherwise = 0)

GENDER – gender (male = 1, female = 0)

WEST – resident of BC, AB, SK or MB (resident of western province = 1, otherwise = 0)

NORTH – resident of a Canadian territory (territorial resident = 1, otherwise = 0)

FSF – familiarity with FireSmart (familiar or very familiar = 1, otherwise = 0)

AGE>55 – age category (selected = 1, otherwise = 0)

EDUC-UNI – education category (if attended university/college/trade school = 1, otherwise = 0)

EDUC – UNI – GRAD – education category (university/college/trade school graduate = 1, otherwise = 0)

EDUC – GRAD – education category (having a graduate degree =1, otherwise = 0)

RURAL x RENT – cross term of rural and renter (rural renter = 1, otherwise =0)

The final model (2) includes 2,427 observations with 16 predictors. Results are listed in table 4.6.1. I conducted a model specification in order to figure out the best model by which to satisfy the logistic regression assumptions. Note, model 1 statistics will not be interpreted, but rather I am showing how model 2 is an improvement compared with model 1 (for an example of how to interpret binary logistic regression outputs, see Strand and Winston 2008).

The Omnibus Chi-square p-value for this model is < 0.01. This is strong evidence against the null meaning that there are statistically significant relationships between FireSmart engagement for individuals and some of the explanatory variables.

The model specification indicates that model 2 has a good fit given that unexplained variation is reduced (-2 log likelihood is 1804.128 compared to -2 log likelihood for model 1 which is 1898.722) (Menard 2000). Also, the R^2 is 0.46 meaning that the predictors can explain 46% of the variation of individual FireSmart engagement. In addition, the Hosmer and Lemeshow Chi-square p-value is > 0.05 at 0.672 meaning that we cannot reject the null hypothesis. Therefore, this test suggests that the model (model 2) fits the data well.

Statistically significant variables include:

- At p < 0.01 - RURAL, RISK-PERC, DAMAGE-EXP, GENDER, AGE, WEST, EDUC – UNI–GRAD, EDUC–GRAD and FSF.
- At p < 0.05 is the interaction term RURAL X RENTER,
- At p < 0.10 is EDUC-UNI.

Table 4.6.1: Binary logistic regression results - Individual engagement of FireSmart

	Model 1		Model 2	
Variables	*B*	Odds ratio	*B*	Odds ratio
Constant	-7.816***	.000	-8.561***	.000

RURAL	1.340***	3.819	1.532***	4.629
RENT	.125	1.133	-.132	.876
RISK-PERC (1)	6.210***	497.829	6.281***	534.564
DAMAGE-EXP (1)	.572***	1.772	.539***	1.715
GENDER (male=1)	-.350***	.705	-.576***	.562
AGE (>55)	.704***	2.022	.495***	1.641
RURAL x RENT	-1.156***	.315	-.939**	.391
FSF	-	-	.643***	1.902
EMPLOYMENT	-	-	.112	1.118
CA- AB	-	-	-.096	.909
NON-CAN	-	-	.959	2.608
EDUC-UNI	-	-	.362*	1.436
EDUC – UNI – GRAD	-	-	.575***	1.777
EDUC – GRAD	-	-	.766***	2.151
WEST	-	-	.876***	2.400
NORTH	-	-	.125	1.133
Omnibus test	915.514, df = 7, p < 0.01.		1010.108, df = 16, p < 0.01.	
-2 log likelihood	1898.722		1804.128	
Nagelkerke r^2	42.5%		46.3%	
H&L test	P = 0.619		P = 0.672	

*$p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; *df* is the number of predictors

The first column for each model represents the variables tested in the model using a step-wise approach. The second column in each model estimates the odds ratio (Exp(B)) for the corresponding variable.

I will use RURAL as an example to describe how to interpret the variables. The value is equal to 4.629 for RURAL, which tells us that the odds of adopting FireSmart by someone living in a rural setting are 4.629 times higher than for someone living in an urban setting. This variable is significant at 1% as indicated by $p < 0.01$. It is also possible to express odds as a percentage by transforming the odds ratio. I subtract one from Exp(B) and multiply by 100 to get the percentage value of 362.9%. The interpretation is that someone living in a rural setting is 363% more likely to engage in FireSmart activities.

The model includes nominal (categorical) variables where dummy variables are used. Therefore, the reference group for education level is an individual who has completed grade 12. Also, I used a dummy variable for age categories in order to assess the difference in FireSmart engagement by age. The reference group for age is 18-34 years. Note, age = 35-54 is excluded from the final model due to multicollinearity with other predictors according to the Corresponding Variable Inflation Factor (VIF=18.08). The model performed much better after omitting this category.

Variables that have a negative coefficient (-B) are less likely than the reference category to adopt FireSmart. For example, the value of the coefficient (B) on GENDER is - 0.576 meaning that the odds of males are lower than those for females of adopting FireSmart given that the dummy variable for GENDER = 1 for males, and 0 for females.

An individual's perception of risk is the most influential factor in determining whether they engage in FireSmart. The odds of engaging in FireSmart are 534 times higher than for those that do not perceive a risk of damage from wildland fire.

The corresponding Variable Inflation Factor (VIF) for risk perception is 1.10 and the collinearity tolerance is 0.90, meaning that there is no multicollinearity caused by this variable or other predictors. Generally, the model meets all logistic regression assumptions. This finding is critical because it shows that educating people on the risks they face is a likely strategy to incite action. Similarly, having experienced damage from wildland fire is statistically significant. The odds of engagement for an individual who experienced damage by a forest fire are about 1.7 times higher than for an individual who had not.

People 55 years and older are more likely to engage in FireSmart than for the base cohorts (18-34): the odds of engagement are 1.64 times higher. In addition, familiarity with FireSmart leads to greater engagement in FireSmart activities. The odds of engaging are 1.9 times higher for individuals who are familiar with the program. While this finding seems intuitive, familiarity does not always lead to engagement.

