

Residential Wood-Burning Appliances: District of Vanderhoof Door to Door Survey Results

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And

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1 Executive Summary

In response to ambient measurements of particulate matter in Vanderhoof exceeding federal and provincial air quality objectives in recent years, the District of Vanderhoof and the BC Ministry of Environment and Climate Change Strategy (BC ENV) funded a door-to-door survey to inform future air quality improvement initiatives. This survey assessed the community's perceptions of air quality in Vanderhoof, how much it is perceived to be affected by smoke from wood burning appliances, how many people in the community use wood burning appliances, and how they use them. The survey door-to-door was conducted from July 21 to August 16, 2017. Of 949 homes targeted by the survey, 552 (58%) homes participated. The key findings from the survey are as follows:

- Community perceptions of air quality seem to contradict ambient measurements, with 89% of residents reporting air quality in Vanderhoof to be "practically always good" or "mostly good, but poor on occasion".
- Most residents (~60%) do not believe that smoke from wood burning appliances affects air quality in the community.
- Over a third of residents (37%) reported using a wood-burning appliance – higher than the average for BC outside Metro Vancouver (30%) and the Northern Region (includes Omineca, Skeena and the Northeast) (34%).
- Approximately half of residents that burn firewood for heat were not aware of whether or how long they seasoned their firewood prior to burning. Burning seasoned firewood produces more heat and less smoke, and can save money by reducing wood consumption by 25%.
- At least 13% of wood-burning appliances in the community are likely not emissions-certified as they are over 23 years old and pre-date a legislative requirement for such certification. Over a quarter of residents with wood-burning appliances did not know if their appliance was emissions-certified. Uncertified appliances do not burn fuel as efficiently and emit more smoke both indoors and outdoors.

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5 Introduction

Air quality in Vanderhoof has been poor for at least the past 6 years relative to federal standards for PM_{2.5} ('fine' particulate matter with a diameter of up to 2.5 micrometers) and relative to air quality in other communities in the province. The community is one of only two in BC that have consistently been categorized in the highest priority "red" air zone management level from 2011-2016, according to the Canadian Ambient Air Quality Standards (CAAQS) for PM_{2.5} (BC ENV, 2017a).

PM_{2.5} is of particular concern for human health because these particles are small enough to readily pass through the respiratory tract and enter the bloodstream. Increases in ambient PM_{2.5} concentrations are associated with many adverse health effects including increased rates of chronic and acute respiratory and cardiac disease and mortality (Apte et al., 2015; BC Lung, 2017b). Even short term increases in PM_{2.5} are associated with an increased risk of heart attacks among those over 65 years of age (BC Lung, 2017b).

Smoke from wood-burning appliances is the focus of this report not only because wood-burning appliances are a major source of PM_{2.5}, but because replacing old, inefficient wood-burning appliances with emissions-certified appliances or alternative heating sources is one of the most direct, cost effective ways that households can improve air quality in their homes and communities. Figure 1 shows the difference in the relative emissions of fine particulate matter between combustion heat sources (US EPA, 2017).

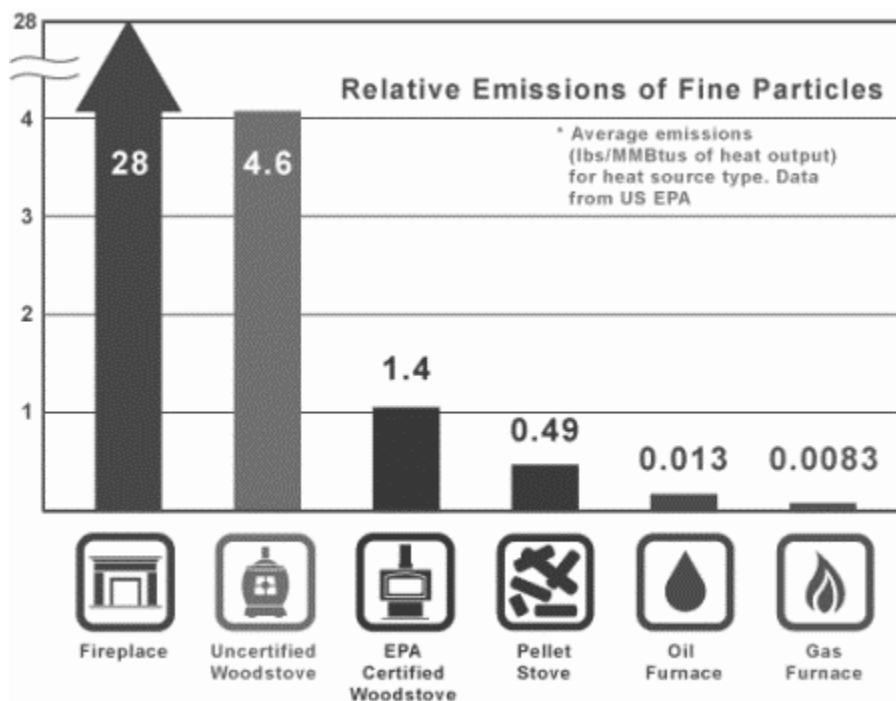


Figure 1: Relative fine particulate matter emissions from combustion heating appliances (US EPA, 2017).

In Libby, Montana, a Rocky Mountain valley community susceptible to winter inversions that exceeded national PM_{2.5} standards in 2004, residential wood combustion was found to contribute 82% of outdoor PM_{2.5} measured during the winter months. A study by Noonan et al. (2012) in Libby found that replacing old, inefficient wood stoves with EPA-certified wood stoves led to decreased indoor PM_{2.5} concentrations of 53% (from a 24-hour average of 45 ug/m³ to 21 ug/m³). This decrease was attributed to decreased indoor escape of wood smoke, greater burn efficiency and lower chimney emissions resulting in less wood smoke re-entering the homes.

A door-to-door survey on residential wood-burning appliance usage was conducted in Vanderhoof from July 21st to August 16th, 2017. The intent of this survey was to determine the current state of wood-burning appliances and behaviours in the community in a manner that will inform future airshed management actions. It was modelled on a similar survey conducted by Jesse Hiemstra for Smithers in 2016 and his recommendations for future surveys (Hiemstra, 2016). This report presents the survey methods, results, sources of error, recommendations for future surveys, and conclusions for Vanderhoof.

6 Survey Methods

The survey targeted 949 single-family and multi-family residences with unobstructed street-level entrances, including duplexes and mobile homes. Apartments, businesses, assisted living facilities, residences displaying “no trespassing” signs, and residences perceived to be vacant, unsafe, unsanitary or otherwise uninviting to canvassing personnel were excluded.

Six neighbourhoods in Vanderhoof were included in the study, as shown in Figure 2: 1st - 7th Streets, Burrard, Loop Road, Northside, PG Hill and Riverview. Loop Road, Aspen and Markay (the latter two, not shown in Figure 2, are located southeast of the PG Hill neighbourhood) were planned as optional neighbourhoods to be included if time permitted. In order to meet the planned project timeline, only the parts of the Loop Road neighbourhood shown in Figure 2 were surveyed. While it would have been preferable to include the Markay and Aspen subdivisions, it is worth noting that because these neighbourhoods are less densely populated and are not located at the bottom of the Nechako River valley, they are less prone to wood smoke accumulation.

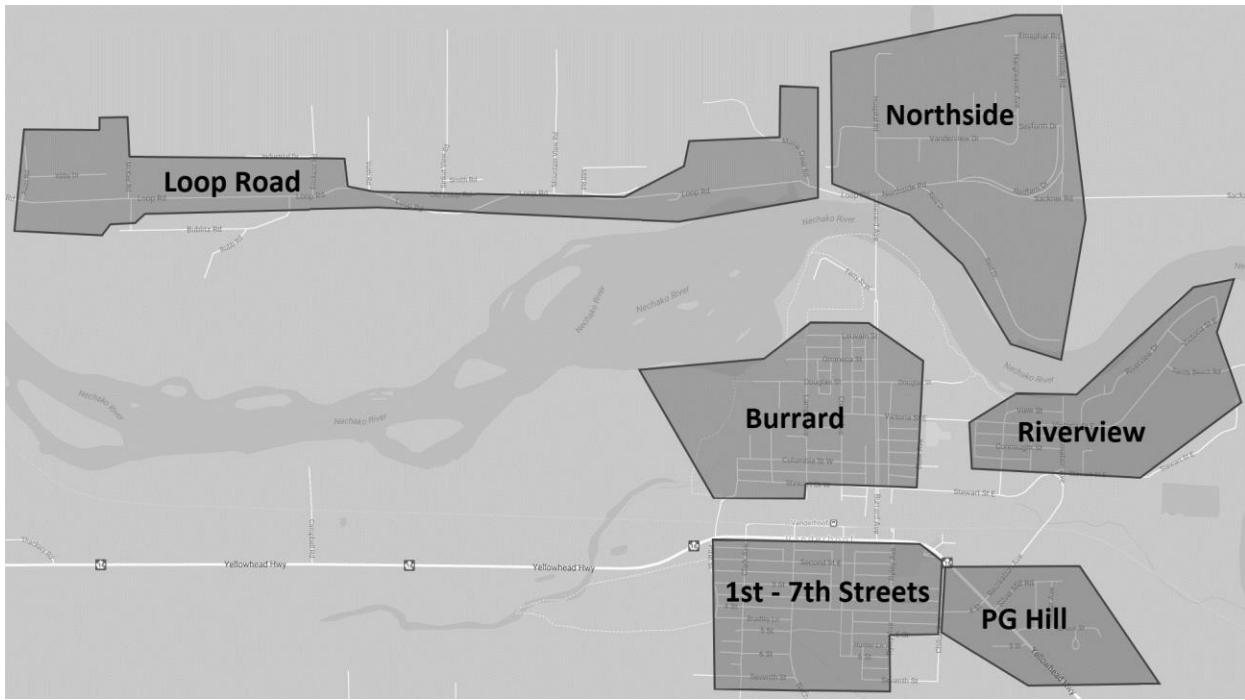


Figure 2: The neighbourhoods included in the Vanderhoof wood-burning appliance survey.

Survey data were collected primarily in person, through surveyors going door-to-door to interview residents and fill out the surveys (see Figure 3 on page 9). Surveyors were provided with a ‘guide’ (see Appendix A on page 46) that included background information on some of the questions they would be asking residents, including how to determine if a wood-burning appliance has EPA or CSA emissions certification, and how to differentiate between emissions and safety certification. Surveyors were also provided with BC Lung pamphlets on “Woodstoves & Your Health” and “Health & Air Quality” to hand out to residents that requested further information.

Surveyors were given neighbourhood maps to track which areas they had visited, and which houses they needed to return to. The surveys were categorized by neighbourhood, but otherwise did not contain any personally identifiable information to protect the privacy of residents. As surveyors went door-to-door, they counted the total number of chimneys and wood piles in each neighbourhood they visited. These counts were used to compare rates of wood-burning reported in the survey to observable indicators of wood-burning.

Paper copies of the surveys were scanned and processed using Optical Mark Recognition software for the multiple-choice questions and Intelligent Character Recognition software for the free-form questions. However, most of the free-form responses had to be manually transcribed because the character recognition software often failed to accurately transcribe the responses. Spot-checking was done to confirm that surveys were processed correctly.

To maximize data capture, surveyors made a repeat visit to non-respondent homes at a different time of day from the initial visit. If residents were still not available to be interviewed, paper surveys were left at their door, along with a ‘Sorry we missed you’ slip explaining the purpose of the survey, contact

information for questions about the survey, and two locations in town at which completed surveys could be dropped off.

Participation in the survey was quite high, with more than half of residences providing responses, and a total of 552 surveys collected. Surveyors reported that residents were generally quite supportive and happy to participate in the survey. Overall, 29% of targeted homes did not participate because residents were not home and/or did not answer the door when surveyors knocked, and did not return surveys left at their door. Leaving pamphlets at non-respondent homes had limited success, with only 4 homes (0.4%) participating in the survey through that method. A further 5% of residents declined to participate in the survey. Table 1 provides a further breakdown of survey responses overall and by neighbourhood.

Table 1: The reporting characteristics of each neighbourhood included in the survey.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
Surveys Received	98	47%	127	61%	20	54%	152	54%	53	46%	102	46%	552	58%
Inaccessible	13	6%	11	5%	7	19%	21	8%	24	21%	25	11%	76	8%
Not Home	73	35%	61	29%	9	24%	100	36%	34	30%	80	36%	277	29%
Refused	23	11%	10	5%	1	3%	6	2%	4	3%	14	6%	44	5%
Households Targeted	207	100%	209	100%	37	100%	279	100%	115	100%	221	100%	949	100%

7 Survey Questions

The survey was composed of 13 questions on wood-burning appliance usage and perceptions of air quality in the community. These questions were based on those used in a similar survey conducted for Smithers in 2016, with modifications made based on recommendations from the Smithers report about how future surveys could be improved (Hiemstra, 2016).

District of Vanderhoof Door-to-Door Wood-Burning Appliance Survey

Please fill in one checkbox per question and mark with an "X".
For written answers, use ALL CAPS and write one letter per box.

<p>Q1 Do you currently use a wood-burning appliance in your home?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No (skip to Q9)</p>	<p>Q8 If pellet stove: how many bags, pallets or tonnes of pellets do you use each year?</p> <p><input type="checkbox"/> bags <input type="checkbox"/> tonnes <input type="checkbox"/> pallets <input type="checkbox"/> other (see below)</p> <p>How many? <table border="1" style="display: inline-table;"><tr><td></td><td></td><td></td></tr></table></p> <p>If other, write description: <table border="1" style="display: inline-table; width: 100px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></p>										
<p>Q2 Do you consider wood your home's primary heat source?</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>											
<p>Q3 What kind of wood-burning heating appliance do you have in your house? (fill out one survey per appliance)</p> <p><input type="checkbox"/> wood stove <input type="checkbox"/> pellet stove <input type="checkbox"/> wood furnace <input type="checkbox"/> pellet furnace <input type="checkbox"/> fireplace <input type="checkbox"/> outdoor wood boiler <input type="checkbox"/> fireplace insert <input type="checkbox"/> don't know</p>											
<p>Q4 Does your wood-burning appliance have an EPA or CSA emissions certification? ("U.S. Environmental Protection Agency" label)</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> Don't know <input type="checkbox"/> No</p>	<p>Q9 Which of the following statements best describes how you feel about air quality in Vanderhoof? "The air quality in Vanderhoof is..."</p> <p><input type="checkbox"/> practically always good <input type="checkbox"/> mostly poor, but occasionally good <input type="checkbox"/> mostly good, but poor on occasion <input type="checkbox"/> practically always poor <input type="checkbox"/> equally likely to be poor or good <input type="checkbox"/> don't know</p>										
<p>Q5 How old is your wood-burning appliance?</p> <p><input type="checkbox"/> less than 2 years <input type="checkbox"/> 15-23 years <input type="checkbox"/> 2-5 years <input type="checkbox"/> over 23 years <input type="checkbox"/> 5-10 years <input type="checkbox"/> don't know <input type="checkbox"/> 10-15 years</p>	<p>Q10 To what extent does smoke from wood-burning appliances affect air quality in your neighbourhood specifically?</p> <p><input type="checkbox"/> large extent <input type="checkbox"/> not at all <input type="checkbox"/> moderate extent <input type="checkbox"/> don't know <input type="checkbox"/> small extent</p>										
<p>Q6 Approximately how much wood do you burn each year?</p> <p><input type="checkbox"/> 1-5 armfuls <input type="checkbox"/> 3-5 cords <input type="checkbox"/> 5-10 armfuls <input type="checkbox"/> 5-7 cords <input type="checkbox"/> 10-15 armfuls <input type="checkbox"/> more than 7 cords <input type="checkbox"/> half cord <input type="checkbox"/> don't know <input type="checkbox"/> 1-2 cords <input type="checkbox"/> other <input type="checkbox"/> 2-3 cords</p>	<p>Q11 To what extent does smoke from wood-burning appliances affect air quality in Vanderhoof?</p> <p><input type="checkbox"/> large extent <input type="checkbox"/> not at all <input type="checkbox"/> moderate extent <input type="checkbox"/> don't know <input type="checkbox"/> small extent</p>										
<p>If other, enter description & amount (eg/ 10TRUCKLOADS): <table border="1" style="display: inline-table; width: 100px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></p>								<p>Q12 To what extend do other sources of air pollution affect air quality in your neighbourhood specifically?</p> <p><input type="checkbox"/> large extent <input type="checkbox"/> not at all <input type="checkbox"/> moderate extent <input type="checkbox"/> don't know <input type="checkbox"/> small extent</p>			
<p>Q7 How long do you season your firewood before burning?</p> <p><input type="checkbox"/> don't season <input type="checkbox"/> 9-12 months <input type="checkbox"/> 1-3 months <input type="checkbox"/> more than 1 year <input type="checkbox"/> 3-6 months <input type="checkbox"/> more than 2 years <input type="checkbox"/> 6-9 months <input type="checkbox"/> don't know</p>	<p>Q13 Can you identify other sources of air pollution that affect air quality in the community? <table border="1" style="display: inline-table; width: 100px;"><tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table></p>										

ID 1

Figure 3: The survey form filled out by surveyors and left in mailboxes for residents that could not be reached at home.

