



NORTHERN UTAH AIR QUALITY SURVEY

FINAL REPORT

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SUBMITTED TO:

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EXECUTIVE SUMMARY

The Utah Department of Environmental Quality (DEQ) contracted with ICF International (ICF), an independent research and consulting firm, to conduct a survey of residents in seven northern Utah counties regarding their opinions surrounding air quality and their home heating and wood burning behaviors. Key objectives of the study (hereafter referred to as the Northern Utah Air Quality Survey) included estimating the percentage of households in the target area which burn wood and the volume of wood burned.

We implemented the survey—consisting of up to four mail contacts over an eight-week period—to a representative sample of 8,600 addresses within the seven-county area. A total of 2,690 completed surveys were received, for a response rate of 33.2 percent (using the American Association of Public Opinion Research’s, or AAPOR’s, RR1 formula). We also cleaned responses and prepared an analytic report.

Within the study area, some type of wood burning appliance was reported by 32 percent of households (see Table 1). Fireplaces were the most cited wood burning appliance (21%), followed by inserts (7%) and wood stoves (7%). Other types of wood burning appliances, such as pellet stoves, cordwood central furnace, etc. were reported by three percent of respondents. Among all respondents with a wood burning appliance, 42 percent reported burning wood in the past 12 months. The highest percentage of wood burning in the last 12 months was reported by those with woodstoves (59%), followed by other appliance types (56%). Across all appliance types in the study area, approximately 95,000 cords of wood were burned.

Table 1. Type of Wood Burning Appliances and Wood Burned

Appliance Type	Households with Appliance Type		Burned Wood in Past 12 Months		Total Cords Burned*	Cords per Household with Appliance Type
	n	%	n	%	n	
Any Appliance	2,679	32%	791	42%	94,709	0.40
Fireplaces	2,671	21%	517	36%	36,130	0.23
Inserts	2,661	7%	142	44%	24,835	0.50
Woodstoves	2,648	7%	244	59%	33,744	0.71
Other	2,612	3%	47	56%	+	+

*includes non-12-month burners

+ For other wood burning appliances, the number of responses to cords burned was too small to estimate mean volume per household

Other findings include:

- A significantly higher percentage of respondents rated air quality in summer months as “very good” or “good” (60%) than in winter months (10%).
- A similar percentage of respondents believed that industry sources (73.9%) and vehicles (67.7%), were “very large” or “large” contributors to air pollution, while a much smaller percentage reported that residential and commercial sources (21.3%) were “very large” or “large” contributors.
- More than half of respondents (53.7%) reported that it was “very likely” that they would reduce idling or driving on poor-air-quality days; other short-term actions that

respondents would “very likely” do to help improve air quality included limiting the use of household products (37.2%) and decreasing home energy use (35.3%). Respondents reported that it was “very unlikely”, however, that they would increase their use of public transportation (36.8%) or telecommute/work from home on poor-air-quality days (34.5%).

- By far, the most popular primary home heating source was natural gas (88.2%), followed by electricity (8.6%). Other primary heat sources (wood, propane, coal, other) were reported by less than one percent of respondents.
- Among those with a wood burning appliance, more respondents reported using their fireplace for enjoyment (70%) than as a primary or secondary/back-up heat source. However, more respondents use inserts (67%), stoves (66%), and other appliances (55%) as secondary/back-up heat sources than for enjoyment or as a primary heat source.
- Most respondents burned wood in their appliances during the months of November through February, with less than 10 percent of respondents burning wood April through September.
- When asked the time of day they typically burned wood in their appliance, respondents reported using about three-quarters of each type of appliance in the evening, and between one-third and half of appliances during the nighttime.
- During a 24-hour period, most appliances were used to burn wood less than four hours each day.
- Just over one percent of all respondents reported having a coal burning appliance in their home (1.22%), and these appliances were used as a secondary or back-up heat source, rather than for enjoyment.
- One quarter of respondents reported having an outdoor fireplace or fire pit (24.8%); half of respondents (58.7%) with an outdoor fireplace or fire pit do not typically use it during the winter, and one-third uses it once per month or less during the winter (34.4%).

CHAPTER 1. INTRODUCTION

Seven Northern Utah counties (Cache, Box Elder, Weber, Davis, Salt Lake, Tooele, and Utah) have been designated by the U.S. Environmental Protection Agency (EPA) as nonattainment areas for the 24-hr PM_{2.5} standard.¹ Fine particulates, PM_{2.5}, can accumulate in urban mountain valleys during meteorological episodes known as persistent cold air pools, more commonly called winter inversions.² Under such conditions a visible layer of haze can develop which can exacerbate health problems and, for sensitive populations, make outdoor activity unsafe. Figure 1 illustrates the nonattainment areas.

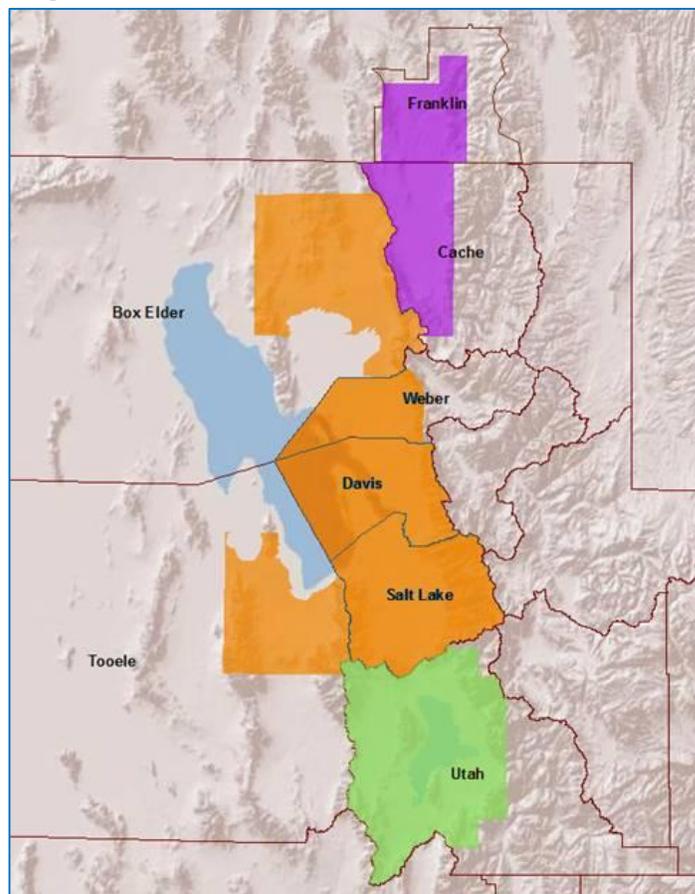
Sources of PM_{2.5} include industrial or manufacturing facilities, mobile sources such as vehicles, and area sources such as smoke from wood burning.³ Research suggests that wood smoke and cooking may be greater contributors to particulate pollution than previously thought.⁴ This survey, along with a new analysis of wood smoke contribution to monitored PM_{2.5} values, reflects the high priority that Utah Department of Environmental Quality (DEQ) puts on gaining a greater understanding of this issue.

It is important to determine wood burning behaviors, and the corresponding amount of wood burned at the county and sub-county level, so that DEQ can compare this data to current methods used to create the wood burning emission inventory. A private research and consulting firm, ICF International, was retained by DEQ to conduct a representative mail survey (hereafter referred to as the Northern Utah Air Quality Survey) of Wasatch Front area residents to ask their opinions about air quality and their home heating and wood burning behaviors in order to ascertain the contribution of wood burning to the air shed. More than 8,500 households were sampled using an address-based sampling (ABS) design; over a two-month fielding period, each household was mailed a pre-notification letter, a questionnaire packet, a thank you postcard, and a replacement questionnaire (for non-responders).

There were 2,690 completed surveys returned, for a response rate of 33.2 percent (using the American Association of Public Opinion Research's, or AAPOR's, RR1 formula).

This final report presents results from the Northern Utah Air Quality Survey and is divided into four chapters: *Methodology Overview*, *Findings*, *Wood Burning Projections*, and *Appendices*.

Figure 1: PM_{2.5} Nonattainment Area



CHAPTER 2. METHODOLOGY OVERVIEW

This section offers a brief overview of the study design and methodology. A complete description of the methodology for this project can be found in *Appendix B: Methodology*.

SAMPLE DESIGN

An address-based sample (ABS) of households stratified by county was designed to meet the key objectives of the study. These objectives included estimating the percentage of households burning wood by appliance (fireplace, insert, stove) and the volume of wood burned by these appliances. The target study area was defined in terms of the seven-county area representing the PM_{2.5} nonattainment (Box Elder, Cache, Davis, Salt Lake, Tooele, Utah, and Weber counties).¹ Within Salt Lake County, two substrata were established to allow for oversampling in one sub-county area, referred to herein as the “Hawthorne oversample area,” defined by a subset of census tracts. We allocated the sample equally to seven counties to support county-level estimates; a slightly smaller sample was allocated to the Hawthorne oversample area. The county-level sample size was derived such that an effect size of 0.3 is detected with 80 percent power using a significance testing level of 0.05. This means that a true 15 percent difference will be detected within these parameters. See Appendix B for a detailed discussion of the sample design.

Table 2: Survey Sample Sizes and Target Completes

County/Area	Sample Size (Target Completes)	USPS Addresses	Addresses Selected
Box Elder*	220	15,692	1,100
Cache*	220	36,134	1,100
Davis	220	103,335	1,100
Salt Lake (non-Hawthorne)	220	303,849	1,100
Hawthorne	180	66,346	900
Tooele*	220	18,238	1,100
Utah	220	154,212	1,100
Weber*	220	84,475	1,100
TOTAL	1720	782,281	8,600

*Denotes partial county. See footnote 1.

DATA COLLECTION

The data collection approach consisted of a multi-contact mail survey protocol following the best practices outlined by the Total Design Method developed by Dillman et al.⁵ We selected a mail survey mode because it offered the ability to present visual references on amounts of wood purchased and burned and because sampling addresses is highly accurate for surveying a very targeted geographic area and obtaining county-level representation. The data collection protocol

¹ Only a part of Weber, Cache, Tooele, and Box Elder Counties were included in the study area:

- Weber County: Wasatch Front
- Cache County: Cache Valley
- Box Elder County: Wasatch mountain range west to the Promontory mountain range and south of Portage)
- Tooele County: Northernmost part of the Oquirrh mountain range to the northern most part of the Stansbury mountain range and north of Route 199

consisted of four mail contacts over an eight-week fielding period. The survey instrument was designed to encourage response from residents who burn wood as well as those who do not, and featured relevant graphics, clear instructions, and formatting visual cues. A discussion of the instrument design is included in *Appendix B*. The eight-page survey instrument is provided in *Appendix A*, and other mail contact materials are provided in *Appendix C*.

WOOD BURNING PROJECTIONS

We calculated the incidence of wood burning by county and appliance (e.g., fireplace, inserts, woodstove, or other), as well as amount of wood burned. To improve the estimates of wood burned (in cords) for each appliance, we used a synthetic estimator that pool county data to estimate average cords burned per appliance. Frequently known as “borrowing strength,” the synthetic estimator allows us to improve the precision for estimates when the sample size is small. Specifically, the volume of wood burned in the past 12 months for appliance-*j* in area-*i* is estimated as:

$$\hat{V}_{i,j} = \hat{A}_{i,j} \times \hat{p}_j \times \bar{v}_j$$

where,

$\hat{V}_{i,j}$ is the estimated volume of wood burned for appliance-*j* in area-*i*

$\hat{A}_{i,j}$ is the estimated total number of households with appliance-*j* in area-*i*

\hat{p}_j is the estimated percentage of households using appliance-*j* to burn wood in past 12 months (all areas)

\bar{v}_j is the estimated mean volume of wood burned per household for appliance-*j* (all areas)

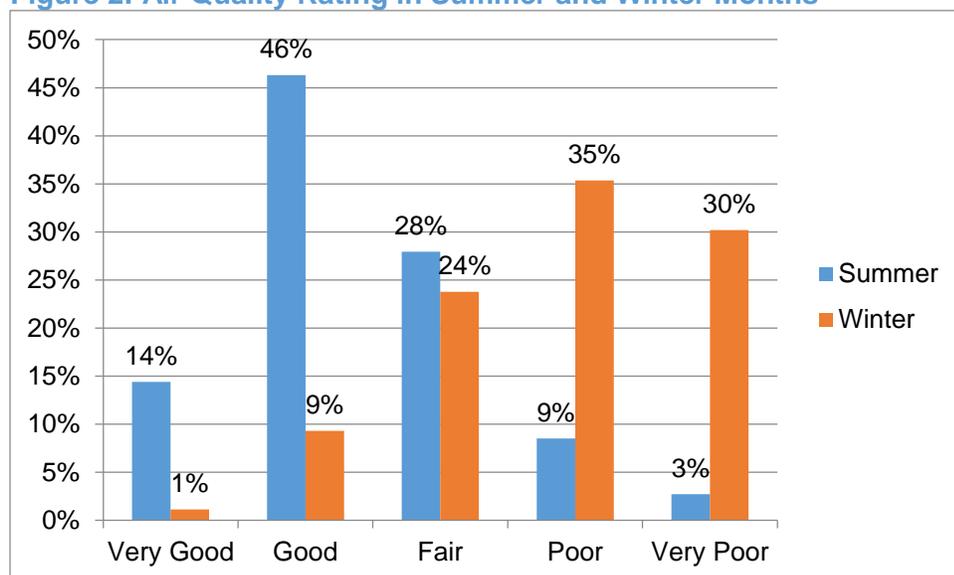
CHAPTER 3. FINDINGS

Within this chapter, we present findings for each section of the Northern Utah Air Quality Survey (see *Appendix A*), including *Opinions on Air Quality*, *Home Heating Sources*, *Wood Burning Devices*, *Coal Burning*, and *Home Characteristics*.

OPINIONS ON AIR QUALITY

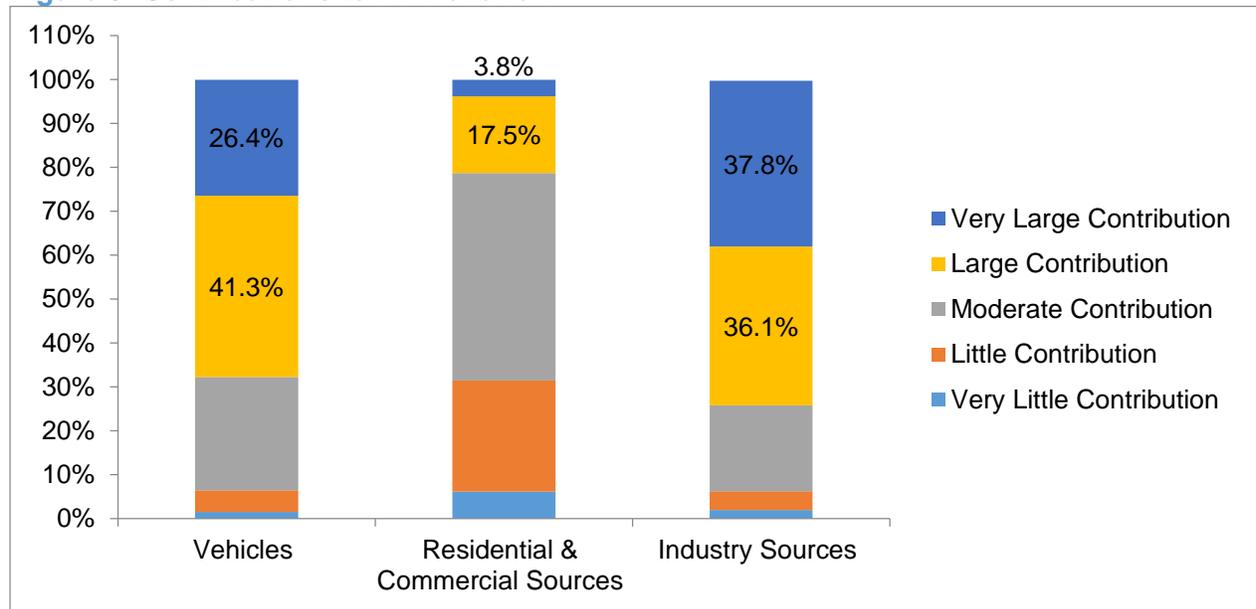
The first section of the survey contained four questions about respondents' views and experiences with air quality. Respondents were asked to describe air quality in Northern Utah in both summer and winter months. As shown in Figure 2, ratings of air quality differed between the summer and winter months, and all differences were statistically significant. Sixty percent of respondents rated the summer air quality as "very good" or "good," while only 10 percent rated the winter air quality as "very good" or "good".