4.6.2 Organizational FireSmart Engagement

The research question for this model is: *what are the factors that affect engagement in FireSmart activities by organizations?*

> H_0: there is no significant relationship between FireSmart engagement by organizations and the explanatory variables.
>
> H_1: there is a significant relationship between FireSmart engagement for organizations and one of the explanatory variables.

I ran a binary logistic regression to determine the characteristics that indicate the likelihood of whether organizations engage in FireSmart. Number of valid observations used in this model are 2,427. Note, similar hypotheses and model objectives stated for the individual engagement model are applied to this model. This model has another dummy variable indicating the type of organization. Organization is a nominal variable that represents respondents answering as structural fire departments, municipal agencies, and associations. The reference category for this variable is wildland fire agency. Results are presented in Table 4.6.2. The following describes the explanatory variables tested in this model:

STRUC FIRE – responding as a member of a structural fire dept. (yes = 1, otherwise =0).

MUNICIPAL – responding as a member of a municipal government (yes= 1, otherwise = 0).

ASSOC – responding as a member of an association (yes = 1, otherwise = 0)

PERC RISK – perceived risk from wildland fire (yes = 1, otherwise = 0)

DAMAGE– experienced damage from wildland fire (yes = 1, otherwise = 0)

CAN-AB – self-identified as Canadian Aboriginal respondent (yes = 1, otherwise =0)

NON-CAN- self-identified as non-Canadian respondent (yes=1, otherwise=0).

Table 4.6.2: Binary logistic regression results - Organization engagement in FireSmart

	Model 1		Model 2	
Variables	*B*	Odds ratio	*B*	Odds ratio
Constant	-3.610***	.027	-4.746***	.009
STRUC FIRE	2.792***	16.312	2.540***	12.678
MUNICIPAL	2.784***	16.176	2.565***	13.003
ASSOC	2.329***	10.271	2.219***	9.201
PERC RISK (1)	-	-	1.556***	4.742
DAMAGE-EXP (1)	-	-	.240	1.271
CAN-AB	-	-	.855**	2.350
NON-CAN	-	-	-17.124	.000
Omnibus test	193.736, df = 3, p < 0.01.		299.855, df = 7, p < 0.01.	
-2 log likelihood	1011.265		954.093	
Nagelkerke r^2	18.7%		24%	
H&L test	P = 0		P = 0.259	

*p<.10; **p<0.05; ***p<.01; *df* is number of predictors

This model is significant as indicated by the Omnibus test for which p < 0.01, meaning that the predictors are statistically significant to improve the explained variability of the probability for organizations to engage in FireSmart. Specification modeling shows that the -2 log likelihood is reduced from 1011.265 in model 1 to 954.093 in model 2, which implies that model 2 is better at predicting the variance of the response variable. Also, the pseudo R^2 increased from 19% to 24% by adding ethnicity, fire risk perception, and past fire experience. The R^2 is relatively low, which

is not surprising when analyzing public opinion (Lewis-Beck and Skalaban 1990). The last column in each model provides the odds ratios of the corresponding variable.

Significant variables that show an increased level of organizational engagement in FireSmart include:

- At $p < 0.01$: STRUC FIRE, MUNICIPAL, ASSOC, PERC RISK (1)
- At $p < 0.05$ is CAN-AB.

To interpret the odds of FireSmart engagement by organizations as compared to wildland agencies (base case category), we could say

- Structural fire departments are around 12.7 times more likely,
- Municipal governments are 13 times more likely,
- Association members are 9.2 times more likely, and
- Those who perceive risk from wildland fire are 4.7 times more likely.

Being of Aboriginal descent is also significant at the 5% level. Results indicate that Aboriginal organizations are 2.4 times more likely to engage in FireSmart than non-Aboriginal and organizational respondents.

While the results show that all organizations are significant predictors in adopting FireSmart, the odds of adoption are about the same for structural fire department and municipal government representatives.

4.6.3 Likelihood of FireSmart Familiarity

The research question for this section is: *what are the factors that increase the odds of being aware of FireSmart?* The dependent variable used in this model is (being familiar of FireSmart=1, otherwise=0). Socio-demographic (independent variable)s are described as follows:

LIVE-RURAL – rural resident (yes=1, otherwise = 0)

AGE > 55 – age category (yes=1, otherwise = 0)

EDUC-UNI – has some education/college/trade training (yes=1, otherwise = 0)

EDUC-GRAD – has graduate degree (yes=1, otherwise = 0)

IND-OIL-GAS – employed in the oil industry (yes=1, otherwise = 0)

IND-FOREST – employed in the forest industry (yes=1, otherwise = 0)

IND-REC – employed in the recreation industry (yes=1, otherwise = 0)

IND-BUILD – employed in the construction industry (yes=1, otherwise = 0)

IND-INSURANCE – employed in the insurance industry (yes=1, otherwise = 0)

IND-MINE – employed in the mining industry (yes=1, otherwise = 0)

IND-LAND PLAN – employed in the land use planning (yes=1, otherwise = 0)

IND-LANDSCAPE – employed in the landscaping industry (yes=1, otherwise=0)

IND-GOV – employed by government (yes=1, otherwise=0)

IND-ENV – employed in the environmental industry (yes=1, otherwise=0)

IND-FIREFIGHT – employed as a firefighter (yes=1, otherwise=0)

MEDIA-TV – TV user (yes=1, otherwise=0)

MEDIA-RADIO – radio user (yes=1, otherwise=0)

MEDIA-PROV-AG – follower of provincial media (yes=1, otherwise=0)

MEDIA-MUNI-OUTREACH – municipal media follower (yes=1, otherwise=0)

MEDIA-FIRESMART-WEB – user of the FireSmart website (yes=1, otherwise=0)

