

# Residential Wood Use Survey to Improve U.S. Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion

Final  
April 2019

Please cite as:

CEC. 2019. *Residential Wood Use Survey to Improve U.S. Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion*. (Unpublished). Montreal, Canada: Commission for Environmental Cooperation. 60 pp.

This report was prepared by Abt Associates, in coordination with Northeast States for Coordinated Air Use Management (NESCAUM), for the Secretariat of the Commission for Environmental Cooperation. The information contained herein is the responsibility of the author and does not necessarily reflect the views of the CEC, or the governments of Canada, Mexico, or the United States. **This document has not been edited or reviewed by CEC editorial staff and is therefore not considered to be a final version for formal publication. Its contents may be subject to change without notice.**

Reproduction of this document in whole or in part and in any form for educational or non-profit purposes may be made without special permission from the CEC Secretariat, provided acknowledgment of the source is made. The CEC would appreciate receiving a copy of any publication or material that uses this document as a source.

Except where otherwise noted, this work is protected under a Creative Commons Attribution Noncommercial-NoDerivative Works License.



© Commission for Environmental Cooperation, 2019

#### Publication Details

*Document category:* Background Document

*Publication date:* April 2019

*Original language:* English

*Project:* OP 2017-18. Improving Black Carbon Emissions Inventory Data for Small-Scale Biomass Combustion.

For more information:

**Commission for Environmental Cooperation**

700, rue de la Gauchetière Ouest, suite 1620

Montreal (Quebec)

H3B 5M2 Canada

t 514.350.4300 f 514.350.4314

info@cec.org / www.cec.org



## Table of Contents

<b>List of Tables .....</b>	<b>iv</b>
<b>List of Abbreviations and Acronyms.....</b>	<b>vi</b>
<b>Abstract.....</b>	<b>vii</b>
<b>Executive Summary .....</b>	<b>vii</b>
<b>Acknowledgments .....</b>	<b>x</b>
<b>1. Background .....</b>	<b>1</b>
<b>2. Technical Approach – Survey Methodology and Data Analysis.....</b>	<b>1</b>
2.1 Technical Approach – Overview .....	2
<i>Wave 1</i> .....	2
<i>Wave 2</i> .....	2
2.2 Sample Design, Survey Instrument and Survey Administration .....	4
2.3 Data Quality and Analysis.....	5
2.4 Sample Stratification and Survey Weights.....	6
<b>3. Survey Results .....</b>	<b>7</b>
3.1 Survey Response Rate.....	7
3.2 Percent of Households Using Each Type of Appliance .....	8
3.3 Average Annual Fuel Consumption Rates .....	10
3.4 Burn Activity by Households with Natural Gas Access .....	13
3.5 Burn Activity in Urban, Suburban, and Rural Homes.....	14
3.6 Burn Activity by Type of Dwelling .....	16
3.7 Burn Activity by Census Division.....	19
3.8 Burn Activity by Heating Degree Days .....	21
3.9 Comparison to Other Surveys .....	23
<b>4 Conclusions.....</b>	<b>25</b>
<b>Bibliography .....</b>	<b>28</b>
<b>Appendix A – Survey Instrument.....</b>	<b>1</b>
<b>Appendix B – Survey Results Tables.....</b>	<b>1</b>

## List of Tables

Table 1. List of States in Wave 2 of the Survey .....	3
Table 2. Sample Frame for Wave 1 of the Survey .....	4
Table 3. Sample Frame for Wave 2 of the Survey .....	4
Table 4. Response Rate by State .....	7
Table 5. Response by Type of Dwelling .....	17
Table B-1. Total Responses by Appliance Type.....	1
Table B-2. Percentage of Households Using Each Appliance Type, by Census Division..	2
Table B-3. Average Fuel Consumption Rate (Cords/Appliance), by Census Division .....	2
Table B-4. Unweighted Responses by Census Division .....	3
Table B-5. Responses by Urban, Suburban and Rural Areas.....	3
Table B-6. Percentage of Homes Using Each Type of Appliance, by Dwelling Type .....	4
Table B-7. Average Fuel Consumption Rate (Cords/Appliance), by Dwelling Type.....	4
Table B-8. Unweighted Responses by Dwelling Type .....	5

## List of Figures

Figure 1. Percentage of Households that Burn Wood .....	9
Figure 2. Percentage of Wood Burning Households Using Each Type of Appliance.....	9
Figure 3. Primary Use of Wood Burning Appliances .....	10
Figure 4. Graphic Included in the Survey to Explain Methods for Estimating the Quantity of Firewood Burned.....	11
Figure 5. Average Cords Burned Per Year by Appliance and Burn Type .....	12
Figure 6. Average Cords Burned Per Year in Wood-Burning Furnaces, Wood-Burning Boilers, and Outdoor Fire Pits.....	12
Figure 7. Percentage of Households Using Each Type of Appliance, by Natural Gas Access .....	14
Figure 8. Average Fuel Consumption Rate (Cords/Appliance), by Natural Gas Access..	14
Figure 9. Percentage of Urban, Suburban, and Rural Households Using Each Type of Appliance .....	15
Figure 10. Average Fuel Consumption Rate (Cords/Appliance) by Type of Appliance in Urban, Suburban, and Rural Homes.....	16
Figure 11. Percentage of Households Using Each Type of Appliance, by Dwelling Type	18
Figure 12. Average Fuel Consumption Rate (Cords/Appliance), by Dwelling Type .....	18
Figure 13. U.S. Census Divisions .....	19
Figure 14. Percentage of Households Using Each Appliance Type, by Census Division	20
Figure 15. Average Fuel Consumption Rate (Cords/Appliance) by Census Division .....	21
Figure 16. Percentage of Households Using Each Appliance Type, by Heating Degree Day Bin .....	22
Figure 17. Average Fuel Consumption Rate (Cords/Appliance), by Heating Degree Day Bin .....	23
Figure 18. Percentage of Households Using Each Appliance Type: Comparison of Multiple Survey Results .....	24

Figure 19. Average Cords Burned per Appliance Type: Comparison of Multiple Survey  
Results ..... 25

## **List of Abbreviations and Acronyms**

ABS	Address-based Sample
ACS	American Community Survey
BC	Black Carbon
CEC	Commission for Environmental Cooperation
EIA	Energy Information Administration
NEI	National Emissions Inventory
NESCAUM	Northeast States for Coordinated Air Use Management
RECS	Residential Energy Consumption Survey
U.S. EPA	United States Environmental Protection Agency