Figure 2: Air Quality Rating in Summer and Winter Months



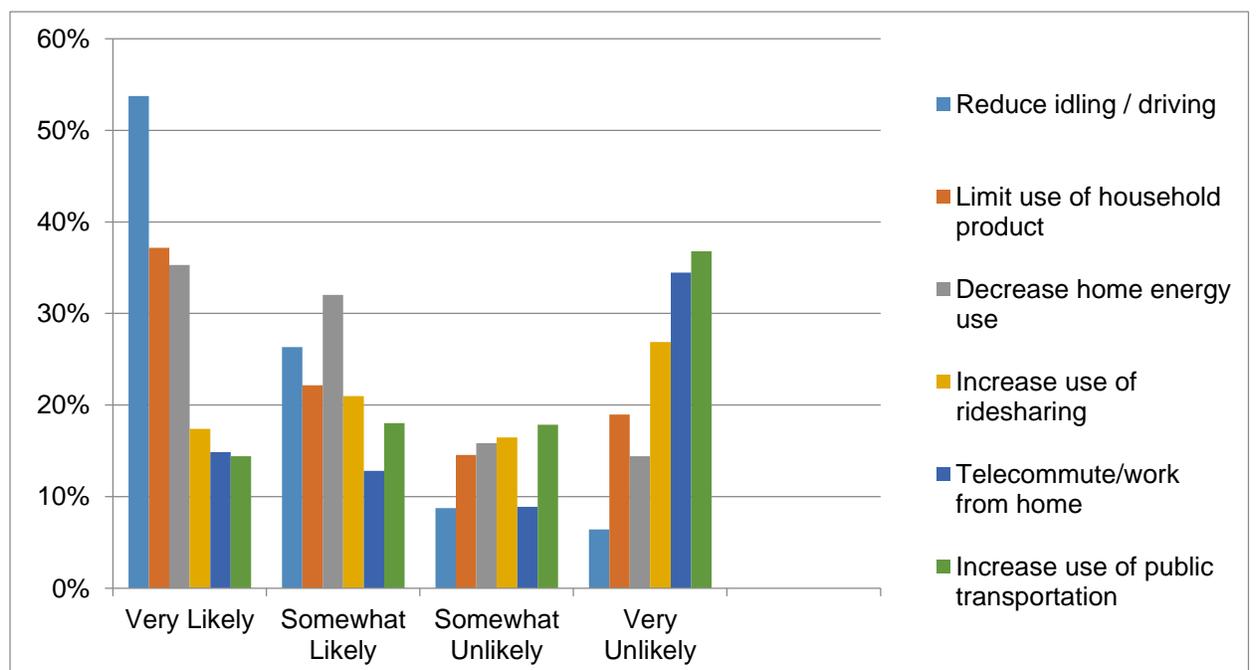
When asked to rate the contributions of different sources of air pollution (Figure 3), just under three-quarters of respondents (73.9%) believed that industry sources (such as mining, refineries, power plant operations, industrial furnaces, and boilers) were "large" or "very large" contributors to air pollution. Two-thirds of respondents thought that the contributions of vehicles (including residential and commercial transportation) was "large" or "very large" (67.7%), and only 21.3 percent of respondents said that residential and commercial sources (such as homes, small businesses, and buildings) were "large" or "very large" contributors to air pollution.

Figure 3: Contributions to Air Pollution



Respondents were asked to rate a list of short-term actions they could take to help improve air quality on poor-air-quality days. For each, they were asked to say how likely they would be to engage or partake in that action. Just over half of respondents (53.7%) said it was very likely that they would reduce idling or driving on poor-air-quality days, and over one-third of respondents said they would limit their use of household products (37.2%) or decrease their home energy use (35.3%). Other actions were less popular. Over one-third of respondents said that it was very unlikely for them to choose actions such as increasing their use of public transportation (36.8%) or telecommuting/working from home (34.5%). About one-quarter of respondents said it was very unlikely that they would increase their use of ridesharing (26.9%).

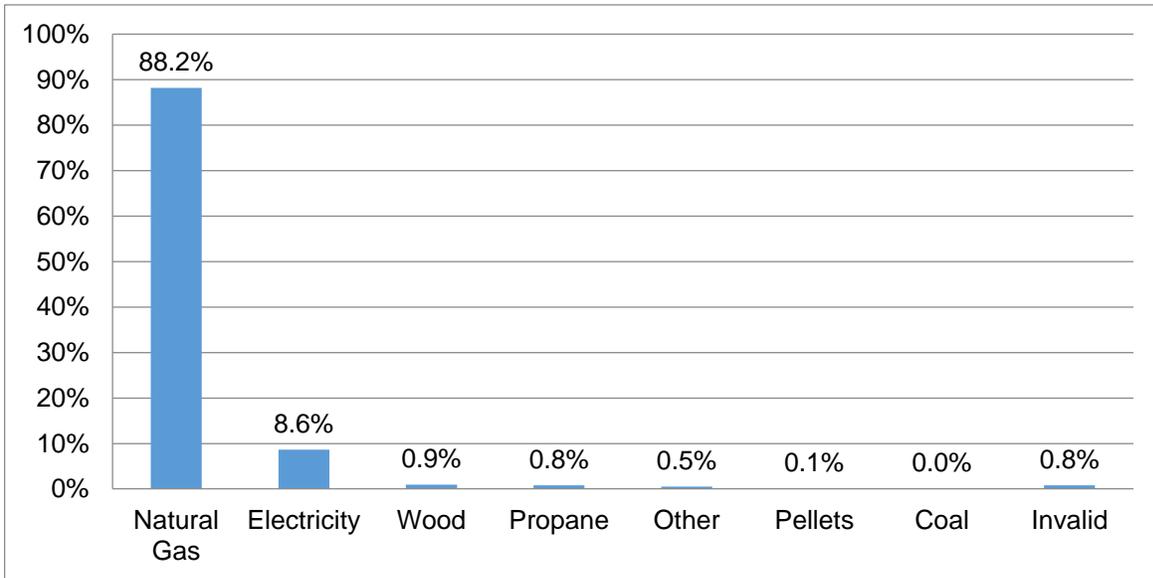
Figure 4: Short-term Actions to Improve Air Quality



HOME HEATING SOURCES

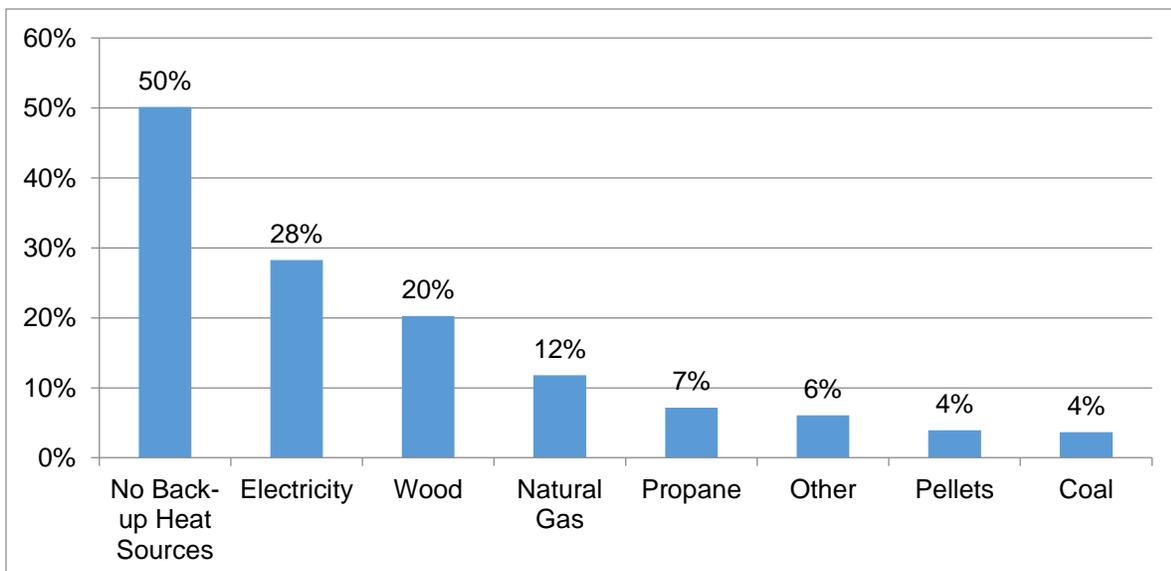
Respondents were asked to report their primary home heat source. For this question, they were directed to choose only one source. Nearly 90 percent of respondents reported that natural gas was their primary heat source, and 8.6 percent reported heating their homes primarily with electricity. Slightly less than one percent of respondents used wood as a primary heat source. Some write-in options provided in the “Other” category include: boiler/steam pipes, geothermal, and solar panels.

Figure 5: Primary Home Heating Source



Similarly, respondents were asked to report their back-up heat sources. For this question, they could select all applicable sources. Half of the respondents reported no back-up heat source, while 28 percent selected electricity and 20 percent selected wood. The most frequent write-in responses in the “Other” category for back-up heating sources include: kerosene (stove, heater, burner), space heater, and blankets/warm clothes.

Figure 6: Back-up Heat Source



WOOD BURNING

Respondents were asked whether they had any wood burning appliances in their home, including fireplaces, inserts, stoves, and other types of appliances. Approximately one-third of respondents reported having a wood burning appliance (32%), while two-thirds did not (68%). For those with a wood burning appliance, 42 percent burned wood in these appliances in the previous 12 months.

Figure 7: Incidence of Wood Burning Appliances

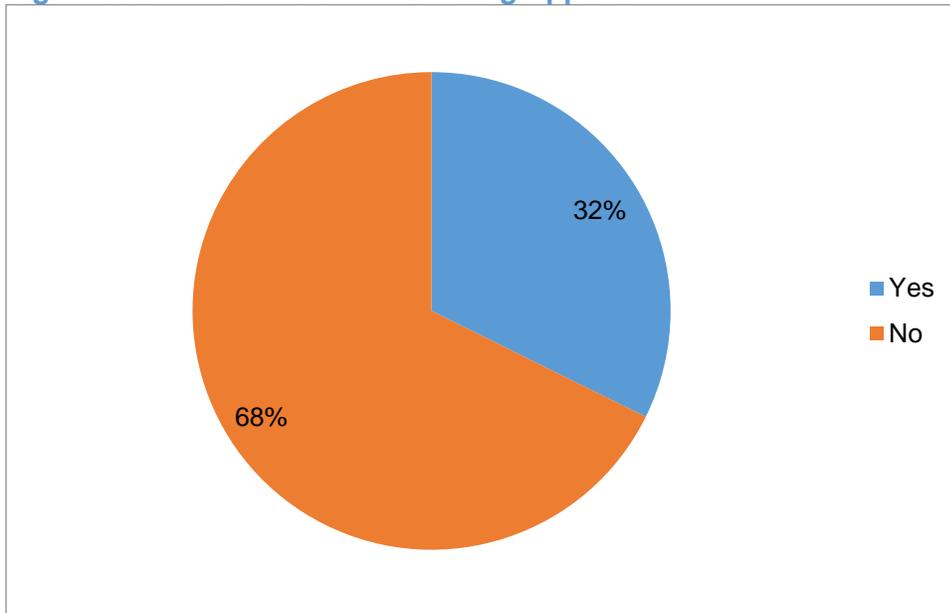
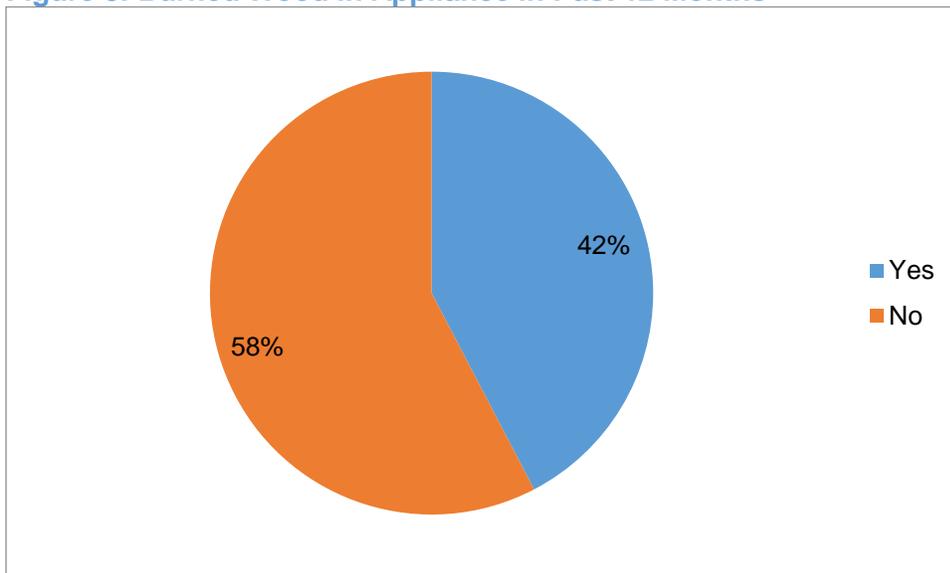
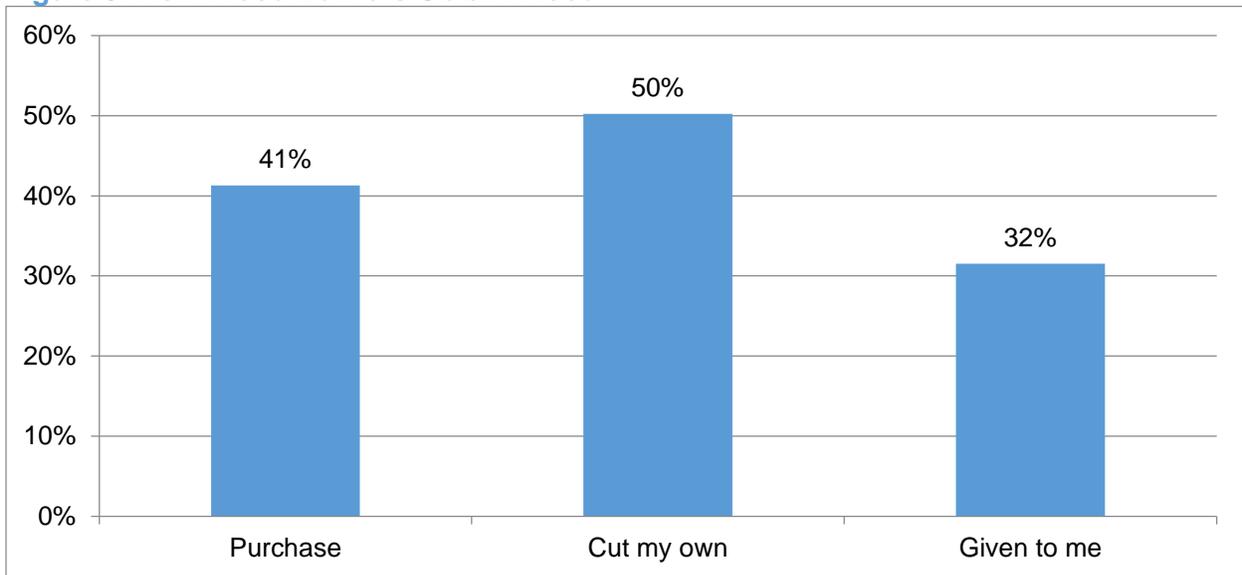


Figure 8: Burned Wood in Appliance in Past 12 Months



Respondents with a wood burning appliance were asked to select how they get their wood, and to select all applicable responses (therefore, percentages add to more than 100%). As shown in Figure 10, half of all respondents who have a wood burning appliance cut their own wood, while just over 40 percent purchase it.