8 Survey Results

The responses to each survey question are presented in this section. Further discussion of the results follows in Section 9. As with any survey, there is inevitably some variation in how individuals interpret and choose to answer questions, and the possibility that some individuals are biased by any number of possible factors, including the desire to provide the answers they think surveyors want to hear. Sources of error are further discussed in Section 9.1, but in general, the surveyors reported having the impression that participants were forthcoming and honest in the responses they provided.

8.1 Question 1: Wood-Burning Use for Home Heating

Question 1 reads: "Do you currently use a wood-burning appliance in your home?"

Approximately two thirds of surveyed households indicated that they are not currently using a wood-burning appliance (Figure 4). Only 11% of the surveyed population use wood as their primary source of heating.

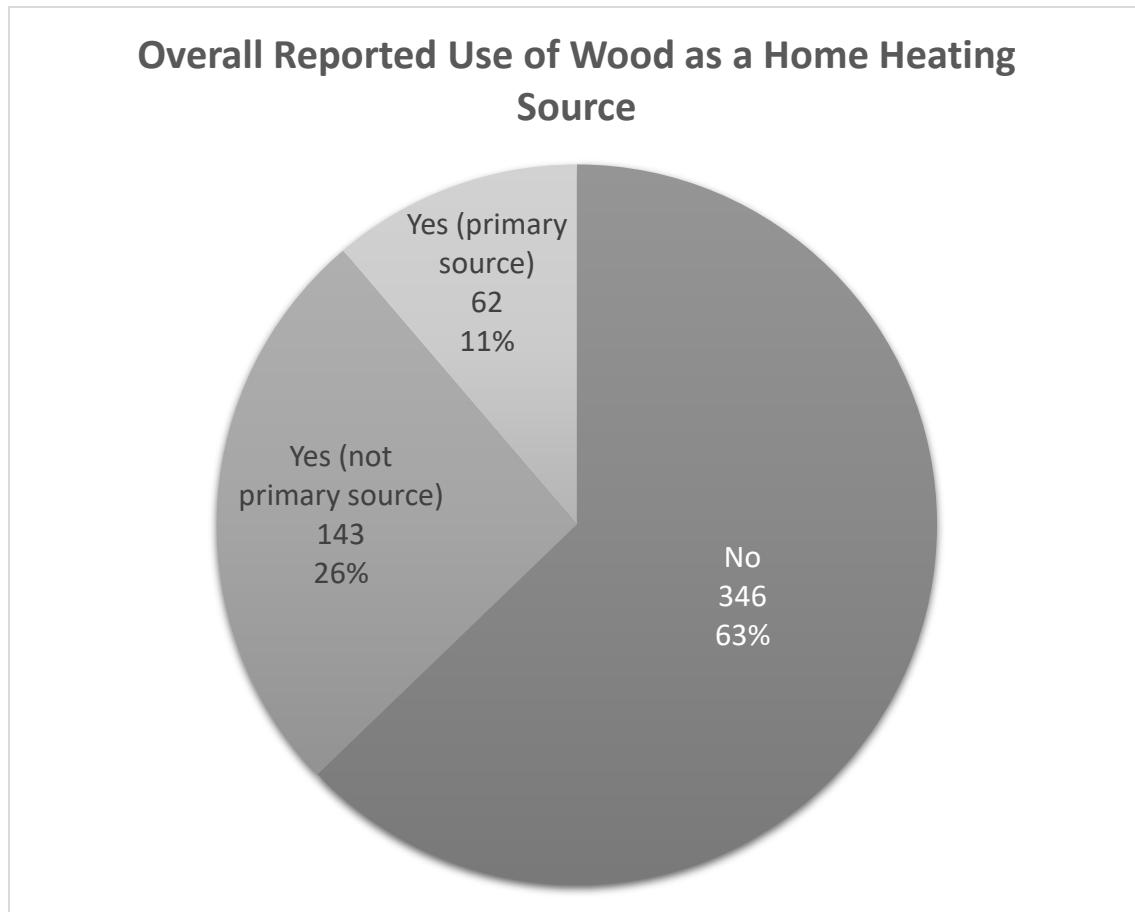


Figure 4: The number and percent of homes surveyed that currently use a wood-burning appliance as either their primary or non-primary heat source, or not at all.

The number of homes surveyed in each neighbourhood, and the portion of those that reported using a wood-burning appliance, are shown in Figure 5. Northside reported the largest absolute number of appliances, but was also the neighbourhood with the most homes surveyed. Loop Road had the least number of homes surveyed, but reported the highest percentage of wood-burning appliances at 75% (Table 2).

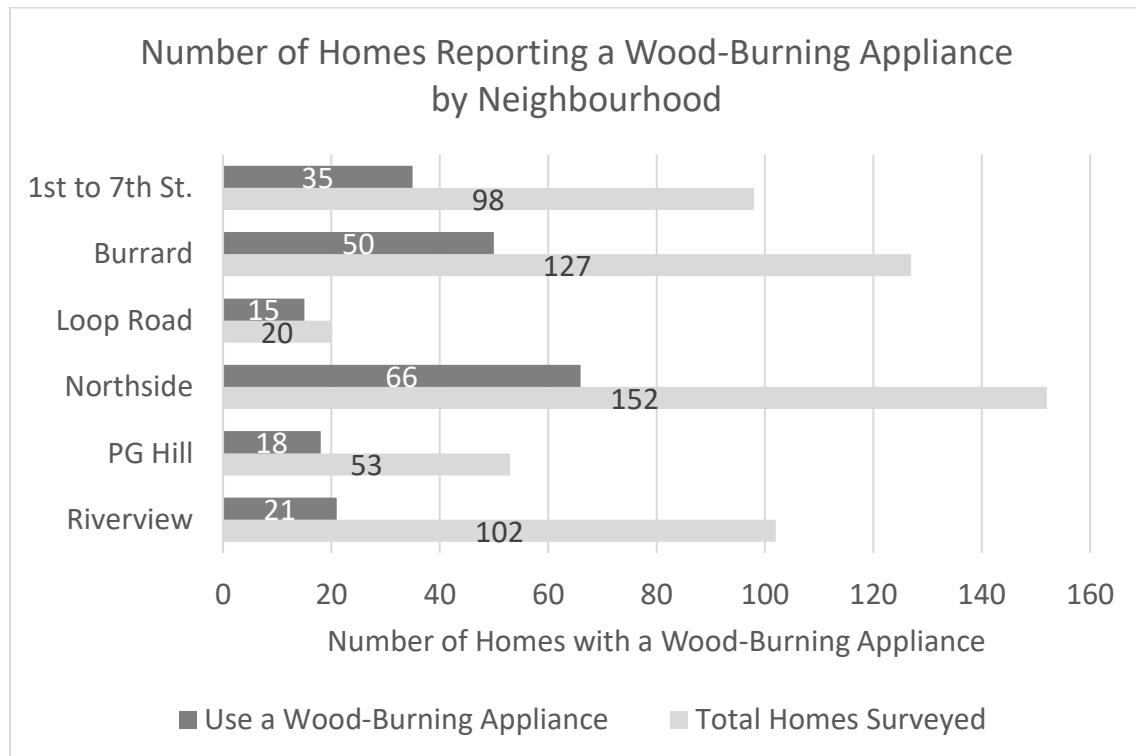


Figure 5: The number of homes surveyed that reported using a wood-burning appliance in each neighbourhood.

Table 2 provides the number of responses recorded in each neighbourhood, and overall. The 'Yes' category includes numbers from the 'Primary' category. The percentages displayed are relative to the total surveys done in that neighbourhood, other than the last column, which is relative to the total number of homes surveyed.

Table 2: Wood-burning appliance usage by neighbourhood.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total Homes Surveyed	
Yes	35	36%	50	39%	15	75%	66	43%	18	34%	21	21%	205	37%
Primary	9	9%	13	10%	7	35%	18	12%	10	19%	5	5%	62	11%
No	63	64%	77	61%	5	25%	86	57%	35	66%	81	79%	347	63%
Total	98	18%	127	23%	20	4%	152	28%	53	10%	102	18%	552	100%

8.1.1 Chimney and Woodpile Count Comparison

Figure 6 compares the percentage of surveyed homes in each neighbourhood that reported using a wood-burning appliance with the percentage of all homes in each neighbourhood at which a chimney or woodpile was observed. The purpose of conducting woodpile and chimney counts was to identify if and to what degree survey respondents are under-reporting wood-burning usage. However, in most neighbourhoods, reported wood-usage was much higher than observable indicators of wood usage.

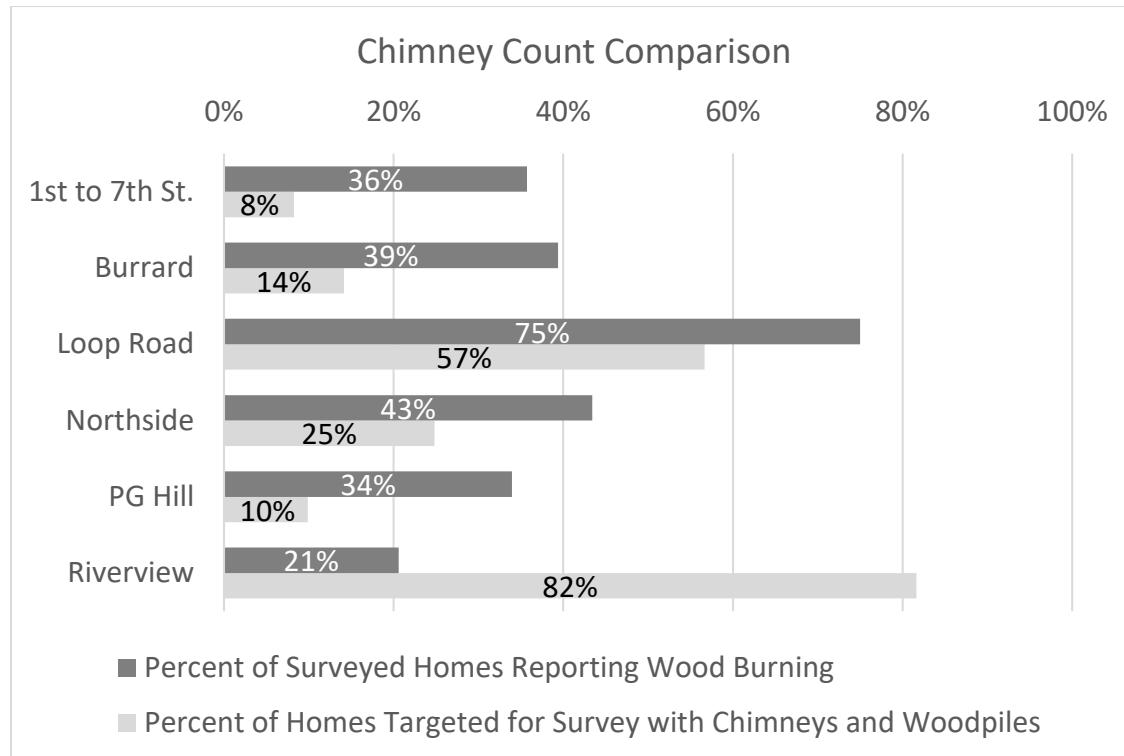


Figure 6: Comparison of the percentage of surveyed homes that reported using wood-burning appliances to the percentage of homes in neighbourhoods that had a chimney or woodpile.

There are several possible sources of error with chimney and woodpile counts that are discussed in Section 9.1, but it should be noted that one explanation of the difference between the chimney counts in Riverview and those done in the other neighbourhoods is that one surveyor conducted the surveys in Riverview, while another surveyor handled the other neighbourhoods, and definition of which chimneys to include clearly differed. Table 3 provides the number of chimneys and woodpiles counted in each neighbourhood, and compares them with neighbourhood size and wood-usage rates.

Table 3: Neighbourhood chimney and woodpile counts, and reported wood-burning appliance usage.

Neighbourhood	1st to 7 th St.	Burrard	Loop Road	Northside	PG Hill	Riverview	Total
Houses surveyed	98	127	20	152	53	102	552
Houses Targeted	194	198	30	258	91	196	967
Chimney count	8	14	6	36	5	145	214
Woodpile Count	8	14	11	28	4	15	80
Chimneys + Woodpiles	16	28	17	64	9	160	294

Percent of Targeted Homes with Observed Chimneys or Woodpiles	8%	14%	57%	25%	10%	82%	30%
Houses that reported using a wood-burning appliance	35	50	15	66	18	21	205
Percent of Surveyed Homes Reporting Wood-Burning	36%	39%	75%	43%	34%	21%	37%

8.2 Question 2: Wood-Burning Use as the Primary Source of Home Heating

Question 2 reads: "Do you consider wood your home's primary heat source?"

Figure 7 presents the variation in wood-burning appliance usage, and usage as the primary heat source, between neighbourhoods. Loop Road reported the highest usage and primary usage rates, Riverview had the lowest, and the other neighbourhoods were close to the average. It should be noted that Loop Road had the lowest number of survey participants, at only 20, implying a greater margin of error, which could partially explain the high wood usage rates reported in the survey. The numeric data associated with Figure 6 are provided above in Table 2.

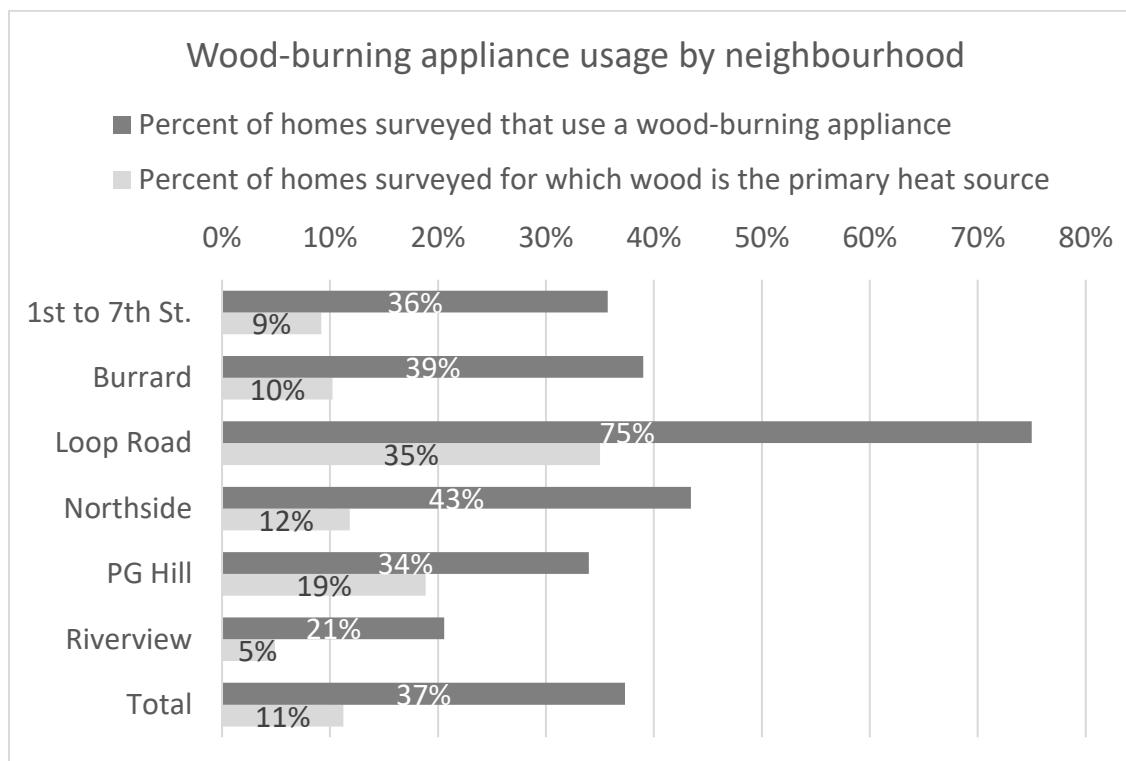


Figure 7: Relative wood-burning appliance usage and primary heat source usage in each neighbourhood.

8.3 Question 3: Types of Wood-Burning Appliances Used for Heating

Question 3 reads: "What kind of wood-burning heating appliance do you have in your house? (fill out one survey per appliance)"

The reported relative frequency of wood-burning appliances is provided in Figure 8. Pellet stoves were the most commonly used wood-burning appliance, followed by wood stoves.

