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Community Engagement With Proactive Wildfire Management in British Columbia, Canada: Perceptions, Preferences, and Barriers to Action

Kelsey Copes-Gerbitz[1]*, Sarah Dickson-Hoyle[1], Sarah L. Ravensbergen[1], Shannon M. Hagerman[2], Lori D. Daniels[1] and Jemina Coutu[1]

[1] Department of Forest and Conservation Sciences, University of British Columbia, Vancouver, BC, Canada, [2] Department of Forest Resources Management, University of British Columbia, Vancouver, BC, Canada

Wildfires in the wildland-urban interface (WUI) are increasingly threatening lives and livelihoods. These growing impacts have prompted a paradigm shift toward proactive wildfire management that prioritizes prevention and preparedness instead of response. Despite this shift, many communities remain unprepared for wildfires in the WUI due to diverse individual and social-political factors influencing engagement with proactive management approaches. The catastrophic fire seasons of 2017, 2018, and 2021 in British Columbia (BC), Canada, highlighted just how vulnerable communities continue to be and the urgent need to understand the factors limiting engagement to future resilience to wildfire. Our study, conducted prior to the catastrophic fire season in 2017, surveyed 77 community leaders across BC to better understand the factors driving engagement, including risk perception, preferences and support for approaches, and key barriers limiting progress. We demonstrate that wildfire risk is an urgent issue facing communities across BC, but a range of factors drive variable community engagement with proactive wildfire management. First Nations and smaller (≤5,000 residents) communities were less likely to have developed a community wildfire plan, even though First Nations were significantly more concerned than municipalities/regional districts about certain values (such as drinking water and biodiversity) that were at risk from wildfire. In general, proactive approaches that were considered effective were also the most supported. The most highly supported approaches included enforcement of regulations and education, both of which are considered provincial responsibility in BC and are unlikely to alter community values in the WUI. In contrast, approaches involving prescribed burning of the understory had the highest levels of opposition. Despite variability in these individual factors, social-political barriers related to financial and social (time and expertise) capacity primarily limited engagement with proactive wildfire management, including provincial and federal funding programs. However, these barriers are not equally felt across community groups; First Nations identified social capacity (such as expertise on government-sponsored approaches and awareness of

funding programs) as significantly more limiting than municipalities/regional districts. Our study illustrates the limitations of implementing a "shared responsibility" of proactive wildfire management in the WUI in BC without targeted supports to address unequal capacity barriers.

INTRODUCTION

Wildfire risk to communities is growing globally (Bowman et al., 2013) with impacts extending into the wildland-urban interface (WUI) where community values and flammable vegetation intersect (Johnston and Flannigan, 2018; Radeloff et al., 2018). Increasing wildfire risk to communities is driven by the convergence of population growth and expansion of the WUI (Radeloff et al., 2018), more intensive land use for agriculture and forestry in surrounding landscapes (Bowman et al., 2011), and climate change impacts (Moritz et al., 2012; Jolly et al., 2015; Hanes et al., 2019). In response to these growing risks, governments and fire agencies are urging communities to proactively address wildfire risk rather than depend wholly on reactive fire suppression that can be ineffective under extreme conditions (Schoennagel et al., 2017; Tymstra et al., 2020). Although an emphasis on proactive wildfire management approaches is an important paradigm shift (Stephens et al., 2013; Higuera et al., 2019; McWethy et al., 2019; Tedim et al., 2019), most communities continue to be underprepared for wildfires in the WUI. Disentangling the unique complexity of factors that drive community engagement in proactive wildfire management is key for targeting appropriate pathways for enhancing community resilience to wildfire (Paveglio et al., 2016; Brenkert-Smith et al., 2017; Paveglio and Edgeley, 2017; Meldrum et al., 2018).

In North America, proactive wildfire management includes a range of approaches, generally categorized into prevention (including mitigation) and preparedness (Tymstra et al., 2020). Prevention attempts to stop wildfire from occurring and minimize the negative consequences if wildfire does occur, and includes reducing human-ignitions through public education and awareness; laws and regulations banning fire-starting activities; and fuel treatments, including prescribed burning (Canadian Interagency Forest Fire Centre, 2017; Tymstra et al., 2020). Fuel treatments are a common approach because they can be a highly effective at reducing risk in the WUI (Stephens et al., 2012; Prichard et al., 2021). Preparedness, on the other hand, includes approaches that help ensure effective response when a fire does occur, such as training and equipment for response organizations; coordination pathways between emergency responders; and community wildfire plans (Canadian Interagency Forest Fire Centre, 2017; Tymstra et al., 2020). Community wildfire plans are beneficial for helping communities prioritize fuel treatments, develop evacuation protocols, and identify key players during wildfire response based on their unique characteristics. Despite this broad range of potential approaches, communities continue to experience catastrophic

effects from wildfires due to variable engagement with proactive wildfire management (McCaffrey, 2015; Brenkert-Smith et al., 2017; Meldrum et al., 2018).

Factors Influencing Proactive Wildfire Management

An individual's values, identities, and perceptions of risks can strongly influence preferences and support for proactive wildfire management (McCaffrey et al., 2013; Paveglio et al., 2015). People are more likely to prefer approaches that they view as effective in reducing wildfire risk and that do not interfere with their values (McCaffrey et al., 2013). Many homeowners, for example, prefer education on wildfire and enforcement of regulations over fuel treatments and prescribed burning (Winter and Fried, 2000) that may change the character and amenity value of forests surrounding their home (Brenkert-Smith et al., 2006; McFarlane et al., 2011). Individual and collective identities (Dickson-Hoyle et al., 2021a) and connection to place (McFarlane et al., 2011; Bihari and Ryan, 2012; Beilin and Reid, 2015) also influence preferences and support for proactive management approaches. Indigenous peoples, for example, are more likely to support culturally-informed approaches such as revitalizing Indigenous burning practices (Miller et al., 2010; Xwisten Nation et al., 2018) or developing a community wildfire plan through community deliberation (Christianson et al., 2014), especially given the historical and ongoing exclusion of Indigenous peoples from fire-related decision-making by centralized governments (Nikolakis and Roberts, 2021; Copes-Gerbitz et al., accepted[1]; Hoffman et al., accepted[2]). Finally, although risk perception is highly personal and mediated by values and identities, many people living in areas at high risk of wildfire in the WUI are aware of the risk (McCaffrey et al., 2013). Nevertheless, an individuals' perception of high risk is not necessarily a singular catalyst for engagement with proactive wildfire management (Martin et al., 2009; Harris et al., 2011; Brenkert-Smith et al., 2012).

The individual factors indicated above are situated within and interact with broader social-political factors that operate at community, regional, and national scales. While social-political factors collectively create the broader context in which individual decisions are made [e.g., policies, programs and funding, organizations or institutions, community-organization

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[1]Hoffman, K. M., Cardinal Christianson, A., Dickson-Hoyle, S., Copes-Gerbitz, K., Nikolakis, W., Diabo, D. A., et al. (accepted). The right to burn: barriers and opportunities for Indigenous-led fire stewardship in Canada. *Facets.*

[2]Copes-Gerbitz, K., Hagerman, S. M., and Daniels, L. D. (accepted). Transforming fire governance in British Columbia, Canada: an emerging vision for coexisting with fire. *Reg. Environ. Change.*

relationships, and trust (Paveglio et al., 2012; McCaffrey et al., 2013; Abrams et al., 2015)], here we define social-political factors as public support or opposition, perceived responsibility for action, and community capacity. Individual preferences for action can collectively manifest as public support or opposition for particular proactive approaches, which in turn can influence community-level engagement in proactive management (Paveglio et al., 2012; McCaffrey et al., 2013). Previous research shows that individuals generally perceive proactive wildfire management as a shared responsibility, with homeowners responsible for their own properties and governments responsible for approaches on public lands, such as education and enforcement (Winter and Fried, 2000; McGee, 2007; Weisshaupt et al., 2007; McCaffrey, 2015). The reality of shared responsibility, however, is complex and often results in a tension between governments' emphasis on "empowering" communities and the existing capacities of communities to accept additional responsibilities (Lukasiewicz et al., 2017; Reid et al., 2018).