Figure 9: How Wood Burners Obtain Wood



Similarly, respondents with wood burning appliances were asked to report how many starter fuels (such as wax logs, compressed sawdust, or other types of commercial solid fuel) they burnt in a typical year. About 87 percent of these respondents reported using zero starter fuels, and additional responses varied widely.

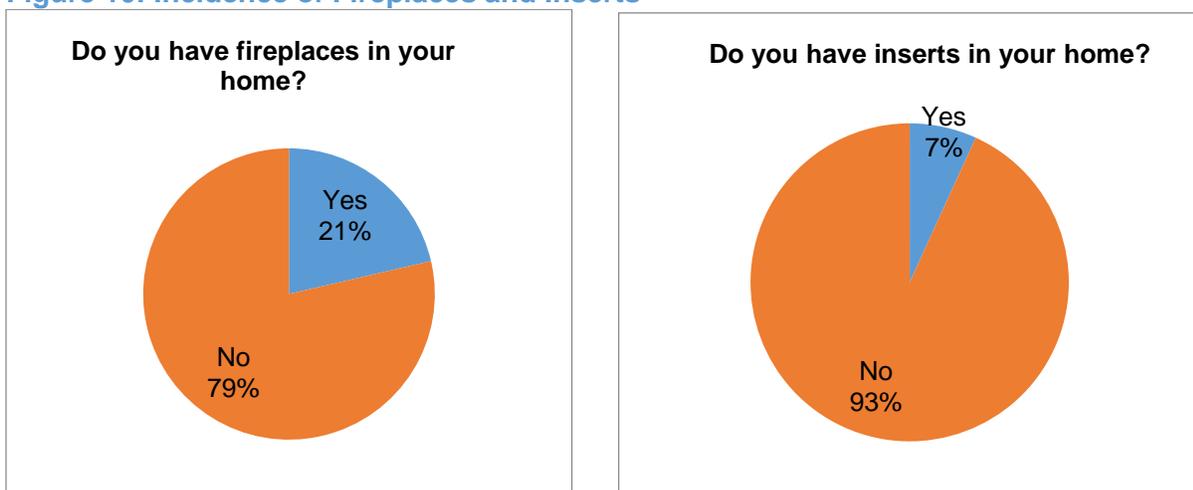
WOOD BURNING DEVICES

Respondents who reported owning a wood burning appliance were directed to appliance-specific sections of the survey about fireplaces, inserts, woodstoves, and other appliances.

INCIDENCE OF WOOD BURNING APPLIANCES

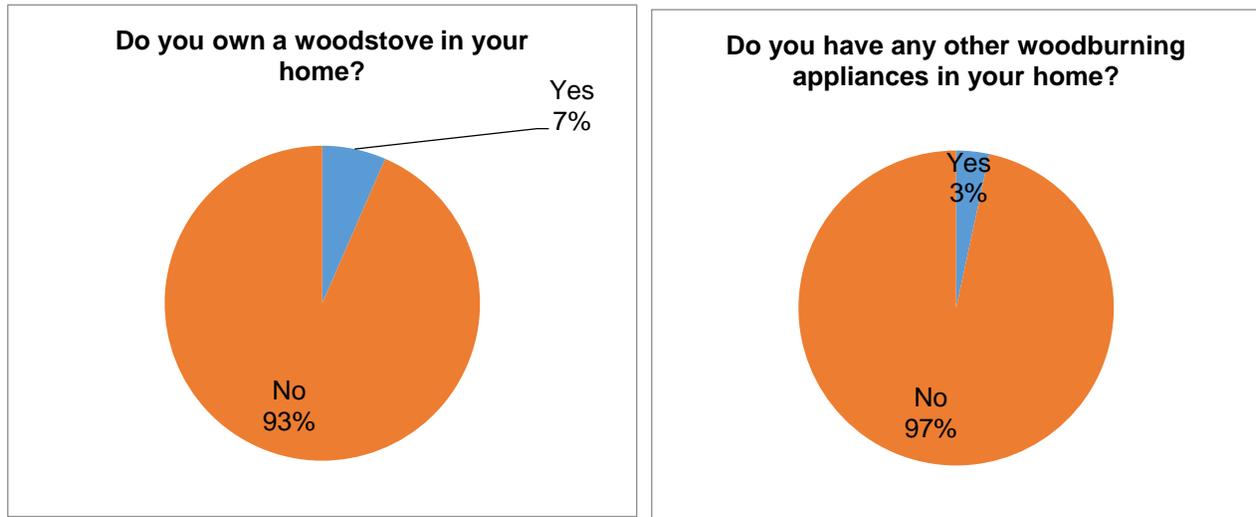
About one-in-five (21%) of all survey respondents reported owning a fireplace. The incidence of inserts was much lower, with only seven percent of all respondents reporting an insert in their home.

Figure 10: Incidence of Fireplaces and Inserts



The incidence of woodstoves was similar to that of inserts, with seven percent of all respondents reporting a woodstove in their home. Only three percent of all respondents owned another wood burning appliance that was not covered in other sections of the questionnaire, such as pellet stoves, cordwood central furnace, or other or unknown type of appliance.

Figure 11: Incidence of Woodstoves and other Wood Burning Appliances



Among those respondents who have any type of wood burning appliance, the highest percentage reported owning a fireplace (66%), followed by inserts (21%), woodstoves (21%), and “other” appliances (11%).

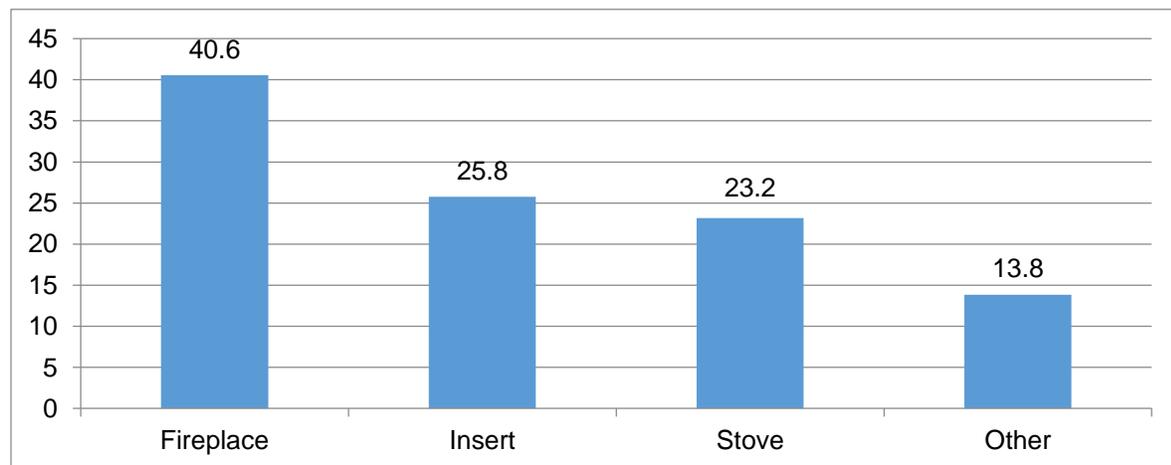
PHYSICAL CHARACTERISTICS OF APPLIANCES

The following section describes appliance characteristics. The base number is all the appliances in that category, which takes into account the possibility that a respondent may have two or more of a given appliance.

i. Mean Age

Respondents were asked to write in the age, in number of years, of the wood burning appliance. Below is the mean age for each appliance type.

Figure 12: Mean Age (Years) of Wood Burning Appliance



ii. EPA Certification

In a two-part question, respondents who owned an insert, stove, or other wood burning appliance were first asked if an EPA certification label was visible on the appliance. Between one-in-five and one-in-three appliances had a visible label (see Figure 13). Of these, about half of the labels on inserts and stoves showed EPA certification, while a majority (85%) of “Other” wood burning appliances with a visible label were EPA-certified.

Figure 13: Label Visible on Appliance

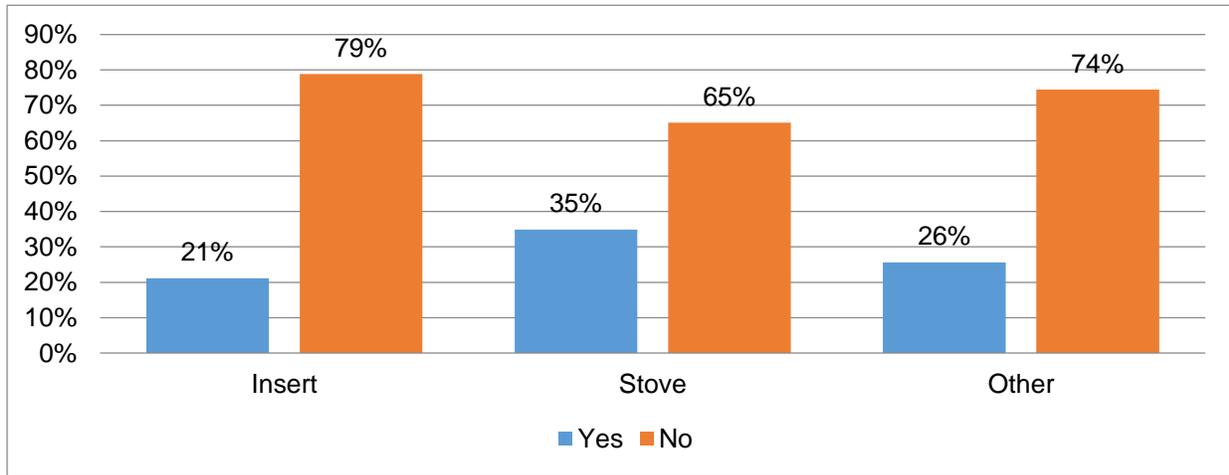
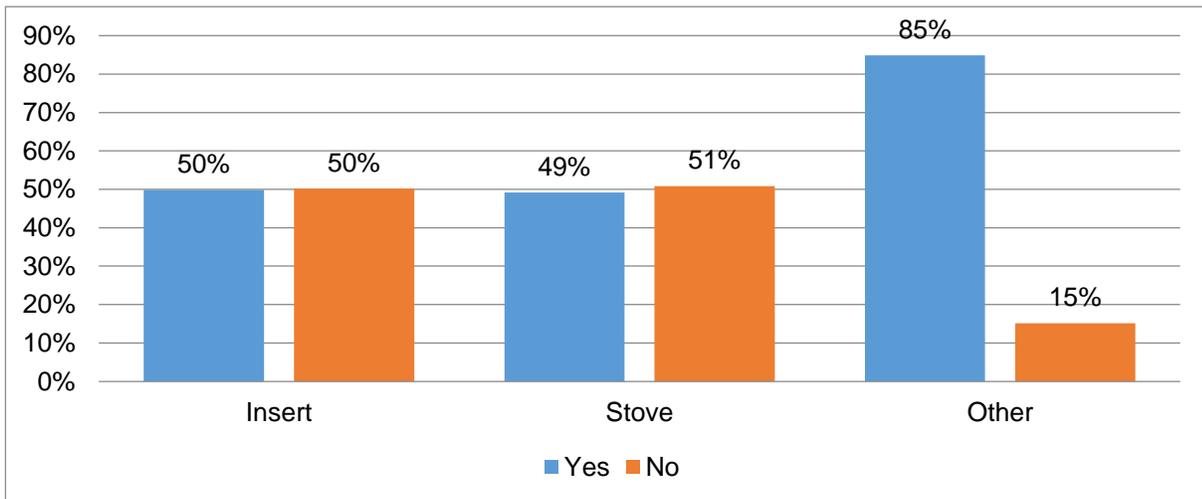


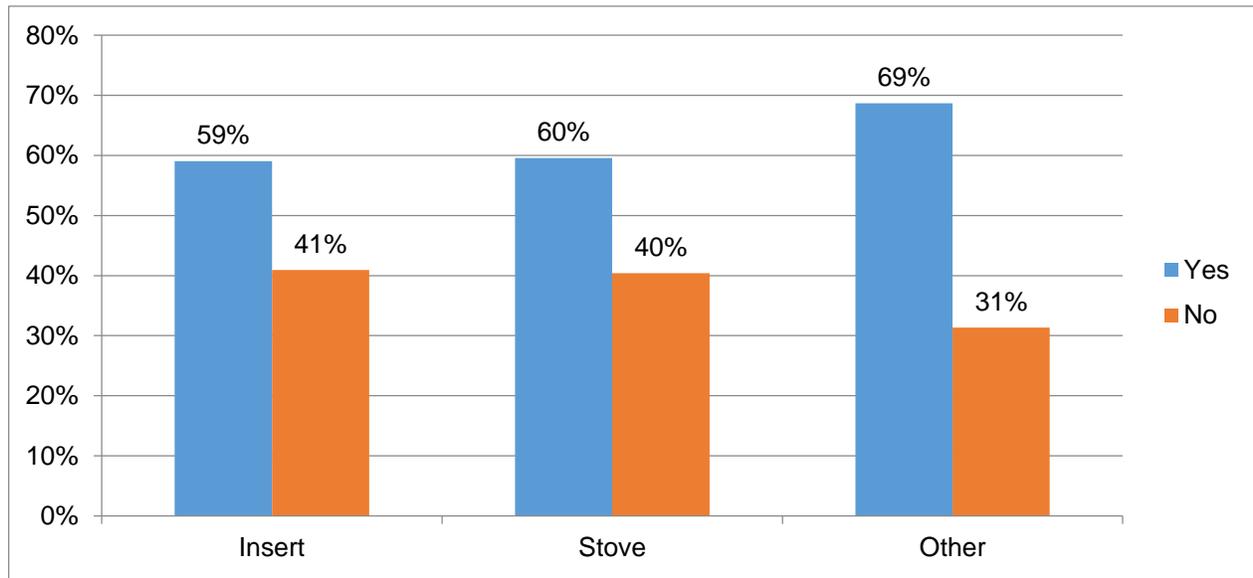
Figure 14: EPA Certification of Wood- Burning



iii. Glass Doors

Respondents were asked if their appliance (inserts, stoves, or other) had glass doors. The presence of a glass door is an indicator that an appliance is more likely to be EPA certified. This information, along with the question of the appliance age was designed to verify the EPA certification question responses. Between 50 and 60 percent of these devices were reported as having glass doors.