MEDIA-FS-COMMUNITY – FireSmart community media user (yes=1, otherwise=0)

MEDIA-PRINTED – printed media user (yes=1, otherwise=0)

MEDIA-INSURANCE –information obtained by insurance agent (yes=1, otherwise=0)

MEDIA-FIRE-PRO – information obtained by a fire professional (yes=1, otherwise=0)

MEDIA-PREP-DAY – have heard of FireSmart at preparedness day (yes=1, otherwise=0)

MEDIA-MUNICIPAL-WEB – visited municipal website (yes=1, otherwise=0)

MEDIA-COMMUNITY – have heard of FireSmart from community media (yes=1, otherwise=0)

MEDIA-OTHER – have heard of FireSmart from different media outlets (yes=1, otherwise=0)

MEDIA-OTHER by AGE >55 – age of > 55 if using other media (yes=1, otherwise=0)

I also ran a binary logistic regression to determine the characteristics of respondents who were more likely to be familiar with FireSmart (FSF). Sample size for this model estimated at 2,427. This model includes two new nominal variables that indicate profession and media outlet. The reference group for profession is "other," which includes retirees whereas the base category for media is social media. Note, several models were tested for cross effects of media with age to determine if there were differences between age cohorts and media preference. However, only one interaction was found to be statistically significant. Other interactions were excluded from the final output table for clarity. The results are presented in (table 4.6.3).

Table 4.6.3: Binary logistic regression results - FireSmart familiarity

	Model 1		Model 2	
Variables	*B*	Odds ratio	*B*	Odds ratio
Constant	-3.436***	.032	-4.651***	.010
LIVE-RURAL	-.288	.750	-.060	.942
AGE (>55)	-.043	.958	-.187	.829
EDUC-UNI	-.442	.642	-.095	.909
EDUC-GRAD	.139	1.150	.340	1.405
IND-OIL-GAS	.737	2.090	.665	1.944
IND-FOREST	2.036***	7.661	1.178***	3.248

IND-REC	-17.598	.000	-16.601	.000
IND-BUILD	-17.584	.000	-16.588	.000
IND-INSURANCE	-17.578	.000	-19.104	.000
IND-MINE	.589	1.801	-.895	.409
IND-LAND PLAN	1.676	5.344	2.578**	13.170
IND-LANDSCAPE	1.351	3.860	2.145**	8.546
IND-GOV	1.203***	3.329	.739**	2.095
IND-ENV	.403	1.497	-.871	.418
IND-FIREFIGHT	2.676***	14.528	1.953***	7.051
MEDIA-TV	-	-	1.066**	2.904
MEDIA-RADIO	-		-.849	.428
MEDIA-PROV	-		1.147***	3.148
MEDIA-MUNI-OUTREACH	-		-.054	.947
MEDIA-FIRESMART-WEB	-		2.754***	15.708
MEDIA-FS-COMMUNITY	-		2.529***	12.537
MEDIA-PRINTED	-		.245	1.277
MEDIA-INSURANCE	-		-.216	.806
MEDIA-FIRE-PRO	-		1.558***	4.750
MEDIA-PREP-DAY	-		.242	1.274
MEDIA-MUNICIPAL-WEB	-		.542	1.720
MEDIA-COMMUNITY	-		-.536	.585
MEDIA-OTHER	-		1.642***	5.165
OTHER-MEDIA by	-		1.672**	5.322

AGE (>55)		
Omnibus test	198.899, df = 15, p < 0.01.	712.5 13df = 29, p < 0.01.
-2 log likelihood	1215.017	701.402
Nagelkerke r^2	16.9%	56%
H&L test	P = 0.831	P =1.70

*p<.10; **p<.05; ***p<.01; *df* is number of predictors

Model 1 includes four socio-demographic variables (live in rural, age, education level and profession/industry). Although Chi-square p-value for model 1 is statistically significant at 1%, it is not great since it shows relatively low R^2 and a bit higher (-2log likelihood) compared with model 2 statistics. By adding media source and media source by age in (model 2), R^2 is improved to more than threefold from 17 to 56%. Model 2 suggested to be the best model since it gives the lowest (-2log likelihood=701.402). Moreover, Chi-square p-value given by Hosmer and Lemeshow test=1.70 which is a strong evidence to accept the null meaning that this model (model 2) fits the data well.

Significant variables at $p < 0.01$ indicate that respondents who work as fire fighters or work in the forest industry are 7.1 and 3.2 times more likely to have heard of FireSmart than if they are retired (the base case for profession variable). Also, significant at $p < 0.01$ are several media outlets. The odds of having heard FireSmart are greater for the following media outlets than for social media:

- 3.1 times more likely through a wildfire provincial agency,
- 15.7 times more likely if on the FireSmart website,
- 12.5 times more likely if aware of the community recognition program,
- 4.8 times more likely through a fire professional staff, and
- 5.2 times more likely through other sources (word of mouth, government, at work, or using printed media).

The odds of having heard of FireSmart are significant at $p < 0.05$ and more likely for those working in land use planning (13.1), landscaping (8.5) or being a government employee (2.1) as compared to those who are retired (base case category).

Finally, the odds of having heard of FireSmart on TV were 2.9 times larger than for social media (significant at $p < 0.05$), and being over 55 years old and reporting other for media (5.3 times).

Chapter 5

Discussion

This section discusses results obtained from analysing characteristics of those individuals and organizations that engaged in FireSmart activities.

5.1 FireSmart Engagement - Individuals

The majority of respondents have adopted fire prevention actions that do not require specialized knowledge, effort or expense. The most frequent percentage of FireSmart activities cited were cleaning and maintenance including roof cleaning (66.5%), and fuels removal (63.6%). Only 13.8% of those who had engaged in FireSmart activities revealed that they changed home siding or other home materials (9%) to non-combustibles. Similar results were given by respondents who conducted FireSmart at the organizational level (see figure 4.2.6). These results are consistent with the findings by (Brenkert-Smith et al. 2006) who report that the least-effort, least-cost options appear to be accepted as reasonable and necessary actions for homeowners towards reducing the likelihood of damage caused by forest fires.