## Abstract

Quantification of air pollutant emissions is essential to the development of emission reduction initiatives in support of air quality targets and climate change mitigation. This report documents a project involving the design and implementation of a survey for the United States to collect data on residential wood use, including local-scale counts of appliances used and quantities of wood burned, to support improved estimation of PM<sub>2.5</sub> and black carbon emissions in North America. This project addresses a key recommendation of the 2015 report by the Commission for Environmental Cooperation titled, *North American Black Carbon Emissions: Recommended Methods for Estimating Black Carbon Emissions*, relating to the need for research to improve data from residential and other small-scale wood/biomass combustion sources, including conducting surveys on use of these fuels. The results of this survey can be used to make detailed estimates of residential wood-burning activity and associated air pollution emissions, including emissions of black carbon.

## Executive Summary

Black carbon (BC) has recently emerged as a major contributor to the fine particulate (PM<sub>2.5</sub>) burden in the air and to global climate change. BC particles are small enough to be inhaled into the lungs, resulting in increased risk of heart failure and respiratory hospital visits. In addition, BC particles strongly absorb sunlight and have a warming impact on climate that is 120-1,800 times stronger than CO<sub>2</sub> per unit of mass over a hundred-year period. BC is produced as a result of incomplete combustion and is emitted in a variety of combustion processes, including residential wood combustion. Since BC is a short-lived climate pollutant with a lifetime of only days to weeks after release in the atmosphere, BC emission reductions represent a potential mitigation strategy that could quickly reduce the rate of warming, particularly in the rapidly changing Arctic, while decreasing adverse health impacts related to PM<sub>2.5</sub> exposure.

Quantification of emissions is key to the development of emission reduction initiatives in support of air quality targets and climate change mitigation. This Commission for Environmental Cooperation (CEC) project involved the design and implementation of a survey for the United States to collect data on residential wood use, including local-scale counts of appliances used and quantities of wood burned, to support improved estimation of PM<sub>2.5</sub> and BC emissions in North America. When developing the survey instrument, the project team relied on: 1) an initial draft survey instrument developed by NESCAUM's Residential Wood Heating (RWH) Workgroup; 2) historical knowledge of residential wood combustion surveys; and 3) a review of residential wood combustion surveys and reports including those from Idaho, Minnesota, Montana, Oregon, Vermont, and Washington, as well as the national Residential Energy Consumption Survey (RECS) from the U.S. Department of Energy's Energy Information Administration (EIA).

After developing the survey instrument, the project team conducted a web-based survey to assess the number of residential wood burning devices in the United States and to identify typical use patterns for those appliances. The survey was conducted in two waves: The first wave focused on the six New England states: Connecticut, Rhode Island, Massachusetts, Maine, New Hampshire, and Vermont. The second wave included those six states, along with Arkansas, Colorado, Georgia, Idaho, Louisiana, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Utah, Washington, and Wisconsin.

The project team utilized an address-based sample (ABS) design to construct the sample frame, in order to target counties within each of the 21 states selected for the survey that have a greater

likelihood to include residents who participate in wood burning activities. In addition, the sample frame included counties in each of the states that have a mix of urban, suburban and rural areas.

The project team programmed the web survey instrument using the Conformat software, a data collection platform that can be used for telephone, mail, and web surveys. Conformat's multi-modal capabilities allow for a streamlined approach to programming, data collection, quality assurance and monitoring, reporting, and data processing. The survey used key features from this software package, including the ability to make questions conditional on responses to other questions and to implement complex skip patterns.

The project team mailed survey invitation letters to a total of 94,502 households in the target states. The expected overall response rate was 4-6% and the anticipated margin of error associated with this response rate is +/-3% at a 95% confidence level. The project team received a total of 2,984 completed responses, for a response rate of 3.2 percent. Even at this lower-than-anticipated response rate, the margin of error is +/-3% at a 95% confidence level.

The results of the survey indicate that:

- The percentage of households burning wood in any type of appliance is approximately 30 percent, with the most common appliances used being conventional fireplaces and outdoor fire pits.
- The average fuel consumption rates for wood-burning furnaces and boilers are higher than the fuel consumption rates for the other appliance types (which is to be expected, as these appliances are typically used as the primary heat source in a home). In addition, the types of wood-burning boilers listed by respondents include a wide range of technologies, resulting in a wide range of responses for fuel consumption rates from boilers.
- In estimates of burning activity, it is often assumed that wood burning is more common in rural areas than in urban or suburban areas, because wood is typically more plentiful in rural areas while other heat sources may not be available. The survey results show that this assumption is true for nearly all appliance types (with the exception of conventional fireplaces, which are used more for pleasure/aesthetic burning rather than heating).

There are differences in average fuel consumption rates for some appliances, but not others. The survey also reveals variations in fuel consumption according to the type of setting (urban, suburban, or rural), as well as the type of dwelling (e.g., single-family home; multiple-resident building).

In contrast with conventional fireplaces and other appliances mainly used for pleasure/aesthetic purposes, appliances that are used more for primary or supplemental heating, such as pellet stoves, wood-burning furnaces, and wood-burning boilers, demonstrate more regional variation in fuel consumption rates, with homes in colder Census Divisions burning more wood per year per appliance. This suggests that the fuel consumption rates from appliances that are mainly used for pleasure/aesthetic burning may be somewhat independent of the home's climate. There are relatively few other surveys of wood-burning activity to compare to the results of this project, and all are in colder climates: Minnesota, Vermont, and Portland, Oregon. Of these states, the current survey only includes Vermont. The results of the current survey compare reasonable well with the results of those surveys, with some exceptions – such as the fact that the current survey found a higher percentage of homes using fireplaces and outdoor fire pits.