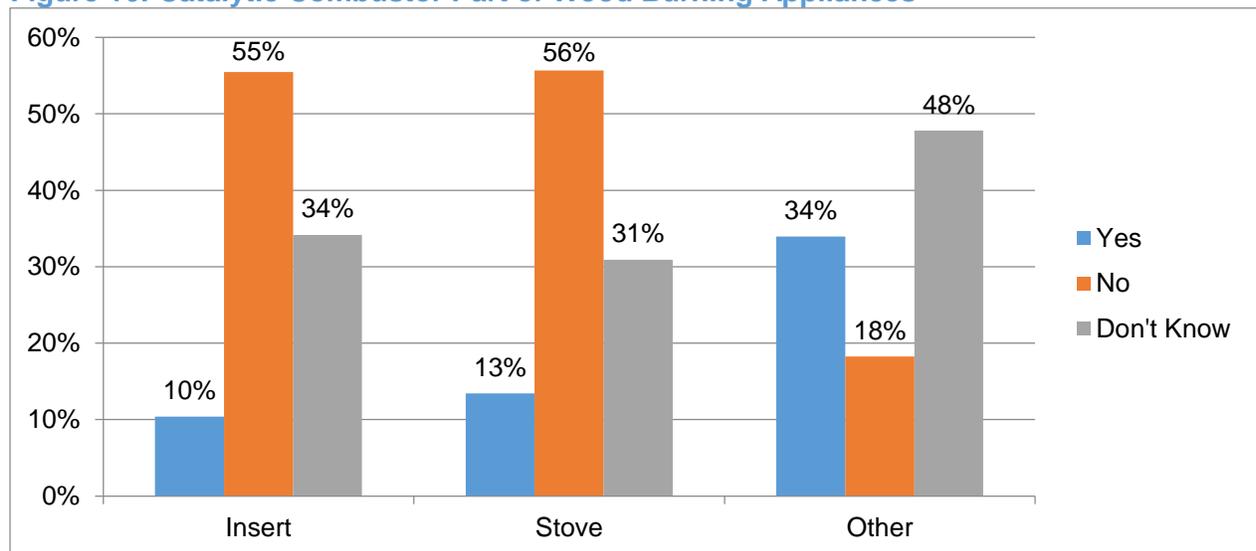
Figure 15: Glass Doors on Wood Burning Appliances



iv. Catalytic Combustors

Catalytic combustors cause all smoke to be burned, increasing the appliance’s overall efficiency. Respondents were asked to report if their insert, woodstove, or other wood burning appliance had a catalytic combustor to control emissions. About one-in-10 inserts (10%) and stoves (13%) had a catalytic combustor, while one-third of other wood burning appliances also had a combustor (34%).

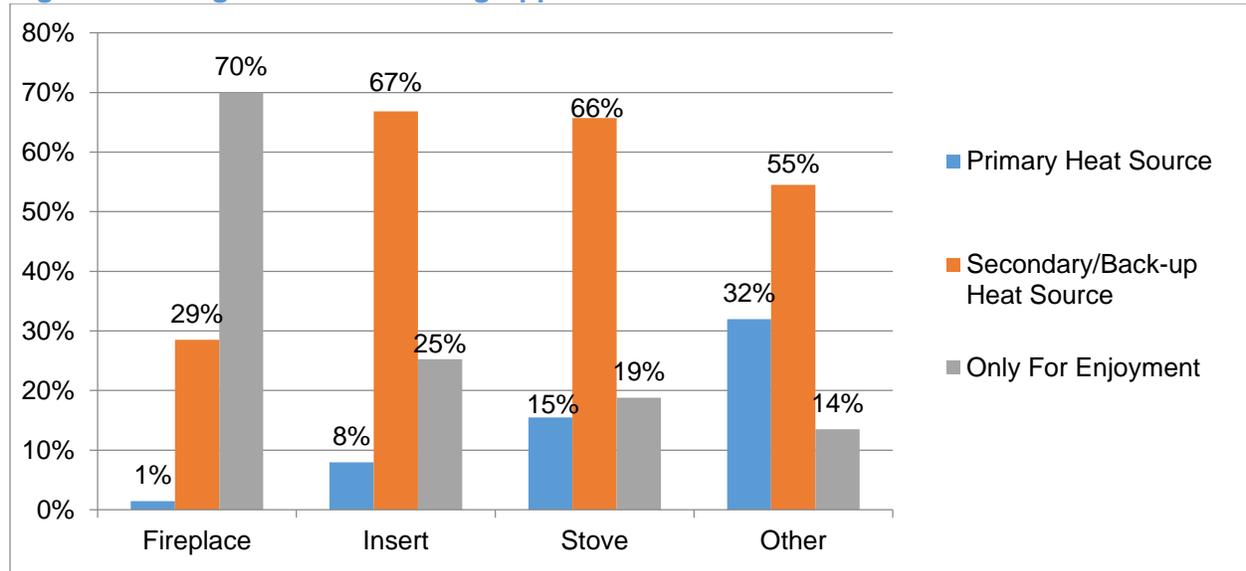
Figure 16: Catalytic Combustor Part of Wood Burning Appliances



USAGE

In each appliance section, respondents were asked to report the type of usage—for example, whether the appliance was used as a primary heat source, as a secondary/back-up heat source, or only for enjoyment. As shown in the figure below, fireplaces were primarily used for enjoyment, while the other devices were used chiefly as a back-up heat source.

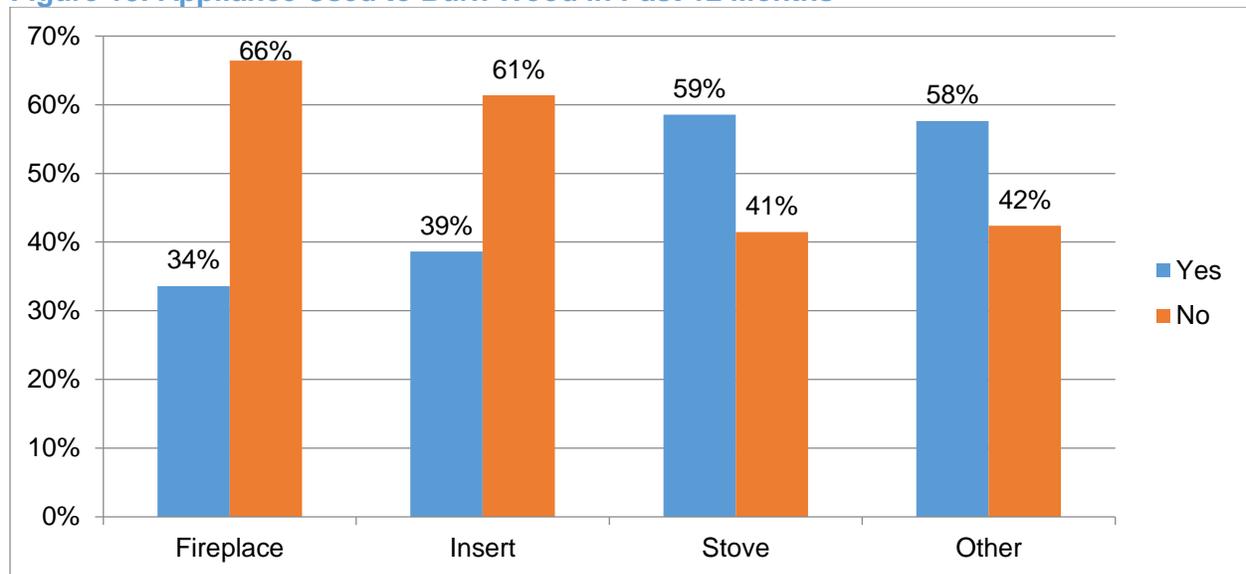
Figure 17: Usage of Wood Burning Appliances



USE IN PAST 12 MONTHS

Respondents were asked whether they had burned wood in their appliance in the previous 12 months. Most fireplaces and inserts have not been used to burn wood in the prior 12 months, while most stoves and other devices were used.

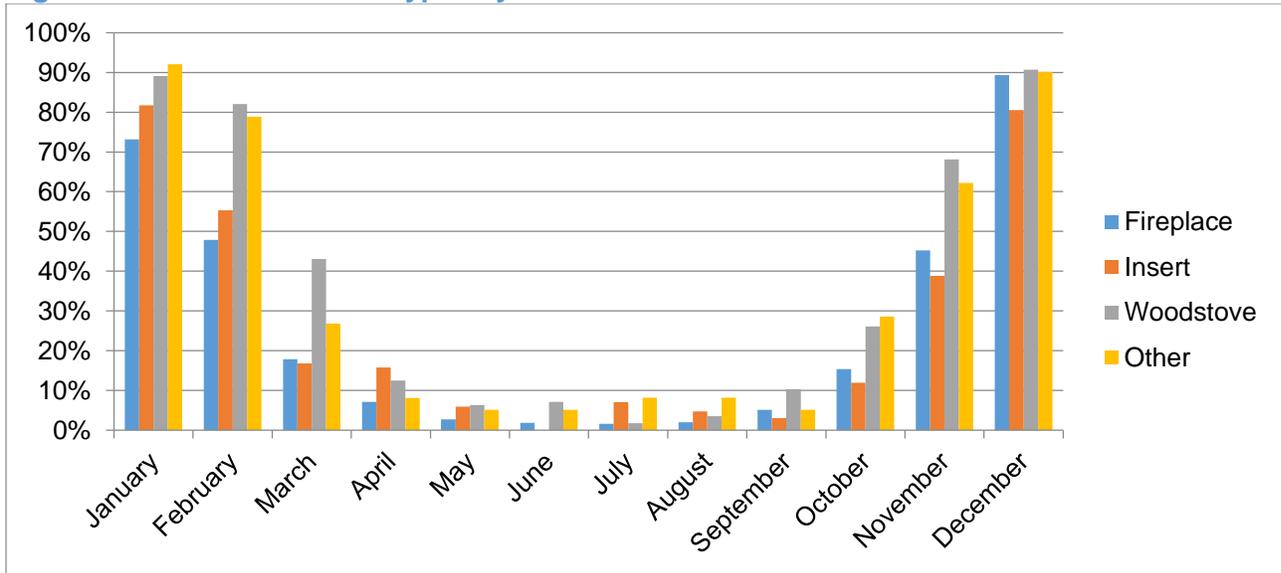
Figure 18: Appliance Used to Burn Wood in Past 12 Months



BURN MONTHS

In order to better understand typical burning behaviors, respondents were asked to check the months they typically used the appliance in question to burn wood. Figure 19 shows that all devices are consistently used to burn wood in January, February, November and December, with minimal use in March and October.

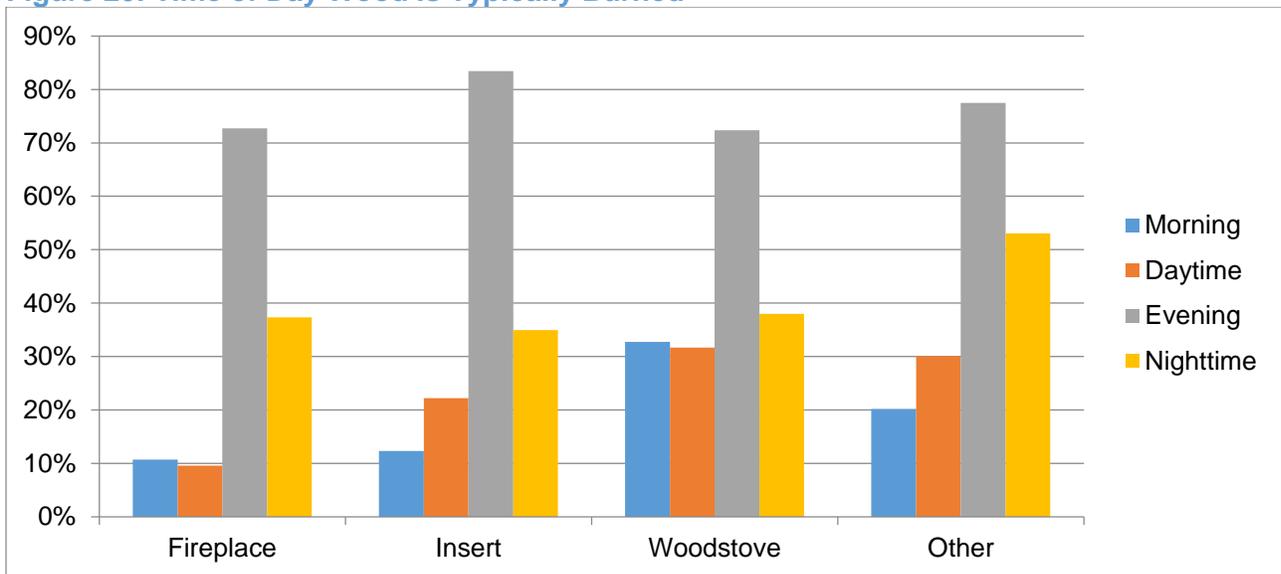
Figure 19: Months Wood Is Typically Burned



BURN TIME OF DAY AND NUMBER OF HOURS

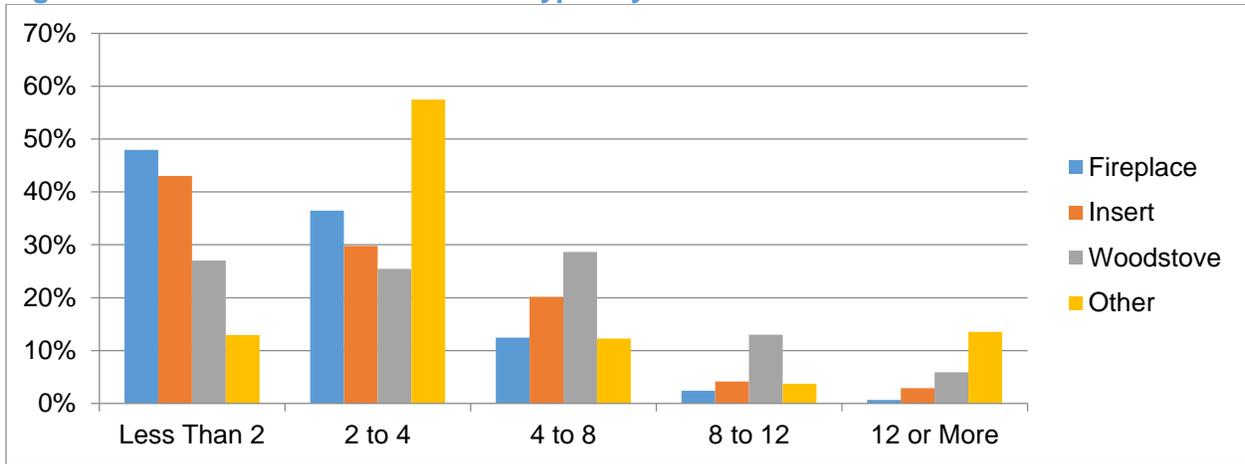
Respondents were asked to report the time of day they typically burned wood in their appliance. Around three-quarters of each type of appliance was used in the evening, and between one-third and half of devices were used to burn wood during the nighttime.

Figure 20: Time of Day Wood Is Typically Burned



Respondents were also asked how many hours they typically burn wood in their appliance during a 24-hour period. Most appliances were used to burn wood less than four hours each day, as shown in Figure 21.

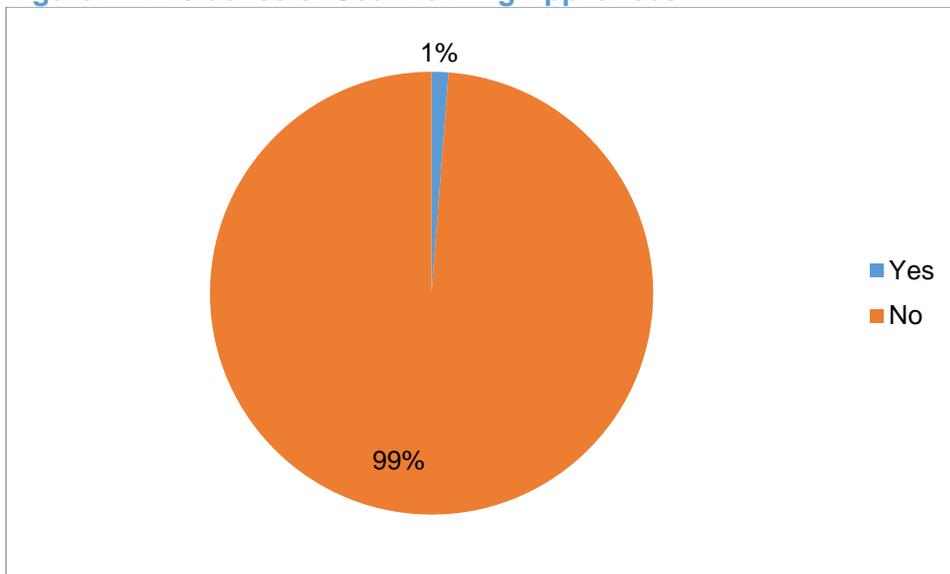
Figure 21: Number of Hours Wood Is Typically Burned



COAL BURNING

The questionnaire included an extra section devoted to coal burning, which was asked of all respondents. Just over one percent of all respondents reported having a coal burning appliance (1.22%).