Those who have never engaged in FireSmart activities reported that they had insufficient knowledge or limited financial resources. While this result is not surprising, Absher et al. (2009) argue that socio-economic factors (e.g., income for example) explain only a fraction of the variability of engaging in fire prevention programs. They suggest that psychological factors such as perceived familiarity with education and prevention programs, or effectiveness and aesthetic impacts of wildland fuel treatments account for a larger fraction of variability of homeowners' willingness to accept and practice fuel mitigation polices as compared with socio-demographic of geographic factors.

Gender and age were also found to be statistically significant in the individual engagement model. Females were more likely to conduct individual FireSmart activities as compared with males. Similarly, compared with youth, people older than 55 years of age are 1.6 times more

likely to engage in individual FireSmart activities, all things being equal. Previous research was mixed regarding socio-demographic impacts on accepting and adopting fuel mitigation programs. While Carpenter et al., (1986) and Wolters et al., (2017) found significant associations between gender and/or age with fuel mitigation engagement, Shindler and Toman (2003), and McGee, (2007) did not find significant relationships.

Education level was also found to be statistically significant meaning that highly educated people are more likely to conduct individual FireSmart activities. This finding is not surprising since people with university degrees (bachelors and higher) are more likely to search upon and participate in projects intended to understand and solve natural resource issues including forest fires (Wolters et al. 2017). Alternatively, Shindler and Toman (2003) did not find significant associations between education level and applications of fuel management.

While ownership (rent versus own) was not statistically significant, the interaction term (rent by rural) was significant and negative. This likely indicates that owners who live in rural areas are more likely to engage in FireSmart activities. This might be because that rural residents are more particularly involved with environmental issues and search for plans to protect their surrounding resources (Bozoglu et al. 2016). Also, Wolters et al. (2017) state that renters might not have the resources or motivation that would encourage them to provide upgrades to temporary accommodations when compared to owners who have financial commitments to the property. The authors also suggest that seasonal vacation structure owners are less likely to conduct remedial actions than permanent homeowners because they spend less time at the residence and are therefore less familiar with wildfire conditions or have less time to modify their property (Wolters et al. 2017, p.8).

They did, however, capture a significant association between familiarity and level of engagement of Firewise, the American equivalent of FireSmart. My results suggest that residents who are familiar with FireSmart are more likely to engage in the program: specifically, the odds of engaging in FireSmart are about 90% higher when an individual is familiar with FireSmart, all else being constant.

The most important variables found in this study that had positive effects on FireSmart engagement were risk perception and fire damage experience. It was hypothesized that the

higher the level of wildfire risk perception, the more likely the participation in Firewise activities. (Wolters et al. 2017; McCaffrey 2004; Martin et al. 2009; Champ 2013; Lindell and Perry, 2000) However, there have been several studies that suggest that while an awareness of fire risk was important, it did not necessarily lead to adoption of risk mitigation actions. Social communication issues (e.g., negotiations regarding where and how programs should be implemented), emulating peers, and lack of financial support, all can influence why individuals do not implement fuel mitigation even if residents positively perceive the fire risk to their communities (Brenkert-Smith et al. 2006; Collins 2005; Gordon et al. 2010; Martin et al. 2007).

5.2 FireSmart Engagement - Organizations

Correlation tests for the binary logistic and multicollinearity diagnostic test using a linear regression were carried out and showed that there is no high collinearity between the predictors used in the FireSmart model for organizations (Midi et al. 2010).

Experience with damage from wildfire became insignificant in this model compared to individual engagement model. The relationship between fire damage experience and adopting fire mitigation behavior has been discussed in previous research. Although Winter and Fried (2000) found that fire damage experience affects individual's support for fuel mitigations, Vogt et al. (2005) demonstrate that fire experience does not influence individuals' acceptance of mechanical fuel mitigations, prescribed fire and defensible space ordinances in communities in Florida, California and Michigan.

Moreover, McGee et al. (2009) demonstrate the variations of residents' approval and adoption of fuel reduction activities caused by fire experiences. Their study was conducted in 2003 after the Lost Creek fire in the Crowsnest Pass and Pincher Creek area in southern Alberta, and the McLure fire in the north Thompson Valley area of British Columbia (BC). The researchers found that respondents who had not been evacuated during a forest fire had conducted two additional fuel mitigation activities in the period following the fire. Respondents who had been evacuated implemented an average of only one new reduction measure on their property. However, those who had lost their homes did not complete any fuel mitigation activities in the

post-fire period. Future research is needed to further explore the relationships among different regions since the results are not harmonious.

Ethnicity in this model means whether the respondent is a Canadian Aboriginal or not. The results show that there is a significant difference between Aboriginals and non-Aboriginals responding as organizations in engaging in coordinated FireSmart activities. While it is not clear why, further research could examine the effects of structure ownership, location regarding proximity to areas at risk, and cultural relationships with fire (Natural Resource Canada 2016).

As it has been discussed before that people who live in close proximity to forest fuels, perceive there to be a risk of damage from wildfire, own their property and are frequently evacuated, are more likely to engage in fuel mitigation activities (Wolters et al. 2017). Alternatively, Christianson et al. (2012) have discussed the historical participation of Aboriginals with forest fuel mitigation agencies and obstacles that restrict their willingness to take positive actions. However, there is little evidence to support whether Aboriginals are more or less willing to engage in fire mitigation activities when compared with Canadian non-Aboriginals.

5.3 FireSmart Familiarity- All Respondents

This research also looked at factors affecting familiarity with the FireSmart program. The model explained about 56% of the variance of increased FireSmart familiarity. Statistically significant predictors were profession, media source, and age interaction with media source.