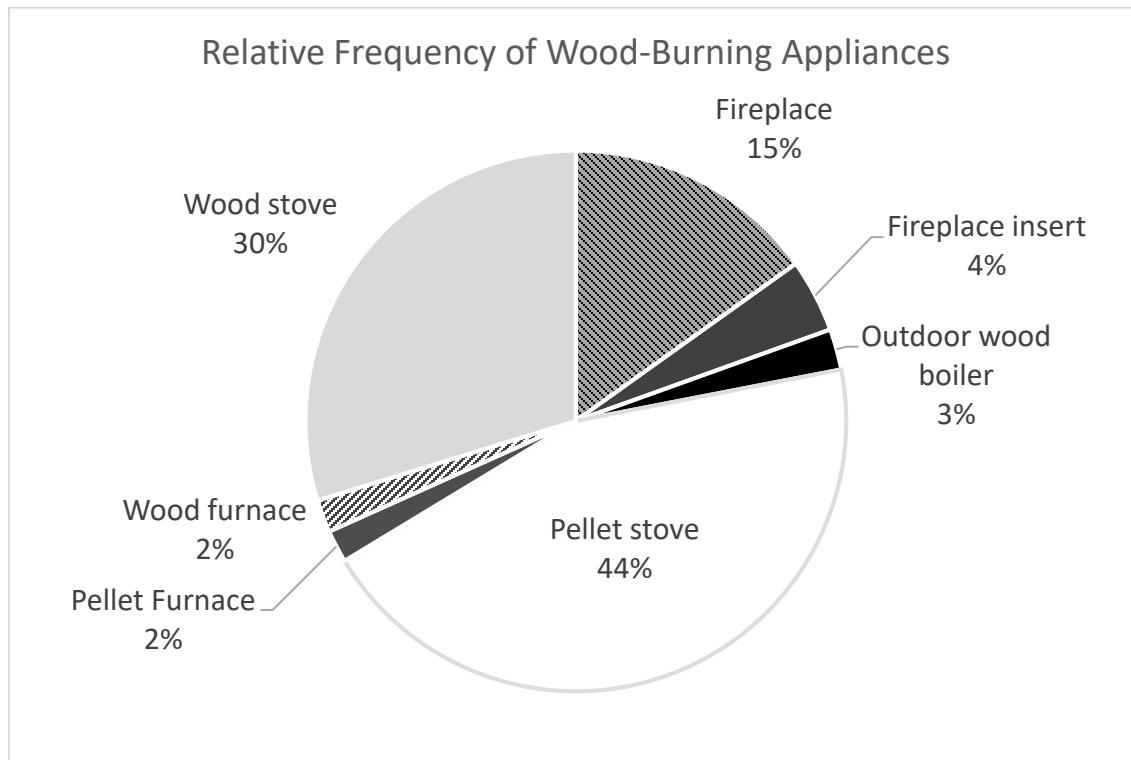


Figure 8: Overall reported frequency of wood-burning appliances.

The variation in wood-burning appliance usage between neighbourhoods is shown in Figure 9. Neighbourhoods reported quite different proportions of appliance usage, with relatively fewer fireplaces and more pellet stoves in Northside, PG Hill and Riverview. Wood stove usage was quite consistent at around 30% in each neighbourhood. While only 13 wood and pellet furnaces and boilers were reported in the study, 9 of those were in Northside (Table 4). The numeric data associated with Figures 8 and 9 are shown in Table 4.

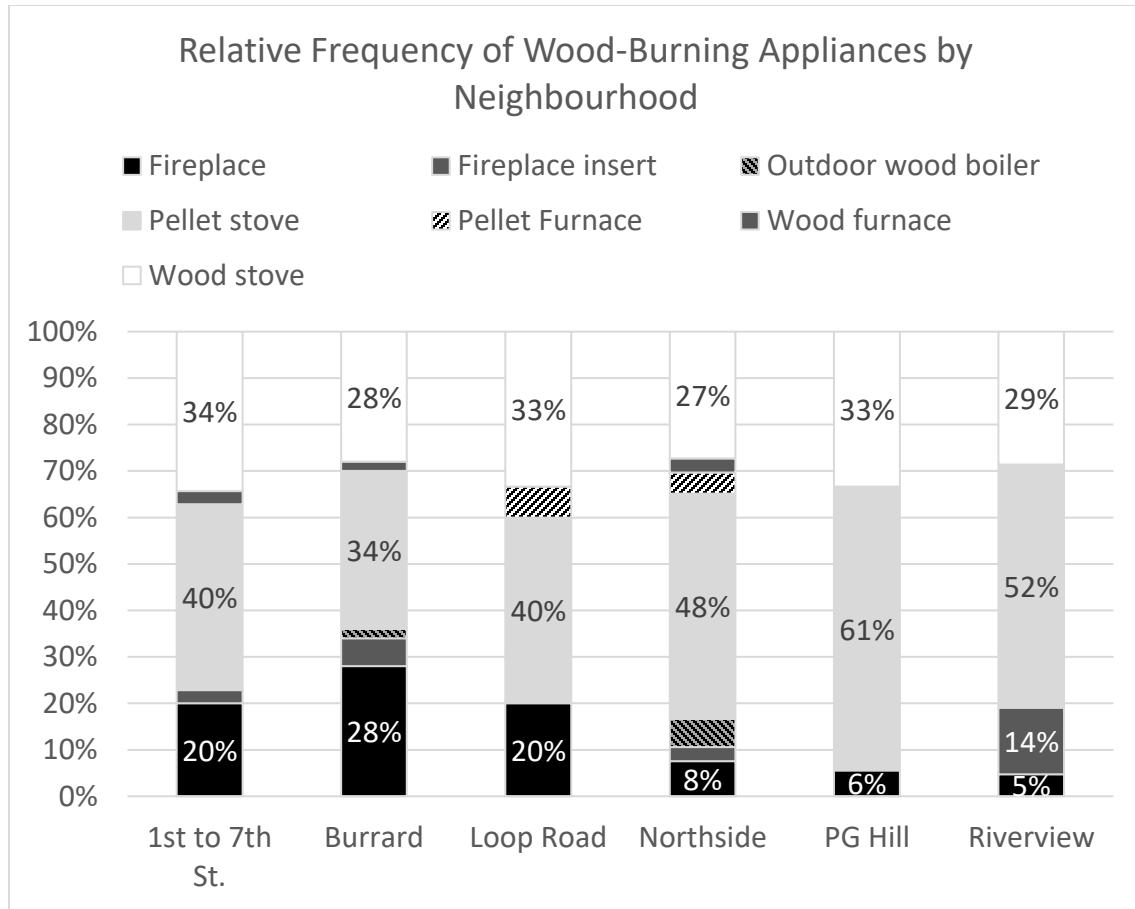


Figure 9: Relative frequency of each type of wood-burning appliance in each neighbourhood.

Table 4: Number and percent of reported wood-burning appliances by neighbourhood.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
Don't know	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Fireplace	7	20%	14	28%	3	20%	5	8%	1	6%	1	5%	31	15%
Fireplace insert	1	3%	3	6%	0	0%	2	3%	0	0%	3	14%	9	4%
Outdoor wood boiler	0	0%	1	2%	0	0%	4	6%	0	0%	0	0%	5	2%
Pellet stove	14	40%	17	34%	6	40%	32	48%	11	61%	11	52%	91	44%
Pellet Furnace	0	0%	0	0%	1	7%	3	5%	0	0%	0	0%	4	2%
Wood furnace	1	3%	1	2%	0	0%	2	3%	0	0%	0	0%	4	2%
Wood stove	12	34%	14	28%	5	33%	18	27%	6	33%	6	29%	61	30%
Total	35	17%	50	24%	15	7%	66	32%	18	9%	21	10%	205	100%

8.4 Question 4: Wood-Burning Appliance Emissions Certification

Question 4 reads: “Does your wood-burning appliance have an EPA or CSA emissions certification? (“U.S. Environmental Protection Agency” label)”

The overall percentage of wood-burning appliances that were reported to be EPA or CSA-certified are presented in Figure 10. Over a quarter of respondents reported that they were not aware of the certification status of their appliance, indicating an opportunity for future community engagement. The surveyor responsible for Riverview reported that all residents he spoke to who had a wood-burning appliance were already familiar with emissions certification, including those unaware of the certification status of their appliance (the other surveyor could not be reached for comment).

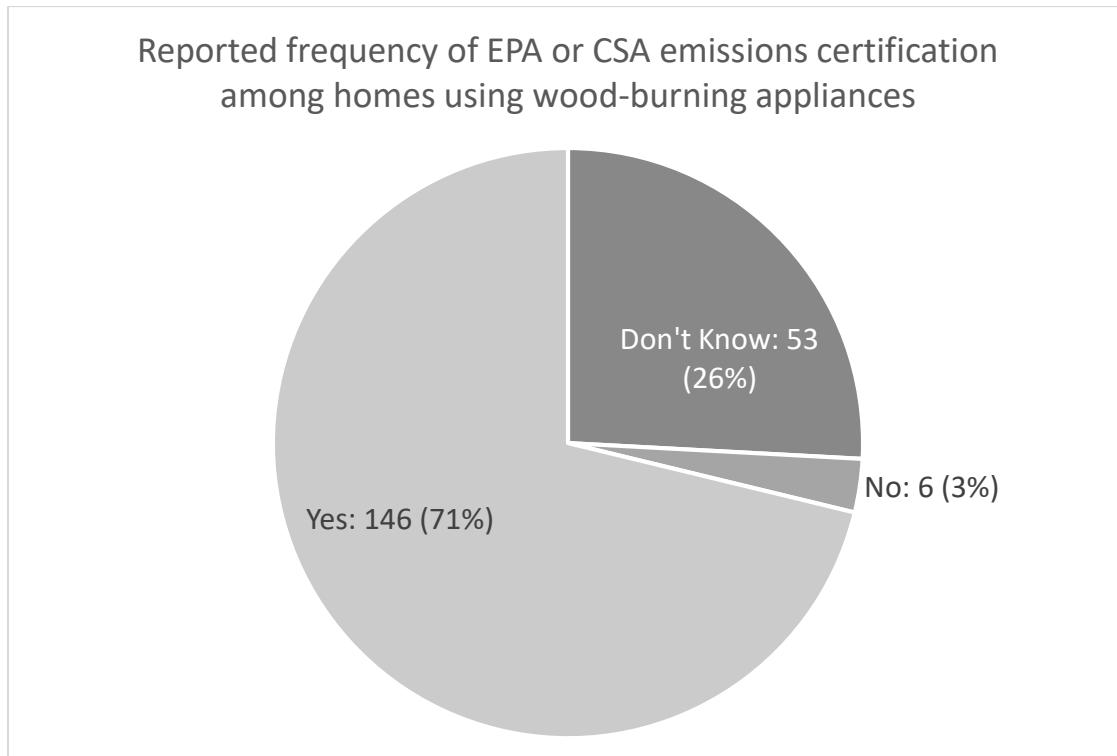


Figure 10: Most surveyed homes with wood-burning appliances reported that their appliances were EPA or CSA-certified.

Figure 10 provides a breakdown by neighbourhood of reported appliance certification levels, while Table 5 provides the numeric values.

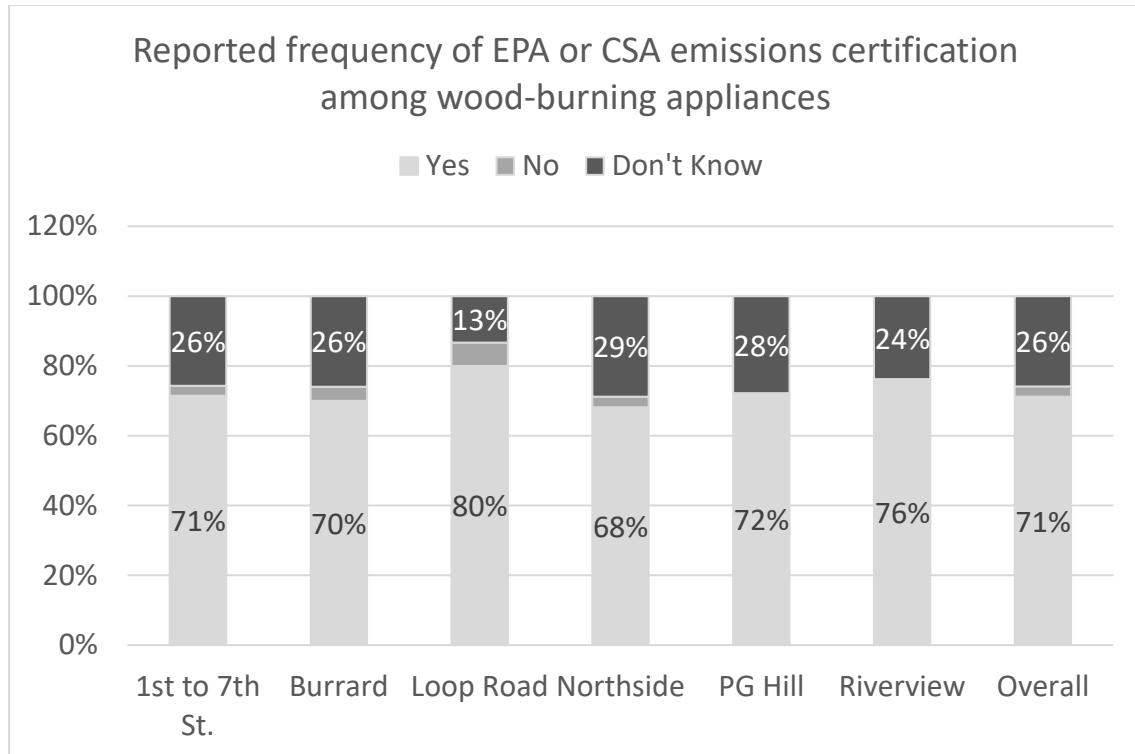


Figure 11: Reported frequency of wood-burning appliance certification by neighbourhood.

Table 5: Number and percent of emissions-certified wood-burning appliances by neighbourhood and overall.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Yes	25	71%	35	70%	12	80%	45	68%	13	72%	16	76%	146	71%
No	1	3%	2	4%	1	7%	2	3%	0	0%	0	0%	6	3%
Don't Know	9	26%	13	26%	2	13%	19	29%	5	28%	5	24%	53	26%
Total	35	17%	50	24%	15	7%	66	32%	18	9%	21	10%	205	100%

8.5 Question 5: Age of Wood-Burning Appliances

Question 5 reads: “How old is your wood-burning appliance?”

The reported age distribution of wood-burning appliances in the community is presented in Figure 12, which shows that 50% of appliances are less than 10 years old, while just over a fifth of respondents were not aware of how old their appliance was.

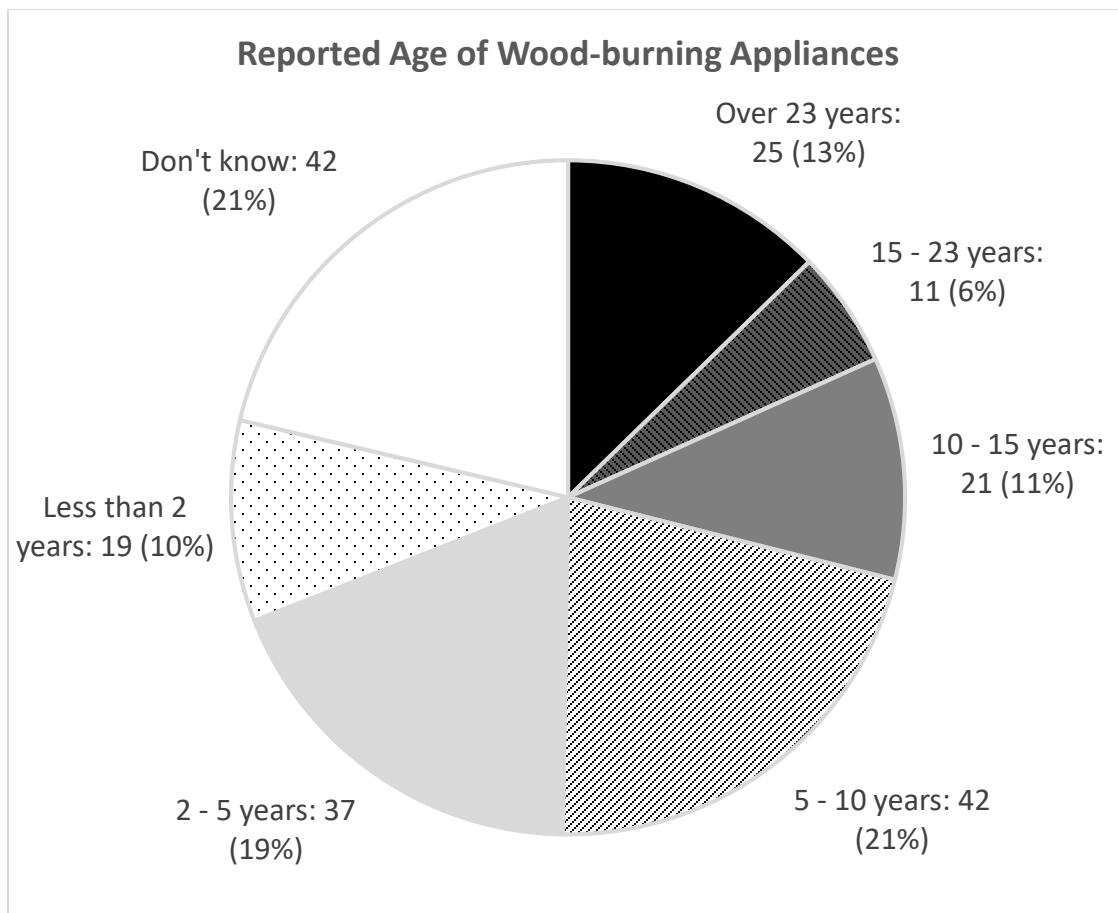


Figure 12: Number and percentage of appliances in each age category.

Figure 13 shows that the reported age distribution of wood-burning appliances varied between neighbourhoods. Appliances more than 23 years old were only reported in 3 neighbourhoods – 1st to 7th St., Burrard and Northside.