While the present survey provides more information about wood-burning activities in more states than any other survey, it has some limitations. Due to resource constraints, the project team was only able to sample 21 states. In addition, care must be taken when analyzing subsets of the data, due to low response rates for some categories. Nevertheless, the results of this survey provide important information about the use of wood-burning appliances and the amount of wood burned throughout the

United States. This information can be used to make detailed estimates of the wood-burning activity and associated air pollution emissions, including BC. In the National Emissions Inventory (NEI), BC is computed as a speciation factor from inventory  $PM_{2.5}$  and is thus directly correlated to  $PM_{2.5}$  estimates. Any improvement in activity data based on the appliance profiles and burn rates established through this survey will lead to direct improvements in estimates of  $PM_{2.5}$ , and hence BC, emissions. The data gathered under this project also highlight the residential wood combustion appliance types where uncertainty associated with  $PM_{2.5}$  and BC emissions factors should be further evaluated.

The results of this project will inform the development of future national emission inventories, and as well as policies that will lead to improved health and environmental outcomes.

## **Acknowledgments**

The Commission for Environmental Cooperation (CEC) extends its sincere appreciation to Abt Associates, the principal authors of this report, for their diligent work in the design and implementation of the data collection and analysis activities for this project: Jonathan Dorn, Frank Divita, David Cooley, Matthew Anderson, and Christopher Hardtke; and to the Northeast States for Coordinated Air Use Management (NESCAUM), for coordinating the work and providing expert advice and guidance: Paul Miller and Lisa Rector.

The CEC also wishes to thank Rich Mason of the U.S. EPA for the time and expertise he contributed during this process.

Finally, the CEC acknowledges the Secretariat staff involved in bringing this project to fruition: Orlando Cabrera-Rivera, Head of the Environmental Quality unit; and Danielle Vallée, Project Lead.

## 1. Background

Black carbon (BC) has recently emerged as a major contributor to the fine particulate (PM<sub>2.5</sub>) burden in the air and to global climate change (CCES, 2010). BC particles are small enough to be inhaled into the lungs, resulting in increased risk of heart failure and respiratory hospital visits (USEPA, 2019). Epidemiological health studies encompassing 460,310,521 person-years find strong relationships between chronic and acute exposure to PM<sub>2.5</sub> at concentrations below current federal health standards, and premature mortality (Di, et al., 2017). In addition, BC particles strongly absorb sunlight and have a warming impact on climate that is 120-1,800 times stronger than CO<sub>2</sub> per unit of mass over a hundred-year period (Bond et al., 2013). BC is produced as a result of incomplete combustion and is emitted in a variety of combustion processes, including residential wood combustion. Since BC is a short-lived climate pollutant with a lifetime of only days to weeks after release in the atmosphere, BC emission reductions represent a potential mitigation strategy that could quickly reduce the rate of warming, particularly in the rapidly changing Arctic, while decreasing adverse health impacts related to PM<sub>2.5</sub> exposure.

Quantification of emissions is essential to the development of emission reduction initiatives in support of air quality targets and climate change mitigation. This project of the Commission for Environmental Cooperation (CEC) involved the design and implementation of a survey for the United States to collect data on residential wood use, including local-scale counts of appliances used and quantities of wood burned, to support improved estimation of PM<sub>2.5</sub> and BC emissions in North America.

This project addresses a key recommendation from the CEC's 2015 report, *North American Black Carbon Emissions: Recommended Methods for Estimating Black Carbon Emissions*, relating to conducting research to improve data from residential and other small-scale wood/biomass combustion sources – through surveys on use of these fuels rather than relying on statistics (CEC, 2015). The collected information from this project also helps address a recommendation from the Arctic Council's Expert Group on Black Carbon and Methane, to expand the detail available on residential wood combustion in emissions inventories.<sup>1</sup>

The objective of the survey is to provide more information to the Northeast States for Coordinated Air Use Management (NESCAUM) and the U.S. Environmental Protection Agency (EPA) to estimate county-level air pollution emissions from wood-burning appliances for use in the National Emissions Inventory (NEI). Currently, there are limited data available to estimate residential wood combustion emissions, and for some wood-burning appliance types the estimates are based largely on expert judgment. These data limitations introduce significant questions regarding the accuracy of county-level estimates of the types and number of wood burning appliances used, the amount of wood burned in these appliances, and the associated air pollutant emissions.

## 2. Technical Approach – Survey Methodology and Data Analysis

When developing the survey instrument, the project team relied on an initial draft survey instrument developed by NESCAUM's Residential Wood Heating (RWH) Workgroup, as well as Abt Associates' historical knowledge of residential wood combustion surveys gained from supporting the U.S. EPA in developing the residential wood combustion emissions estimation tool for the National Emissions

---

<sup>1</sup> Report forthcoming. See Expert Group on Black Carbon and Methane, available at <https://arctic-council.org/index.php/en/expert-groups/339-egbcm> (accessed January 2019)

Inventory. That experience included reviewing residential wood combustion surveys and reports on wood combustion activity, including those from Idaho, Minnesota, Montana, Oregon, Vermont, and Washington, as well as the national Residential Energy Consumption Survey (RECS) from the Energy Information Administration (EIA). While the RECS survey has national coverage, it only asks a few questions about woodstoves and fireplaces and does not include other appliances such as wood boilers and furnaces. The other state and local surveys reviewed are narrower in geographic scope, but broader in terms of the types of questions asked regarding wood burning activity. Of these, the survey from Minnesota is of especially high quality, because it asks questions about a range of appliance types, including outdoor recreational burning, which is not often included in other wood combustion surveys. In addition, the Minnesota survey provides the respondent with ample background information to help him/her answer the questions more accurately, such as multiple different methods to estimate the amount of wood the respondent burns in a year. The project team drew from each of these survey instruments, and particularly from the Minnesota survey, to inform the survey instrument for this project. The survey instrument is included as Appendix A to this report.

The project team then conducted a web-based survey using this instrument, to assess the number of residential wood burning devices in the United States and to identify typical use patterns for those appliances. The survey was conducted in two waves: The first wave focused on the six New England states: Connecticut, Rhode Island, Massachusetts, Maine, New Hampshire, and Vermont. The second wave included those six states, along with Arkansas, Colorado, Georgia, Idaho, Louisiana, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Utah, Washington, and Wisconsin.

The remainder of this section describes the technical approach for implementing each wave of the survey.

## **2.1 Technical Approach – Overview**

### **Wave 1**

The target population for this study was adults who participate in residential wood burning activities in Connecticut, Rhode Island, Massachusetts, Maine, New Hampshire and Vermont. Since participation in residential wood burning activities varies throughout the region, the project team utilized an address-based sample (ABS) design to construct the sample frame, in order to target counties within each of the states that have a greater likelihood of including residents who participate in wood burning activities. The sample frame also included counties in each of the six states that have a mix of urban, suburban and rural areas. Final sample selection criteria were determined in consultation with NESCAUM's RWH Workgroup.