The results suggest that FireSmart familiarity could be enhanced through specific media channels. Results also suggest that being engaged in certain professions leads to greater odds of familiarity. Several media outlets are positively associated with FireSmart familiarity. An individual is more likely to be familiar with FireSmart if he/she watches TV. According to Statistics Canada (2017), Canadian adults spent an average of 202 minutes a day watching TV. Also, the model showed information provided through provincial wildfire agency websites, the FireSmart website, the FireSmart community recognition program, and information from fire professional were all significant predictors of FireSmart familiarity. It is worth mentioning that other media is statistically significant and comprises of a respondent employer, the governmental

and word of mouth. Finally, results suggest that those working in land use planning, landscaping, government, forestry, and firefighting are more likely to be familiar with FireSmart.

It is interesting that "other media" when interacted with age > 55 was positive and statistically significant. The odds of FireSmart familiarity of the older cohort using other media are 5.32 times more when compared with younger cohorts, all else being equal. While different media outlets have substantial effect on variation of FireSmart familiarity, the odds of FireSmart familiarity is the highest (16 times) given specific media programs organized by the FireSmart Canada website. This result seems to be consistent with the finding that Canadians most commonly interact with businesses through their websites (McKinnon 2016).

In attempts to figure out what source of media would increase younger cohorts' knowledge of FireSmart, a model was run including age ranges between 18-34 and 35-54 and interacted with different media sources. The model indicated that younger cohorts are more likely to be familiar with FireSmart using social media (see the result table in Appendix B). The odds of FireSmart familiarity were 7.93 and 6.81 times more for social media users ages 18-34 and 35-54, respectively when compared to people 55 years of age and older. According to Statista (2017), 22.7 million Canadians use social networks, and this number is projected to grow to 24.1 million by 2022.

Canadians believe that social media is the best way to reach relatives and friends in emergency situations. More than 50% of Canadians are registered to more than one social media account. Furthermore, using social media is different between Canadian millennials and other age groups. While YouTube, Instagram, Twitter and Snapchat are growing in use among millennials in Canada, older cohorts are less likely to have tried such media networks (McKinnon 2016). Therefore, it is critical to understand preferences of using social media platforms for different age groups in order to be effective at making FireSmart awareness and adoption policies.

Chapter 6

Conclusion and Policy Implications

6.1 Summary and Conclusion

This research sought to identify socio-economic factors that influence awareness of and engagement in FireSmart Canada. There are four key findings: (1) the majority of respondents had never heard of FireSmart Canada; (2) the most influential factor leading to FireSmart adoption by individuals is perceived risk of damage from wildland fire; (4) perceptions of responsibility for risk mitigation vary between individuals and organizations, and (5) both individual and organizations' preferences for risk mitigation strategies favour positive approaches such as incentives tied to homeowner insurance.

First, the majority of respondents revealed that they had never heard of FireSmart and can generally be categorized as urban (63%), not threatened by fire (90%), and who live in provinces east of Manitoba (76.7%). This is not surprising given research done by others that indicates risk perception and damage experience is influential in inciting self-protective action (e.g. McCaffrey et al. 2004). The survey targeted both urban and rural residents because many urbanites choose to recreate in rural settings, and sometimes own vacation property at risk of damage from wildfire, and that would therefore benefit from adopting FireSmart recommendations. More research is warranted to identify those who spend time in fire-prone rural and wildland settings.

Second, the research suggests that positive risk perception is the most critical factor influencing individuals' and communities' adoption of FireSmart. This finding is supported by research conducted by Ryan and Wamsley (2008) who found that risk perception is positively influenced by wildfire experience and an understanding of landscape features (e.g., proximity to hazardous forest fuels). Because only 4.4% of the survey participants in this study have experienced wildfires, it is not surprising that individuals do not fully perceive fire risk.

Third, if individuals do not think they are responsible for protecting their own property, rather that the government will protect them by either suppressing fires, or paying for damages, they will not be likely to act (McGee 2005). This research indicated that 45.6% of respondents felt that homeowners were responsible for protecting private property. However, collectively, 45.1% of respondents believed protecting private property is the responsibility of local government (16%), the provincial government (14.8%), and the community (14.3%). This result is interesting because it suggests that individuals might not take risk mitigation actions if they believe another agent is responsible for wildfire protection.

Finally, when asked about how to increase engagement in FireSmart, respondents clearly favoured strategies that were positive in nature, and provided incentives. The most strongly supported initiative was to tie insurance premiums to program compliance. Strategies that were punitive received the least support from both individuals and organizations.

Results were also strongly tied to open comments provided by respondents who offered suggestions to increase FireSmart awareness and adoption. Overall, respondents suggested measures to educate and inform the public and offered very wide-ranging suggestions regarding advertising (using all media outlets), increasing awareness of wildland fire risk, and therefore, the need to mitigate fire risk. The top three suggestions were education/provide information, increase awareness by advertising.

While education about the program is highly important, it will also be critical to educate people about fire risk to their communities. The more awareness of fire risk, the more likely people will search for effective methods to safeguard their property and communities from wildfires (Ryan and Wamsley 2008; McCaffrey 2004). Ryan and Wamsley also suggest using a variety of media outlets such as newspapers, television, radio and the Internet. My research suggested that certain media sources are used more than others, but also that education and outreach can occur through employment. For example, a relationship with individuals who are employed in industries associated with land and forest management could be used to play a greater role in raising the awareness of wildfire risk/damage and developing more effective mitigation strategies (Ryan et al. 2006; Shindler and Toman 2003).