Community capacity to engage with proactive wildfire management is mediated by the broader social-political context. This capacity, including both social (staff time, expertise) and financial (funding) capacity, can be a major barrier for communities if adequate supports are unavailable (Abrams et al., 2015). For example, external government funding is fundamental to the ability of communities to prioritize proactive wildfire management over other issues, both before (Harris et al., 2011; McCaffrey, 2015; Labossière and McGee, 2017) and after (Meldrum et al., 2018) a wildfire event. Access to funding alone is not sufficient, however; social capacity is needed to apply for, develop, and implement proactive approaches within the scope of a given funding program (Harris et al., 2011; Labossière and McGee, 2017; Reid et al., 2018). Many communities require a "champion" who has the expertise, social license, and organizational relationships to successfully engage proactively in wildfire management (Koebele et al., 2015; Labossière and McGee, 2017; Paveglio et al., 2018). Understanding and addressing the unique social-political factors that can manifest as barriers to engagement is a priority for targeting efforts to ensure communities are adequately prepared for wildfire (Brenkert-Smith et al., 2017; Paveglio et al., 2018).

While diverse individual and social-political factors make generalizing the findings across communities difficult (McCaffrey et al., 2013; Christianson et al., 2014; Paveglio et al., 2015; Meldrum et al., 2018), different community characteristics influence engagement with proactive fire management. Specifically, community type, population size, and connection to the surrounding landscape influence engagement (Paveglio et al., 2015). Following Paveglio et al. (2015) "archetypes," the spectrum of communities ranges from formal or incorporated communities in high-density suburban areas (outside large cities), to those with somewhat lower density (often second homes) and high recreational or outdoor amenity value, to low-density rural communities (often unincorporated), to resource-dependent communities that draw their livelihoods from surrounding environments. At one end of the spectrum, high-density suburban and high amenity communities tend

to have sufficient financial and social capacity to undertake proactive wildfire management (and rely on external expertise to do so), although high-amenity communities are more likely to focus management efforts beyond the WUI (Trainor et al., 2009; Paveglio et al., 2015). At the other end of the spectrum, rural and resource-dependent communities with lower populations tend to have less financial and social capacity (Trainor et al., 2009; Paveglio et al., 2015). Nevertheless, rural or remote communities are often characterized by a strong connection to place and sense of community that support an individuals' engagement in community-level approaches (Dickson-Hoyle et al., 2021a), especially where approaches align with cultural values such as in Indigenous communities (Christianson et al., 2014). Contrasting levels of engagement also reflect the broader reality that wildfire risk is unequally distributed, in part due to the fact that some communities are subject to greater vulnerabilities than others (Collins and Bolin, 2009; Wigtil et al., 2016; Davies et al., 2018; Erni et al., 2021). Despite these trends, identifying the unique local individual and social-political factors driving and limiting community engagement in proactive wildfire management is a key research need (McCaffrey, 2015; Brenkert-Smith et al., 2017; Meldrum et al., 2018), especially in Canada (McGee et al., 2015; Sankey, 2018; Johnston et al., 2020) where approximately four million people are living in interface areas at risk to wildfire (Erni et al., 2021).

Proactive Wildfire Management in Canada

In Canada, wildfire management is primarily a provincial responsibility, except on federal (Indian Reserves, National Parks, and Department of Defense) and municipal lands (Tymstra et al., 2020). In the westernmost province of British Columbia (BC), Canada, catastrophic wildfire seasons between 1998 and 2021 forced the evacuation of over 125,000 people, burned over ∼5.7 million hectares, and cost more than $5 billion (CAD; adjusted for inflation to 2020) in direct suppression alone (Public Safety Canada, 2021; Copes-Gerbitz et al., accepted, see text footnote 1, BC Wildfire Season Summary undated). Although much of the area burned was outside the WUI, it exceeds the total calculated WUI in BC (∼5.5 million hectares; Johnston and Flannigan, 2018). Three of the last five wildfire seasons (2017, 2018, and 2021) affected the largest area burned, with significant and ongoing social-ecological impacts (Abbott and Chapman, 2018). The 2003 wildfire season was one of the first to have catastrophic effects in the WUI in BC (Filmon, 2004). It catalyzed a shift toward proactive wildfire management and prompted new provincial and federal funding programs (the Strategic Wildfire Prevention Initiative, known as the Community Resiliency Investment Program since 2018; and Indigenous and Northern Affairs Canada's On-Reserve Forest Fuel Reduction Treatment program) to support proactive approaches (Filmon, 2004). While these funding programs have continued to evolve and some progress in proactive wildfire management has occurred (Labossière and McGee, 2017; Copes-Gerbitz et al., 2020; Devisscher et al., 2021), communities across BC largely remain unprepared for ongoing catastrophic fire

seasons affecting the WUI (Abbott and Chapman, 2018; Daniels et al., 2018).

In BC, the WUI covers approximately 6% of land area and is primarily concentrated in the southern half of the province where there is a higher density of communities (Johnston and Flannigan, 2018). In general, the BC Wildfire Service (a provincial government organization) is responsible for wildfire management, although historically has been a response-focused organization (Copes-Gerbitz et al., accepted, see text footnote 1). The responsibility for proactive wildfire management in the WUI is not currently mandated, although the BC Wildfire Service and provincial Ministry of Forests, Lands, Natural Resource Operations, and Rural Development have started to prioritize it since 2017 (Abbott and Chapman, 2018; Copes-Gerbitz et al., accepted, see text footnote 1). These provincial organizations work directly with incorporated or formal communities (municipalities), while unincorporated communities (those in more rural locations outside of municipal boundaries) are primarily represented by regional districts. First Nations[3] communities living on Reserve lands were—until recently—required to work directly with the federal (rather than provincial) government to access proactive wildfire management funding. Across most of BC, First Nations continue to claim sovereignty over lands that were never formally ceded to the government and are actively revitalizing proactive wildfire management across their traditional territories (Lewis et al., 2018; Verhaeghe et al., 2019; Nikolakis and Roberts, 2021; Hoffman et al., accepted, see text footnote 2).

Given that proactive wildfire management funding in BC is targeted at the community-level, our study sought to understand the perspectives of community-level decision-makers (rather than homeowners) who can act as important leaders in motivating action in their communities, including elected and appointed community leaders, emergency services coordinators, fire chiefs, and forest managers (Koebele et al., 2015; Labossière and McGee, 2017; Madsen et al., 2018). We sought to better understand the factors driving engagement with proactive wildfire management across BC to supplement the limited case study data available (Labossière and McGee, 2017). There were two main objectives of our study:

(1) To quantify perceptions of wildfire risk, preferred approaches, and barriers to action in the WUI
(2) To explore the influences of community type, population, region and level of engagement on risk perception, preferred approaches, and barriers to action.

Through this study, we highlight that despite widespread perception of high risk, a range of factors drive variable community engagement with proactive wildfire management. Further, we demonstrate that capacity–both social and financial–is a persistent barrier to action and limits the ability of communities to "share responsibility" for wildfire management.

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[3]First Nations are a distinct group of Indigenous peoples recognized by the Constitution of Canada (Department of Justice Canada 1982).

MATERIALS AND METHODS

Data Collection

We used an online survey to elicit the perspectives of community-level decision-makers who are involved directly or indirectly with addressing wildfire risk in the WUI in BC. Our targeted sample included elected officials (e.g., mayors and councilors of municipalities or elected Chiefs and Councilors of First Nations), Chief Administrative Officers, public safety or emergency services coordinators, fire chiefs, foresters or land managers, or private-sector fire practitioners. The survey was designed and pre-tested with feedback from an advisory panel that included leaders from multiple organizations engaged in proactive wildfire management (Czaja and Blair, 2005). The survey was created with FluidSurveys software[4] and distributed between September 2016 and March 2017 through individual email invitations (via the advisory panel) as well as through member newsletters of relevant organizations (the Union of BC Municipalities, First Nations Emergency Services Society and the BC Community Forest Association). Via this distribution method, communities included organized municipalities, unincorporated communities that are managed by regional districts, First Nations communities on Federal Reserves, and First Nations communities living outside of Reserves (the latter two collectively referred to as First Nations). In total we received 77 completed surveys; all questions had at least an 86% completion rate.

The survey was comprised of 26 questions, including multiple choice, Likert-scale, and open-ended questions (**Supplementary Material**). In the first sections of the survey, we asked about the characteristics of the community the respondent represented, including respondents' role as a decision-maker or manager (to ensure respondents met our definition of relevant decision-maker), and community priorities, including (but not limited to) addressing wildfire risk. The latter sections of the survey addressed wildfire. This included questions about perceived wildfire risks, followed by questions about levels of support and preferences for a range of proactive wildfire management approaches. Finally, we asked about potential barriers to undertaking these approaches in their community.