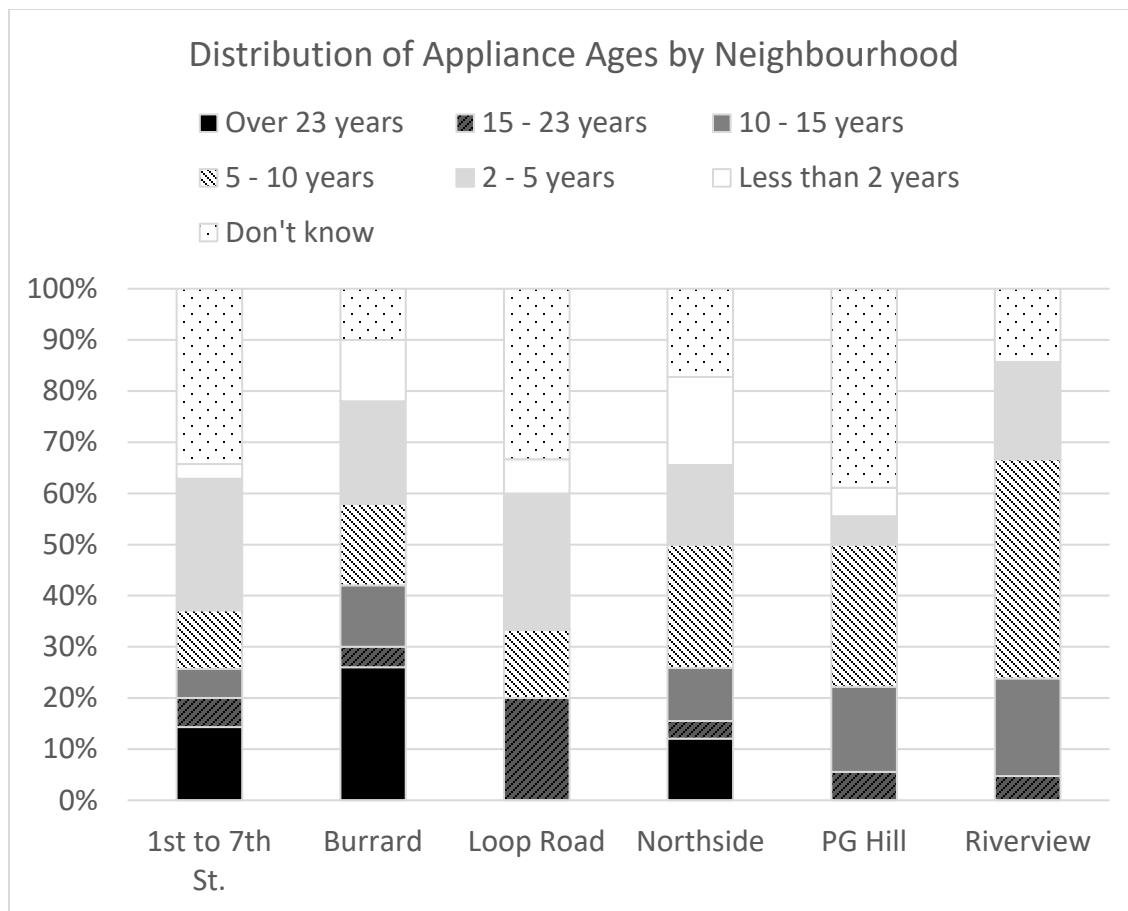


Figure 13: Relative distribution of wood-burning appliance ages by neighbourhood.

Table 6: Number and percentage of wood-burning appliance in each age category by neighbourhood.

Age	Less than 2 years	2 - 5 years	5 - 10 years	10 - 15 years	15 - 23 years	Over 23 years	Don't know	Total	
1st to 7th St.	1	3%	9	26%	4	11%	2	6%	35
Burrard	6	12%	10	20%	8	16%	6	12%	50
Loop Road	1	7%	4	27%	2	13%	0	0%	15
Northside	10	17%	9	16%	14	24%	6	10%	58
PG Hill	1	6%	1	6%	5	28%	3	17%	18
Riverview	0	0%	4	19%	9	43%	4	19%	21
Total	19	10%	37	19%	42	21%	21	11%	197*

*Out of 205 total surveys that reported using an appliance, 8 (all from Northside) did not provide a response to appliance age.

The responses to questions 4 and 5 on appliance emissions certification status and age are compared in Figure 14. As expected, most appliances that were reported to not be EPA or CSA emissions-certified were more than 23 years old, before the Solid Fuel Burning Domestic Appliance Regulation came into

effect (which required appliances manufactured after November 1, 1994 to be EPA or CSA emissions-certified¹). The numeric data associated with Figure 14 are presented in Table 7 below.

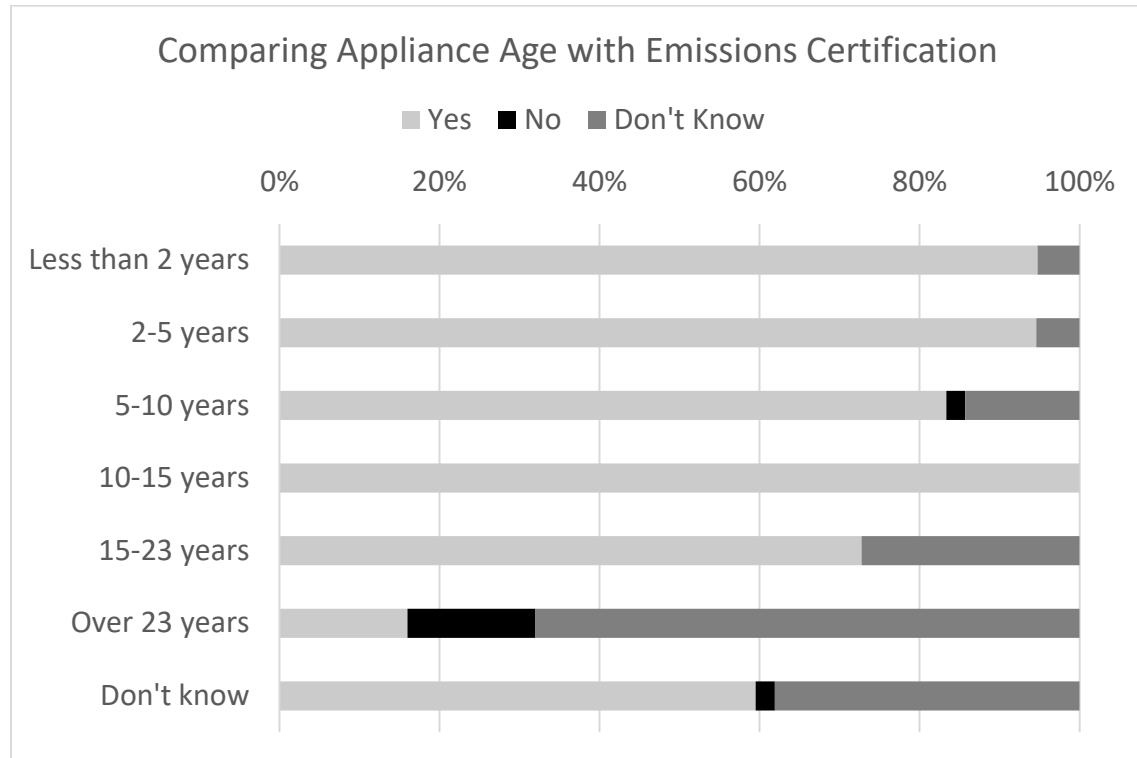


Figure 14: Comparing the data from questions 4 and 5 show that most of the appliances over 23 years old were either not certified or of unknown certification.

Table 7: Comparison of emissions certification status and appliance age.

Appliance Age	Does your Appliance have EPA or CSA Emissions Certification?						Total	
	Yes		No		Don't Know			
Less than 2 years	18	12%	0	0%	1	2%	19	10%
2-5 years	35	24%	0	0%	2	4%	37	19%
5-10 years	35	24%	1	17%	6	13%	42	21%
10-15 years	21	14%	0	0%	0	0%	21	11%
15-23 years	8	5%	0	0%	3	7%	11	6%
Over 23 years	4	3%	4	67%	17	38%	25	13%
Don't know	25	17%	1	17%	16	36%	42	21%
Total	146	100%	6	100%	45	100%	197*	100%

*Out of 205 total surveys that reported using an appliance, 8 (all from Northside) did not provide a response to appliance age.

¹ For more information on wood-burning appliance requirements, see the BC Ministry of Environment Factsheet at http://www2.gov.bc.ca/assets/gov/environment/air-land-water/air/reports-pub/sfbdar_factsheet.pdf, or the regulation itself at http://www.bclaws.ca/civix/document/id/complete/statreg/218_2016.

8.6 Question 6: Consumption of Wood Fuel for Home Heating

Question 6 reads: "Approximately how much wood do you burn each year?"

Figure 15 presents the overall frequency of reported wood usage, along with the frequency of usage by residents that used wood as their primary heat source. As would be expected, 'primary' wood users tended to report using much more wood. Four of the surveys that reported using wood as their primary heat source also reported using half a cord or less of wood. One possible explanation for this could be that those surveys are from homes with multiple appliances that primarily rely on pellets for heating (the number of homes that filled out multiple surveys was not tracked, though the number is believed to be low). There were also a number of surveys that did not report wood as their primary heat source, but still used more than 2 cords in a year, including one home that reported using more than 7 cords in a year (surveys were checked to confirm that data were processed correctly).

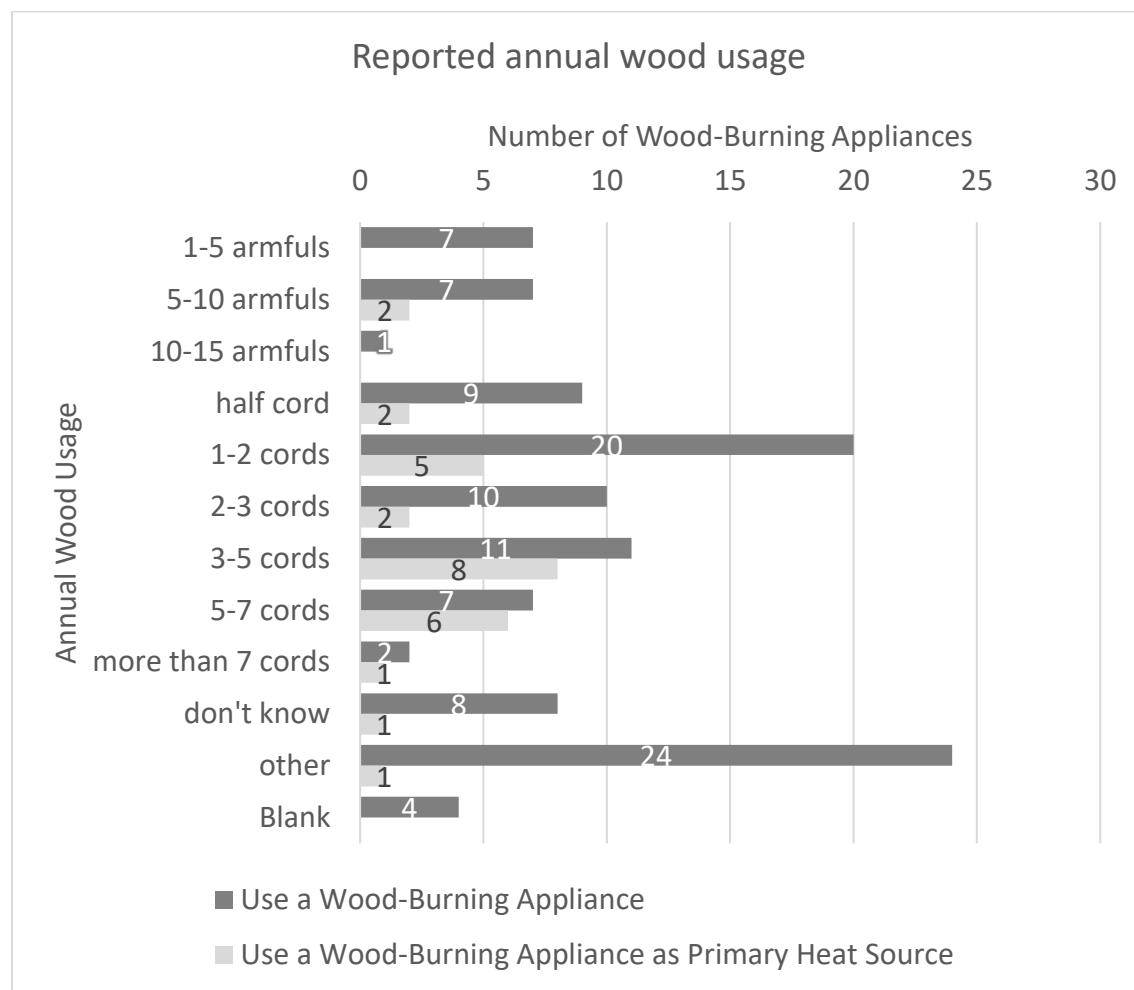


Figure 15: Frequency of responses for each category of annual wood use from households that reported currently using a non-pellet wood-burning appliance.

The data associated with Figure 15 are provided in Table 8 below. The 'other' category was intended to allow residents to use a different unit of measure, but was primarily used to explain that the appliance was not actually in use, so no wood was burned. Of the 24 'other' responses, 3 reported that the

appliance was new and 1 reported that the resident had just moved, so no data were available. The remainder reported that the appliance was not used. There were also 4 surveys that left the field blank. There are only 110 wood-burning appliances shown in this table as 95 of the 205 wood-burning appliances in the survey use pellet fuel, which is shown in Section 8.8.

Table 8: The frequency of cordwood usage by all non-pellet wood-burning appliances, and only those that are used as the home's primary heat source.

	Use a Wood-Burning Appliance		Use a Wood-Burning Appliance as Primary Heat Source	
1-5 armfuls	7	6%	0	0%
5-10 armfuls	7	6%	2	7%
10-15 armfuls	1	1%	0	0%
half cord	9	8%	2	7%
1-2 cords	20	18%	5	18%
2-3 cords	10	9%	2	7%
3-5 cords	11	10%	8	29%
5-7 cords	7	6%	6	21%
more than 7 cords	2	2%	1	4%
don't know	8	7%	1	4%
other	24	22%	1	4%
Blank	4	4%	0	0%
Total	110	100%	28	100%

Figure 16 shows the non-pellet wood usage frequency in each neighbourhood. The half cord and various armful categories were combined to make the graph easier to interpret. It shows that there are a relatively small number of homes in most neighbourhoods burning more than 5 cords per year, while more than half of homes use 1-2 cords or less per year. The numeric data associated with Figure 16 are provided below in Table 9.

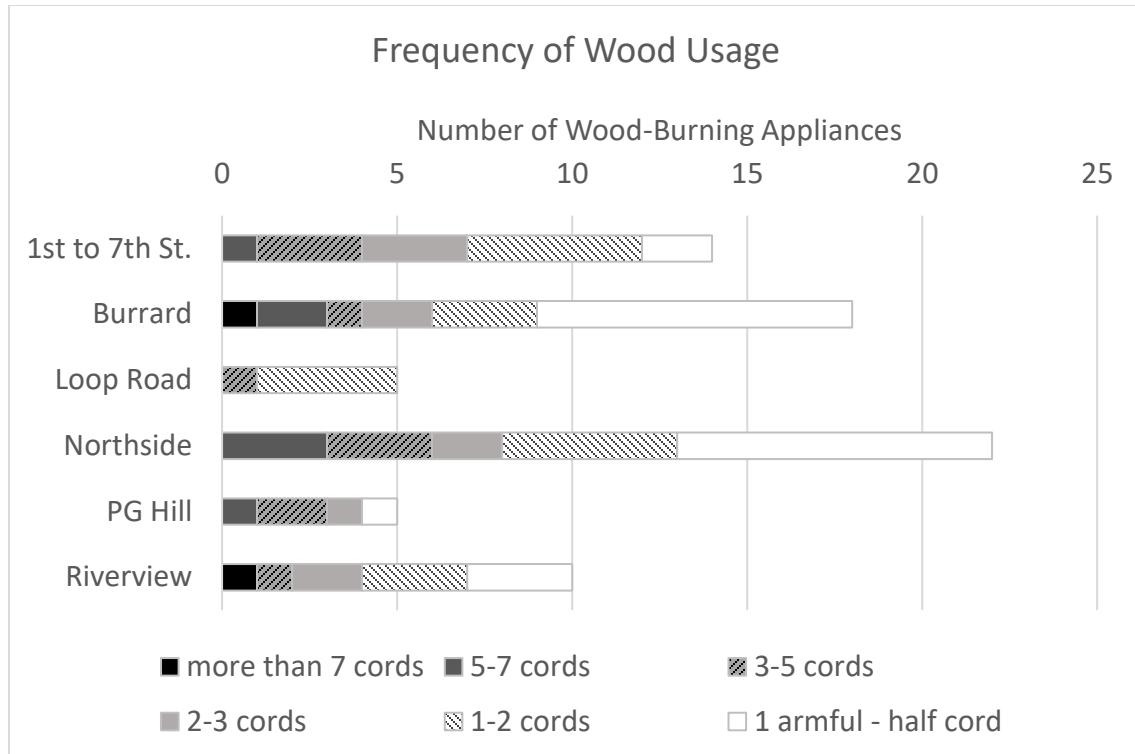


Figure 16: Relative distribution of wood burned by neighbourhood. This graph only includes survey responses that provided a numeric value for wood burned each year. The categories 1-5 armfuls, 5-10 armfuls, 10-15 armfuls and half cord were combined into one category to make the graph easier to interpret.