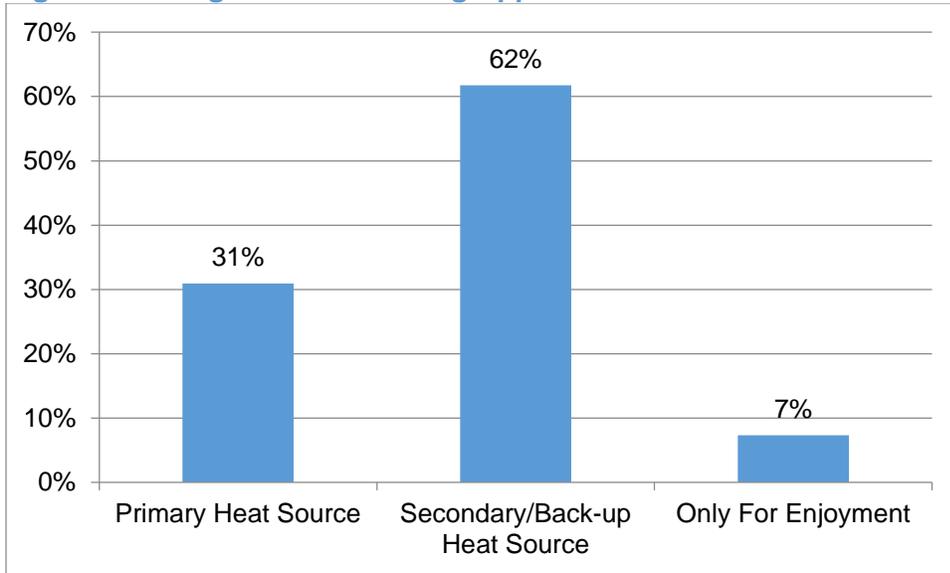
Figure 22: Incidence of Coal Burning Appliances



i. Usage

Coal burning devices were used primarily as a secondary or back-up heat source.

Figure 23: Usage of Coal Burning Appliances



ii. Burn Behaviors

Coal burning appliances were used mainly during the winter months, and during the evening and nighttime.

Figure 24: Months Coal Is Typically Burned

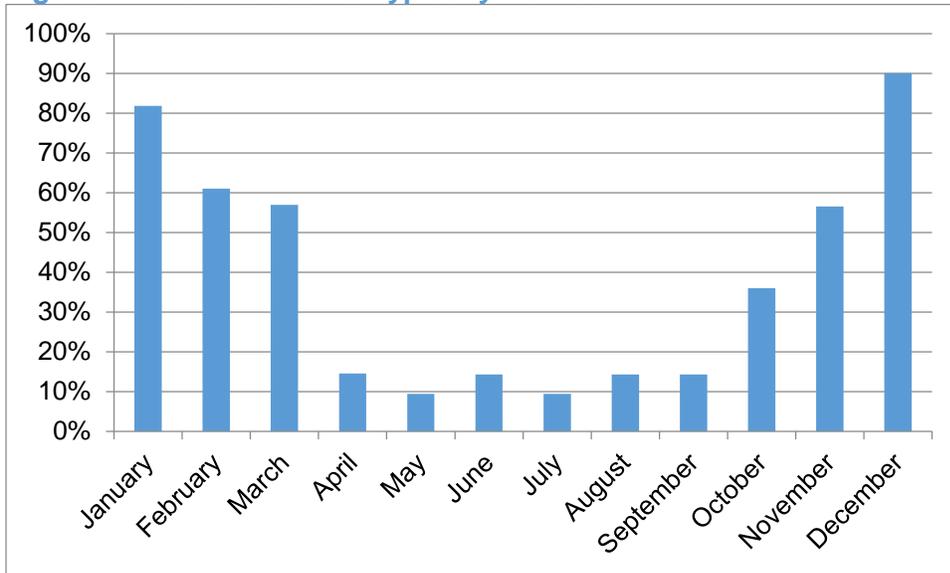
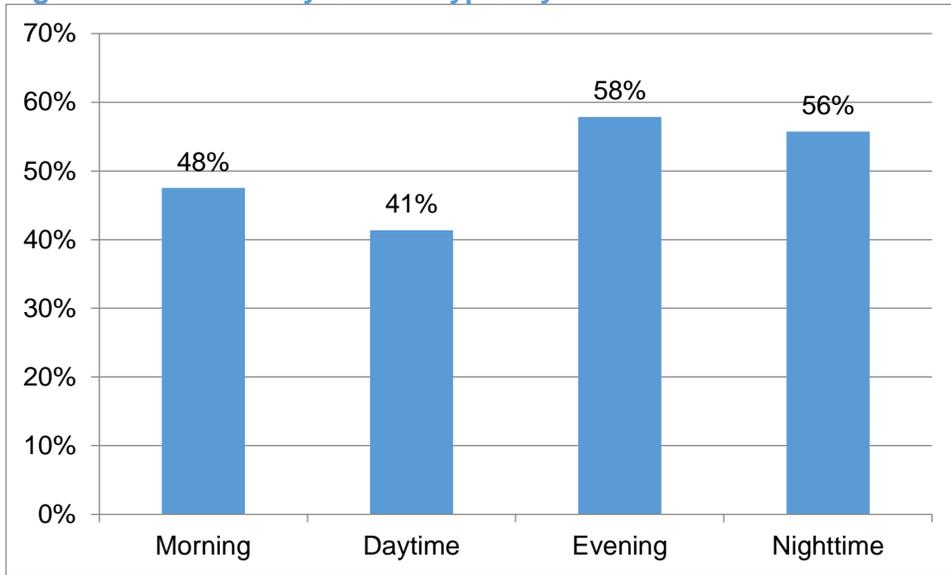
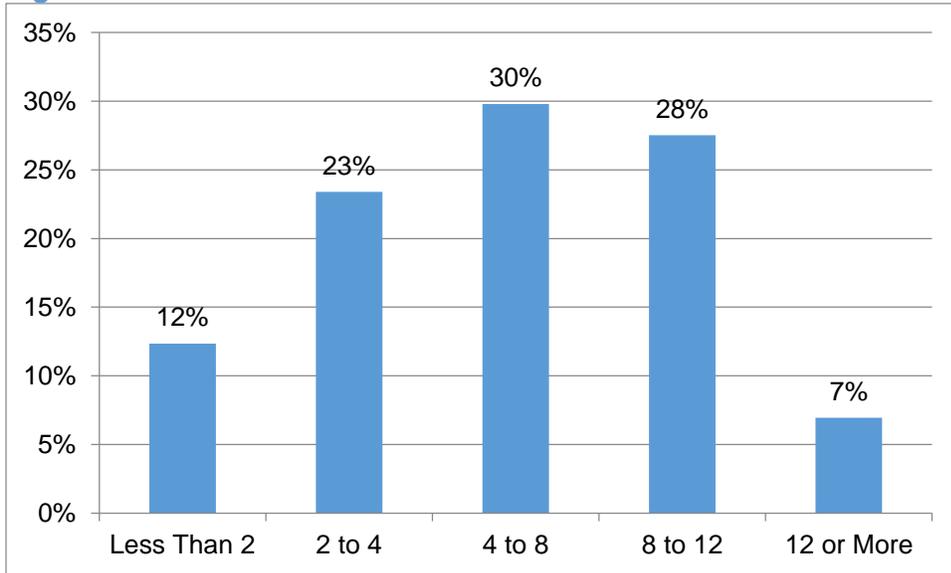


Figure 25: Time of Day Coal Is Typically Burned



In a typical 24-hour period, a majority of respondents reported using their coal burning devices for four hours or more, with 35 percent reporting use for eight or more hours per day.

Figure 26: Number of Hours Coal Is Burned



HOME CHARACTERISTICS

The last section of the questionnaire contained questions about respondents' homes, including whether they owned or rented, the building type, and age. Over two-thirds of respondents (69%) owned their home, and lived in a single-family detached home (69%).

Figure 27: Housing Status

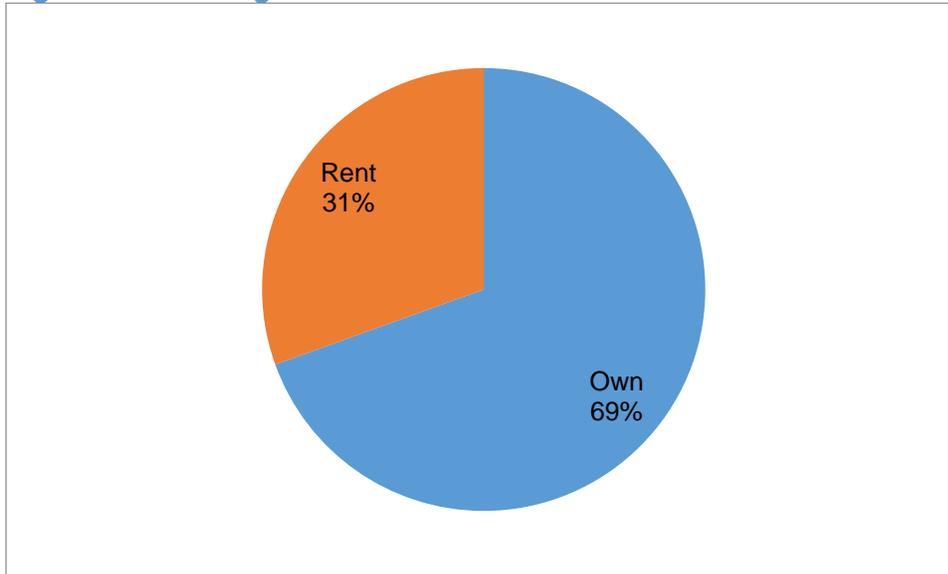
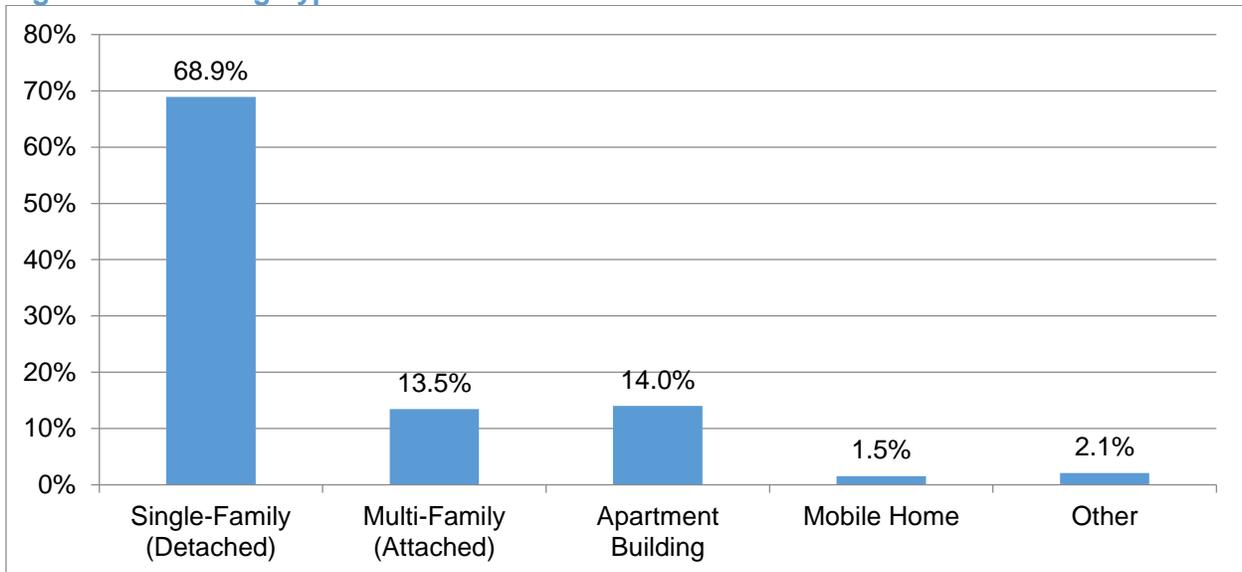
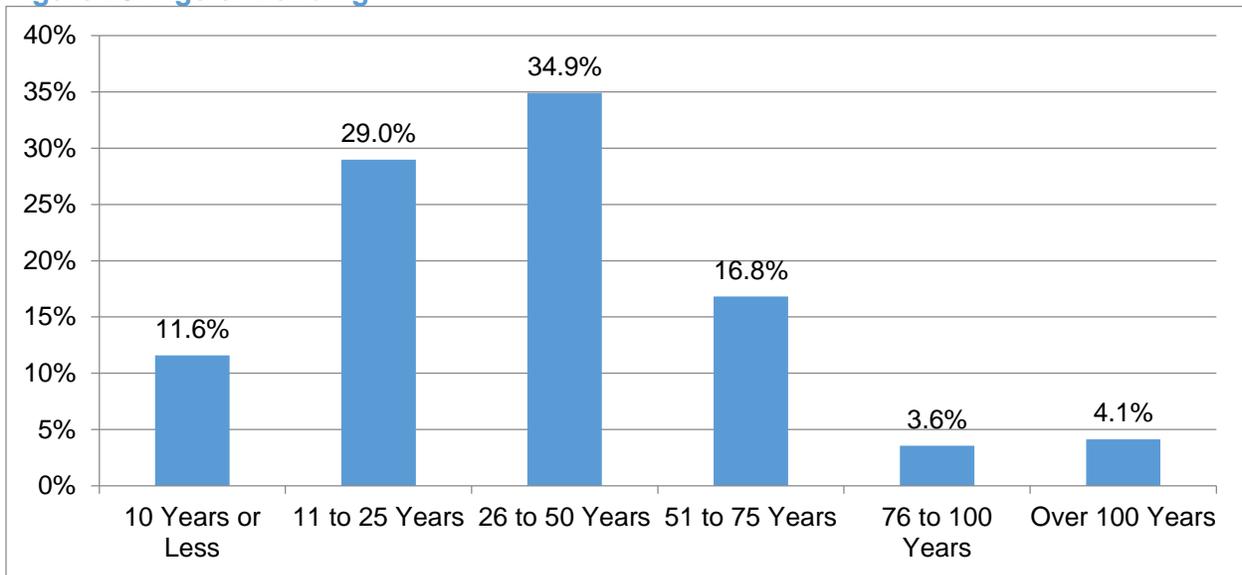


Figure 28: Building Type



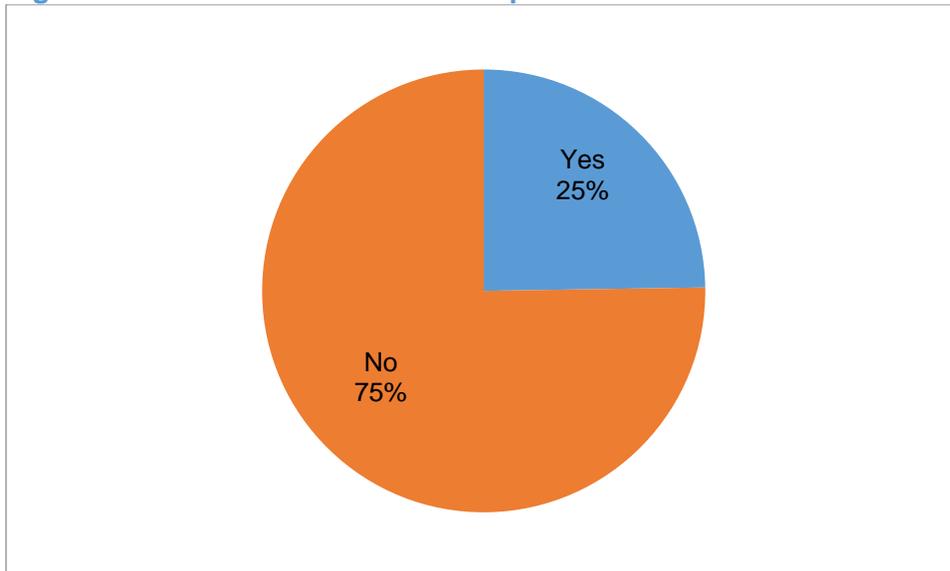
Approximately one-third of respondents lived in buildings that were 26 to 50 years-old, while 29 percent lived in newer buildings built between 11 and 25 years ago. One-in-six (16.8%) lived in older homes, built between 51 and 75 years ago.