Data Analyses

Given our interest in variation among communities, we defined four categories and grouped responses as follows: (1) community type (First Nations versus municipalities/regional districts); (2) population (fewer than or equal to versus more than 5,000 residents); (3) level of engagement (with versus without a community wildfire plan); and (4) region (Coast versus Kamloops versus Southeast, versus Northern; **Figure 1**). The first three regions correspond to individual fire management centers, while the Northern region includes respondents from the Cariboo, Northwest, and Prince George fire centers combined, because of a low response rate ($n = 12$). We note that although there are a low number of responses in some regions, we see this as reflective of the relatively small number of communities (Northern and Coast) and historical low
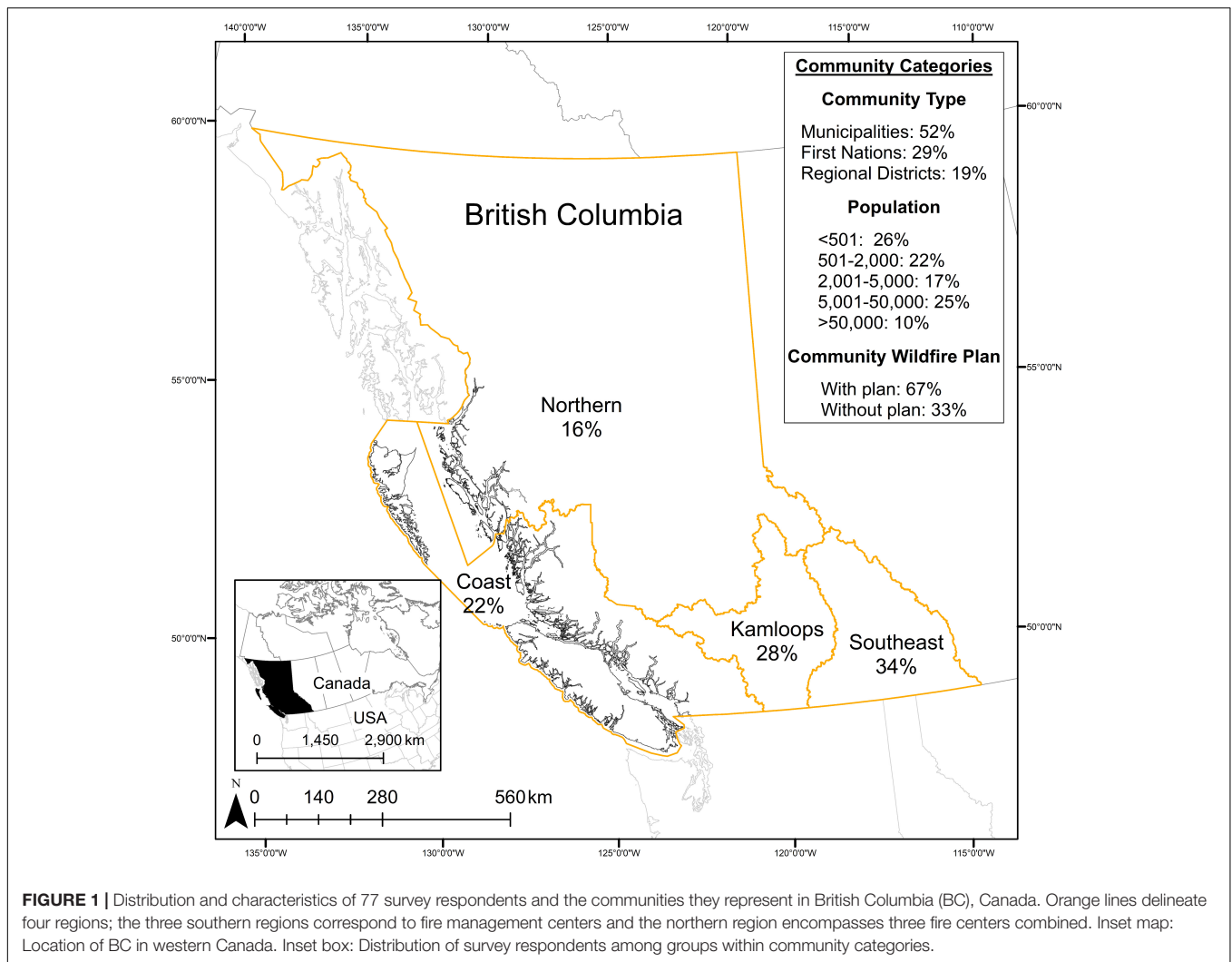
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[4]http://www.fluidsurveys.com

FIGURE 1 | Distribution and characteristics of 77 survey respondents and the communities they represent in British Columbia (BC), Canada. Orange lines delineate four regions; the three southern regions correspond to fire management centers and the northern region encompasses three fire centers combined. Inset map: Location of BC in western Canada. Inset box: Distribution of survey respondents among groups within community categories.
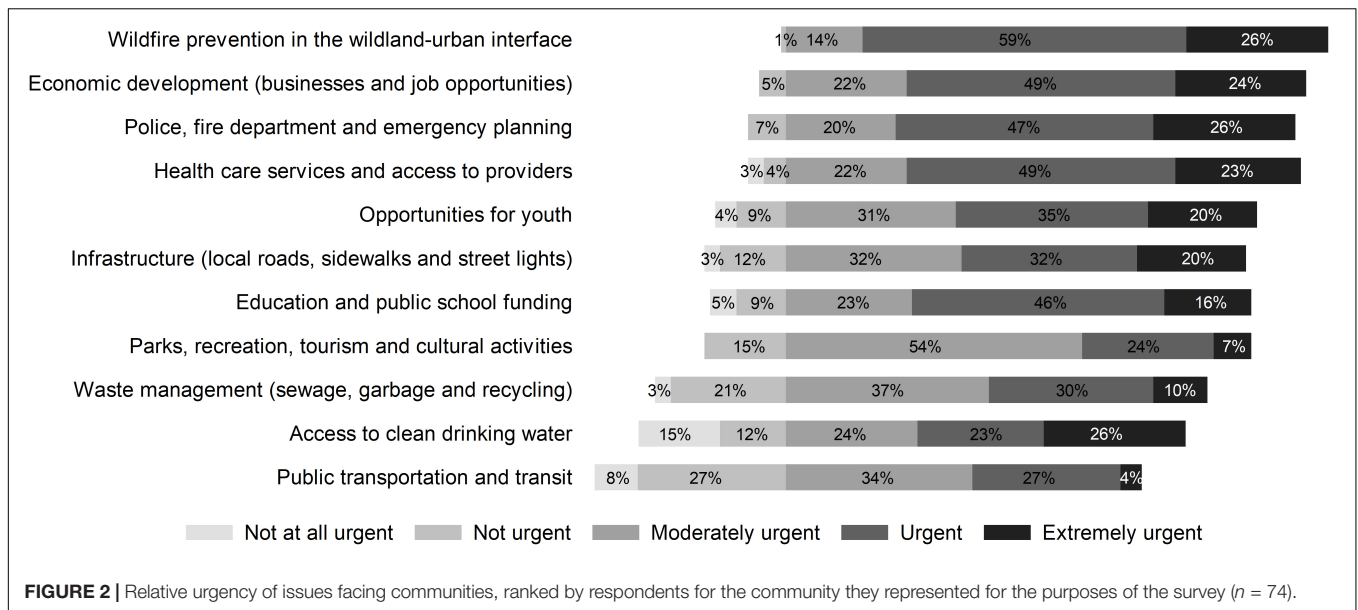
fire frequency (Coast). In subsequent analyses, groups within categories were independent variables, while dependent variables included perceptions of risk, preferred approaches, and barriers to action. Differences among and within categories were analyzed using non-parametric tests on ordinal and nominal variables using SPSS Statistics Version 24.0.

To examine differences in perspectives on ordinal variables, we ranked and compared responses among groups. For categories with two groups (e.g., categories 1-3) we used the Mann-Whitney U-test ("U"); for the four regions, we used the Kruskal Wallis-H test ("χ^2") and Dunn's *post hoc* pairwise comparisons with a Bonferroni correction (Lewis-Beck et al., 2011). Both tests ranked each score of the dependant variable, adjusted for tied ranks, and calculated median rank values for each group (Lewis-Beck et al., 2011; Agresti, 2013). Medians, rather than means, were statistically compared because the data were not normally distributed (Agresti, 2013). Therefore, statistical outcomes indicate relative rankings among groups. Adjusted p-values are shown where applicable (e.g., among regions).