The project team designed and deployed a web survey to collect data. A web survey allows participants to self-administer the survey at their pace and encourages participation through sending an initial invitation letter and a follow-up reminder postcard, two weeks after sending the invitation letter. In total, 18,000 invitation letters were mailed to households in the target states. The survey was designed assuming an overall response rate of 6%, which would lead to a total of 1,080 completed surveys. The anticipated margin of error associated with this response rate is +/-3% at a 95% confidence level.

### **Wave 2**

The target population for the expanded study under Wave 2 is adults who participate in residential wood burning activities across the 21 states listed in Table 1 below.

**Table 1. List of States in Wave 2 of the Survey**

#	State	Census Region/Division
1	New York	Northeast / Middle Atlantic
2	New Jersey	Northeast / Middle Atlantic
3	North Carolina	South / South Atlantic
4	Georgia	South / South Atlantic
5	Arkansas	South / West South Central
6	Michigan	Midwest / East North Central
7	Wisconsin	Midwest / East North Central
8	Missouri	Midwest / West North Central
9	Colorado	West / Mountain
10	Idaho	West / Mountain
11	Utah	West / Mountain
12	Washington	West / Pacific
13	Pennsylvania	Northeast / Middle Atlantic
14	Ohio	Midwest / East North Central
15	Louisiana	South / West South Central
16	Connecticut	Northeast / New England
17	Rhode Island	Northeast / New England
18	Massachusetts	Northeast / New England
19	Maine	Northeast / New England
20	New Hampshire	Northeast / New England
21	Vermont	Northeast / New England

Similar to Wave 1 of the survey, the project team used ABS design to construct the sample frame, in order to target counties within each of the states that have a greater likelihood of including residents who participate in wood burning activities. In addition, the sample frame included counties in each of the 21 states that have a mix of urban, suburban, and rural areas. Final sample selection criteria were determined in consultation with NESCAUM, the U.S. EPA and the CEC.

The project team used the same web survey as for Wave 1. Invitation letters were mailed to a total of 76,502 households in the target states – which included the six states from Wave 1 – with the letters including an incentive (a chance to win one of fifty \$100 gift cards). Given the response rate under Wave 1 and the inclusion of an incentive in Wave 2, the expected overall response rate was 4%, or a total of 3,024 completed surveys. The anticipated margin of error associated with this response rate is +/-3% at a 95% confidence level. Winners were selected through a random drawing of names of individuals who had completed the survey under either Wave 1 or Wave 2.

## 2.2 Sample Design, Survey Instrument and Survey Administration

As mentioned above, the project team used an ABS design to construct the sample frame. In consultation with NESCAUM, the U.S. EPA and the CEC, counties within the target states were identified for sampling based on the prevalence of residential wood burning activities. An initial assessment of wood burning activities was assembled from data contained in the Energy Information Administration’s Residential Energy Consumption Survey (RECS; EIA, 2019) and the U.S. Census Bureau’s American Community Survey (ACS; U.S. Census Bureau, 2019). The counties were inclusive of urban, suburban, and rural residential areas. The project team acquired the individuals’ names and addresses for the sample from a vendor, based on the agreed-upon specifications. The sample frames by state for Waves 1 and 2 of the survey are provided in Tables 2 and 3, below.

**Table 2. Sample Frame for Wave 1 of the Survey**

State	Sample Size
Connecticut	3,350
Maine	3,879
Massachusetts	5,334
New Hampshire	2,670
Rhode Island	873
Vermont	1,894
<b>TOTAL</b>	<b>18,000</b>

**Table 3. Sample Frame for Wave 2 of the Survey**

State	Sample Size
Arkansas	2,992
Colorado	2,625
Connecticut	960
Georgia	4,976
Idaho	1,737
Louisiana	2,113
Maine	1,305
Massachusetts	1,447
Michigan	7,418
Missouri	5,083
New Hampshire	859
New Jersey	2,216
New York	7,738

State	Sample Size
North Carolina	7,011
Ohio	7,117
Pennsylvania	8,640
Rhode Island	245
Utah	1,007
Vermont	644
Washington	5,006
Wisconsin	5,363
<b>TOTAL</b>	<b>76,502</b>

Following the approval of the final survey questionnaire by NESCAUM’s RWH Workgroup, the project team programmed the web survey instrument using the Conformat software, a data collection platform that can be used for telephone, mail, and web surveys. Conformat’s multi-modal capabilities allow for a streamlined approach to programming, data collection, quality assurance and monitoring, reporting, and data processing. The survey used key features of this software, including the ability to make questions conditional on responses to other questions and to implement complex skip patterns.

Once programming revisions were complete, the web survey instrument was reviewed and tested via autopilot. An autopilot generates hundreds of mock responses to ensure that all conditionals and skip patterns are working as intended. NESCAUM RWH workgroup members, the CEC, and the U.S. EPA were given the opportunity to remotely test the web program, and changes were made based on their feedback.

Concurrent to web programming, the project team, in coordination with NESCAUM, the CEC and the U.S. EPA, made final changes to the survey invitation letter and reminder postcard, and provided final versions to NESCAUM. The invitation letter included a link to the web survey, a unique passcode for each respondent to access the web survey, and a QR code that linked to the survey. It was mailed to participants, and reminder postcards were sent two weeks later, to further encourage participation.

### **2.3 Data Quality and Analysis**

Data were collected using the Conformat data collection system. As part of the programming of the survey instrument on the web, several machine edit features were entered. These procedures helped to ensure that survey records accurately mirror respondents’ reports. More specifically, the project team used its web system to:

- Eliminate problems of response entry error by automatically assigning single punch fields of appropriate width for each separate data item. This includes utilizing range and consistency checks in the program;
- Ensure that skip patterns are administered properly, by programming them to ensure that all questions for which a particular respondent is qualified to answer are exhibited in appropriate sequence; and
- Permit immediate and comprehensive edits of the survey instrument.