Table 9: Distribution of annual household wood use by neighbourhood. This table only includes survey responses that answered ‘Yes’ to using a wood-burning appliance, and excludes pellet-burning appliances, which are covered in question 8.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
1-5 armfuls	1	5%	2	6%	0	0%	3	10%	0	0%	1	10%	7	6%
5-10 armfuls	1	5%	4	12%	0	0%	2	6%	0	0%	0	0%	7	6%
10-15 armfuls	0	0%	1	3%	0	0%	0	0%	0	0%	0	0%	1	1%
half cord	0	0%	2	6%	0	0%	4	13%	1	14%	2	20%	9	8%
1-2 cords	5	24%	3	9%	4	50%	5	16%	0	0%	3	30%	20	18%
2-3 cords	3	14%	2	6%	0	0%	2	6%	1	14%	2	20%	10	9%
3-5 cords	3	14%	1	3%	1	13%	3	10%	2	29%	1	10%	11	10%
5-7 cords	1	5%	2	6%	0	0%	3	10%	1	14%	0	0%	7	6%
more than 7 cords	0	0%	1	3%	0	0%	0	0%	0	0%	1	10%	2	2%
don't know	0	0%	1	3%	0	0%	6	19%	1	14%	0	0%	8	7%
other	6	29%	14	42%	1	13%	2	6%	1	14%	0	0%	24	22%
Blank	1	5%	0	0%	2	25%	1	3%	0	0%	0	0%	4	4%
Total	21	19%	33	30%	8	7%	31	28%	7	6%	10	9%	110	100%

Other: all ‘other’ responses were either related to the appliance being new or not used, so no value was provided.

8.7 Question 7: Duration of Firewood Seasoning

Question 7 reads: "How long do you season your firewood before burning?"

Figure 17 shows that among residents that provided a value, the vast majority reported seasoning their firewood for more than 2 years. The associated numeric data are provided in Table 10. Note that Figure 17 and Table 10 only include surveys that indicated that the house used a non-pellet wood-burning appliance. It is unclear why this question was left blank on so many surveys, as the surveyor could not be reached for comment. Of the 20 blanks, 8 of those surveys reported in a free-form response that they do not use their appliance at all. The other 12 indicated that they do burn non-pellet wood.

Approximately half of residents (46% excluding blanks) using non-pellet wood-burning appliances reported not being aware of whether or how long they season their wood, suggesting an opportunity to raise awareness in the community about the benefits of burning seasoning firewood².

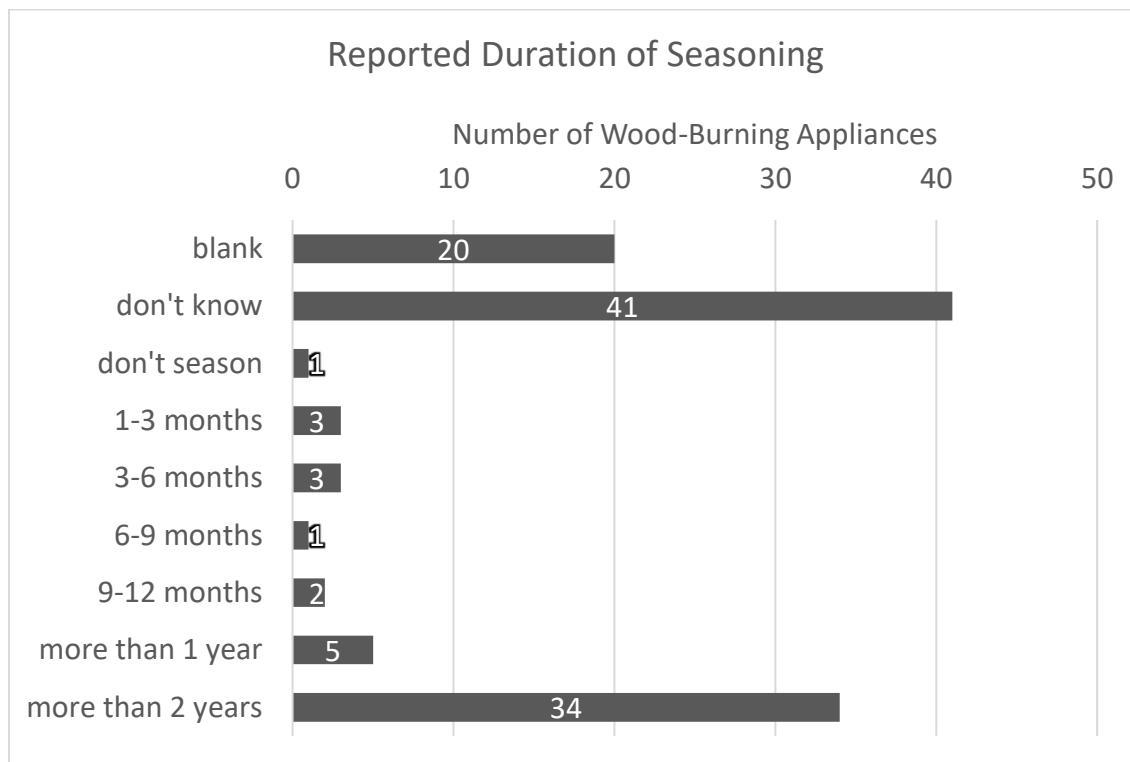


Figure 17: Duration of firewood seasoning before burning in non-pellet wood-burning appliances.

² According to BC Lung, firewood should be seasoned for at least six months, as it will produce more heat and less smoke, which can save money by reducing wood consumption by 25 percent. Read more at:

<https://bc.lung.ca/protect-your-lungs/air-quality-lung-health/wood-smoke/preparing-your-wood>

Table 10: Reported duration of (non-pellet) firewood seasoning prior to burning.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
don't season	0	0%	0	0%	0	0%	1	3%	0	0%	0	0%	1	1%
1-3 months	0	0%	2	6%	0	0%	0	0%	0	0%	1	10%	3	3%
3-6 months	1	5%	0	0%	0	0%	2	6%	0	0%	0	0%	3	3%
6-9 months	0	0%	1	3%	0	0%	0	0%	0	0%	0	0%	1	1%
9-12 months	0	0%	0	0%	0	0%	0	0%	0	0%	2	20%	2	2%
more than 1 year	2	10%	0	0%	1	13%	1	3%	1	14%	0	0%	5	5%
more than 2 years	9	43%	9	27%	3	38%	8	26%	2	29%	3	30%	34	31%
don't know	7	33%	19	58%	1	13%	6	19%	4	57%	4	40%	41	37%
Blank	2	10%	2	6%	3	38%	13	42%	0	0%	0	0%	20	18%
Total	21	19%	33	30%	8	7%	31	28%	7	6%	10	9%	110	100%

8.8 Question 8: Consumption of Pellet Fuel for Home Heating

Question 8 reads: "If pellet stove: how many bags, pallets or tonnes of pellets do you use each year?"

Figure 18 shows the frequency of annual pellet consumption by all pellet-burning appliances, and specifically by homes using wood as the primary heat source. The associated numeric data are shown in Table 11. Survey responses used three units – pallets, tonnes and bags of pellets. To facilitate comparison, pallets and tonnes of pellets were converted into bag equivalents, assuming that 1 pellet pallet is equivalent to 1 tonne, and 1 tonne of pellets is equivalent to 50 bags of pellets.

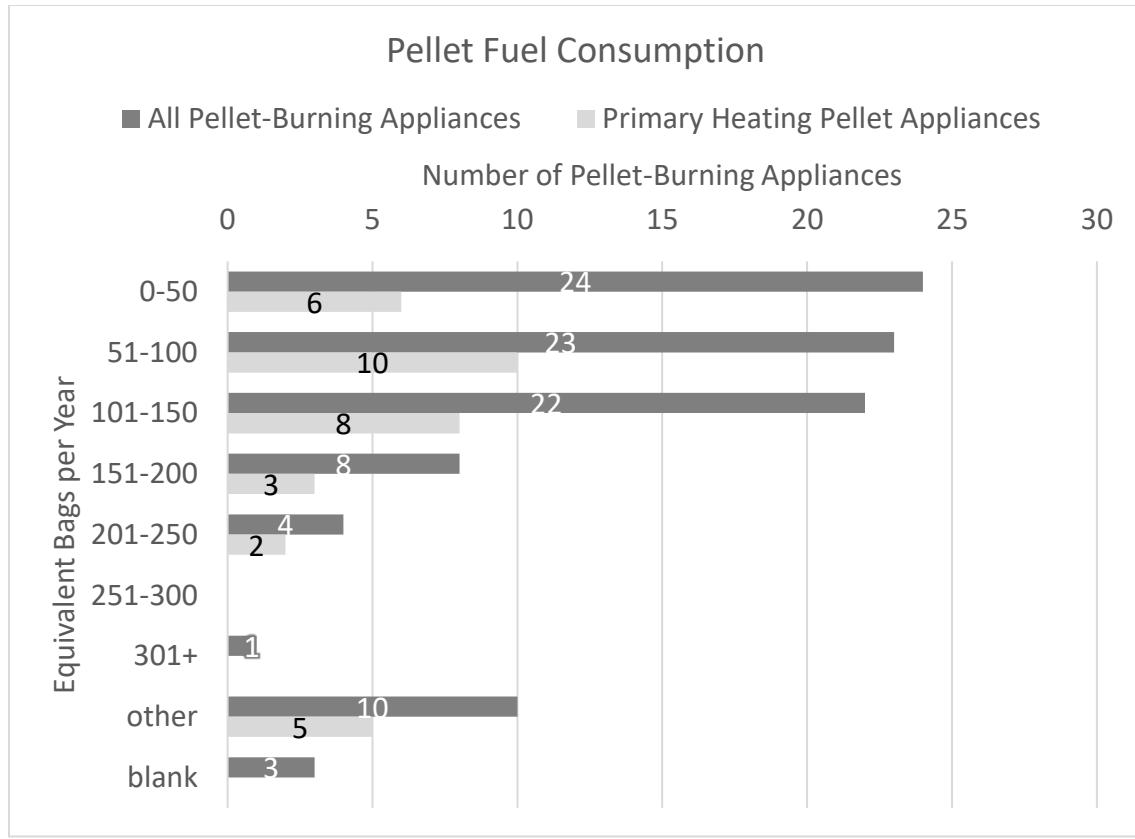


Figure 18: Annual household pellet consumption (assuming tonnes and pallets of pellets are equivalent to 50 pellet bags).

None of the 10 ‘other’ responses provided a value – 4 of them were ‘unknown’, 3 of the appliances were not used, 2 of the appliances were new, and one resident was new to the area and therefore did not have data yet on fuel consumption. There was no explanation associated with the 3 blanks.

Table 11: Frequency of pellet usage among all pellet-burning appliances, and just those in homes using wood as their primary heat source.

Equivalent Bags of Pellets	All Pellet-Burning Appliances		Primary Heating Pellet Appliances	
0-50	24	25%	6	18%
51-100	23	24%	10	29%
101-150	22	23%	8	24%
151-200	8	8%	3	9%
201-250	4	4%	2	6%
251-300	0	0%	0	0%
301+	1	1%	0	0%
other	10	11%	5	15%
blank	3	3%	0	0%
Total	95	100%	34	100%

8.9 Question 9: Perception of Air Quality in Vanderhoof

Question 9 reads: "Which of the following statements best describes how you feel about air quality in Vanderhoof? "The air quality in Vanderhoof is..."

Figure 19 shows community perception about air quality is quite positive, with only 4% of residents feeling that air quality in Vanderhoof is not at least mostly good, but poor on occasion.

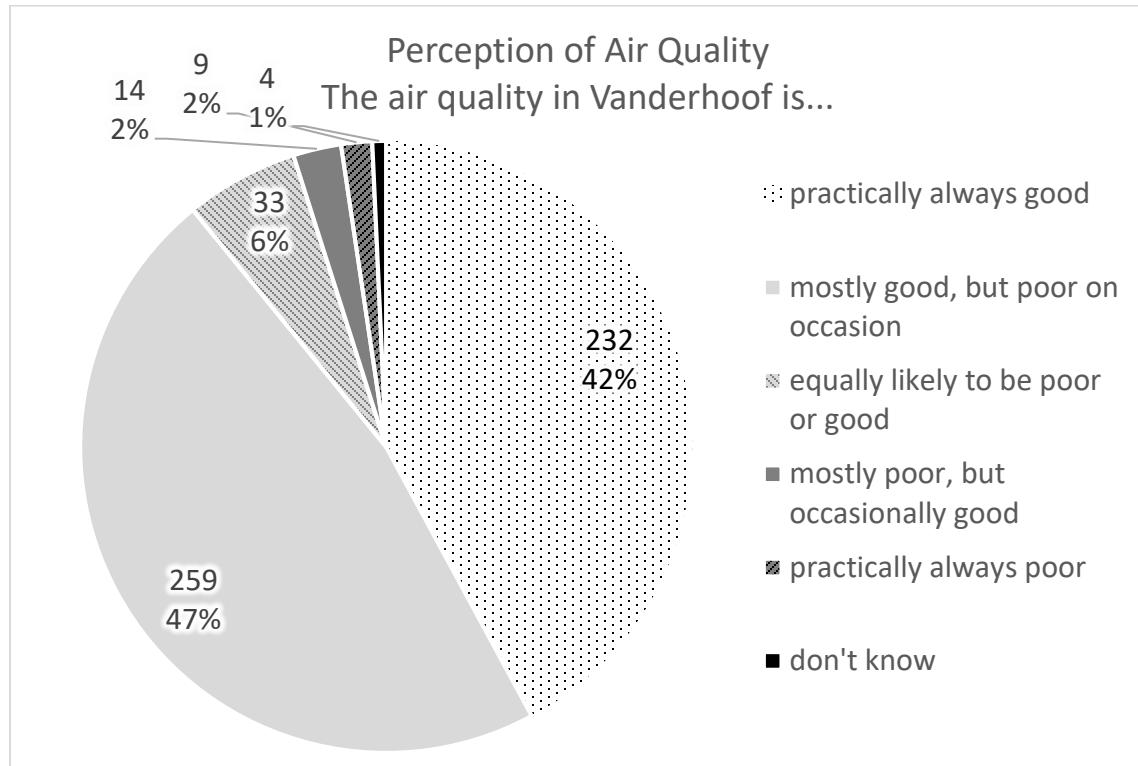


Figure 19: Overall perception of air quality in Vanderhoof is quite positive.

Figure 20 shows the relative perceptions of Vanderhoof air quality from each neighbourhood. Riverview reported the greatest dissatisfaction with air quality. The numeric data associated with Figure 20 are provided in Table 12.

Relative Neighbourhood Perceptions of Air Quality: The air quality in Vanderhoof is...

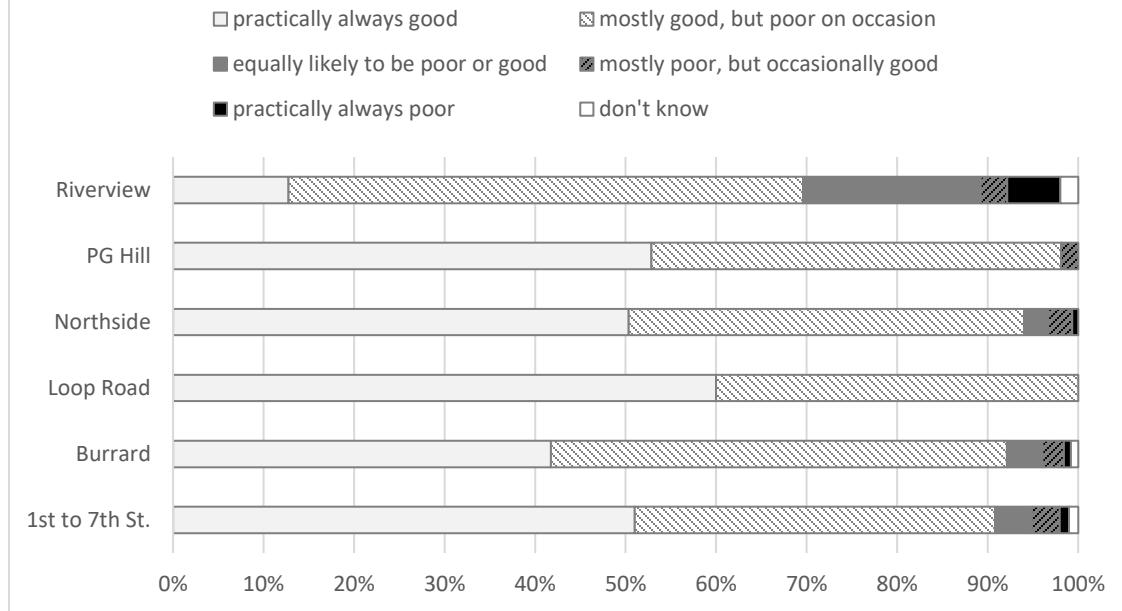


Figure 20: Perception of air quality in Vanderhoof in each neighbourhood.