To test for association between nominal variables (categories 1-3), we used a contingency table to determine if the differences between observed and expected frequencies were sufficient to signify a pattern in the larger population (Lewis-Beck et al., 2011). Where expected cell frequencies were greater than five, Chi-square tests ("χ^2") determined if there was a statistically significant association between variables. For significant outcomes, Phi (Φ) was used to determine strength of association and *post hoc* tests of adjusted standardized residuals were reported. For all statistical tests, the significance level was 0.05 and exact (2-tailed) p-values were presented because the datasets were small with many tied ranks, the number of observations among groups was uneven, and the data were skewed and not normally distributed (Mehta and Patel, 2012; Hinton et al., 2014).

RESULTS

Our results demonstrate that wildfire risk is an urgent issue facing communities across BC. However, there is variable

FIGURE 2 | Relative urgency of issues facing communities, ranked by respondents for the community they represented for the purposes of the survey (*n* = 74).

engagement with, preferences, and support for proactive wildfire management. Nevertheless, communities consistently think everyone should be doing more to reduce wildfire risk. Both financial and social capacity factors constrain engagement; these barriers are most pronounced for smaller (≤ 5,000 residents) and First Nations communities.

Perception of Wildfire Risk

Wildfire in the WUI was perceived as one of the most urgent issues facing communities (**Figure 2**), with 85% of respondents ranking it urgent or extremely urgent. In comparison, the next most urgent issues were economic development (63% urgent or extremely urgent) and emergency services (e.g., police, fire department, emergency planning; 63%). Despite the relative urgency of wildfire risk overall, respondents from First Nations communities were significantly more concerned about the urgency of wildfire risk than respondents from municipalities and regional districts (**Table 1**, Q10). Likewise, respondents from the Kamloops region (**Table 2**, Q10) were significantly more concerned about the urgency of wildfire risk than respondents from other regions. Ninety-six percent of respondents expect wildfire in the WUI will impact their community within the next 10 years; only one respondent from the Southeast region did not expect wildfire to impact their community within this timeframe. A majority of respondents (69%) rated the wildfire risk around their community as high or severe (**Figure 3**). Only two respondents, one each from the Coast and Southeast regions, rated the wildfire risk as low.

Across all respondents, the anticipated likelihood of wildfire impact was greatest for the loss of structures (85%), local livelihoods (79%), and recreational opportunities (78%) (**Figure 4**). Respondents representing First Nations communities ranked the likelihood of damage to drinking water and biodiversity significantly higher than respondents from municipalities and regional districts (**Table 1**, Q16). There were

no significant differences among respondents from different regions or from communities with contrasting populations.

Preferences for Wildfire Management Approaches

Almost all respondents indicated that all levels of government; industry and business; and individual homeowners should be doing more to reduce wildfire risk in the WUI (**Figure 5**). Ninety-five percent of respondents thought that the provincial government should be doing more, whereas only 75% of respondents thought the same about municipal governments. Respondents from smaller communities (≤ 5,000 residents) significantly felt that the federal government should be doing much more to reduce wildfire risk in the WUI compared to respondents from larger communities (> 5,000 residents; $U = 361$, $z = -2.379$, $p = 0.019$).

Many, but not all, proactive wildfire management approaches were both considered effective and supported by respondents (**Figures 6A,B**). The approaches ranked most effective and most supported included enforcement of the BC Wildfire Act (92 and 95%, respectively), tree pruning (94, 90%), and selective cutting with wood removal (90, 95%). In contrast, while raising awareness of ignition risks was one of the most highly supported approaches (95%), it was not considered one of the top five most effective approaches (84%).

Approaches involving prescribed burning of the understory (either with or without tree cutting) had the highest amount of opposition compared to other management approaches (23 and 22%, respectively). These two prescribed burning approaches, together with livestock grazing and selective cutting while leaving woodchips, were the four approaches that were considered least effective and had the highest rates of uncertainty of effectiveness among respondents. There were no significant differences in support or perceived effectiveness for approaches that included prescribed burning among the various community categories.

TABLE 1 | Perceptions of wildfire risk and fuels management among types of communities in British Columbia.
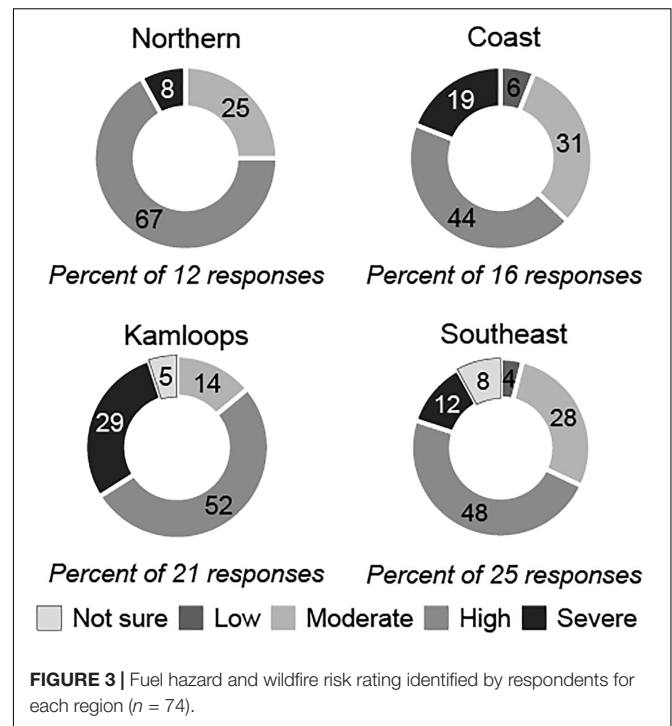
Question		Mean ranked value by community		U (z)	*p*-value
		First Nations communities and reserves ($n = 19$)	Municipalities and Regional Districts ($n = 53$)		
	Urgency (Q10) and likelihood of impacts (Q16)				
10	Views on urgency of wildfire prevention in WUI	28.5[a]	40.9[b]	359.0 (−2.510)	0.011
16	Views on the likelihood of wildfire causing damage to drinking water	25.2[a]	40.5[b]	289.5 (−2.892)	0.004
16	Views on the likelihood of wildfire causing loss of biodiversity	24.3[a]	39.7[b]	271.5 (−3.000)	0.002
	Effectiveness of management techniques (Q20)				
20	Selective cutting, piling the wood, and burning of wood piles	28.4[a]	39.2[b]	340.0 (−2.126)	0.033
	Barriers to proactive management (Q23) and funding programs (Q25)				
23	Other priorities although wildfire risk is a concern	41.7[a]	31.4[b]	293.5 (−2.051)	0.043
25	Lack of awareness of funding programs	23.1[a]	38.3[b]	239.0 (−2.887)	0.003
25	Concern about liability related to management actions or inactions	22.5[a]	34.9[b]	229.0 (−2.508)	0.012
25	Lack of qualified practitioners to prepare plans and prescriptions	22.2[a]	37.4[b]	224.5 (−2.938)	0.003
25	Lack of qualified practitioners to implement fuel management treatments	23.6[a]	37.6[b]	247.5 (−2.656)	0.008
25	Lack of guidelines on best practices for fuels reduction treatments	20.1[a]	36.7[b]	185.0 (−3.223)	0.001
25	Lack of guidelines on range of treatment costs	19.9[a]	36.1[b]	182.5 (−3.195)	0.001
25	Lack of evidence that treatments are effective	23.9[a]	35.0[b]	252.5 (−3.285)	0.023

Low mean rank values indicate high levels of concern (Question 16), support for approaches (Question 20), and more-limiting barriers (Questions 23 and 25). Within each row, values with the same superscript are not significantly different (Mann-Whitney U-test, α = 0.05). P-values all < 0.05.

TABLE 2 | Perceptions of wildfire risk and fuels management among regions of British Columbia.

Question	Mean ranked value by region				χ^2	p-Value
	Northern (n = 12)	Coast (n = 16)	Kamloops (n = 21)	Southeast (n = 25)		
Urgency (Q10)						
10 Views on urgency of wildfire prevention in WUI	38.1[b]	42.3[b]	27.8[a]	42.3[b]	8.217	0.039
Effectiveness of management techniques (Q20)						
20 Selective cutting and burning of wood piles	49.3[b]	34.8[ab]	25.2[a]	41.1[b]	7.917	0.002
20 Selective cutting of wood removal	41.2[b]	40.7[b]	25.5[a]	40.5[b]	9.513	0.020
20 Selective cutting of small understory trees and some large overstory trees	44.5[b]	36.1[b]	25.5[a]	36.2[b]	8.415	0.035
Personal support for management techniques (Q21)						
21 Selective cutting then wood removal	39.8[ab]	49.1[b]	24.9[a]	36.2[ab]	15.612	0.001
21 Selective cutting of small understory trees and some large overstory trees	51.8[c]	45.0[bc]	25.6[a]	33.1[ab]	16.959	< 0.001
21 Enforcement of bans, restrictions, fines	34.0[a]	53.1[b]	30.4[a]	31.9[a]	22.115	< 0.001
Barriers to proactive management (Q23)						
23 Lack of public support for fuels management	40.3[ab]	31.1[ab]	24.6[a]	39.3[b]	8.532	0.033
23 Negative public response to past fuels management	44.1[b]	4.5[b]	24.1[a]	32.8[ab]	7.936	0.044

Low mean rank values indicate high levels of concern (Question 10), effectiveness or support for approaches (Questions 20, 21), and more-limiting barriers (Question 23). Within each row, values with the same superscript are not significantly different [Kruskal-Wallis H ("χ^2") test, $\alpha = 0.05$].