Since wildfire prevention of a community is perceived to be the responsibility of homeowners, the community, and provincial and local governments as suggested in Figures (4.4.1) and (4.4.2), collaborative work is needed among all stakeholders to facilitate FireSmart efforts. The majority of respondents who commented, suggested a more collaborative approach, which is also supported in the literature. Sturtevant and Jakes (2008) discussed collaborative fire risk mitigation and activities conducted throughout this process. There are several stages that individuals and organizations can benefit from when they work together. For instance, public outreach is intended to reach homeowners and change their perceptions towards wildfire risk reduction across the landscape. Multiagency educational workshops and newsletters are recognized as methods for outreach, demonstrating a unified community voice.

Also, collaborative activities utilize social gatherings such as festivals, parades, and tree-planting for example to gather information and share messages in order to develop partnerships in wildfire management. Sturtevant and Jakes (2008) listed a set of desired outcomes generated through collaborative risk reduction plans. This includes increased capacity in leadership, networks, and resources; increased understanding, mutual learning, and fire preparedness; increased support and mobilization of resources; and therefore, proper implementation of projects and policies.

Lack of FireSmart adoption for individuals and organization was also found to be connected with limited financial resources. While it would not be FireSmart Canada's mandate to secure funding, following recommendations for greater collaboration among all stakeholders could lead to greater opportunities to secure resources, particularly where such activities could be associated with reductions in loss and damage. A greatly underutilized partner would be the insurance industry. Results indicated that individuals are least likely to have heard of FireSmart knowledge from insurance brokers. However, a reduction in insurance premiums associated with FireSmart compliance was the most strongly supported strategy. Using a collaborative approach to education and awareness, FireSmart Canada could work with the insurance industry to play a more significant role in first increasing the public's awareness about the risk of wildfires and secondly, to work toward premium reductions to incentivise the use of FireSmart in mitigating risk to customers.

6.2 Research Limitations

While this research indicated the importance of fire risk awareness as a precursor to FireSmart adoption, there are some limitations. There are other elements could enhance the conclusion if they are taken into account. First, because the survey questions were designed collectively by the Canadian Forest Fire Interagency Centre and experts from provincial fire agencies, the author received the data and had a limited ability to investigate relationships such as how property was related to land ownership, seasonal use of property, and whether the respondent had more than one property, for example. Furthermore, it was not possible to evaluate and assess perceptions of risk versus to actual risk.

Second, the sample underrepresents the population in some areas. Ontario represent 24% of the total while the actual population in Ontario represents 38.7% of the total Canadian population. The implication of sample selection bias is that an area that had too few observations might lead to underestimating the contribution in affecting the outcome of interest: for example, in my study, engagement in FireSmart across all Canadian regions.

The third limitation is that the statistical model does not explain a high variability of individual FireSmart engagement. While socio-demographic variables along with FireSmart familiarity and fire risk perception and experience explain about 46%, Absher et al. (2009) suggest that socio-demographic variables explain only a fraction of the variability of homeowners' acceptance of fire prevention policies. They state that psychological variable (e.g., perceived fire risk, perceived effectiveness of prevention programs, and public beliefs about maintaining the aesthetic of forests) explain a larger fraction of individuals' willingness to adopt wildfire protection activities.

I examined the accuracy of this finding by estimating an individual FireSmart engagement model using only one psychological variable (risk perception). I found my results to be consistent with those of Absher et al. given that risk perception explained around 34% of the variance whereas other socio-demographic variables explain only 12% of the variability of FireSmart engagement. This research was limited to examine additional psychological variables (e.g., perceived effectiveness, beliefs of maintaining forest aesthetic for residents living in forested areas prone to fire risk) to their effect on FireSmart adoption behavior.

6.3 Future Research

Wildfire managers face trade-offs balancing costs and benefits associated with wildfire protection programs. Findings showed that the majority of respondents revealed a financial inability (budget constraint) to be the greatest barrier to taking action. Forest fires are a natural phenomenon, which occur frequently meaning that WUI residents must coexist with the risk of fire. One way to assist both homeowners and organizations in adopting fire mitigation measures is to explore management efficiency.

Future research should evaluate the economics of activities associated with wildfire management including home code structuring and the effectiveness of forest fuel treatments such as thinning and prescribed burning. Research that assess programs using cost-effectiveness could show the effective blend of activities given a finite budget. Cost-effectiveness analysis is proposed rather than cost-benefit analysis due to difficulties in measuring values and benefits of fire prevention and mitigation, and to avoid monetizing non-market benefits and values.

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Appendix A

Survey –English Version

FireSmart Canada

The Wildland Urban Interface (WUI) is named to describe where urban landscapes meet with environments that are prone to wildfire. FireSmart Canada and Dr. Hayley Hesseln, an Associate Professor at the University of Saskatchewan are collaborating to assess Canadians' awareness of FireSmart and its activities. As the value of our findings depends on your involvement, we would like to thank you for taking time to participate. The online survey should take about 15 minutes, and asks questions about FireSmart, your knowledge of wildfire risk and wildfire mitigation strategies. Results of the survey will help us develop better methods and tools to help protect private property and communities. Survey results will be used in a report, and in scholarly publications. Only aggregated data will be reported. By completing this questionnaire your free and informed consent is implied and indicates that you understand the above conditions to participate in this study.

About the survey

Survey Introduction

Participation in this survey is voluntary, and you can decide not to participate at any time by closing your browser, or choosing not to answer any questions you do not feel comfortable with. Survey responses will remain anonymous. Since the survey is anonymous, once it is submitted it cannot be removed. There are no known risks to participating in this survey; however, as with any online-related activity, the risk of breach of confidentiality might occur. We will make every effort to protect the confidentiality and anonymity of every participant, including safely securing and storing data.

By selecting “continue” and completing this questionnaire your free and informed consent is implied and indicates that you understand the above conditions to participate in this study. This survey is hosted by ZEF, a Finnish company. See the following for more information on ZEF’s privacy and data security policy.