Table 12: Survey responses on the perception of air quality in Vanderhoof.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
practically always good	50	51%	53	42%	12	60%	76	50%	28	53%	13	13%	232	42%
mostly good, but poor on occasion	39	40%	64	50%	8	40%	66	43%	24	45%	58	57%	259	47%
equally likely to be poor or good	4	4%	5	4%	0	0%	4	3%	0	0%	20	20%	33	6%
mostly poor, but occasionally good	3	3%	3	2%	0	0%	4	3%	1	2%	3	3%	14	3%
practically always poor	1	1%	1	1%	0	0%	1	1%	0	0%	6	6%	9	2%
don't know	1	1%	1	1%	0	0%	0	0%	0	0%	2	2%	4	1%
Blank	0	0	0	0	0	0%	1	1%	0	0%	0	0%	1	0%
Total	98	100%	127	100%	20	100%	152	100%	53	100%	102	100%	552	100%

8.10 Question 10: Perception of Wood Smoke on Neighbourhood Air Quality

Question 10 reads: "To what extent does smoke from wood-burning appliances affect air quality in your neighbourhood specifically?"

Figure 21 shows that most people did not feel that smoke from wood-burning appliances had any effect on air quality in their neighbourhood, which suggests an opportunity for community engagement and awareness on the effects of wood smoke on community air quality and health.

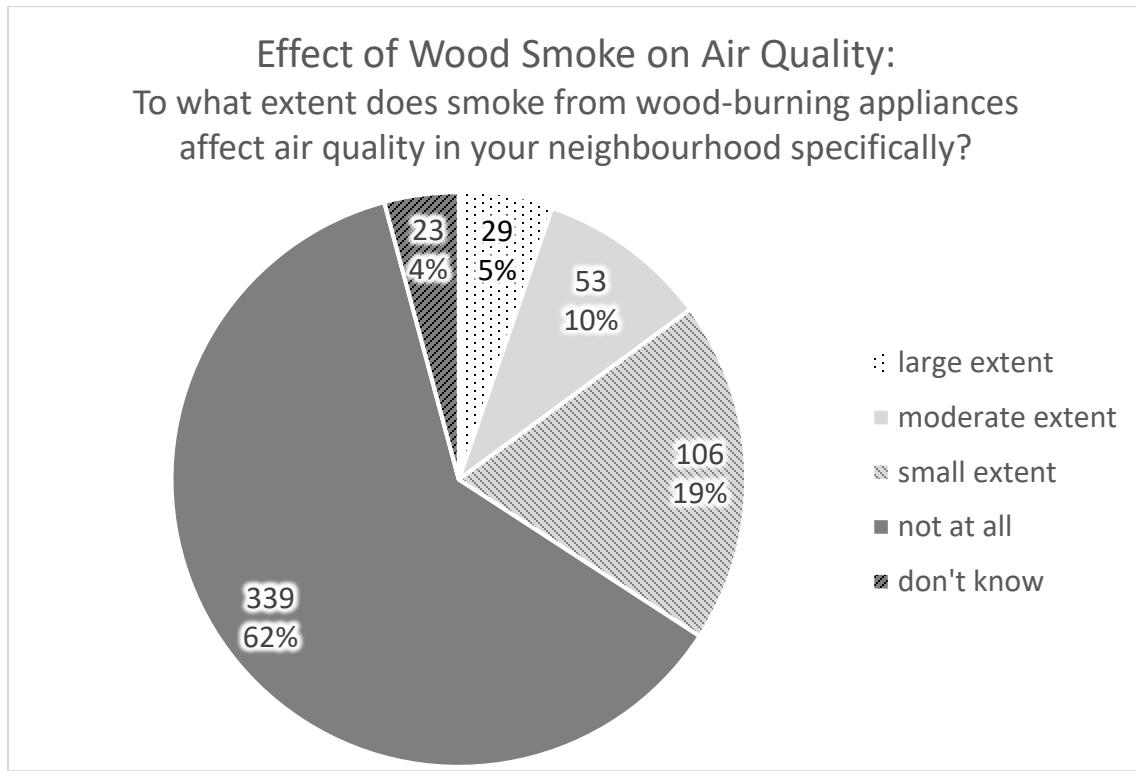


Figure 21: Perception of the effect of wood smoke on neighbourhood air quality.

Figure 22 shows that there is very little difference between the perceptions of those that do and do not use wood-burning appliances on the effect of such appliances on neighbourhood air quality. The numeric data associated with Figures 21 and 22 are provided in Table 13.

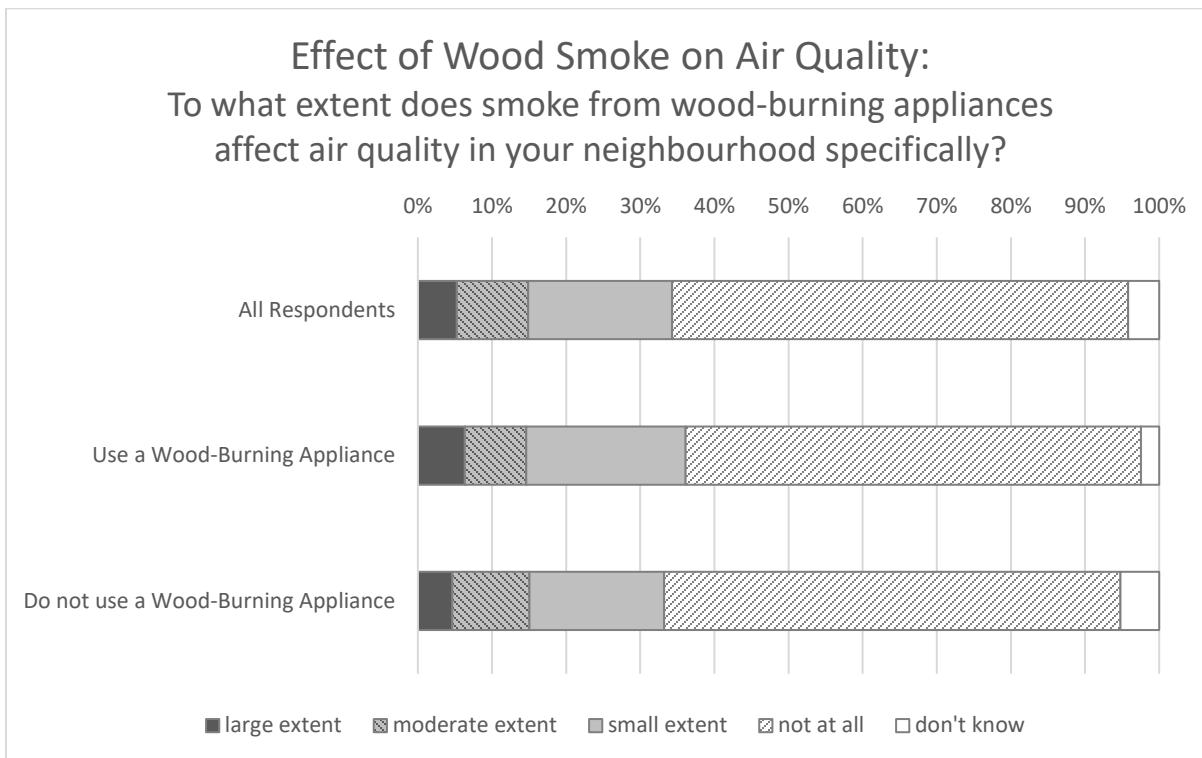


Figure 22: Perception of the effect of wood smoke on neighbourhood air quality, split up by whether the residence used a wood-burning appliance.

Table 13: Perception of residents on the effect of wood smoke on neighbourhood air quality.

	All Respondents		Use a Wood-Burning Appliance		Do not use a Wood-Burning Appliance	
large extent	29	5%	13	6%	16	5%
moderate extent	53	10%	17	8%	36	10%
small extent	107	19%	44	21%	63	18%
not at all	339	62%	126	61%	213	61%
don't know	23	4%	5	2%	18	5%
Blank	1	0%	0	0%	1	0%
Total	552	100%	205	100%	347	100%

Figure 23 shows the variation between neighbourhoods in their perceptions of how wood smoke affects neighbourhood air quality. Riverview again stands out as having the greatest concern regarding air quality, with relatively fewer homes in Riverview reporting that appliance smoke has no effect on neighbourhood air quality than any other neighbourhood. The numeric data associated with Figure 23 are provided in Table 14.

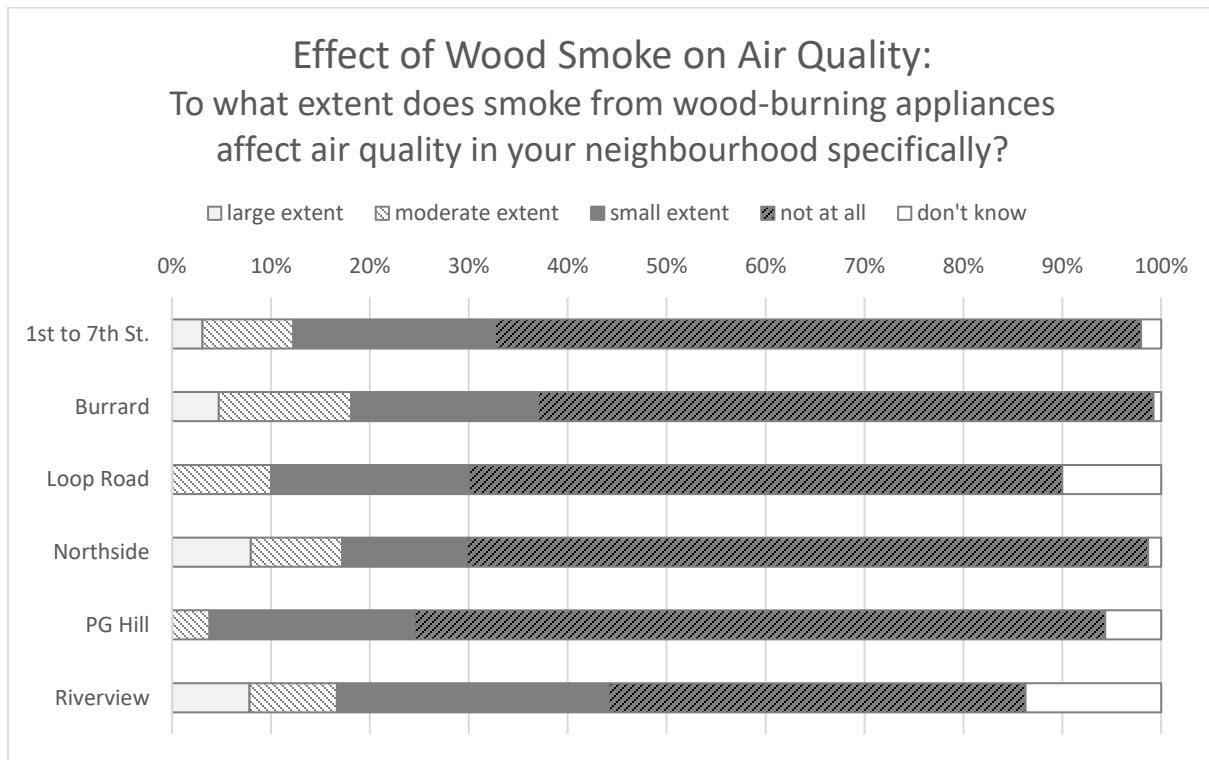


Figure 23: Perception of the effect of wood smoke on neighbourhood air quality.

Table 14: Survey responses on the extent to which smoke from wood-burning appliances affects neighbourhood air quality.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
large extent	3	3%	6	5%	0	0%	12	8%	0	0%	8	8%	29	5%
moderate extent	9	9%	17	13%	2	10%	14	9%	2	4%	9	9%	53	10%
small extent	20	20%	24	19%	4	20%	18	12%	11	21%	28	27%	105	19%
not at all	64	65%	79	62%	12	60%	104	68%	37	70%	43	42%	339	62%
don't know	2	2%	1	1%	2	10%	2	1%	3	6%	13	13%	23	4%
blank	0	0%	0	0%	0	0%	2	1%	0	0%	1	1%	3	1%
Total	98	100%	127	100%	20	100%	152	100%	53	100%	102	100%	552	100%

8.11 Question 11: Perception of Wood Smoke on Vanderhoof Air Quality

Question 11 reads: "To what extent does smoke from wood-burning appliances affect air quality in Vanderhoof?"

Figure 24 shows the community's perceptions of the effect of smoke from wood-burning appliances on air quality in Vanderhoof. Results are quite similar to those in the previous question, with the majority of residents reporting that smoke from wood-burning appliances has no effect on air quality in Vanderhoof, which again suggests an opportunity for community engagement and awareness on the effects of wood smoke on community air quality and health.

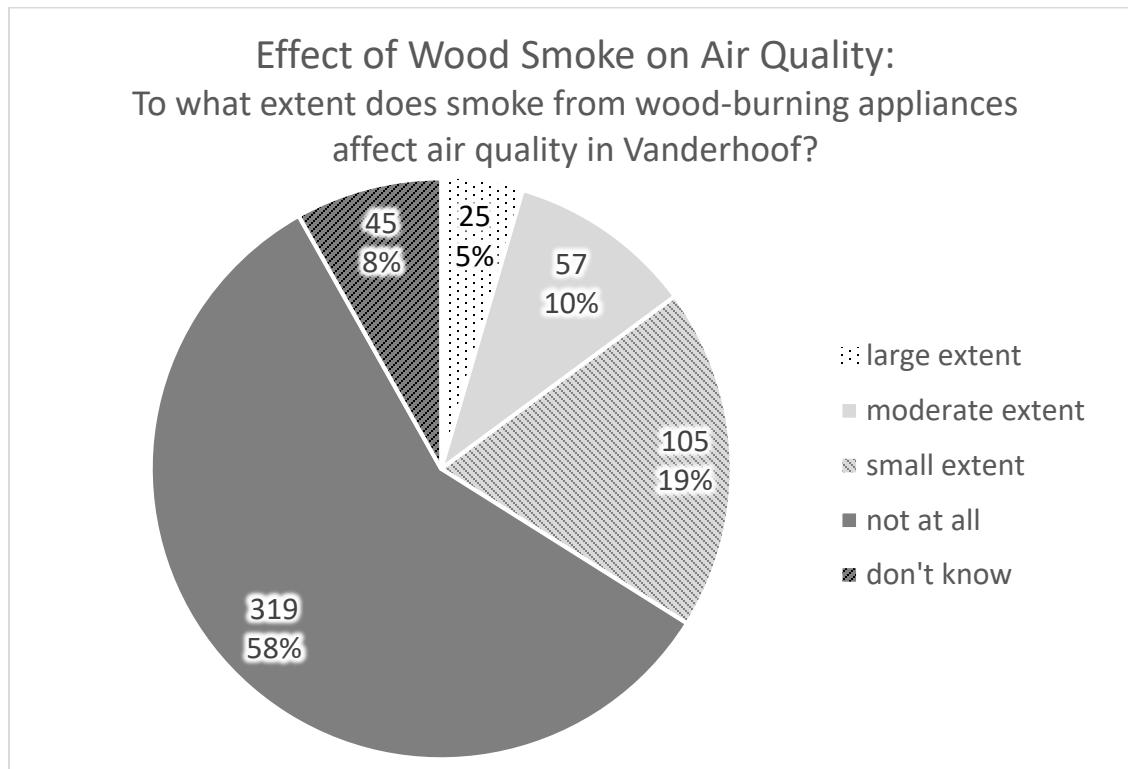


Figure 24: Perception of the effect of wood smoke on overall Vanderhoof air quality.

Figure 25 shows the variation between neighbourhoods in their perceptions of how wood smoke affects Vanderhoof's air quality. Riverview stands out even more than in the previous question, with relatively far fewer homes in Riverview reporting that wood smoke has no effect on air quality in Vanderhoof than any other neighbourhood. The numeric data associated with Figures 24 and 25 are provided in Table 15.

Effect of Wood Smoke on Air Quality: To what extent does smoke from wood-burning appliances affect air quality in Vanderhoof?

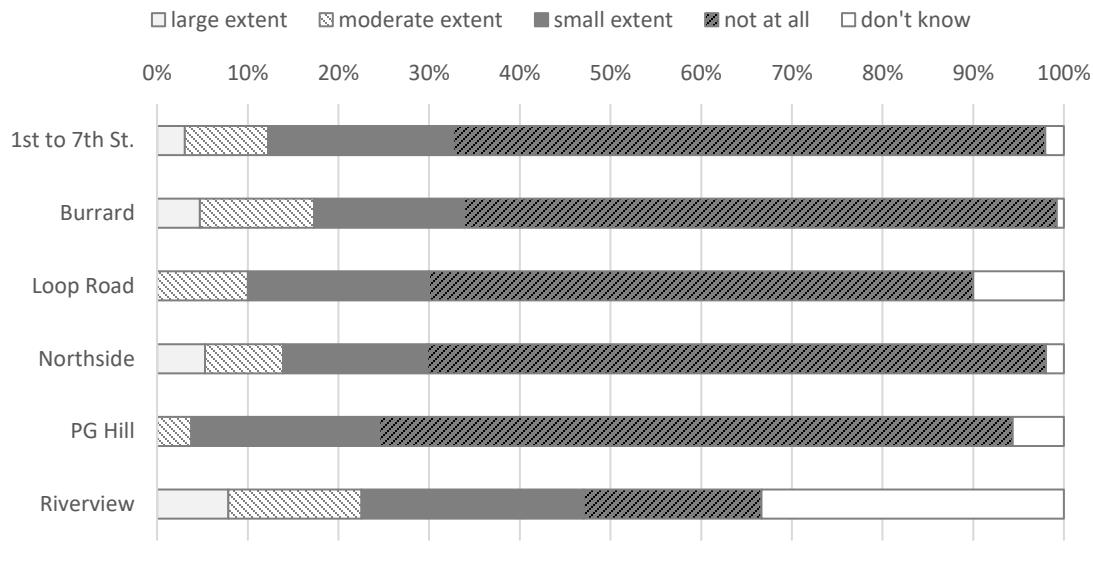


Figure 25: Perception of the effect of wood smoke on overall Vanderhoof air quality.