The web system was programmed to recognize the allowable range for key-entered item values. If an entry was made outside of the allowable range the value was rejected and the program alerted the

respondent that an error had been made. The instrument would not advance on the screen until an appropriate value was entered. Often checks were set to include only probable rather than all possible values. In this way, when a seemingly aberrant value (e.g., “I burn 80 cords of wood a year”) was encountered, a prompt would ask the respondent to verify this answer. Each and every item was checked online to ensure that the data collected were all within acceptable range specifications.

Consistency checks were programmed into the web system for certain types of items. Consistency checks are generally of three types: logical consistency, replicability, or mathematical equivalence. Logical consistency pertains to a situation in which a respondent, asked two separate questions about related items, responds similarly. Mathematical equivalence checks were also programmed into the system to ensure that percentages assigned to mutually exclusive and exhaustive response alternatives add up to 100 percent.

The project team made only minor corrections to survey responses to address inconsistencies. For example, three respondents indicated that they have wood-burning furnaces, but they also stated that these appliances distribute heat through a boiler system. Another respondent stated that he/she has a wood-burning furnace, but listed the brand name of a wood-burning boiler. The responses for each of these respondents were switched from furnace to boiler. Similarly, three respondents stated that they have wood-burning boilers, but they also stated that these appliances distribute heat through a forced-air furnace. The responses for each of these respondents were switched from boiler to furnace. In all, the project team made manual corrections to 7 out of 2,984 responses (0.2% of the total).

## **2.4 Sample Stratification and Survey Weights**

In the development of the sampling design, the project team assumed that there would be a relatively low response rate from homes that burn wood. For this reason, the team stratified the sampling design to purposefully oversample areas where wood-burning activity is thought to be more common, based on data from the Census Bureau’s ACS. The purpose of this approach is to increase the likelihood of receiving responses from homes that burn wood.

Sample stratification was based on two variables defined at the Census tract level:

1. Population density = Population (in 2010 Census), with categories defined as:
  - 1: population density 5000+ per square mile;
  - 2: population density 1500–4999 per square mile;
  - 3: population density 350–1499 per square mile;
  - 4: population density less than 350 per square mile.
2. Percent of housing units reporting that they burn wood to heat their homes (from the ACS), with categories defined as:
  - 1: 0% households burning wood;
  - 2: 0.1%–2.9% households burning wood;
  - 3: 3.0%–9.9% households burning wood;
  - 4: 10+% households burning wood.

Each Census tract in the sampled states was assigned a score equal to the sum of the two above variables minus 1. The score ranged from 1 to 7, with the higher values indicating higher propensity to burn wood. Households in the higher numbered strata were sampled at a higher rate.

Because of the stratification, each respondent does not have an equal chance of being selected, and the responses must be weighted to correct for the oversampling.

The survey weights are based on the base probability of selection:

$$\text{Base Probability of Selection} = \frac{\text{\# of housing units}}{\text{\# of mailouts per stratum}}$$

While these sampling weights can account for the oversampling, the project team made additional adjustments to the survey weights to calibrate the sample with known information about the population from the ACS. The following characteristics were used to calibrate the sampling weights:

1. Population by state;
2. Use of wood as the primary heating source;
3. Type of home (e.g., detached single-family, duplex);
4. Household size;
5. Household income.

This step was accomplished using the Survey package in the R statistical program.<sup>2</sup> The approach makes adjustments to the initial calculated survey weights in order to correct for differences between the responses received from the survey and known data. For example, if the survey received a disproportionately high number of responses from detached single-family homes in a certain state, then the survey weights for responses from detached single-family homes would be adjusted to bring them into proportion with the actual number of detached single-family homes in that state, as reported by the ACS.

The resulting survey weights can be interpreted as the number of homes represented by each survey response. All of the survey results discussed in Section 3 were developed using the survey-weighted data, rather than the raw response data.

### 3. Survey Results

This section discusses the results of the survey, including the response rate, estimated percentage of homes that use each appliance, and the associated fuel consumption rates. The results are also discussed in terms of regional variation and differences in responses between households in urban and rural zip codes. Detailed data tables are provided in Appendix B.

#### 3.1 Survey Response Rate

There were 94,502 invitation letters mailed out, and the project team received a total of 2,984 completed responses, for a response rate of 3.2 percent. Even at this lower-than-anticipated response rate, the margin of error is +/-3% at a 95% confidence level. Table 4 shows the response rate by state.

**Table 4. Response Rate by State**

State	# of Responses	# of Surveys Sent	Response Rate (%)
AR	68	2,992	2.27
CO	90	2,625	3.43
CT	140	4,310	3.25
GA	91	4,976	1.83

---

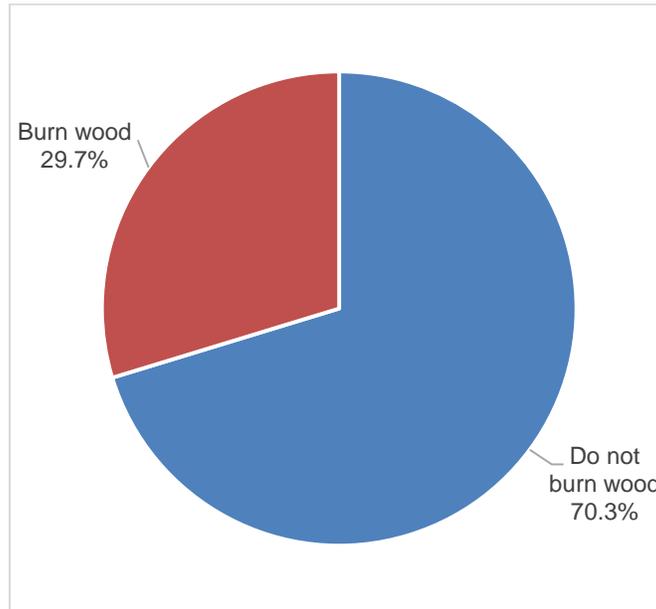
<sup>2</sup> R is an open-source statistical computer program, available here: <https://www.r-project.org/>

<b>State</b>	<b># of Responses</b>	<b># of Surveys Sent</b>	<b>Response Rate (%)</b>
ID	42	1,737	2.42
LA	33	2,113	1.56
ME	223	5,184	4.30
MA	215	6,781	3.17
MI	237	7,418	3.19
MO	113	5,083	2.22
NH	150	3,529	4.25
NJ	46	2,216	2.08
NY	240	7,738	3.10
NC	183	7,011	2.61
OH	170	7,117	2.39
PA	301	8,640	3.48
RI	34	1,118	3.04
UT	37	1,007	3.67
VT	126	2,538	4.96
WA	181	5,006	3.62
WI	264	5,363	4.92
<b>TOTAL</b>	<b>2,984</b>	<b>94,502</b>	<b>3.16</b>