This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office: ethics.office@usask.ca or (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

You may also contact Principal Investigator Dr. Hayley Hesseln, Associate Professor in the College of Agriculture and Bioresources at the University of Saskatchewan if you have questions about the project. You can email her at h.hesseln@usask.ca, or leave a message at (306) 966-8407.

Respondent role

I am responding to this survey as:

Choices:

- 1. An urban homeowner
- 2. A rural homeowner
- 3. An urban renter
- 4. A rural renter
- 5. A member of a structural fire department
- 6. Member of a wildland fire agency
- 7. Member of municipal government
- 8. Member of a community association, Home Owner Association, or Strata
- 9. A member of another organization (please list)

FireSmart Canada Awareness

FireSmart Canada

Please indicate your level of awareness.

Choices:

- 1. I have never heard of FireSmart Canada.
- 2. I have heard of FireSmart Canada (e.g. familiar with the term, aware of the organization).
- 3. I am very familiar with FireSmart Canada (e.g. visited website, used products).

FireSmart Canada

Where did you hear about FireSmart Canada?

I have heard about FireSmart Canada through the following media outlets.

Please select all that apply, and click "continue."

Choices:

- 1. Television
- 2. Radio
- 3. Provincial fire agency website/outreach
- 4. Municipal fire department website/outreach
- 5. FireSmart website
- 6. FireSmart Canada Community Recognition Program
- 7. Social media (e.g. Facebook, Twitter)
- 8. Printed material (e.g. pamphlets, manuals)
- 9. Insurance company
- 10. Fire professional (e.g. fire personnel, fire marshal)
- 11. Wildfire Community Preparedness Day
- 12. Municipal association website/outreach
- 13. Community association website/outreach
- 14. Other (please specify)

Your risk

1. Do you believe that you live in an area where a wildfire could be a threat to your community or personal property?

Choices:

- 1. Yes
- 2. No

2. What are the first three digits/letters of your postal code?

FireSmart participation

Has your community ever been threatened/damaged by wildfire?

Choices:

- 1. Damaged - (please indicate the year)
- 2. Threatened - (please indicate the year)
- 3. No

FireSmart Activities – Individuals

Protecting your home from wildfire starts with simple actions. Whether you are doing regular yard maintenance or making large-scale changes during renovations or landscaping, you can make choices that will help protect your home from wildfire.

1. There are many activities FireSmart Canada recommends to help protect your home, your community, and the environment. (Examples include:

- Establishing priority zones;
- Using fire-resistant building materials (e.g. siding, windows, roofing);
- Using fire-resistant roof construction (e.g. metal shingles, cement and concrete products);
- Using fire resistant attachments (e.g. decks, porches, fences);
- Removing burnable debris from your yard;
- Using lean, clean and green landscaping to reduce the risk of fire spread;
- Providing access for emergency vehicles.
- Preparing a disaster plan (e.g. emergency contacts, plans for pets, available tools).)

2. Please indicate whether you have conducted FireSmart activities on your property.

Choices:

- 1. Yes
- 2. No

FireSmart Activities – Organizations

Protecting your community from wildfire is possible through vegetation management, structure modification, and providing access to appropriate infrastructure.

1. There are many options FireSmart Canada recommends to mitigate the risks from wildfire to your community and the surrounding environment. (Examples include:
- Fuel removal, reduction, and fuel conversion;
- Reduction of surrounding forest density;
- Availability of open space;
- Modification of buildings in the wildland-urban interface;
- Construction of a community fireguard (e.g. fuels breaks, fire breaks);
- Proper disposal of forest debris (e.g. composting rather than burning);
- Ensuring an adequate water supply;
- Making infrastructure available (e.g. access routes, utilities, road standards, emergency services); and
- Preparing a community disaster plan (e.g. emergency contacts, plans for pets, available tools).)
2. Please indicate whether you have conducted FireSmart activities in your community.

Choices:

- 1. Yes
- 2. No

FireSmart activities undertaken - individuals

Please select all that apply and then click "continue."

Choices:

- 1. Changed roofing to less flammable material
- 2. Regularly cleaned, roof, eaves and gutters
- 3. Changed siding to less flammable material
- 4. Changed other material (e.g. wood deck) to less flammable material
- 5. Landscaped with fire resistant plants
- 6. Regularly removed fuels
- 7. Thinned forest vegetation

- 8. Provided better access for emergency vehicles
- 9. Changed doors and windows to tempered or thermal panes
- 10. Prepared a disaster plan
- 11. Other

FireSmart activities undertaken - organizations

Please select all that apply and then click "continue."

Choices:

- 1. Conducted fuel removal, reduction, and fuel conversion
- 2. Reduced surrounding forest density
- 3. Increased availability of open space
- 4. Modified buildings in the wildland-urban interface
- 5. Constructed a community fireguard (e.g. fuels breaks, fire breaks)
- 6. Conducted proper disposal of forest debris (e.g. composting rather than burning)
- 7. Ensured an adequate water supply
- 8. Enhanced infrastructure availability (e.g. access routes, utilities, road standards, emergency services)
- 9. Prepared a community disaster plan (e.g. emergency contacts, plans for pets, available tools)
- 10. Other

Please tell us why you HAVE NOT taken action to reduce the risk of wildfire damage to your property.

What are the top three reasons you HAVE NOT taken action to mitigate potential fire hazards.

Choices:

- 1. I do not know what action to take.
- 2. I do not have the financial resources to take action.
- 3. Taking action is not my responsibility.
- 4. I am not physically able to take action.

- 5. I do not believe fire will negatively affect my property.
- 6. Other

If there are other reasons we have not mentioned, please provide them in the space provided.

If you do not wish to add additional comments, please click "continue."

Please tell us why you HAVE NOT taken action to reduce the risk of wildfire damage to your community.

What are the top three reasons you HAVE NOT taken action to mitigate potential fire hazards.