Table 15: Survey responses on the extent to which smoke from wood-burning appliances affects air quality in Vanderhoof.

	1st to 7th St.		Burrard		Loop Road		Northside		PG Hill		Riverview		Total	
large extent	3	3%	6	5%	0	0%	8	5%	0	0%	8	8%	25	5%
moderate extent	9	9%	16	13%	2	10%	13	9%	2	4%	15	15%	57	10%
small extent	20	20%	21	17%	4	20%	24	16%	11	21%	25	25%	105	19%
not at all	64	65%	83	65%	12	60%	103	68%	37	70%	20	20%	319	58%
don't know	2	2%	1	1%	2	10%	3	2%	3	6%	34	33%	45	8%
blank	0	0%	0	0%	0	0%	1	1%	0	0%	0	0%	1	0%
Total	98	100%	127	100%	20	100%	152	100%	53	100%	102	100%	552	100%

8.12 Question 12: Perceived Effect of Other Sources of Pollution on Neighbourhood Air Quality

Question 12 reads: “To what extent do other sources of air pollution affect air quality in your neighbourhood specifically?”

Figure 26 shows the community’s perceptions of the effect that other sources of air pollution have on air quality. More of the community (55%) feel that other sources of pollution have at least a small or greater effect on their neighbourhood’s air quality than smoke from wood-burning appliances (34% – question 10). This could be in part because of how generally ‘other’ sources of air pollution can be

interpreted, but also indicates that smoke from wood-burning appliances is not the only or overarching air quality concern for the community.

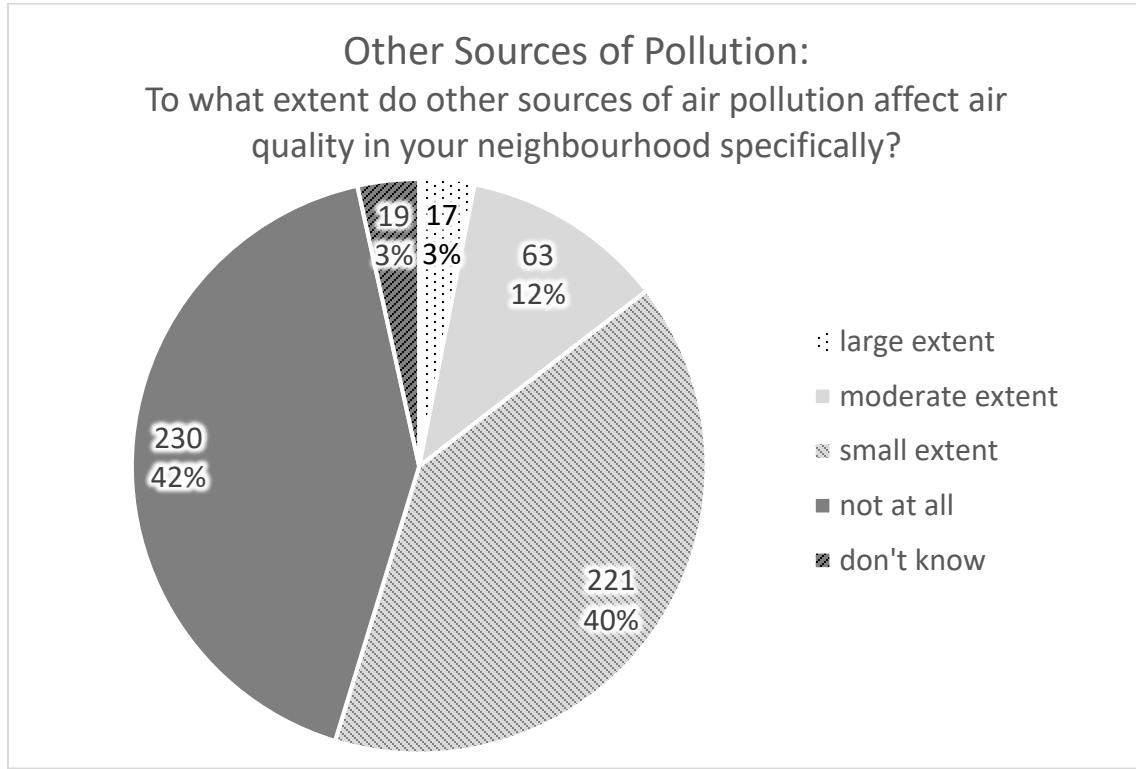


Figure 26: Perception of the effect of other sources of pollution on neighbourhood air quality.

Figure 27 shows that wood-burning appliance users were slightly more concerned about the effects of other sources of air pollution on their neighbourhood. The numeric data associated with Figures 26 and 27 are provided in Table 16.

Effect of Wood Smoke on Air Quality: To what extent do other sources of air pollution affect air quality in your neighbourhood specifically?

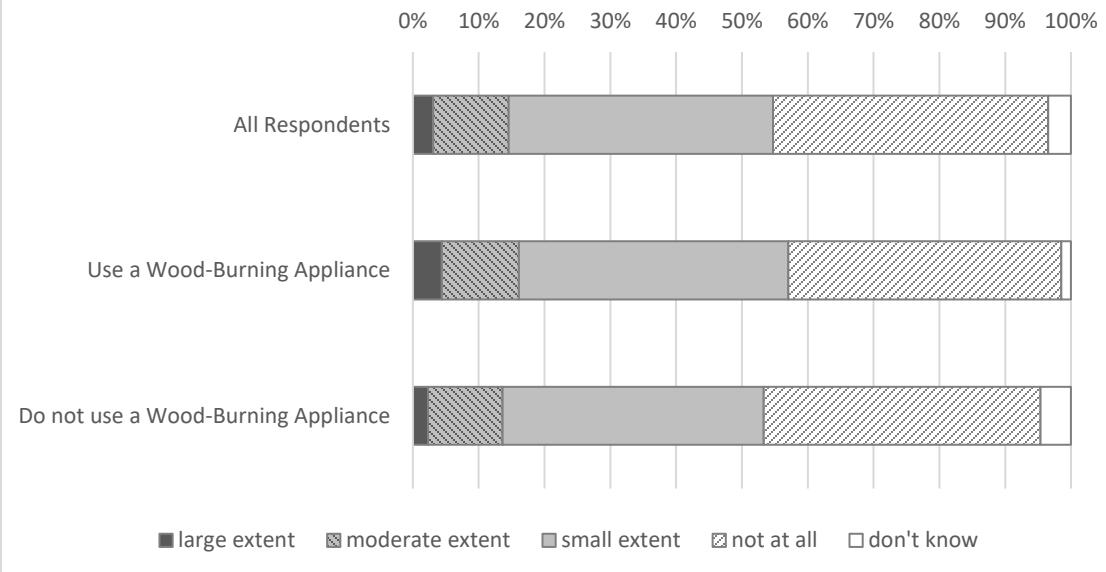


Figure 27: Perception of the effect of other sources of pollution on neighbourhood air quality from all survey responses, and just from those that do and do not use a wood-burning appliance.

Table 16: Number and percentage of responses on the effect of other sources of pollution on neighbourhood air quality from users and non-users of wood-burning appliances.

	All Respondents		Use a Wood-Burning Appliance		Do not use a Wood-Burning Appliance	
large extent	17	3%	9	4%	8	2%
moderate extent	63	12%	24	12%	39	11%
small extent	221	40%	84	41%	137	39%
not at all	230	42%	85	41%	145	42%
don't know	19	3%	3	1%	16	5%
Blank	2	0%	0	0%	2	1%
Total	552	100%	205	100%	347	100%

Figure 28 shows the variation between neighbourhoods in their perceptions of how other sources of air pollution affect their neighbourhood's air quality. Residents in Riverview reported other sources of pollution having a greater impact on their neighbourhood's air quality than other neighbourhoods. The numeric data associated with Figure 28 are provided in Table 17.

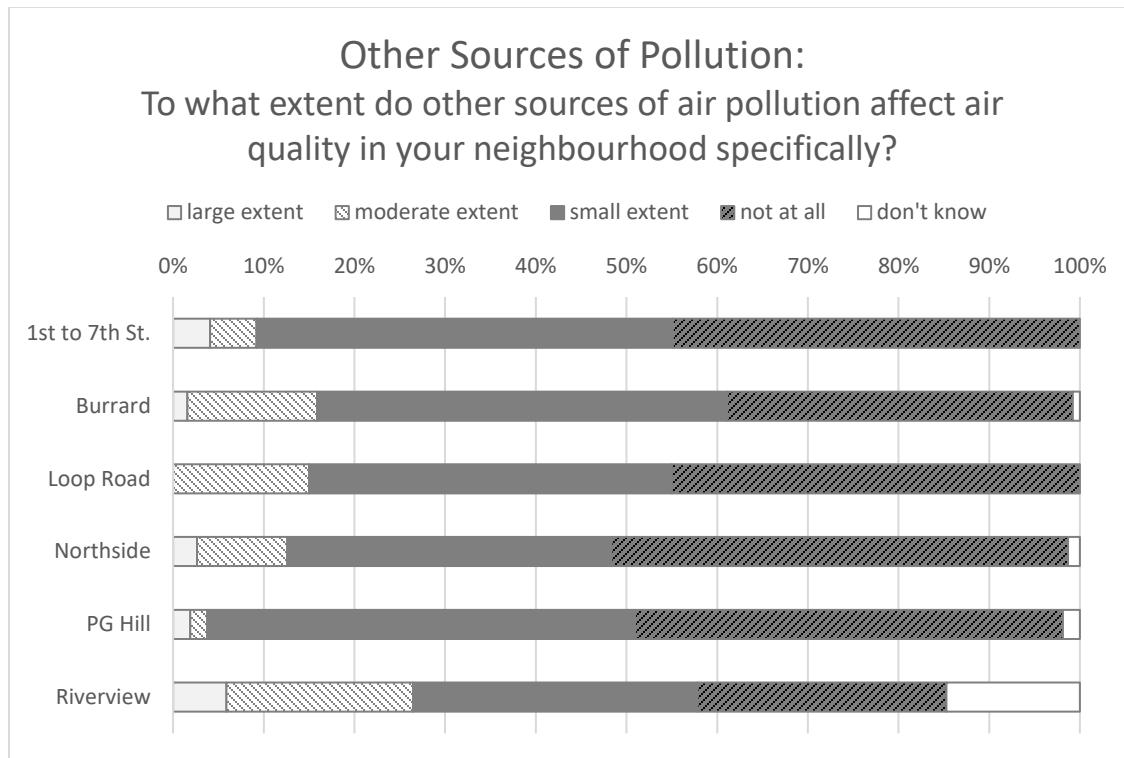


Figure 28: Perception of the effect of other sources of pollution on neighbourhood air quality.

Table 17: Number and percentage of responses on the effect of other sources of pollution on neighbourhood air quality from each neighbourhood.

	1st to 7th St.	Burrard	Loop Road	Northside	PG Hill	Riverview	Total	
large extent	4	4%	2	2%	0	0%	17	3%
moderate extent	5	5%	18	14%	3	15%	63	11%
small extent	45	46%	57	45%	8	40%	221	40%
not at all	44	45%	48	38%	9	45%	230	42%
don't know	0	0%	1	1%	0	0%	19	3%
blank	0	0%	1	1%	0	0%	2	0%
Total	98	100%	127	100%	20	100%	552	100%

8.13 Question 13: Identifying Other Sources of Air Pollution

Question 13 reads: "Can you identify other sources of air pollution that affect air quality in the community?"

Figure 29 shows the most frequently reported categories of air pollution in the community.

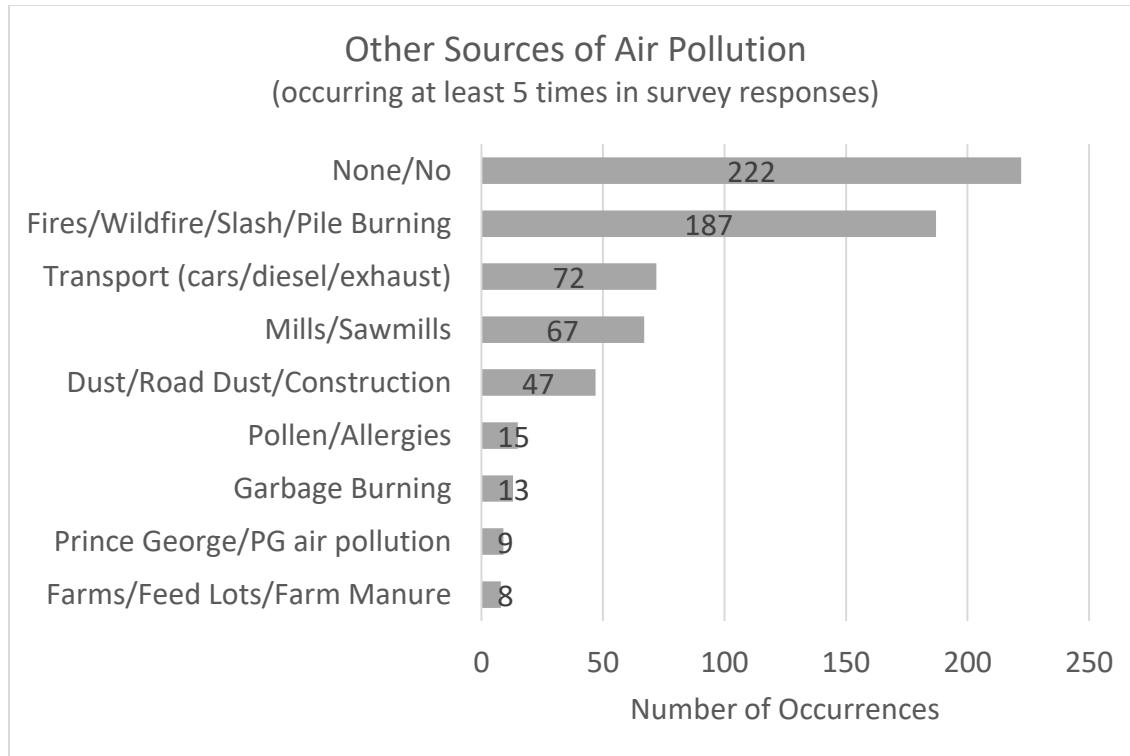


Figure 29: Frequency of most commonly cited other sources of air pollution.

Table 18 shows how frequently each ‘other’ pollution source was reported in survey responses. General categories of pollution sources are provided in the left column. Each unique pollution source as identified in surveys by a specific word or phrase is provided in the middle column, with the context in which they appeared in brackets, and the frequency of each word/phrase in the right column. Double counting was avoided by subtracting, for example, the number of ‘fire’s that were also included in the forest and wildfire counts. There are more responses (665) than there were surveys (552) because some surveys reported more than one source.

Table 18: Other sources of air pollution that affect air quality in the community.

Category	Search Term/Terms (description)	Frequency of Occurrences	
Agriculture	Farm	4	1%
	Feed Lot	2	0%
	Manure	2	0%
Blanks	Survey question left blank	6	1%
Drug Use	Crack/Pot/Weed (Neighbours/Kids smoking...)	4	1%
Dust	Dust	35	5%
	Roads (Road Dust/Road Construction)	12	2%
Fires (other)	Garbage/Plastic Burning	13	2%
Fires (wood)	Fires	161	24%
	Forest/Wildfires	18	3%
	Debris/Pile/Slash Burning	8	1%
	Outdoor/Wood Boilers	4	1%
Industry	L&M	4	1%
	Mills/Sawmills	67	10%
Noise	Noise	3	0%
No Other Sources	None/No	222	33%
Pollen	Allergies	3	0%
	Cottonwood	2	0%
	Hay/Hayfever	2	0%
	Pollen	8	1%
Prince George	Prince George/PG	9	1%
Sewage Odours	Lagoon/Septic/Sewer	4	1%
Transportation	Car(s)	15	2%
	Diesel/Trucks	22	3%
	Exhaust	2	0%
	Train	2	0%
	Vehicles	31	5%
Total		665	100%

9 Discussion

Use of wood-burning appliances in the District of Vanderhoof was reported to be slightly higher than in previous surveys done for the province in 2012 and Smithers in 2016 (Table 19). However, emissions certification was reported to be ~10% higher in Vanderhoof than in Smithers or the province outside Metro Vancouver. This is likely at least in part because a greater percentage of wood-burning appliances in Vanderhoof are pellet stoves/furnaces (46%) than in Smithers (16%) or BC excluding Metro Vancouver (7%). The 2012 BC survey reported that pellet stoves have higher emissions certification rates (89%) than wood stoves (71%) and wood fireplaces/inserts (40%) (Mustel Group, 2012).

Table 19: Comparison of wood-burning appliance usage for heating (using provincial and regional data from Mustel Group (2012) and Smithers data from Hiemstra (2016)).

	BC outside Metro Vancouver	Northern Region (Omineca, Skeena and the Northeast)	Smithers	Vanderhoof
Homes using a wood-burning appliance	30%	34%	22%	37%
Homes using appliance as primary heat source	10%	N/A	6%	11%
Emissions Certification	N/A	62% ¹	60%	71%
Wood fireplace or insert as % of all appliances	42%	N/A	20%	19%
Wood stoves as % of all appliances	58%	N/A	58%	30%
Pellet appliances as % of all appliances	7%	N/A	16%	46%

¹ Calculated from 2012 survey data – values were provided for each appliance type but not overall.