Figure 29: Age of Building



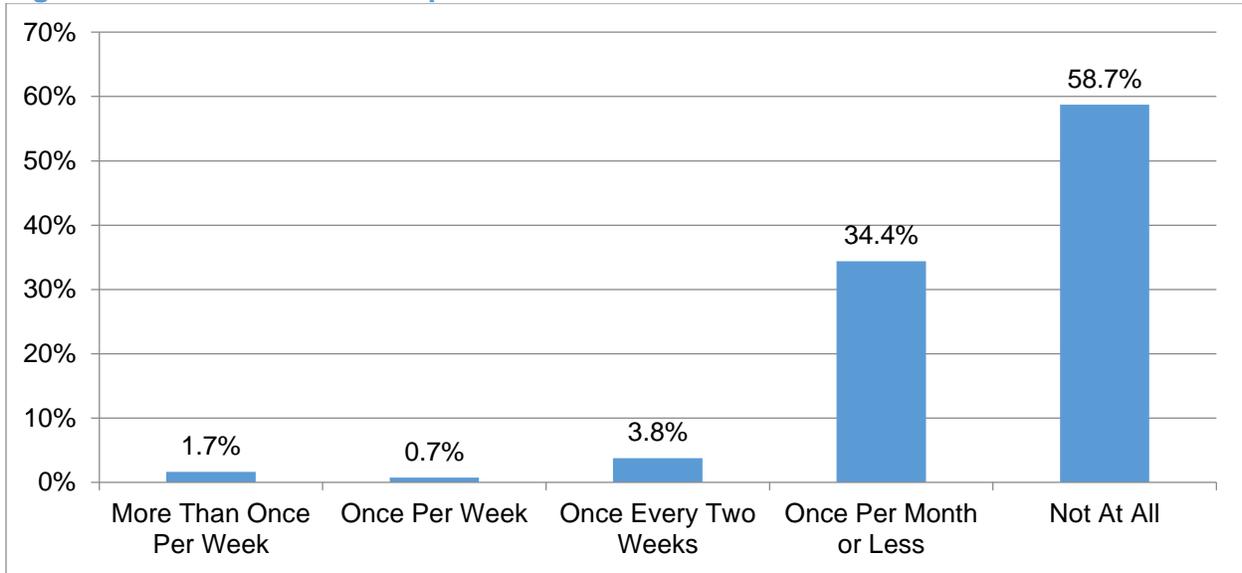
Respondents were also asked whether they had an outdoor fireplace or fire pit, and, if so, how often they typically use it during the winter. One-quarter of respondents reported having an outdoor fireplace or fire pit (24.8%).

Figure 30: Incidence of Outdoor Fireplaces or Fire Pits



Over half of respondents (58.7%) with an outdoor fireplace or fire pit do not typically use it during the winter, and one-third uses it once per month or less during the winter (34.4%).

Figure 31: Use of Outdoor Fireplaces in Winter



CHAPTER 4. WOOD BURNING PROJECTIONS

A primary objective of the survey was to estimate the incidence of wood burning and amount of wood burned by county. The sample allocation was developed to minimize variability of the survey estimates at the county level (within budgetary constraints) to achieve this objective. When survey returns were tallied, the number of responses received supported estimates of incidence of wood burning at, or better than, the targeted precision levels. However, the percentage of households that reported burning wood was low, and thus the number of households reporting volume of wood burned (in cords) was too small at the county level to make precise estimates. To improve the estimates for each appliance, we used a small area estimation approach.

This method, used to estimate the wood burned in each area, borrows strength from neighboring areas to provide more precise estimates. The approach combines estimates for each appliance type across areas to improve the precision of appliance-specific estimates based on small sample sizes in each area. Specifically, the volume of wood burned in the past 12 months for appliance-j in area-i is estimated as follows.

$$\hat{V}_{i,j} = H_i \times \hat{a}_{i,j} \times \hat{p}_j \times \bar{v}_j \text{ for stoves and inserts}$$

$$\hat{V}_{i,j} = H_i \times \hat{a}_{i,j} \times \hat{p}_{i,j} \times \bar{v}_j \text{ for fireplaces}$$

where,

$\hat{V}_{i,j}$ is the estimated volume of wood burned for appliance-j in area-i

H_i is the total number of occupied households in area-i

$\hat{a}_{i,j}$ is the estimated percentage of households appliance-j in area-i

\hat{p}_j is the estimated percentage of appliance-j burning wood across all areas (or group of areas)

$\hat{p}_{i,j}$ is the estimated percentage of appliance-j burning wood in area-i

\bar{v}_j is the estimated mean volume of wood burned for appliance-j across all areas (or group of areas)

Because fireplaces were the most frequently reported appliance, the sample size for estimating the percentage of households that burned wood in fireplaces was large enough for county-level estimates. For stoves and inserts, we estimated the percentage of households burning wood using the entire area. For all appliances, we used the entire area to estimate the mean volume of wood burned per household. For other wood burning appliances, the number of responses to cords burned was too small to obtain an estimate of mean volume per household.

The following tables provide estimates of: households with any/a specific wood burning appliance, the percentage of households burning wood in the past 12 months, and the total cords burned per household with any wood burning appliance. The tables also include the 2011 EPA calculations of cords burned for the study area. In these tables, “n” refers to the respondent sample size and “%” refers to the weighted mean (percentage).

ALL WOOD BURNING APPLIANCES

Table 3: Projections for All Wood Burning Appliances

	Total Households		Households with any Appliance		Burned Wood in Past 12 Months		Total Cords Burned	Cords per Household w/any Appliance*	2011 EPA
	n		n	%	n	%	n		n
All areas	729,228		2,679	32%	791	42%	94,709	0.40	136,626
Box Elder	16,207		399	37%	151	49%	3,234	0.54	3,281
Cache	35,375		361	30%	104	46%	5,120	0.48	7,101
Davis	95,238		391	25%	103	31%	9,725	0.41	19,120
Salt Lake	344,089		596	35%	170	42%	41,747	0.35	59,189
Hawthorne	73,361		255	24%	63	31%	5,630	0.32	
Non-Hawthorne	270,728		341	38%	107	44%	36,117	0.35	
Tooele	18,281		293	38%	84	52%	2,567	0.37	3,105
Utah	143,005		319	32%	82	50%	22,793	0.50	28,735
Weber	77,033		320	30%	97	39%	9,523	0.42	16,095

* includes non 12-month burners

FIREPLACES

Table 4: Projections for Fireplaces

	Total Households		Households with Fireplace		Burned Wood in Past 12 Months		Typical Cords Burned		Total Cords Burned	Cords per Household with Fireplace*	2011 EPA
	n		n	%	n	%	n	Mean	n		
All areas	729,228		2,671	21%	517	36%	191	0.65	36,130	0.23	33,116
Box Elder	16,207		397	17%	70	30%	25	0.98	541	0.19	867
Cache	35,375		359	16%	58	34%	18	0.58	1,247	0.22	1,876
Davis	95,238		390	20%	80	26%	27	0.41	3,133	0.16	5,054
Salt Lake	344,089		596	24%	140	38%	47	0.54	20,392	0.24	12,797
Hawthorne	73,361		255	18%	55	29%	15	0.24	2,409	0.18	
Non-Hawthorne	270,728		341	26%	85	39%	32	0.57	17,983	0.25	
Tooele	18,281		292	15%	43	33%	19	0.77	593	0.22	672
Utah	143,005		318	19%	57	42%	27	1.08	7,268	0.27	7,597
Weber	77,033		319	20%	69	30%	28	0.59	2,956	0.19	4,254

* includes non 12-month burners

INSERTS

Table 5: Projections for Inserts

	Total Households	Households with Insert		Burned Wood in Past 12 Months		Typical Cords Burned		Total Cords Burned	Cords per Household with Insert*	2011 EPA
	n	n	%	n	%	n	Mean	n		
All areas	729,228	2,661	7%	142	44%	63	1.14	24,835	0.50	46,314
Box Elder	16,207	395	10%	41	37%	20	1.06	826	0.50	1,007
Cache	35,375	358	6%	21	26%	9	1.28	1,108	0.50	2,183
Davis	95,238	388	5%	20	30%	7	0.74	2,451	0.50	5,874
Salt Lake	344,089	595	6%	20	35%	6	1.10	10,995	0.50	22,316
Hawthorne	73,361	255	5%	8	11%	1	0.01	1,870	0.50	
Non-Hawthorne	270,728	340	7%	12	41%	5	1.17	9,126	0.50	
Tooele	18,281	292	10%	12	64%	9	1.21	902	0.50	1,169
Utah	143,005	318	10%	16	73%	8	1.37	6,968	0.50	8,824
Weber	77,033	315	4%	12	43%	4	1.07	1,585	0.50	4,941

* includes non 12-month burners

WOODSTOVES

Table 6: Projections for Woodstoves

	Total Households		Households with Stove		Burned Wood in Past 12 Months		Typical Cords Burned		Total Cords Burned	Cords per Household with Stove*	2011 EPA
	n		n	%	n	%	n	Mean	n		
All areas	729,228		2,648	7%	244	59%	157	1.19	33,744	0.71	57,196
Box Elder	16,207		391	16%	67	56%	43	1.41	1,867	0.71	1,408
Cache	35,375		355	11%	42	66%	27	1.09	2,765	0.71	3,042
Davis	95,238		389	6%	26	49%	16	0.94	4,141	0.71	8,192
Salt Lake	344,089		594	4%	25	59%	15	1.40	10,360	0.71	24,076
Hawthorne	73,361		254	3%	7	36%	3	0.55	1,351	0.71	
Non-Hawthorne	270,728		340	5%	18	62%	12	1.46	9,008	0.71	
Tooele	18,281		293	8%	26	71%	20	1.49	1,072	0.71	1,264
Utah	143,005		314	8%	28	63%	17	1.12	8,557	0.71	12,314
Weber	77,033		312	9%	30	57%	19	0.96	4,982	0.71	6,900

* includes non 12-month burners

OTHER WOOD BURNING APPLIANCE

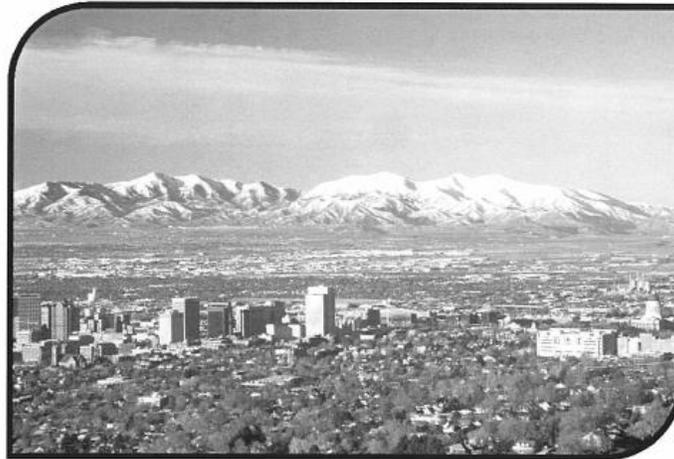
Table 7: Other Wood Burning Appliances

	Total Households	Households with Other Appliance		Burned Wood in Past 12 Months	
	n	n	%	n	%
All areas	729,228	2612	3%	47	56%
Box Elder	16,207	381	5%	17	76%
Cache	35,375	349	3%	2	0%
Davis	95,238	384	0%	2	50%
Salt Lake	344,089	590	4%	6	43%
Hawthorne	73,361	253	2%	2	58%
Non-Hawthorne	270,728	337	4%	4	41%
Tooele	18,281	287	12%	14	69%
Utah	143,005	310	3%	1	100%
Weber	77,033	311	3%	5	80%

* includes non 12-month burners

APPENDIX A: QUESTIONNAIRE

Northern Utah Air Quality Survey



This survey is sponsored by the Division of Air Quality within the Utah Department of Environmental Quality. Your participation in this survey will contribute to a better understanding of the different sources of air pollution in our region and how we can maintain clean, healthy air for all residents.



Utah Department of
Environmental Quality

MARKING INSTRUCTIONS

- Use a No. 2 pencil or a blue or black ink pen only.
- Do not use pens with ink that soaks through the paper.
- Make solid marks that fill the response completely.
- Make no stray marks on this form.

CORRECT: ●

INCORRECT: ✓ ✗ ◐ ◑



{ M a s t e r i d }

{tray} {presort}



Air Quality

1. In general, how would you describe the air quality in Northern Utah during the summer months?
- Very Good
 - Good
 - Fair
 - Poor
 - Very Poor
2. In general, how would you describe the air quality in Northern Utah during the winter months?
- Very Good
 - Good
 - Fair
 - Poor
 - Very Poor

3. Think about the winter days when air quality is a problem in Northern Utah. To what extent would you say that each of the following sources of air pollution contributes to the problem?

Source of Pollution	Very Little Contribution	Little Contribution	Moderate Contribution	Large Contribution	Very Large Contribution
a. Vehicles (including residential & commercial transportation)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Residential & Commercial Sources (homes, small businesses, buildings, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Industry Sources (mining, refinery, power plant operations, industrial furnaces, boilers, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Poor air quality days can be forecast a few days in advance. How likely or unlikely would you be to take the following short-term actions to help improve air quality during the periods when air quality is a real problem?

Action	Very Unlikely	Somewhat Unlikely	Somewhat Likely	Very Likely	Not Applicable
a. Telecommute/work from home	<input type="radio"/>				
b. Increase use of public transportation	<input type="radio"/>				
c. Reduce idling and unnecessary driving	<input type="radio"/>				
d. Increase use of ridesharing (carpooling, vanpooling, etc.)	<input type="radio"/>				
e. Decrease home energy use (by turning down thermostat, water heater, etc.)	<input type="radio"/>				
f. Limit use of household products (such as certain hairsprays, air fresheners, paint, etc.) that contain pollutants	<input type="radio"/>				



Your Home Heating Sources

5. What is the primary heat source in your home? (Check only one)
 - Natural Gas
 - Propane
 - Electricity
 - Wood
 - Pellets
 - Coal
 - Other (Please Specify): _____

6. What backup heat sources, if any, do you have in your home? (Check all that apply)
 - Natural Gas
 - Propane
 - Electricity
 - Wood
 - Pellets
 - Coal
 - Other (Please Specify): _____
 - No backup heat sources in home

7. Do you have any wood-burning appliances in your home? (Wood-burning appliances include fireplaces, inserts, stoves, and other types of wood-burning appliances.)
 - Yes
 - No → Skip to page 8, Coal burning appliances

8. Have you burned any wood in these appliances during the past 12 months?
 - Yes
 - No

9. How do you get your wood? (Check all that apply)
 - Purchase
 - Cut my own
 - Given to me

10. How many starter fuels (such as wax logs, compressed sawdust, or other types of commercial solid fuel) do you burn in a typical year? (If none, enter "0")

_____ Starter fuels per year

How To Estimate Cords Of Wood

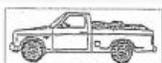
The following illustrations are provided to assist you with estimating the cords of wood you have burned in your wood-burning appliances in the past 12 months. Please use these guidelines to come up with your most accurate estimate when reporting the cords of wood you burn in this survey (if applicable).