FIGURE 3 | Fuel hazard and wildfire risk rating identified by respondents for each region (n = 74).

Perceptions of effectiveness and personal support for two proactive management approaches—selective cutting with wood removal and selective cutting of small understory trees and some large overstory trees—differed significantly among regions (**Table 2**, Q20, 21). Respondents from the Kamloops region perceived these approaches as being significantly more effective than respondents from all other regions, although respondents from the Southeast region shared a similar high level of personal support. Respondents from the Coast region supported enforcement of bans, restrictions, and fines significantly less than respondents from the other three regions. Respondents from First Nations felt that selective cutting and burning of wood piles was significantly more effective compared to respondents from municipalities and regional districts (**Table 1**, Q20), but there were no other differences in terms of support.

Engagement With and Barriers to Proactive Wildfire Management

Community participation in proactive wildfire management, funded through provincial or federal funding programs, was relatively high overall, but uneven across community categories. Eighty-nine percent of communities had participated in one or more approaches; the most common were: developing a community wildfire plan (67%) or fuel management prescriptions (55%), and participating in FireSmart (55%). Fewer communities had actually conducted (48%) or maintained (9%) a fuel treatment or updated an existing community wildfire plan (41%). Eleven percent of communities had not applied for or received funding for any management approaches. Municipalities and regional districts had significantly higher rates of community wildfire plan development than First Nations
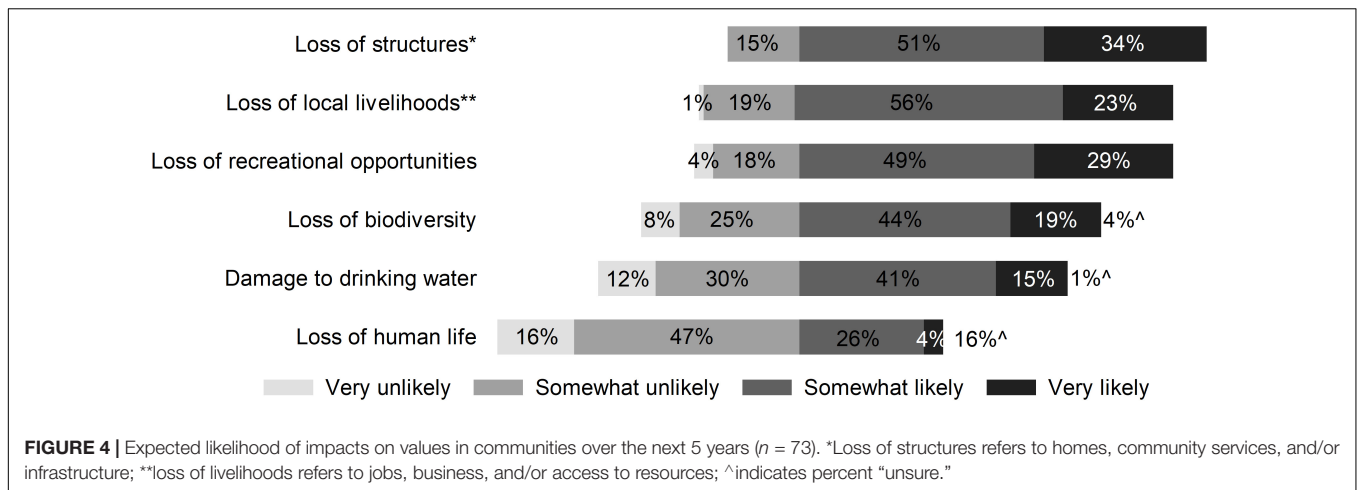
FIGURE 4 | Expected likelihood of impacts on values in communities over the next 5 years (n = 73). *Loss of structures refers to homes, community services, and/or infrastructure; **loss of livelihoods refers to jobs, business, and/or access to resources; ^indicates percent "unsure."
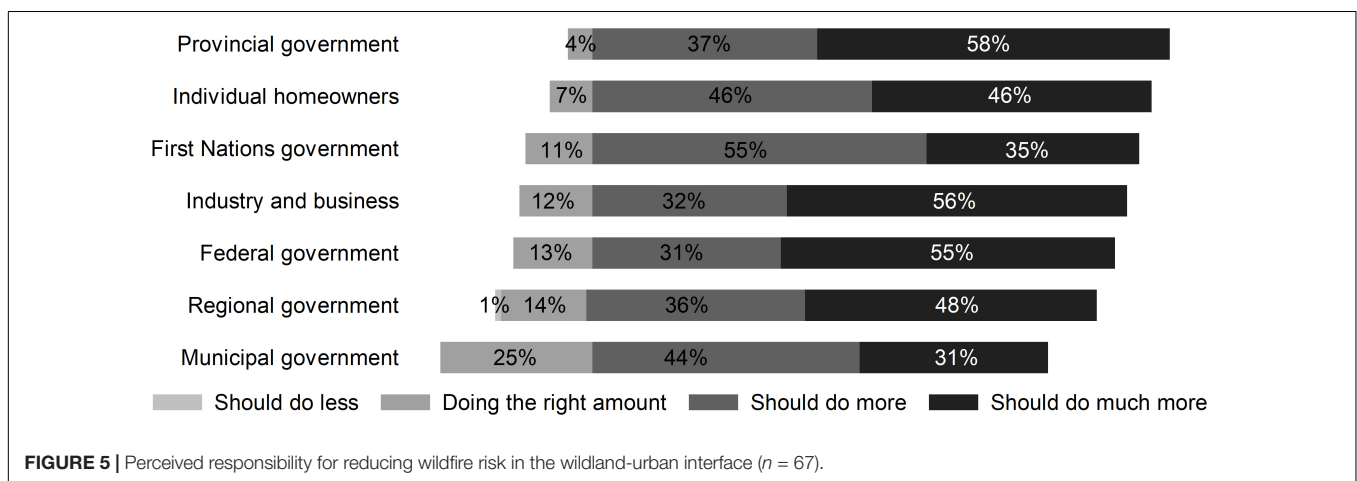