### 3.2 Percent of Households Using Each Type of Appliance

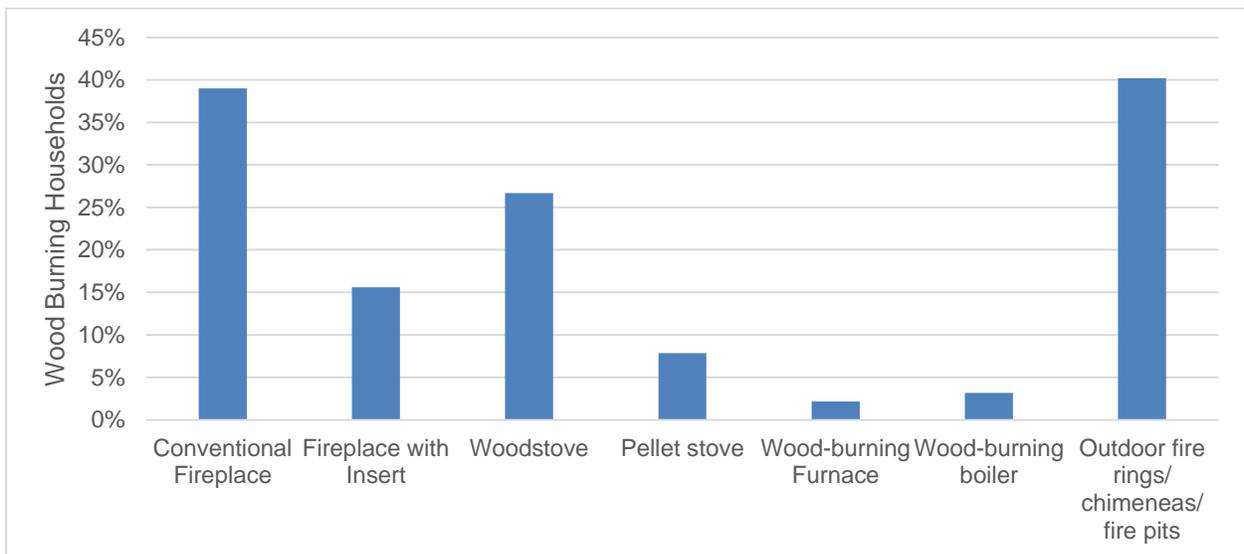
The percentage of households burning wood in any type of appliance is estimated at approximately 30 percent (Figure 1).

**Figure 1. Percentage of Households that Burn Wood**



Of those households that burn wood, the most common appliances used are conventional fireplaces and outdoor fire pits, each accounting for approximately 40 percent of wood-burning households (Figure 2).

**Figure 2. Percentage of Wood Burning Households Using Each Type of Appliance**



*Note: The percentage of wood burning households using each type of appliance adds up to greater than 100 percent because many households use more than one type of appliance.*

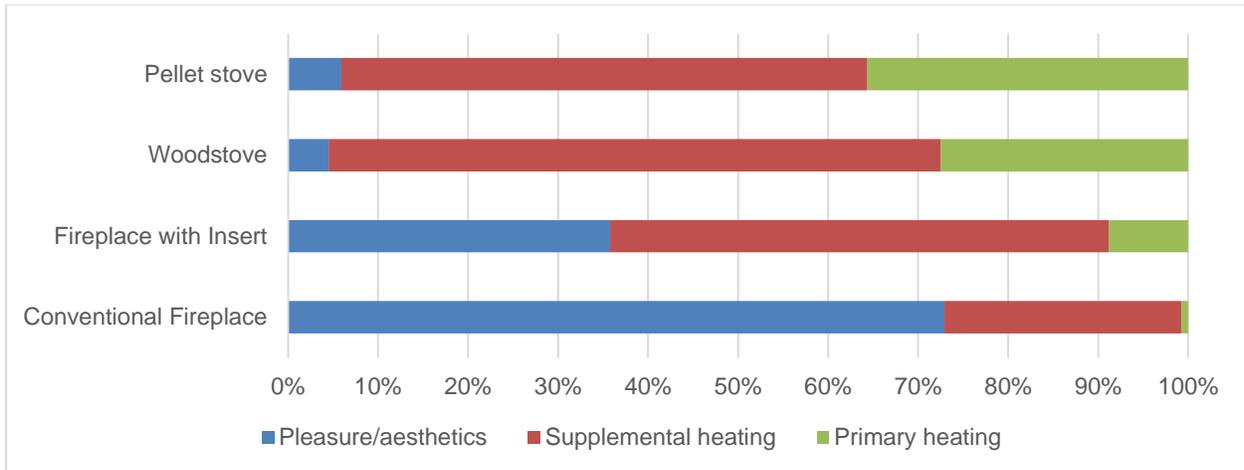
For conventional fireplaces, fireplaces with inserts, woodstoves, and pellet stoves, the survey asked respondents about the primary use of their appliances: primary heating, supplemental heating, or pleasure/aesthetics. This question was not asked for wood-burning furnaces, wood-burning boilers, or

outdoor fire pits. It was assumed that furnaces and boilers are used for primary heating, and that outdoor fire pits are only used for pleasure/aesthetics. The results show that the majority (69 percent) of households that use conventional fireplaces use them primarily for pleasure/aesthetics (Figure 3). Less than one percent of households use their conventional fireplaces for their primary source of heat.

A majority of households using fireplaces with inserts, woodstoves, or pellet stoves use them for supplemental heat. Each of these types of appliances is also more likely to be used as the primary heat source in the home; 27 percent and 35 percent of respondents with woodstoves and pellet stoves use them as their primary heat source, respectively.

In addition to asking whether the respondent used a particular appliance, the survey also asked whether the appliance is EPA-certified. However, upon closer review of the results, a high proportion of respondents stated that their appliances are EPA-certified, but the model of appliance indicated actually was that of a non-certified appliance. This suggests confusion among respondents about whether their appliances are certified. Given the prevalence of these inconsistencies, the project team ultimately decided not to report on proportion of homes using certified appliances.