HOW MUCH WOOD WILL YOUR TRUCK HAUL?

Firewood is commonly measured in cords. A standard cord is the amount of tightly piled wood in a stack 4 ft wide x 4 ft high x 8 ft long. The average half-ton pickup can carry a half-cord of dry wood without overloading the vehicle.

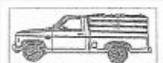
The illustrations at right demonstrate the relative volume of a cord of wood and are not recommendations of how much wood your truck is capable of hauling safely. The weight of your truck haul can be found in your owner's manual.

SMALL PICKUP – 1/4 TON



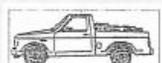
With or without racks, this truck will hold approximately 1/2 cord of wood (approx. 1,331 lbs.).

LONG BED PICKUP – 1/2 or 3/4 TON



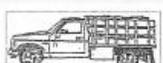
Without racks, this truck bed holds approx. 1/2 cord of firewood (approx. 1,331 lbs.). With racks, it will hold approx. 1 full cord (approx. 2,662 lbs.).

SHORT-BED PICKUP – 1/2 TON



With or without racks, this truck will hold approximately 1/2 cord of wood (approx. 1,331 lbs.).

STANDARD 1 TON TRUCK



With high racks, this truck bed will hold approx. 2 cords of firewood (approx. 5,324 lbs.).



Your Wood-Burning Appliances

The following sections ask about several different wood-burning appliances that you might use to heat your home, including fireplaces, inserts, stoves, and other types of appliances.

Fireplaces

11. Do you have any fireplaces in your home (that is, open fireplaces with no stove inserted)?

- Yes No → *Skip to page 5, Inserts*

→ Please complete the following questions for the fireplaces that you have used most frequently to heat your home (up to two):

Question	Fireplace #1	Fireplace #2 (if applicable)
a. Age of fireplace (usually the same age as home)	_____ years	_____ years
b. How is this fireplace used? (Check only one)	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment
c. Has this fireplace been used to burn wood in the past 12 months?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
d. How many cords of wood do you burn in this fireplace in a typical year? (Please see the illustration on page 3 for help giving an accurate estimate)	_____ cords	_____ cords
e. During which months do you typically use this fireplace to burn wood? (Check all that apply)	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec
f. What time(s) of day do you typically burn wood with this fireplace? (Check all that apply)	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime
g. How many hours do you typically burn wood in this fireplace in a 24-hour period? (Check only one)	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more



Inserts

12. Do you have any inserts in your home (that is, woodstoves that are inserted into an existing fireplace)?

- Yes No → *Skip to page 6, Woodstoves*

→ Please complete the following questions for the inserts that you have used most frequently to heat your home (up to two):

Question	Insert #1	Insert #2 (if applicable)
a. Age of insert (based on manufacture date on label, or best estimate)	_____ years	_____ years
b. How is this insert used? (Check only one)	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment
c. Is a label visible on this insert?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
d. IF YES TO C: Does the label indicate that this insert is EPA certified?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
<p><i>NOTE: If your insert is certified, the back label will look similar to this:</i></p>		
e. Does this insert have any glass doors?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
f. Does this insert have a catalytic combustor (to control emissions)?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know
g. Has this insert been used to burn wood in the past 12 months?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
h. How many cords of wood do you burn in this insert in a typical year? (Please see the illustration on page 3 for help giving an accurate estimate)	_____ cords	_____ cords
i. During which months do you typically use this insert to burn wood? (Check all that apply)	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec
j. What time(s) of day do you typically burn wood with this insert? (Check all that apply)	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime
k. How many hours do you typically burn wood in this insert in a 24-hour period? (Check only one)	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more

Woodstoves

13. Do you have any woodstoves in your home (that is, standalone woodstoves that are connected to a chimney and burn wood logs)?

Yes No → *Skip to page 7, Other Wood-burning Appliances*

↳ Please complete the following questions for the woodstoves that you have used most frequently to heat your home (up to two):

Question	Woodstove #1	Woodstove #2 (if applicable)
a. Age of stove (based on manufacture date on label, or best estimate)	_____ years	_____ years
b. How is this stove used? (Check only one)	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment
c. Is a label visible on this stove?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
d. IF YES TO C: Does the label indicate that this stove is EPA certified?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
<p><i>NOTE: If your stove is certified, the back label will look similar to this:</i></p> 		
e. Does this stove have any glass doors?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
f. Does this stove have a catalytic combustor (to control emissions)?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know
g. Has this stove been used to burn wood in the past 12 months?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
h. How many cords of wood do you burn in this stove in a typical year? (Please see the illustration on page 3 for help giving an accurate estimate)	_____ cords	_____ cords
i. During which months do you typically use this stove to burn wood? (Check all that apply)	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec
j. What time(s) of day do you typically burn wood with this stove? (Check all that apply)	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime
k. How many hours do you typically burn wood in this stove in a 24-hour period? (Check only one)	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more



Other Wood-Burning Appliances

14. Do you have any other wood-burning appliances in your home (such as pellet stoves, cordwood central furnace, other, or unknown type) that were not already covered on the preceding pages?

- Yes No → *Skip to page 8, Coal-Burning Appliances*

↳ Please complete the following questions for the other wood-burning appliances that you have used most frequently to heat your home (up to two):

Question	Wood-Burning Appliance #1	Wood-Burning Appliance #2 (if applicable)
a. Age of wood-burning appliance (based on manufacture date on label, or best estimate)	_____ years	_____ years
b. How is this wood-burning appliance used? (Check only one)	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment
c. Is a label visible on this wood-burning appliance?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
d. IF YES TO C: Does the label indicate that this wood-burning appliance is EPA certified?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
<p><i>NOTE: If your appliance is certified, the back label will look similar to this:</i></p> 		
e. Does this wood-burning appliance have any glass doors?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
f. Does this wood-burning appliance have a catalytic combustor (to control emissions)?	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know	<input type="radio"/> Yes <input type="radio"/> No <input type="radio"/> Don't Know
g. Has this appliance been used to burn wood in the past 12 months?	<input type="radio"/> Yes <input type="radio"/> No	<input type="radio"/> Yes <input type="radio"/> No
h. How many cords of wood do you burn in this appliance in a typical year? (Please see the illustration on page 3 for help giving an accurate estimate of cords)	Unit of weight used: _____ <input type="radio"/> Cords <input type="radio"/> Tons <input type="radio"/> 40-lb bags of pellets	Unit of weight used: _____ <input type="radio"/> Cords <input type="radio"/> Tons <input type="radio"/> 40-lb bags of pellets
i. During which months do you typically use this appliance to burn wood? (Check all that apply)	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec
j. What time(s) of day do you typically burn wood with this appliance? (Check all that apply)	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime
k. How many hours do you typically burn wood in this appliance in a 24-hour period? (Check only one)	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more



Coal-Burning Appliances

15. Do you have any coal-burning appliances in your home?

- Yes No → *Skip to the next section, About Your Home*

→ Please complete the following questions for the coal-burning appliances that you have used most frequently to heat your home (up to two):

Question	Coal-Burning Appliance #1	Coal-Burning Appliance #2 (if applicable)
a. How is this coal-burning appliance used? (Check only one)	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment	<input type="radio"/> Primary heat source <input type="radio"/> Secondary/backup heat source <input type="radio"/> Only for enjoyment
b. During which months do you typically use this appliance to burn coal? (Check all that apply)	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec	<input type="radio"/> Jan <input type="radio"/> Feb <input type="radio"/> Mar <input type="radio"/> Apr <input type="radio"/> May <input type="radio"/> Jun <input type="radio"/> Jul <input type="radio"/> Aug <input type="radio"/> Sep <input type="radio"/> Oct <input type="radio"/> Nov <input type="radio"/> Dec
c. What time(s) of day do you typically burn coal with this appliance? (Check all that apply)	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime	<input type="radio"/> Morning <input type="radio"/> Daytime <input type="radio"/> Evening <input type="radio"/> Nighttime
d. How many hours do you typically burn coal in this appliance in a 24-hour period? (Check only one)	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more	<input type="radio"/> Less than 2 <input type="radio"/> 2 to 4 <input type="radio"/> 4 to 8 <input type="radio"/> 8 to 12 <input type="radio"/> 12 or more

About Your Home

16. Do you own or rent your home?

- Own
 Rent

17. What type of building do you live in?

- Single-family (detached)
 Multi-family (attached)
 Apartment building
 Mobile home
 Other

18. What is the age of the building in which you live?

- 10 years or less
 11 to 25 years
 26 to 50 years
 51 to 75 years
 76 to 100 years
 Over 100 years

19. Do you have an outdoor fireplace or fire pit?

- Yes
 No → *Skip to End*

20. How often do you typically use your outdoor fireplace and/or fire pit during the winter?

- More than once per week
 Once per week
 Once every two weeks
 Once per month or less
 Not at all

End

Thank you! You have completed the survey. Please return this survey in the postage-paid envelope provided.

APPENDIX B: METHODOLOGY

QUESTIONNAIRE DEVELOPMENT

ICF developed the survey questionnaire starting from a draft provided by the DEQ. The survey was self-administered via mail mode only and was designed to be printed on two pages of 11" x 17" paper with a middle fold, forming a booklet of 8.5" x 11" pages.

Based on the draft questionnaire and an understanding of the key research questions, we revised the questionnaire to fit the booklet format and to follow best practices for mail survey design (such as those described in the Total Design Method⁶), as follows:

- The cover page was designed with a prominent, high-quality graphic of the local landscape to make the booklet more visually interesting and to emphasize the personal relevance of the survey topic to respondents.
- We recognized the possibility that the survey could be perceived as concerning only the effects of wood burning, increasing the threat of non-response bias due to under-response from non-wood burning residents. To counteract this possibility, we framed the survey as a study of general air quality in the region of interest (rather than a study of wood burning specifically) and designed the survey's first page to include items relevant to all area residents (e.g., "In general, how would you describe the air quality in Northern Utah in the summer months?"). Several items from the 2013 Envision Utah Air Quality Survey were adapted for use in the first section of the survey.
- In addition to reviewing item wording, we systematically manipulated several visual elements to further reduce ambiguity and simplify cognitive processing for respondents:
 - Contrasting shading distinguished response areas from the background; similarly, banded shading on tables visually separated rows.
 - Darker shading differentiated non-substantive response options from substantive ones (e.g., the "N/A" column in item 4).
 - Visual aids assisted with the potentially difficult estimation of wood volume and helped locate EPA labels on stoves.Different sections of the survey applied to different respondents depending on whether they burned wood for heat and (if so) which appliances they used for this purpose. To simplify the respondent's task of navigating through the survey, we provided prominent navigational instructions with arrows immediately following branching responses.⁷ In addition, visually distinct section headers were used throughout the survey to help respondents quickly identify the content on each page.

After receiving final approval from the DEQ on the SAPI questionnaire design, we formatted the questionnaire for optical scanning using Scantron® Design software. Twenty mock questionnaires were scanned as part of a software pre-test.

SAMPLING DISCUSSION

We selected an ABS frame of households stratified by county designed to meet the key objectives of the study. Dual study objectives included estimating the percentage of households burning wood, and more importantly, the volume of wood burned by these households. The target area was defined in terms of the seven-county area described in Table 8. Within Salt

Lake County, we defined two substrata to allow for oversampling in one sub-county area, the Hawthorne area, defined by a subset of census tracts.

ADDRESS BASED SAMPLE (ABS) FRAME

The source of the ABS frame was the Computerized Delivery Sequence File (CDSF), a list of addresses that originates from the USPS. With more than 782,281 residential addresses for the nonattainment area, the CDSF provides a comprehensive frame that reaches the entire population living at addresses receiving mail delivery. With 729,228² occupied housing units in the area, we estimate that the coverage of the CDSF is virtually 100 percent.

We selected the sample using Virtual Genesys, which we license from Marketing Systems Group (MSG). We included all residential addresses including city-style addresses (99.9%), central drop points (<0.1%) rural-route addresses (<0.1%), and highway contract (<0.1%). P.O. boxes were excluded since most people also receive mail at their residential address.³ To maximize coverage of the population, we included units identified by the USPS as vacant (2.0%). Table 8 shows the total number of addresses and the number selected for the survey.

TARGET SAMPLE SIZE

The sample size was derived for county estimates of the percentage of households burning wood. The sample size for each area was determined such that an effect size of 0.3 is detected with 80 percent power using a significance testing level of 0.05. To determine the sample size, we used a conservative estimate of variability by assuming a proportion of P=0.5. The population variability for a proportion is $P*(1-P)$ or $0.5*(1-0.5) = 0.25$. Assuming equal sample sizes, a 0.3 effect size is: $0.3 = (\mu_1 - \mu_2)/\sqrt{0.25}$. This means that the sample size is determined such that a true 15 percent difference ($\mu_1 - \mu_2$) will be detected with 80 percent power using a significance testing level of 0.05. The minimum sample size for detecting a 15 percent difference is 176 using the assumptions above. We increased the sample size to 220 to account for design effects (DEFF=1.25 per county). Design effects account for the increase in variability due to the sampling design and variation in survey administration (e.g. differential response across demographic groups.) This increase in variability will decrease the power to detect differences and will increase error margins. Therefore, an increase in sample size is required to counter balance the design effects. Table 8 presents the target number of completed surveys per area.

² 2011-2013 American Community Survey (ACS)

³ There is a small number of P.O. Boxes (<0.3%) that are the only way the residence receives mail.