Choices:

- 1. We do not know what action to take.
- 2. We do not have the financial resources to take action.
- 3. Taking action is not my responsibility of my organization/government.
- 4. We do not believe fire will negatively affect our community.
- 5. Other

If there are other reasons we have not mentioned, please provide them in the space provided.

If you do not wish to add additional comments, please click "continue."

Taking action:

What would encourage you to take action on your property or in your community to reduce wildfire risk?

1. Monetary fines for non-compliance with FireSmart standards.

Please click anywhere on the panel to register your degree of support. The centre is neutral.

2. Peer pressure from community members to engage in FireSmart activities.

Please click anywhere on the panel to register your degree of support. The centre is neutral.

3. Mandatory building codes (legislation)

Please click anywhere on the panel to register your degree of support. The centre is neutral.

4. Reduction in insurance premiums for compliance with FireSmart standards.

Please click anywhere on the panel to register your degree of support. The centre is neutral.

5. Land use/zoning policies

Please click anywhere on the panel to register your degree of support. The centre is neutral.

6. Refusal of home insurance unless in compliance with FireSmart standards.

Please click anywhere on the panel to register your degree of support. The centre is neutral.

7. Refusal of fire suppression engagement due to fire responder safety concerns.

Please click anywhere on the panel to register your degree of support. The centre is neutral.

8. Technical assistance from FireSmart personnel

Please click anywhere on the panel to register your degree of support. The centre is neutral.

9. Other (please describe)

If you do not wish to add additional comments, please click "continue."

Fire protection responsibility - homes/property

Who do you think is most responsible for mitigating the risk of damage from wildfire to private homes/property?

Choices:

- 1. Homeowner
- 2. Neighbourhood
- 3. The community
- 4. Local government
- 5. Provincial government
- 6. Federal government
- 7. Other (please specify)

Fire protection responsibility - community

1. Who do you think is most responsible for mitigating the risk of damage from wildfire to a community?

Choices:

- 1. Homeowner
- 2. Neighbourhood
- 3. The community

- 4. Local government
- 5. Provincial government
- 6. Federal government
- 7. Other (please specify)

Participation

1. How would you get your community/neighbourhood involved in FireSmart?
   If you do not wish to comment, please click "continue."

Please tell us about yourself

We remind you that your answers are confidential and will be used for statistical purposes only.

1. In which industry do you work?
   Choices:
   - 1. Oil and gas
   - 2. Forestry
   - 3. Recreation/tourism
   - 4. Building, development, real estate
   - 5. Insurance
   - 6. Mining
   - 7. Land-use planning
   - 8. Landscaping
   - 9. Government
   - 10. Environment
   - 11. Firefighting (structural or wildland)
   - 12. Retired
   - 13. Other (please specify)
   - 14. Prefer not to say.
2. I identify as a:
   Choices:
   - 1. Canadian - Aboriginal (First Nations, Métis, Inuit)

- 2. Canadian - Non Aboriginal
- 3. Non Canadian
- 4. Prefer not to say

3. Gender

Choices:

- 1. Male
- 2. Female
- 3. Other

4. My age is:

Choices:

- 1. 18-24
- 2. 25-34
- 3. 35-44
- 4. 45-54
- 5. 55-64
- 6. 65 and over
- 7. Prefer not to say

5. Income

Choices:

- 1. < $20,000
- 2. $20,000 - 39,999
- 3. $40,000 - 59,999
- 4. $60,000 - 79,999
- 5. $80,000 - 99,999
- 6. $100,000 - 149,999
- 7. $150,000-199,999
- 8. > $200,000
- 9. Prefer not to say

6. Education

Choices:

- 1. Up to Grade 12

- 2. Some college or trade-school
- 3. College graduate or trade-school graduate
- 4. Graduate degree

7. I live in the province/territory of:

Choices:

- 1. Alberta
- 2. British Columbia
- 3. Manitoba
- 4. New Brunswick
- 5. Newfoundland and Labrador
- 6. Northwest Territories
- 7. Nova Scotia
- 8. Nunavut
- 9. Ontario
- 10. Prince Edward Island
- 11. Quebec
- 12. Saskatchewan
- 13. Yukon

8. Do you have questions, or would you like a copy of the results? (If so, please contact Principal Investigator Dr. Hesseln, Associate Professor in the College of Agriculture and Bioresources at the University of Saskatchewan. You can reach her at h.hesseln@usask.ca, or leave a message at 306.966.8407.)

Appendix B

Regression Results

Logistic regression results – FireSmart familiarity

Variables	*B*	Odds ratio
Constant	-3.885***	.021
LIVE-RURAL	-.418	.658
Age (18-34)	-.578*	.561
Age (35-54)	-.712**	.491
EDUC-UNI	-.325	.723
EDUC-GRAD	.300	1.350
IND-FOREST	2.125***	8.370
IND-REC	-17.158	.000
IND-BUILD	-17.152	.000
IND-INSURANCE	-17.453	.000
IND-MINE	.804	2.234
IND-LAND PLAN	1.266	3.545
IND-LANDSCAPE	1.804*	6.074
IND-GOV	1.372***	3.944
IND-ENV	.531	1.701
IND-FIREFIGHT	2.733***	15.377
RISK-PERC	.949***	2.582
DAMAGE-EXP	.209	1.232
AGE(18-34) by TV	-17.806	.000
AGE(18-34) by RADIO	-18.273	.000
AGE(18-34) by	2.071**	7.931

SOCIALMEDIA		
AGE(35-54) by TV	.884	2.421
AGE(35-54) by RADIO	-.426	.653
AGE(35-54) by SOCIALMEDIA	1.918***	6.805
AGE(18-34) by RURAL	-.354	.702
AGE(35-54) by RURAL	-.370	.691
χ^2	276.6 *df*=25, *p*<.01.	
-2 log likelihood	1137.1	
Nagelkerke r^2	23.2%	
H&L test	*p*=.208	