FIGURE 5 | Perceived responsibility for reducing wildfire risk in the wildland-urban interface (n = 67).
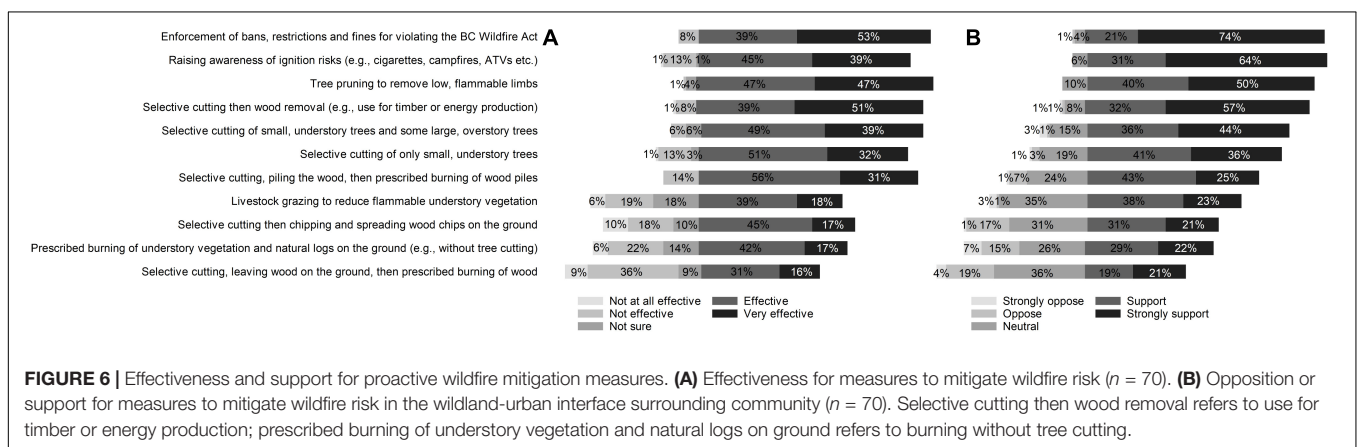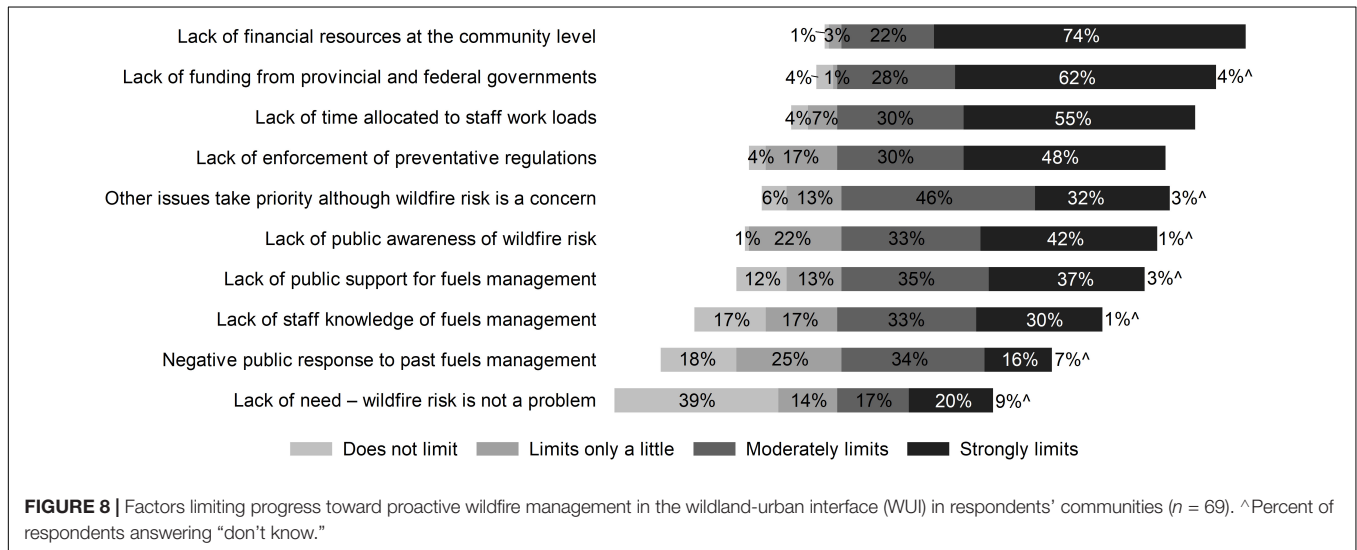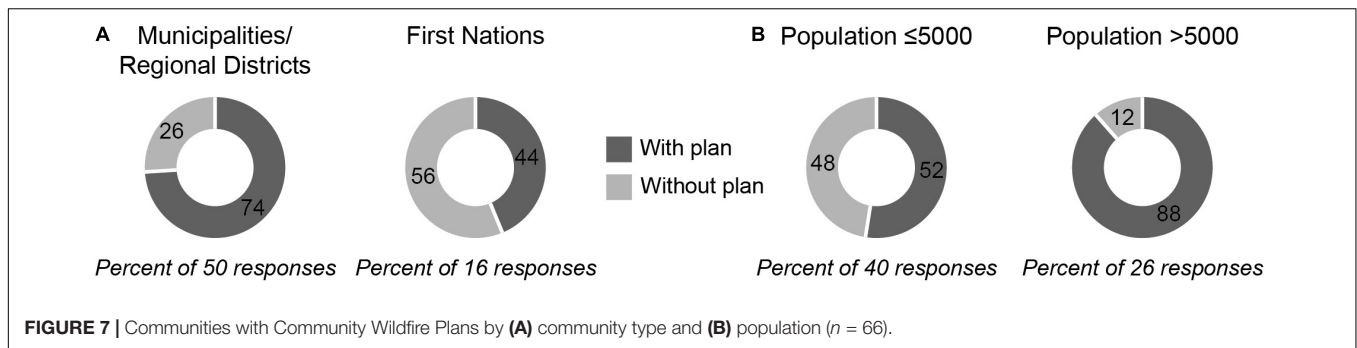

FIGURE 6 | Effectiveness and support for proactive wildfire mitigation measures. **(A)** Effectiveness for measures to mitigate wildfire risk (n = 70). **(B)** Opposition or support for measures to mitigate wildfire risk in the wildland-urban interface surrounding community (n = 70). Selective cutting then wood removal refers to use for timber or energy production; prescribed burning of understory vegetation and natural logs on ground refers to burning without tree cutting.

communities (χ^2 = 4.991, φ = −0.275, p = 0.035; **Figure 7A**). Larger communities with > 5,000 residents also had significantly higher rates of participation than communities with ≤ 5,000 residents (χ^2 = 9.170, φ = −0.373, p = 0.003; **Figure 7B**).

Across all respondents, capacity-related factors limited progress toward proactive wildfire management approaches in the WUI. Respondents identified a lack of financial resources at

the community level (96%), lack of funding from provincial and federal governments (90%), and a lack of time allocated to staff work loads (86%) as the most important factors moderately or strongly limiting progress toward proactive wildfire management (**Figure 8**). Although capacity issues were widespread, variation among communities highlighted the strong negative impacts when capacity is lacking. Specifically, all communities that

FIGURE 7 | Communities with Community Wildfire Plans by **(A)** community type and **(B)** population (*n* = 66).

FIGURE 8 | Factors limiting progress toward proactive wildfire management in the wildland-urban interface (WUI) in respondents' communities (*n* = 69). ^Percent of respondents answering "don't know."

had not developed a community wildfire plan or participated in any management approaches ranked a lack of financial resources at the community level as moderately (14%) or strongly limiting (86%).

Other barriers, beyond capacity, varied among community types and regions. Respondents from municipalities and regional districts felt that "other issues take priority although wildfire risk is a concern" was a more strongly limiting factor to proactive wildfire management than did those from First Nations communities (**Table 1**, Q23). All respondents whose communities had not conducted any management approaches rated "other issues take priority although wildfire risk is a concern" as strongly (50%) or moderately (50%) limiting. In addition, respondents from the Kamloops region indicated that a "lack of public support" and "negative public response to past fuels management" were significantly more limiting factors than other regions (**Table 2**, Q23).
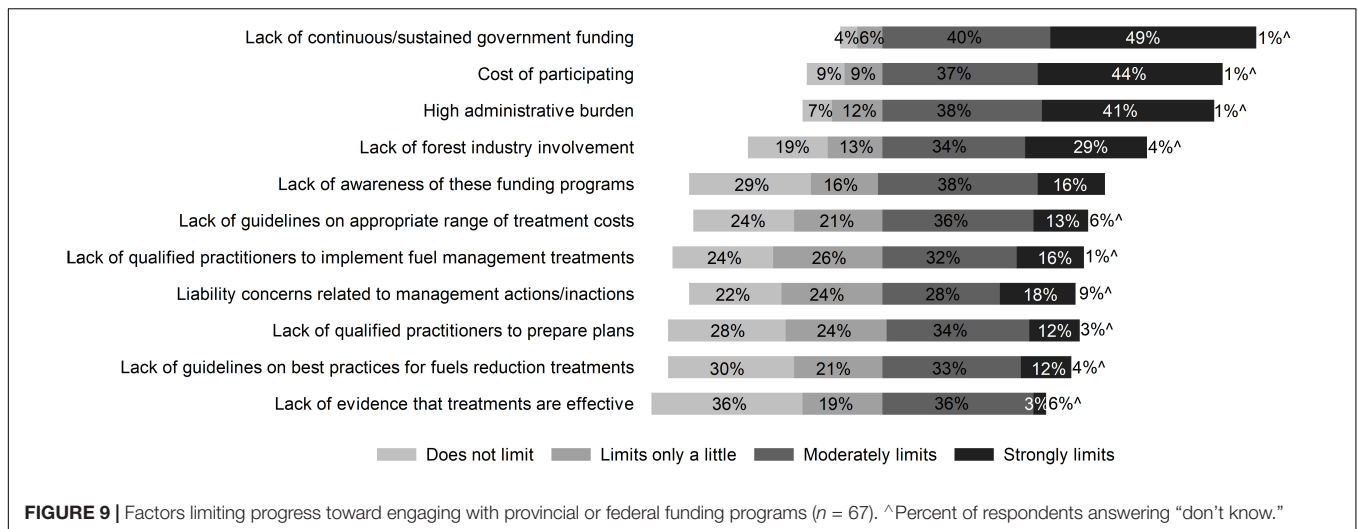
Respondents similarly identified capacity-related barriers as limiting progress toward engaging in provincial and federal funding programs. Respondents ranked a lack of continuous or sustained government funding (89%), costs of participating (81%), and high administrative burdens (79%) as the most important factors moderately or strongly limiting progress toward engaging with provincial or federal funding programs (**Figure 9**). Of the seven communities without a community

wildfire plan and that have not participated in any approaches, the most limiting factors were lack of continuous or sustained funding from governments (86% strongly limits, 14% moderately limits) and costs of participating (57% strongly limits, 43% moderately limits).