In the 2016 Smithers survey and the 2017 Vanderhoof survey, most residents reported that air quality in their community was either practically always good (29% of Smithers residents and 42% of Vanderhoof residents) or mostly good, but poor on occasion (42% of Smithers residents and 47% of Vanderhoof residents). This contrasts with measured air quality – based on Canadian Ambient Air Quality Standards (CAAQS), Smithers was in the highest “red” management level from 2011-2015, while Vanderhoof has remained in the “red” management level from 2011-2016, in both cases due to elevated PM_{2.5} concentrations (BC ENV, 2017a). In 2016, Vanderhoof was also one of three communities in the province that exceeded both the annual and 24-hour provincial objectives for PM_{2.5} (BC Lung, 2017b).

The high percentage of people that reported air quality in Vanderhoof being practically always good is particularly surprising because the survey ran from July 21 to August 16 of 2017, only weeks after a Smoky Skies Bulletin had been issued for the region due to wildfire smoke (Northern Health, 2017). Air quality in Vanderhoof was poor only a few days before the survey started, with 24-hour PM_{2.5} concentrations exceeding the provincial objective of 25 ug/m³ on July 18th and 19th (with 24-hour concentrations of 52 and 34 ug/m³, respectively), and then again toward the end of the survey on August 11th and 12th (with 24-hour concentrations of 68 and 92 ug/m³, respectively) (BC Air Data Archive website, 2017).

As the 2016 Smithers report stated, the conflict between measured and perceived air quality may in part be due to some portion of the community not being aware of how air quality in Vanderhoof compares with other communities in BC and/or the adverse health impacts of PM_{2.5}. There is also inevitably some variation in what some residents define as ‘good’ air quality. Finally, it is also possible that some residents intentionally misrepresented their opinion to influence the results and recommendations of the survey, though surveyors did not report getting that impression.

9.1 Sources of Error

Sources of error are discussed below to provide additional context and limitations of the results, and for consideration in the planning and implementation of future surveys. It should be noted that while there is room for improvement in future surveys, the survey nonetheless produced valid, insightful information on the state of wood-burning appliance perceptions and usage in Vanderhoof.

To some extent, sources of error are unavoidable in voluntary surveys. Not everyone will want to participate, and some people will be at work, on vacation or otherwise unavailable. If those that do not participate do not share the same behaviours and/or beliefs as those that do participate, those behaviours and/or beliefs may be underrepresented in the survey results. Furthermore, there could be individuals that are not entirely honest for any number of reasons, including not wanting to admit to a behaviour or belief out of shame or a perceived social stigma, because they want to manipulate the survey results and any government policy that might follow, or because something simply slipped their mind while they were being interviewed.

While there will always be some unknowns and limitations, many sources of error can be minimized through sufficient sample size and appropriate survey design and implementation. The survey sought to include as many community members as possible by surveying all neighbourhoods in the Vanderhoof core and as many homes in surrounding subdivisions as time allowed, by visiting homes multiple times at different times of day including the evening when no one could initially be reached, and when that also failed by leaving surveys along with directions on where they could be dropped off.

Some limitations were unavoidable, such as not being able to conduct surveys in apartment buildings and assisted living facilities. Overall wood-burning appliance usage rates for the entire community are likely at least a bit lower than reported as such residences would be more likely to be heated through other sources. Inevitably at some homes, the resident that is available to be interviewed is not the resident most knowledgeable about the appliance(s) in use at the home. This would likely result in some ‘Don’t Know’ responses that are not representative of the household and community. However, other surveys face the same limitations, so their results are still comparable.

9.1.1 Survey Design

There were some aspects of the survey design that led to possible errors and limitations in interpreting the results. Question 3 requests that households fill out one survey per appliance, but no record was kept of which surveys were from the same household, or how many households submitted more than one survey, though surveyors reported that there was at least one. This resulted in those households with two or more appliances submitting duplicate answers for questions 9-13, and prevented wood/pellet fuel usage from being tracked by household. The chimney and woodpile count also has inherent errors. The chimney count is not selective to just wood-burning appliances, as it includes

chimneys for other heating sources like natural gas and heating oil as well as chimneys no longer in use, and as such would be expected to overestimate wood-use. The woodpile count would be expected to underestimate wood usage due to some homes storing wood out of view indoors or in sheds, though one surveyor reported that “many” homes had woodpiles but stated that they were not currently using a wood-burning appliance, and that the woodpile was simply left over from when the appliance had been active. This could also indicate that some people reported not using a wood-burning appliance only because the survey was done in the summer.

9.1.2 Survey Implementation

While overall the survey produced a large sample of useful data, including a 58% response rate that is impressive for a door-to-door survey, there were also some sources of error associated with the survey implementation. There were some surveys for which questions were left blank even when ‘don’t know’ was an option, and when answers on those surveys to previous questions indicated that a response to those questions would be expected. The surveys were checked to confirm that the blanks were not errors caused by the optical mark recognition software. Several questions had 4 or less blanks, so it is possible that they were from the 4 surveys that were returned by residents as opposed to being filled out by survey staff (records were not kept of which surveys those were). However, there were 8 surveys that indicated currently using a wood-burning appliance that left question 5 (appliance age) blank, and 20 surveys that indicated currently using a non-pellet wood-burning appliance that left question 7 (duration of seasoning) blank. It is unknown if the surveyor accidentally skipped the question or forgot to record a response, as they could not be reached for comment.

Implementation issues were not just restricted to blanks. One surveyor reported not feeling very confident about woodpile counts meaning an appliance is in the house or working, and did not appear to have been very comprehensive in their chimney and woodpile counts for neighbourhoods other than Riverview. Some neighbourhoods were also reportedly more difficult to count chimneys in due to large trees obstructing the view of rooflines. Another factor that may have influenced results was the way surveyors posed questions to residents. One surveyor reported rewording questions to make them more understandable, such as asking for questions 10 and 11 if “when people nearby are burning wood stoves, does it bother you?”, or for question 13 if there is “anything you can think of that might be bothering you that might be a source of air pollution?”

There were also fewer ‘Sorry we missed you’ leaflets used than expected, suggesting that they may not always have been left at houses where they should have, which may have reduced the number of homes that participated in the study. On a more positive note, unlike the Smithers survey, no other door to door surveys or other forms of in-person solicitation were noted during the course of the survey, so ‘survey fatigue’ among residents was not believed to be an issue.

9.2 Recommendations for Future Surveys

A number of recommendations for future surveys have come up through talking to the surveyors about their experience and interpreting the results. Chimney and woodpile counts do not appear to provide very reliable information on wood-burning appliance usage, and as such do not necessarily need to be included in future studies. Alternatively, these counts could be included as survey questions to tie the counts to specific forms, enabling possible correlations between those counts and other survey

responses to be examined. Another option would be for surveyors to make a note on surveys for which residents provided a response that appeared to conflict with visible indications of wood usage.

Question 1 could be reworded, as suggested in the 2016 Smithers survey, to “do you currently have a wood-burning appliance in your home?” and an “appliance not currently being used” response option could be added to questions 6, 7 and 8 on firewood/pellet usage and duration of seasoning. This would hopefully reduce the number of conflicting results of people reporting to ‘currently’ use an appliance, but then reporting “not used” for fuel usage, as well as ensuring that residents with an appliance but not ‘currently’ using it because of the time of year are still asked how much wood they use in a typical year.

Not keeping track of how many homes submitted more than one survey, or which surveys those were, introduced some errors into the survey (mentioned in Section 9.1), and required fuel usage to be compared between appliances rather than households. This could be avoided by adding an extra question that is simply a box to tick if they have multiple appliances in their household. Instructions could then be added for surveyors to only fill in appliance-specific information (questions 2-8) on the 2nd or 3rd survey for that home. Then, assuming surveys have a unique ID as they did in this survey, data from ‘multiple appliance’ surveys occurring consecutively could be identified by the survey author and combined to generate household fuel consumption data. If consecutive homes had multiple appliances, the appliances could still be grouped by household based on which surveys have responses to questions 9-12.

This survey added extra categories for question 6 on wood usage based on recommendations from the 2016 Smithers survey. However, these new categories used a different unit of ‘armfuls’ that could not be converted into cords, as residents likely have varying opinions on what constitutes an armful of wood. In future surveys, if the categories are all be in the same unit, more analysis would be possible, such as comparing the annual wood consumption of certified and non-certified wood stoves used for primary heating. A description of how many armfuls or pieces of wood are in a cord could be provided to help residents decide on the appropriate category (e.g. 0 - 0.5 cords is equivalent to up to 25 armfuls, or 250 split, fire-ready log pieces). Alternatively, using a free-form response where residents instead provide a specific number or fraction of cords would allow even greater data analysis and correlation between variables.

Instead of asking survey respondents to identify other sources of air pollution that affect air quality in the community, question 13 could ask respondents to rank 5 most common categories of air pollution based on what has the most harmful effects on air quality and health, including wood smoke from appliances as one of the options, to provide a clearer indication of how the community perceives wood smoke relative to other sources. A free-form question could still be included afterwards to help identify if there are any other significant local pollution sources not included in the ranking. Alternatively, questionnaires could ask respondents to rank each common pollution source out of 5, and be asked to list any other sources that have adverse air quality effects, and to also rank those out of 5.

10 Conclusions

The door-to-door survey in Vanderhoof collected a large dataset from over 50% of targeted residences in Vanderhoof on the prevalence of wood-burning appliances, behaviours associated with their use and community perceptions about air quality in Vanderhoof. These data will be used to assist in formulating further air zone management actions to improve air quality for the community.

Findings from the survey that are of particular relevance to elevated PM_{2.5} in the community include a slightly higher prevalence of wood-burning appliance use in Vanderhoof (37%) relative to the average for the Northern Region (Omineca, Skeena and the Northeast) (34%). While most wood-burning appliances were reported to be emissions-certified, over a quarter of residents were not aware of the emissions certification status of their appliance, and less than 40% of non-pellet wood-burning appliance users reported seasoning their wood for at least 6 months before burning. Overall, about 60% of all residents reported that smoke from wood-burning appliances has no effect on air quality in their neighbourhood and in Vanderhoof.

Given the prevalence of residential wood-burning, the community would likely benefit from educational activities that promote awareness of the adverse health impacts associated with wood smoke, the benefits of burning seasoned wood and the indoor and outdoor emissions associated with the various wood-burning appliances compared to alternative heating sources. It could also help residents make informed decisions if the capital and operational costs relevant to Vanderhoof were provided for each heating option presented. Materials summarizing Vanderhoof's burning control bylaws and providing information on BC's updated Solid Fuel Burning Domestic Appliance Regulation could also be made readily available.

It is also worth considering approaches that other communities have taken to reduce wood smoke. The Cowichan Valley Regional District's Airshed Protection Strategy (<https://www.cvrdr.ca/documentcenter/view/70959>) proposed several actionable items to be considered by the community, including bylaw changes to ban the use of residential wood-burning appliances during air quality advisories, with the exception of homes with no other form of heating, requiring the removal or upgrading of non emissions-certified woodstoves upon the sale of homes, only allowing emissions-certified woodstoves to be installed in new homes being constructed, and promoting alternative energy pilot and grant programs. Port Alberni (<https://www.portalberni.ca/content/solid-fuel-burning-wood-stoves>) not only banned the installation of new solid-fuel burning appliances that do not meet the latest CSA/EPA emissions standards, they also required that all existing devices in the city be removed by a certain date.

Some or all of the above bylaw amendments might not be agreeable to the Vanderhoof community, but they are options to keep in mind if public opinion on PM_{2.5} shifts. A less controversial option that has been offered in 18 regional districts and over 44 municipalities since 2008 is the BC Wood Stove Exchange Program (BC ENV, 2017b). The program works with communities to provide incentives to encourage residents to replace old wood-burning appliances with more efficient, emissions-certified appliances. Such a program would complement an educational awareness initiative by providing residents with an opportunity to act on the information they're provided with, if they're so inclined, without imposing any obligations on less other residents.

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Finally, and most importantly, the time, energy and hardship the surveyors put into this project was greatly appreciated.

The survey was designed through collaboration between the BC ENV and the District of Vanderhoof, and conducted by the District of Vanderhoof. This report was prepared by Evan Morrow. The conclusions expressed herein may or may not be supported by the BC ENV and the District of Vanderhoof.

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13 Appendix A: Surveyor Guide

Introductory Text

Hi, my name is.....and I am working with the District of Vanderhoof to survey residents about wood heat. The survey is 8 questions long and takes approximately 3-5 minutes to complete. Would you be willing to complete our survey?

NOTE: Count the number of chimneys and woodpiles in each neighbourhood.

1. Do you currently use a wood-burning appliance in your home?

Yes No (If not, skip to question 8)

2. Do you consider wood your home's primary heat source?

Yes No

3. What kind of wood heating appliance do you have in your house? (note there may be more than one appliance in a house, if so fill out relevant survey questions for both appliances)

- | | | |
|------------------------------------|--|---|
| <input type="radio"/> woodstove | <input type="radio"/> fireplace insert | <input type="radio"/> outdoor wood boiler |
| <input type="radio"/> wood furnace | <input type="radio"/> pellet stove | <input type="radio"/> don't know |
| <input type="radio"/> fireplace | <input type="radio"/> pellet furnace | |

4. Does your wood burning appliance have EPA or CSA emissions certification? EPA certified stoves will have a permanent label on the back with the words "U.S. Environmental Protection Agency" prominently visible. Please note that emission certification is different than safety certification which may be from the ULC or CSA. (Note: If pellet, this question does not apply)

Yes No

Note: If the homeowner has questions on whether their stove is EPA certified some additional information that they can provide is:

- Nearly all EPA certified stoves and inserts have a door with a positive latch and seal and have a glass viewing area built into the door.
- 100% of EPA stoves have some means of adjusting airflow into the stove.
- Solid metal doors likely indicate a pre-EPA air tight stove.
- Lack of an air control probably means it is an uncertified EPA-exempt stove designed to fit through a loophole in the EPA regulation.
- Glass doors without a positive latch and air seal probably mean it is a factory built fireplace or a pre EPA insert.

5. How old is your wood burning appliance?

- | | | |
|---|-------------------------------------|----------------------------------|
| <input type="radio"/> less than 2 years | <input type="radio"/> 10 - 15 years | <input type="radio"/> don't know |
| <input type="radio"/> 2 - 5 years | <input type="radio"/> 15 - 22 years | |
| <input type="radio"/> 5 - 10 years | <input type="radio"/> over 22 years | |

6. Approximately how much wood do you burn each year?
- | | | |
|--|---|---|
| <input type="radio"/> 1-5 bundles
(bundle=armful) | <input type="radio"/> 1 - 2 cords | <input type="radio"/> don't know |
| <input type="radio"/> 6-10 bundles | <input type="radio"/> 2 - 3 cords | <input type="radio"/> Some other amount |
| <input type="radio"/> 11-15 bundles | <input type="radio"/> 3 - 5 cords | (bundles, truckloads,
etc.) |
| <input type="radio"/> Half cord | <input type="radio"/> 5 - 7 cords | |
| | <input type="radio"/> more than 7 cords | |

If pellet stove: how many bags, pallets or tonnes of pellets do you use each year?

7. How long do you season your firewood for before burning it? (Note: If pellet, this question does not apply)
- | | | |
|------------------------------------|--|----------------------------------|
| <input type="radio"/> don't season | <input type="radio"/> 6 - 9 months more
than 1 year | <input type="radio"/> don't know |
| <input type="radio"/> 1 - 3 months | | |
| <input type="radio"/> 3 - 6 months | <input type="radio"/> don't know | |
8. How much you agree with the following statement: "wood-burning appliances significantly contribute to air pollution problems in Vanderhoof":
- | | | |
|--------------------------------------|---|----------------------------------|
| <input type="radio"/> Strongly Agree | <input type="radio"/> Disagree | <input type="radio"/> don't know |
| <input type="radio"/> Agree | <input type="radio"/> Strongly Disagree | |
9. Which of the following statements best describes how you feel about air quality in Vanderhoof? "The air quality in Vanderhoof is..."
- | | | |
|--|---|--|
| <input type="radio"/> Practically always
good | <input type="radio"/> Equally likely to be
poor or good | <input type="radio"/> Practically always
poor |
| <input type="radio"/> Mostly good, but
poor on occasion | <input type="radio"/> Mostly poor, but
occasionally good | <input type="radio"/> Don't know |
10. To what extent does smoke from wood-burning appliances affect air quality in your neighbourhood specifically?
- | | | |
|---------------------------------------|------------------------------------|----------------------------------|
| <input type="radio"/> Large extent | <input type="radio"/> Small extent | <input type="radio"/> Don't know |
| <input type="radio"/> Moderate extent | <input type="radio"/> Not at all | |
11. To what extend do other sources of air pollution in Vanderhoof and the surrounding area affect air quality in your neighbourhood specifically?
- | | | |
|---------------------------------------|------------------------------------|----------------------------------|
| <input type="radio"/> Large extent | <input type="radio"/> Small extent | <input type="radio"/> Don't know |
| <input type="radio"/> Moderate extent | <input type="radio"/> Not at all | |

Can you identify other sources of air pollution that affect air quality in the community?

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