**Figure 3. Primary Use of Wood Burning Appliances**



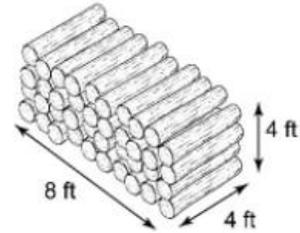
### 3.3 Average Annual Fuel Consumption Rates

The fuel consumption rate for each appliance type is calculated as the survey-weighted average of the amount of wood burned in each appliance. The survey allowed respondents to provide multiple measurements of the amount of wood burned, including cords, face cords, and bundles. The survey also provided the respondents with a graphic (Figure 4) explaining how to estimate the quantity of firewood burned in each appliance type used in the household. The project team converted all responses to cords using the conversion factors shown in Figure 4 (e.g., face cords are equal to one-third of a cord; bundles are equal to 0.006 cords).

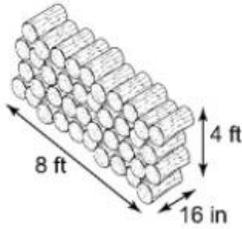
**Figure 4. Graphic Included in the Survey to Explain Methods for Estimating the Quantity of Firewood Burned**

**ESTIMATING HOW MUCH FIREWOOD YOU USE.**

A **full cord** is a large amount of wood. It measures 4 feet high by 4 feet wide by 8 feet long (4' x 4' x 8') and has a volume of 128 cubic feet.



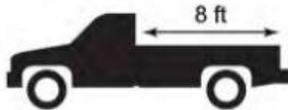
**A full cord**



**A face cord**

**x3**

A **face cord of wood** is 4 feet high by 8 feet long and is as wide as the individual firewood pieces, but averages 16 inches wide. A 16-inch wide face cord (sometimes called a **fireplace cord**) is equal to one-third of a full cord.



**Full-size pick-up**

**x2**

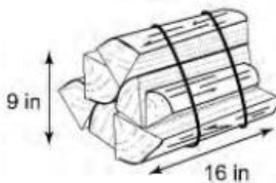
**Two full-size pick-up truck loads** (8 foot box) equals **one full cord**, whether the wood is stacked carefully so it is about level with the truck box sides, or is thrown into the truck box with the top of the pile about as high as the cab.



**Compact pick-up**

**x4**

**Four compact pick-up truckloads** (6 foot box) equals **one full cord of wood**, whether the wood is stacked carefully so it is about level with the truck box sides, or is thrown into the truck box with the top of the pile about as high as the cab.