For most respondents, factors related to expertise and guidance were among those most likely to be noted as "does not limit." These factors included lack of evidence for treatment effectiveness (36%), lack of best practice guidelines on fuels reduction (30%), and lack of qualified practitioners to prepare plans (28%). In contrast, respondents from First Nations communities ranked expertise and guidance-related factors as significantly more limiting to progress engaging with funding programs than did municipalities and regional districts (**Table 1**, Q25). Furthermore, respondents from First Nations communities that felt that "lack of awareness of funding programs" was significantly more limiting than municipalities and regional districts (**Table 1**, Q25).

DISCUSSION

Overall, we identify two key findings: (1) there is a disconnect between the high perception of risk and the level of engagement in proactive wildfire management in BC, and (2) capacity

FIGURE 9 | Factors limiting progress toward engaging with provincial or federal funding programs (*n* = 67). ^Percent of respondents answering "don't know."

barriers primarily limit engagement, and these barriers are more significant for smaller and First Nation communities. We contextualize these findings below and offer insights to the ways in which proactive wildfire management in BC may be improved.

High Risk Perception Not a Singular Catalyst for Action

Respondents from all communities, regardless of type, population, level of engagement, and region, consistently recognized the high urgency of wildfire risk. This is important because awareness of risk is a key enabling factor for engagement with proactive wildfire management (Harris et al., 2011; McCaffrey et al., 2013), and is especially important given our sample of community decision-makers who often perform the role of local community champion pursuing proactive approaches (Koebele et al., 2015; Labossière and McGee, 2017; Paveglio et al., 2018). Nevertheless, there was significant variability among communities as to what values are viewed as being at risk, which can mediate individual decisions as to whether or which proactive approaches to undertake (McCaffrey et al., 2013; Paveglio and Edgeley, 2017). In our study, First Nations were the only community category that significantly identified wildfire risk to drinking water and biodiversity. This likely reflects the importance of these values for First Nations' health and wellbeing (Christianson et al., 2014; Christianson, 2015), as well as the priorities and challenges for many First Nations communities relating to access to clean drinking water (Patrick, 2011).

Despite the urgency of addressing wildfire risk, it is not a singular catalyst for action for communities in BC, mirroring findings from Alberta, Canada (Harris et al., 2011) and the United States (Martin et al., 2009; McCaffrey et al., 2013; Brenkert-Smith et al., 2017). Most communities in BC had received provincial or federal funding to develop community wildfire plans and fuel treatments, but fewer were at the stage of updating their plan or conducting fuel treatments. This trend

is consistent with findings that only 46% of communities across BC had developed a community wildfire plan by 2015 (Union of British Columbia Municipalities, unpublished data) and less than 10% of hazardous fuels were treated in BC between 2004 and 2014 (BC Forest Practices Board, 2015). Furthermore, both First Nations and smaller (≤ 5,000 residents) communities were less likely to have developed a community wildfire plan, likely reflecting the reality that First Nations (Christianson et al., 2014; Asfaw et al., 2019) and smaller communities (Trainor et al., 2009; Abrams et al., 2015) face larger capacity barriers to engage with proactive wildfire management.

One potential set of factors influencing engagement is individual support for and perceived effectiveness of approaches (McFarlane et al., 2011; Brenkert-Smith et al., 2017). Similar to communities in Alberta (McFarlane et al., 2011) and the United States (Winter and Fried, 2000; Brenkert-Smith et al., 2006), respondents identified enforcement of regulations as a highly supported and effective approach. On the other hand, education to raise awareness of ignition risks was equally supported as enforcement but was ranked as the sixth (of 11) most effective approach, reflecting the fact that most supported approaches tend to be those that are easiest to implement and less likely to affect community values (McGee, 2007; Faulkner et al., 2009; McFarlane et al., 2011). Enforcement and education are also considered a government responsibility in BC (for example, through the provincially coordinated and funded FireSmart program), which may contribute to a greater emphasis on these activities by local communities.

Among proactive management approaches to mitigate fuels, there were four that respondents considered least effective or were unsure about the effectiveness for their communities. Tree cutting but leaving woodchips used to be a common practice but is no longer permitted in BC due to short-term increases in fuel loads and potential surface fire intensity. Similarly, prescribed fire in dense forests without first cutting and removing trees may result in undesirable fire effects. Thus, a perceived lack of effectiveness for these two approaches may reflect respondents' expertise in fire

behavior and forest management; this is confirmed by the finding that "lack of information regarding fuel treatments" is not strongly limiting. In contrast, prescribed burning following tree cutting and livestock grazing were also considered less effective by respondents although they have proven effective in other jurisdictions (Schwilk et al., 2009; Prichard et al., 2021; Rouet-Leduc et al., 2021). These approaches are not common practice for reducing fire risk in BC, so respondents may not be familiar with the effectiveness of these approaches, which can be a barrier to uptake (McGee, 2007; McCaffrey et al., 2013). As well, tree cutting, prescribed burning, and grazing may negatively affect amenity values and may therefore be seen as less effective (Winter and Fried, 2000; McFarlane et al., 2011; McCaffrey et al., 2013). These discrepancies highlight the important role of community leaders as experts but also the important knowledge and experience gaps in BC.

Preferences and support for proactive approaches also varied by region and community type, but interpretations of these findings may be limited by the set of approaches included in the survey and the fewer number of responses from the Coast and Northern regions. Respondents from the Kamloops and Southeast region were more likely to support two of the selective cutting options that reduce the density of fuels on the landscape, perhaps because these are the regions that were historically characterized by open forests adapted to frequent fire (BC Ministry of Forests, and BC Ministry of Environment, 1995) compared to wetter forest ecosystems on the Coast, for example. In addition, only respondents from the Kamloops region indicated that public opposition is a barrier to engagement, suggesting it is not a driving factor province-wide but may be regionally important. The lack of difference between First Nations and municipalities/regional districts with regards to preferences and support was surprising given other evidence from Canada that Indigenous peoples' preferences for wildfire management are tied to their cultural identities (Miller et al., 2010; Christianson et al., 2014; Christianson, 2015; Xwisten Nation et al., 2018). We attribute this to the fact that the survey questions on preferences and support did not specifically include culturally-informed approaches such as revitalizing cultural burning, which is a key priority for many First Nations in BC (Lewis et al., 2018; Xwisten Nation et al., 2018; Verhaeghe et al., 2019; Nikolakis and Roberts, 2021). Beyond these individual factors, however, there is a widespread gap between high levels of risk perception and equivalent levels of engagement: a gap we largely attribute to financial and social capacity barriers.

Overcoming Capacity Barriers to Proactive Wildfire Management

Although individual values and preferences influence engagement with proactive wildfire management, the broader social-political context is increasingly recognized as a significant barrier to engagement (Steelman et al., 2004; Abrams et al., 2015; Meldrum et al., 2018). While financial capacity is only one part of this context, our research demonstrates that it is a key barrier in BC: all communities that had not yet undertaken

any proactive approaches or engaged with provincial or federal funding programs indicated that financial barriers were strongly limiting progress. Similarly, lack of funding is a major barrier to developing and implementing community wildfire plans for communities across the United States (Reams et al., 2005; Absher et al., 2017) and in Alberta (Harris et al., 2011). Our findings are consistent with one of the few case studies from BC, which also found that provincial funding was critical to the ability of two communities to undertake proactive wildfire management and that these communities were concerned that a lack of sustained funding would hamper their future efforts (Labossière and McGee, 2017). Our results demonstrate external funding is imperative given limited budgets for communities in BC that must make trade-offs with other critical services such as education, health care, infrastructure, and police services.