Table 8: Sample Allocation to Strata

County/Area	Sample Size (Target Completes)	USPS Addresses	Addresses Selected
Box Elder*	220	15,692	1,100
Cache*	220	36,134	1,100
Davis	220	103,335	1,100
Salt Lake (non-Hawthorne)	220	303,849	1,100
Hawthorne	180	66,346	900
Tooele*	220	18,238	1,100
Utah	220	154,212	1,100
Weber*	220	84,475	1,100
TOTAL	1,720	782,281	8,600

*The following portions of the County were included in the study area:

Weber County: Wasatch Front

Cache County: Cache Valley

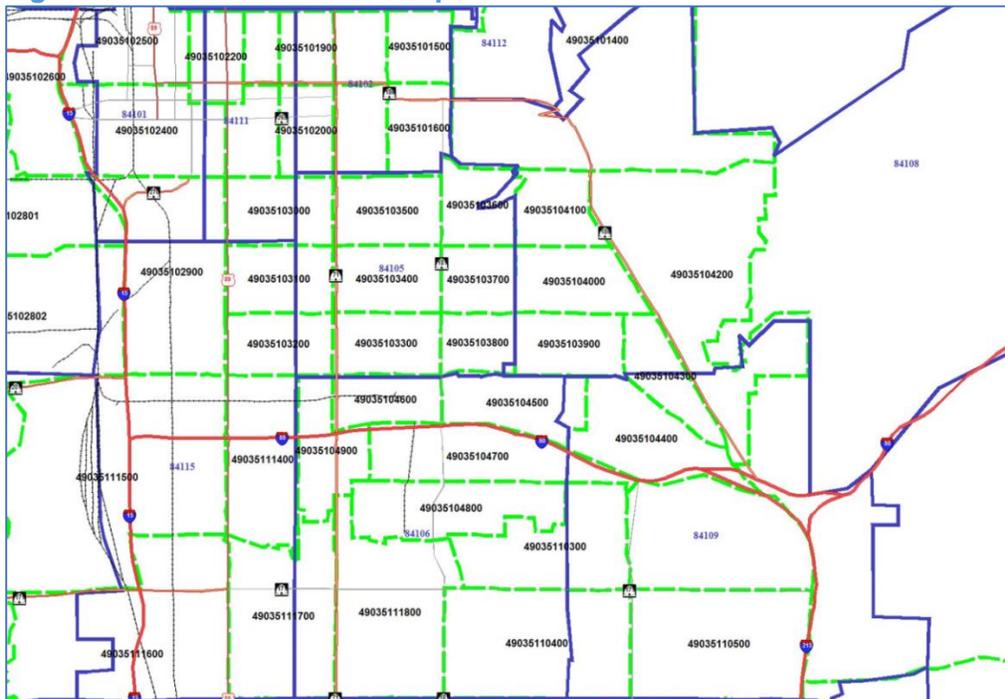
Box Elder County: Wasatch mountain range west to the Promontory mountain range and south of Portage

Tooele County: Northernmost part of Oquirrh mountain range to the northern most part of Stansbury mountain range and north of Route 199

HAWTHORNE OVERSAMPLE

We oversampled a specific area of Salt Lake City, known as “Hawthorne,” to align wood burning data with information from an air quality monitoring station located there. To identify the Salt Lake County addresses on the CDSF that are located in Hawthorne, we identified the census tracts in the neighborhood (Figure 32) CDSF addresses geocoded to the Hawthorne census tracts were stratified as Hawthorne and those that were not geocoded in these tracts were stratified as the rest of Salt Lake County.

Figure 32: Hawthorne Oversample Area with Census Tracts



DATA COLLECTION PROTOCOL

To survey residents of Northern Utah about their wood burning behaviors, we selected a mail survey protocol following the Total Design Method (TDM) formulated by methodologist Don Dillman. This mail survey design included four contacts over the course of eight weeks:

- A **pre-notification letter** was sent to respondents on DEQ letterhead. It alerted respondents that a survey packet was on its way, explained the study's importance, and invited them to participate.
- The **survey packet** included a survey cover letter, the eight-page questionnaire, and a pre-paid return envelope. The survey packet was sent one week after the pre-notification letter.
- A **thank you/reminder postcard** was sent a few days after the survey packet, reinforcing the survey's importance, thanking respondents who had already responded, and encouraging non-responders to complete the survey.
- We sent a **replacement questionnaire** to non-responders three weeks after the first packet mailing. A revised cover letter stressed the importance of returning the completed survey.

FIELDING SCHEDULE

DEQ representatives met with ICF's project team on January 18, 2015 for a project kick-off meeting. The first mail contact was mailed to 8,600 residents of Northern Utah on January 26, 2015. The full fielding schedule is shown in Table 9.

Table 9: Mailing Schedule

Date	Mail Contact	Volume
Week of Jan. 26	Pre-notification Letter	8,600
Week of Feb. 2	First Survey Mailing	8,600
Week of Feb. 9	Thank you/Reminder Postcard	8,600
Week of Feb. 23	Replacement Survey Mailing	7,740

We tested a template of the mail survey, and scanned all incoming returned questionnaires upon receipt at our Martinsville, Virginia survey operations center.

DATA PROCESSING

ICF uses an automated system to clean, standardize, and prepare datasets for analysis. For this project, we:

- Removed duplicate record if two surveys were sent in from the same household;
- Performed a quality review of the data;
- Applied specific data-processing rules developed by ICF and approved by DEQ (described below); and
- Converted raw survey data into an Excel data file for weighting and delivery to DEQ.

Because mail surveys are self-administered, respondents can enter contradictory information or ignore certain skip instructions. For this survey, we applied the following data processing rules to two types of questions:

1. Questions on wood burning appliance ownership

Questions impacted: Q7, Q8, Q11, Q12, Q13, and Q14.

Description of rules:

- Set Q11=1 if a respondent said they did not have a fireplace (Q11=2) but provided either age (Q11a); primary use (Q11b); whether or not burned wood (Q11c); or cords burned (Q11d).
- Set Q12=1 if a respondent said they did not have an insert (Q12=2) but provided either age (Q12a); primary use (Q12b); whether or not burned wood (Q12g); or cords burned (Q12h).
- Set Q13=1 if a respondent said they did not have a stove (Q13=2) but provided either age (Q13a); primary use (Q13b); whether or not burned wood (Q13g); or cords burned (Q13h).
- Set Q14=1 if a respondent said they did not have a other appliance (Q14=2) but provided either age (Q14a); primary use (Q14b); whether or not burned wood (Q14g); or cords burned (Q14h).
- Set Q15=1 if a respondent said they did not have a coal burning appliance (Q14=2) but provided primary use (Q15b).
- Set Q7=1 if a respondent said they did not have any wood-burning appliances (Q7=2) but reported having a fireplace (Q11=1), insert (Q12=1), stove (Q13=1), or other wood burning appliance (Q14=1).
- Set Q8=1 if a respondent said they did not burn any wood in past 12 months (Q8=2) but reported burning wood in past 12 months in a fireplace (Q11d=1), insert (Q12g=1), stove (Q13g=1), or other wood burning appliance (Q14g=1).

2. Questions on amount of wood burned

Questions impacted: Q11d, Q12h, Q13h, and Q14h.

The questions on amount of wood burned were extremely important, given that they were used to calculate projections at the county-level and overall. Therefore, the recorded values for these questions received additional scrutiny. Tables 10 and 11 shows what rules we applied to either flag or edit certain responses.

Table 10: Data Processing Rules

Scanned value for Q11d, Q12h, Q13h, Q14h	Action
All values above four	Flagged for mail room to recheck
All decimals except .25 and .5	Flagged for mail room to recheck
Fractions other than 1/2, 1/4, 1/5, 1/10	Flagged for mail room to recheck
Values accompanied by a “?” such as 1/2?	Flagged for mail room to recheck
Other unclear responses such as: 1/4 OF 1/2	Flagged for mail room to recheck
1/2 ton	1/2 Ton = 1/2 cord so applied “1/2”
“Greater than” or “Less than” signs, such as <1/4	Applied value in question, such as 1/4
Value with intervals, such as 0–1	Applied mid-point of interval: 0–1 => .5
Non-specific amounts	Applied the following: <ul style="list-style-type: none"> • Two bundles => 0.0156 cords • Two-to-three logs => 0.00468 cords (assumed three logs) • Two small bags => 0.0156 cords (assumed a small bag = bundle) • 12 pieces => 0.01872 cords • Very little => 0.0156 cords
Gas, N/A, none, zero, 0	Applied “0”

Table 11: Additional Data Processing Rules Related to Appliance Information

Case	Rule
Different writing formats	Standardized writing, e.g.: <ul style="list-style-type: none"> • “1& 1/2” => “1.5” • “one” = “1,” etc.
If respondent sent in a survey twice	Included data from first survey only
If respondent listed identical information for two appliances side-by-side	Included data from first appliance only

Please note: In addition to the data processing rules in Table 10, amounts of wood burned above three cords for each appliance were excluded from our projections.

WEIGHTING

Weighting for the Northern Utah Air Quality Survey was completed in two steps. The first step is to compute a design weight to account for unequal selection probabilities. Second, the weights were post-stratified so that weighted totals matched known population estimates, or control totals.

Design Weight:

The sample was defined as eight strata defined according to county, with Salt Lake County divided to produce an oversample of the Hawthorne area. The design weight for a stratum was defined as the number of available USPS Addresses in the stratum divided by the number of addresses selected to receive the survey.

Post-Stratification:

The post-stratification was implemented using a raking, or iterative proportional fitting algorithm. The weights were matched to known counts of occupied housing units in three categories: tenure by county, home type by county, and home age by county. Population controls were computed from the 2009–2013 American Community Survey five-year estimates.

OVERVIEW OF RESPONSE RATES

A total of 8,600 addresses were selected for the sample, and a total of 2,690 households returned a completed survey. This is a response rate of 33.2 percent. We use AAPOR's RR1 calculation, which is the standard, accepted response rate for mail surveys; it is calculated as the number of complete returned surveys over the number of eligible households. Undeliverable mail returns are considered ineligible.

Table 12. Response Rates by Area

County/Area	Addresses Selected	Undeliverable Mail	Completed Returns	Response Rate (RR1)
Box Elder*	1,100	69	401	38.9%
Cache*	1,100	80	362	35.5%
Davis	1,100	54	391	37.4%
Salt Lake (non-Hawthorne)	1,100	45	342	32.4%
Hawthorne	900	69	255	30.7%
Tooele*	1,100	74	297	28.9%
Utah	1,100	35	322	30.2%
Weber*	1,100	77	320	31.3%
TOTAL	8,600	503	2,690	33.2%

APPENDIX C: MAIL MATERIALS

PRE-NOTIFICATION LETTER



UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

Salt Lake County Resident 12345678A
980 Beaver Creek Drive
Martinsville, VA 24112
1 0

January 16, 2015

Dear Salt Lake County Resident,

I am writing to ask for your help with an important study. The Division of Air Quality within the Utah Department of Environmental Quality (DEQ) is conducting a survey of households in seven Northern Utah counties to better understand residents' opinions and behaviors on key issues related to air pollution.

In about a week, you will receive a short survey in the mail with a pre-paid return envelope. I would like to encourage you to complete the survey and return it in the envelope provided. DEQ has hired an independent research firm, ICF International, to administer the survey.

Findings from this study will help DEQ better understand air quality issues and allow us to be more effective in reducing the wide variety of air pollution sources in our region. Your household has been randomly selected to participate in this survey. To ensure that our findings are accurate, it is important that all recipients complete and return the survey.

Your participation in the survey is voluntary. Your answers will be kept completely confidential and survey results will only be reported in group form.

For further information about the study, please feel free to contact the toll-free study verification line at 1-844-403-3934.

We hope that you find the survey interesting and that you enjoy the opportunity to participate.

Sincerely,

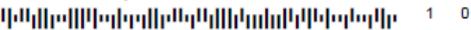
Bryce C. Bird

Director, Division of Air Quality
Utah Department of Environmental Quality

COVER LETTER



UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

Salt Lake County Resident  12345678A
980 Beaver Creek Drive
Martinsville, VA 24112
 1 0

January 16, 2015

Dear Salt Lake County Resident,

I am writing to ask for your help with an important study about air quality in Northern Utah. The Division of Air Quality within the Utah Department of Environmental Quality (DEQ) is conducting a survey of households in seven counties to better understand the different sources of air pollution in our region.

The best way we have to understand air pollution in Northern Utah is to ask a cross-section of people who live in the area about their behaviors and opinions on key issues. Your household was randomly selected to participate in this study. We are asking you to take a few moments today to complete the enclosed questionnaire and return it at your earliest convenience.

If you do not know the answers to all of the questions, please direct those questions to another person (such as the homeowner) who can help you provide the information requested.

The survey will take about 10 minutes to complete. Your participation is voluntary and your answers will be kept completely confidential. Survey results will only be reported in group form. DEQ has hired an independent research company called ICF International to administer the survey.

If you have any questions about the survey, please feel free to call the study verification line at 1-844-403-3934. To contact DEQ, please call Joel Karmazyn at (801) 536-4423.

By taking a few minutes to complete the questionnaire today, you will help DEQ a great deal as we work to form a complete picture of air quality issues in Northern Utah.

Many thanks,

Bryce C. Bird

Director, Division of Air Quality
Utah Department of Environmental Quality

POSTCARD

Northern Utah Air Quality Survey
c/o ICF International
980 Beaver Creek Drive
Martinsville, VA 24112

PRESORT
FIRST CLASS
U.S. POSTAGE
PAID
MARTINSVILLE, VA
PERMIT NO. 40

Salt Lake County Resident  12345678A
980 Beaver Creek Drive
Martinsville, VA 24112

 1 0



UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

January 16, 2015

Dear Salt Lake County Resident,

Last week, we mailed you a questionnaire because your household was randomly selected to take part in an important study on air quality in Northern Utah. Findings from this study will help the Division of Air Quality better understand the different sources of air pollution in our region.

If you have already completed the survey, please accept our sincere thanks! If not, please take a moment to complete the survey today. We are very grateful for your help with this important study.

If you did not receive a questionnaire, or if you would like us to send you a replacement, please call the toll-free survey number: 1-844-403-3934.

Sincerely,

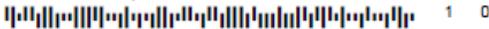
Bryce C. Bird

Director, Division of Air Quality
Utah Department of Environmental Quality

SECOND COVER LETTER



UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

Salt Lake County Resident  12345678A
980 Beaver Creek Drive
Martinsville, VA 24112
 1 0

February 10, 2015

Dear Salt Lake County Resident,

About three weeks ago, we sent you a survey request asking for your help with an important study of the air quality in Northern Utah. To the best of our knowledge, we have not yet received your responses.

We are writing because of the importance that your household's responses have for helping us obtain accurate results in developing viable air quality policies. The only way we can do that is by asking for community-level information.

If you do not know the answers to all of the questions, please direct those questions to another person (such as the homeowner) who can help you provide the information requested.

Simply complete the enclosed questionnaire and return it in the stamped envelope provided. The survey will only take about 10 minutes to complete.

If you have any questions about the survey, please feel free to call the study verification line at 1-844-403-3934. To contact DEQ, please call Joel Karmazyn at (801) 536-4423.

Many thanks,

Bryce C. Bird

Director, Division of Air Quality
Utah Department of Environmental Quality

REFERENCES

- ¹ EPA, “2006 24-Hour PM_{2.5} Standards — Region 8 Final Designations, October 2009.” Last updated on 4/19/2013. <http://www.epa.gov/pmdesignations/2006standards/final/region8.htm>
- ² Neil P. Lareau, Erik Crosman, C. David Whiteman, John D. Horel, Sebastian W. Hoch, William O. J. Brown, and Thomas W. Horst, 2013: The Persistent Cold-Air Pool Study. *Bull. Amer. Meteor. Soc.*, **94**, 51–63. doi: <http://dx.doi.org/10.1175/BAMS-D-11-00255.1>
- ³ University of Utah Atmospheric Sciences Department Mountain Meteorology Group, “Frequently Asked Questions about Wintertime PM_{2.5} Pollution in Utah’s Salt Lake Valley.” Last updated 01/05/2015 <http://home.chpc.utah.edu/~whiteman/PM2.5/PM2.5.html>
- ⁴ K.E. Kelly, R. Kotchenruther, R. Kuprov and G.D. Silcox, “Receptor model source attributions for Utah’s Salt Lake City airshed and the impacts of wintertime secondary ammonium nitrate and ammonium chloride aerosol.” *Journal of the Air & Waste Management Association*, 63:5, 575-590.
- ⁵ D. A. Dillman, J. D. Smyth and L.M. Christian, *Internet, Phone, Mail, and Mixed-mode Surveys: The Tailored Design Method*. Hoboken, NJ: John Wiley & Sons (2014).
- ⁶ *Ibid.*
- ⁷ C. Redline, D. A. Dillman, A.N. Dajani and M.A. Scaggs (2003). Improving navigational performance in US Census 2000 by altering the visually administered languages of branching instructions. *Journal of Official Statistics-Stockholm*, 19(4), 403-420.