While, Labossière and McGee (2017) noted that population size did not seem to affect the ability of two BC communities to complete proactive approaches, our study found that smaller ($\leq$ 5,000 residents) and First Nations communities were less likely to develop a community wildfire plan. Because community wildfire plans, under the provincial funding program, were cost-shared between the government and communities from 2004–2017, our findings provide further evidence that a lack of financial resources within more rural and remote communities can be a major barrier to action (Trainor et al., 2009; Paveglio et al., 2015; Wigtil et al., 2016). To address this financial burden, provincial government wildfire funding models in BC have recently changed to provide 100% of funding to communities and expand the scope to support approaches on First Nations reserves (previously only allowed under the federal funding stream) and private property.

In addition to financial capacity, social capacity (including staff time and expertise) also limits the ability of communities to undertake proactive wildfire management. These barriers are unequally experienced, with First Nations identifying greater limits to capacity. Beyond the barriers faced by municipalities and regional districts, First Nations face additional jurisdictional issues that affect awareness of and access to potential funding programs because of the role of the Federal government holding jurisdiction over Reserve land (Hoffman et al., accepted, see text footnote 2). We also note that the unique expertise and knowledge of First Nations–such as in relation to cultural burning–is not necessarily supported by current government-led initiatives for proactive wildfire management (Christianson et al., 2014; Hoffman et al., accepted, see text footnote 2). In contrast, respondents from municipalities and regional districts did not identify social capacity challenges as a major limitation to engagement, instead indicating that addressing wildfire risk is one of many competing priorities. Similarly, in Alberta, local governments struggled with adding proactive wildfire management to their already full agendas and often did not have a dedicated member of staff for wildfire issues (Harris et al., 2011).

A key challenge to addressing these capacity barriers is interpreting and applying the idea of wildfire management as a "shared responsibility," in which all individuals and levels of government contribute through coordinated and collective action (McLennan and Handmer, 2012; Smith et al., 2016; Lukasiewicz et al., 2017). This idea is taking hold in

Canada (McGee et al., 2015; Canadian Council of Forest Ministers, 2016; Sankey, 2018), including in BC (Filmon, 2004; BC Wildland Fire Management Branch, 2010; Abbott and Chapman, 2018). However, the reality of how that responsibility is shared is still uncertain and often contested with unclear mechanisms for accountability (McLennan et al., 2019; Atkinson and Curnin, 2020). Despite an increasing emphasis in government policies and discourse on empowering and building resilience in communities, governments and wildfire agencies retain authority over wildfire and emergency management and expect that individuals will act on government advice and direction (Lukasiewicz et al., 2017; Atkinson and Curnin, 2020). Often the "shared responsibility" approach shifts responsibilities for proactive wildfire management from governments to communities and individuals without governments providing the necessary coordination or capacity supports needed to act on that responsibility (McLennan et al., 2019; Atkinson and Curnin, 2020).

Our study indicates that community decision-makers mirror the governments' emphasis on shared responsibility (**Figure 5**), yet the provincial government was ranked as the group that should be doing the most. In some ways, the provincial government has already heeded this call through the development and adaptation of funding programs, hiring more staff to reduce the burden on communities and provide expertise where needed, and showing a willingness to work with and learn from Indigenous and local experts (Abbott and Chapman, 2018; Emergency Management BC and Ministry of Forests, 2018). However, lessons learned from the 2017 fire season demonstrate that meaningful shared responsibility–in which communities are empowered (including through financial and social capacity building) to be "true partners and leaders" (Abbott and Chapman, 2018: 81)–continues to be an ongoing challenge, particularly for First Nations and rural communities (Abbott and Chapman, 2018; Verhaeghe et al., 2019; Dickson-Hoyle and John, 2021; Nikolakis and Roberts, 2021). This is a pervasive issue in wildfire-prone countries that must be addressed to help communities in the WUI minimize catastrophic impacts from future fires (BC Forest Practices Board, 2015; Lukasiewicz et al., 2017; Reid et al., 2018).

The Future of Proactive Wildfire Management in British Columbia

Our survey is the first study into perceptions of wildfire risk, preferred approaches, and barriers to proactive wildfire management for communities in BC. As research elsewhere has shown (McCaffrey et al., 2013; Abrams et al., 2015; Meldrum et al., 2018), our study highlights that addressing wildfire risk is an urgent priority for communities but there are many barriers to action—and that these barriers are experienced unequally across communities. At the same time, there is growing evidence that diverse communities are successfully undertaking proactive wildfire management. One pathway for this proactive management is through the BC Community Forest tenure, in which risk reduction and preparedness actions in the WUI can be prioritized (BC Community Forest Association, 2020; Copes-Gerbitz et al., 2020; Devisscher et al., 2021). The proactive

management undertaken by the Logan Lake Community Forest in the WUI (Labossière and McGee, 2017), for example, helped protect the community from damage during the 2021 fire season in BC (British Columbia FireSmart, 2021). Another pathway is direct action by First Nations to revitalize fire stewardship and build capacity for wildfire response (Lewis et al., 2018; Xwisten Nation et al., 2018; Verhaeghe et al., 2019; Dickson-Hoyle and John, 2021). Both pathways provide key opportunities for First Nations and smaller communities (among others) to translate a high perception of risk into action in the WUI.

Nevertheless, challenges remain, and many communities will continue to be unprepared without additional changes to enhance financial and social capacities. For the former, despite changes to the provincial funding model after the 2017, 2018, and 2021 fire seasons, there is still a significant funding deficit between reactive (suppression) and proactive wildfire management in BC. Direct wildfire suppression costs from 2003–2017 were $3.1 billion (CAD)–with an additional $1.5 billion spent since 2018–compared to $78 million for proactive management in the WUI over that same time period (Daniels et al., 2018). Experts suggest at least several billion dollars of committed funding from the government is needed to meaningfully address wildfire risk in BC (Copes-Gerbitz et al., accepted, see text footnote 1), especially given the high cost of fuels treatments in the WUI at a median of $5,000 per hectare (BC Forest Practices Board, 2015; Daniels et al., 2018).

Enhancing social capacity could occur through outreach positions within government to help communities navigate funding programs (Copes-Gerbitz et al., 2020), additional research and training for a range of individuals to develop expertise in proactive wildfire management (such as certifications for burn bosses to undertake prescribed burning, guidelines for fuels treatments, and development of community wildfire plans), and policy changes to help recognize expertise of First Nations communities (e.g., through cultural burn plans; Hoffman et al., accepted, see text footnote 2). Lessons from Community Forests (Copes-Gerbitz et al., 2020) and First Nations (Lewis et al., 2018; Lake and Christianson, 2019; Verhaeghe et al., 2019; Dickson-Hoyle and John, 2021; Dickson-Hoyle et al., 2021b) in BC can be used to help guide more communities develop social capacity for proactive wildfire management. As a key example, Secwépemc communities (a group of First Nations communities in the central interior of BC) called for sharing responsibility through the establishment of First Nations Emergency Management Offices with funded Emergency Management Coordinators, initial attack crews, and First Nations firekeepers—an opportunity to simultaneously share responsibility while decentralizing resources to support new responsibilities (Dickson-Hoyle and John, 2021). Furthermore, successes from other fire-prone jurisdictions [such as the Working in Fire program in South Africa and the Prescribed Fire Training Exchanges (TREX) in the United States] also provide important models for social capacity building.

For the future of proactive wildfire management in the WUI, and as Brenkert-Smith et al. (2017) and Paveglio et al. (2018) similarly argue, our findings indicate that it is imperative to recognize and address the variety of barriers and needs of communities across BC: there is no one-size-fits-all approach.

While, First Nations and smaller communities continue to face persistent capacity barriers accessing funding and undertaking proactive management in its current form in BC, these communities also hold unique expertise for addressing wildfire risk (Abbott and Chapman, 2018; Hoffman et al., accepted, see text footnote 2). Learning from noteworthy examples such as the FireSmart Canada booklet *Blazing the Trail: Celebrating Indigenous Fire Stewardship*, aligning funding and risk reduction approaches (e.g., community wildfire plans) with these underappreciated forms of expertise could help advance proactive wildfire management for communities across BC.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available due to confidentiality requirements outlined in our ethics approval from the University of British Columbia Behavioural Research Ethics Board. Questions about the datasets should be directed to KC-G, kelsey.copes-gerbitz@ubc.ca.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of British Columbia Behavioural Research Ethics Board. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LD, SH, and JC designed the study. SR, LD, and SH collected and analyzed the data. KC-G, SD-H, and SR drafted the manuscript. All authors contributed to manuscript finalization.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/ffgc.2022.829125/full#supplementary-material

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