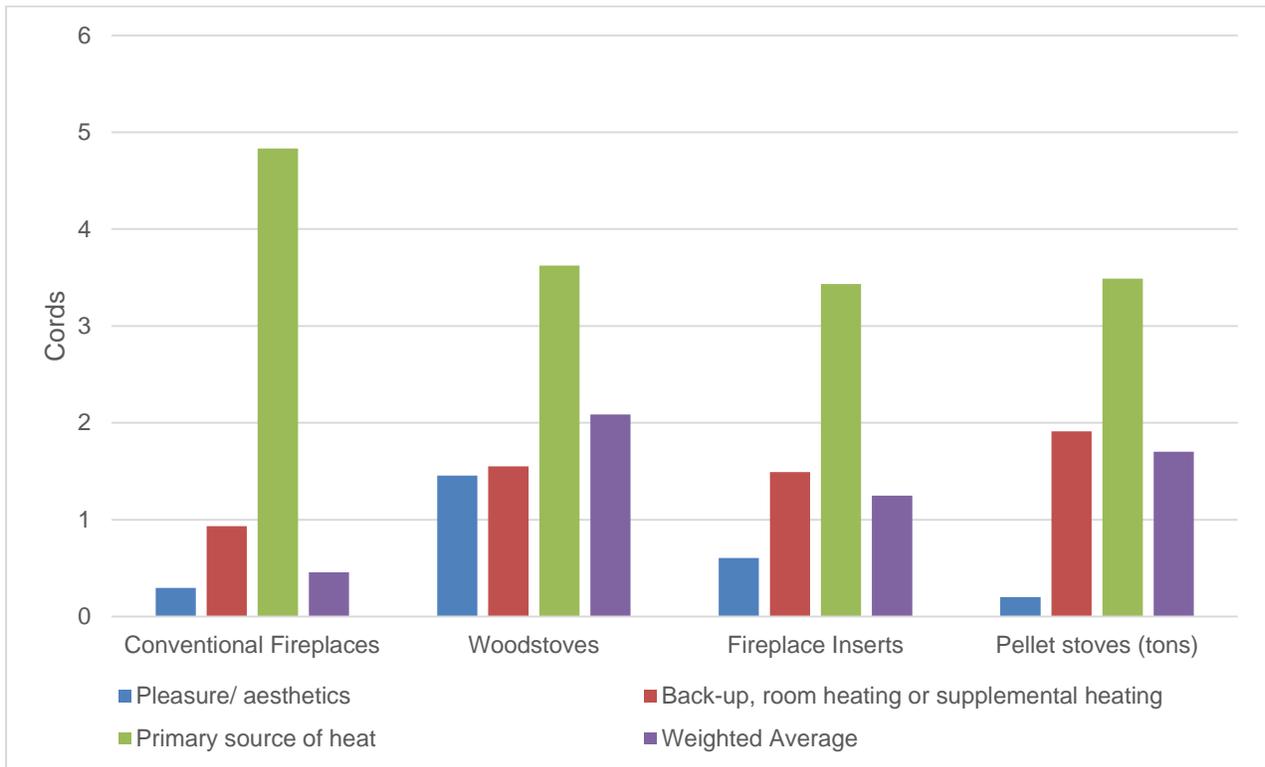


**x170**

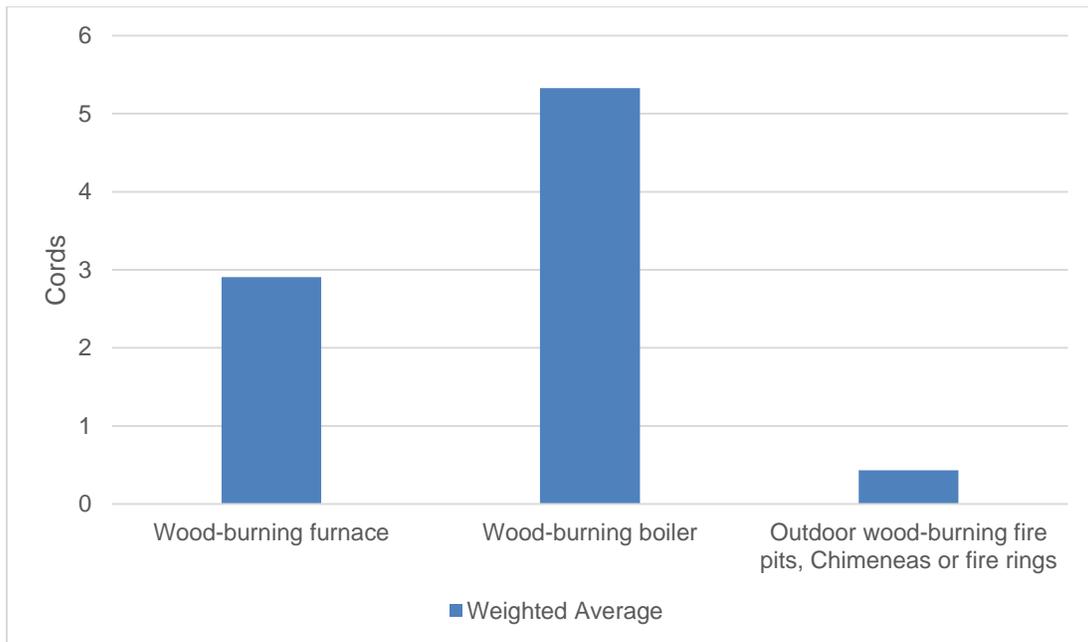
**Bundles of wood** sold at gas stations, hardware stores and state parks are often 0.75 cubic feet. They often measure about 16 inches x 9 inches x 9 inches. 170 bundles equals **one full cord**.

Figures 5 and 6 show the estimated fuel consumption rate (cords/year) per appliance type. Figure 5 includes conventional fireplaces, woodstoves, fireplaces with inserts, and pellet stoves, broken down by burn type (e.g., primary heat, supplemental heat, or pleasure/aesthetics) and including a weighted-average fuel consumption rate.

**Figure 5. Average Cords Burned Per Year by Appliance and Burn Type**



**Figure 6. Average Cords Burned Per Year in Wood-Burning Furnaces, Wood-Burning Boilers, and Outdoor Fire Pits**



The fuel consumption rates for appliances used as the primary heat source are relatively high. For example, households that use conventional fireplaces as the primary heat source burn nearly 5 cords per year, on average. However, as discussed in Section 3.2, above, very few homes use conventional fireplaces as the primary heat source. Homeowners with conventional fireplaces more commonly use them for pleasure/aesthetic burning, which has a fuel consumption rate of 0.3 cords per year. As a result, the weighted-average fuel consumption rate for fireplaces is 0.5 cords per year.

As shown in Figure 6, the average fuel consumption rates for wood-burning furnaces and boilers are higher than the fuel consumption rates for the other appliance types. This is to be expected, as these appliances are typically used as the primary heat source in a home. In addition, the types of wood-burning boilers listed by respondents include a wide range of technologies, from low-mass units with fireboxes approximately twice the size of a typical woodstove, to units with fireboxes more than 15 times larger than a typical woodstove. As a result, there was a wide range of responses for fuel consumption rates from boilers.

The fuel consumption rate for outdoor fire pits, which are assumed to be exclusively used for pleasure/aesthetic burning, is 0.44 cords per year.

### **3.4 Burn Activity by Households with Natural Gas Access**

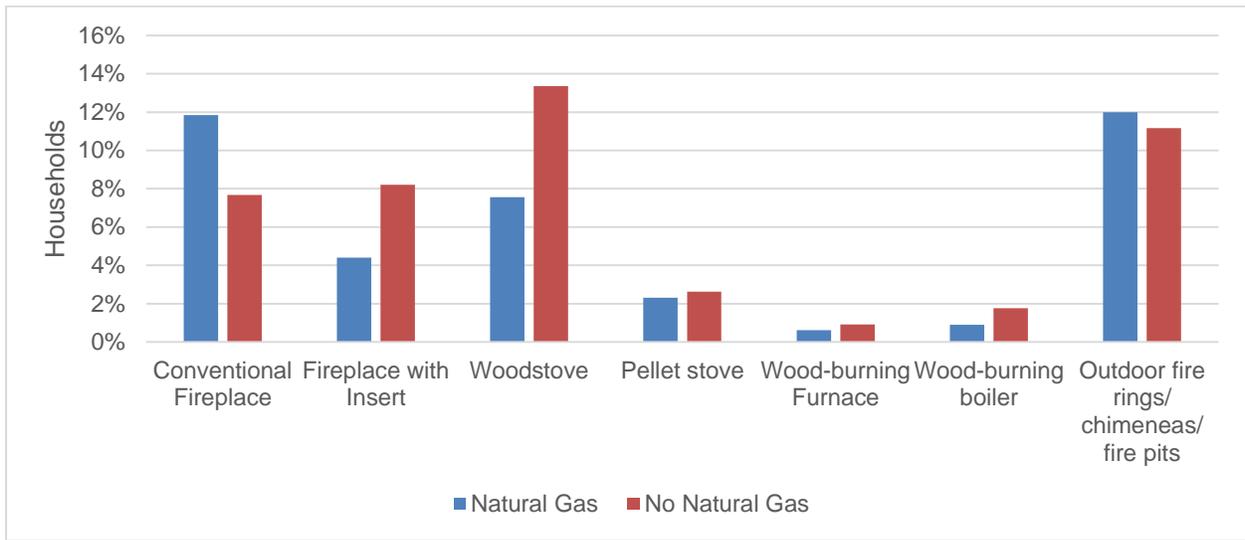
Homes that lack access to natural gas may be more likely to burn wood as a primary or secondary heating fuel than homes with natural gas access. To determine the difference in burn activity between homes with and without natural gas access, the project team used ACS data on the proportion of homes in each county using different heating fuels as the primary heat source (U.S. Census Bureau, 2019). Counties with less than 10 percent of homes using natural gas as the primary heat source were flagged as counties lacking natural gas service.

Figure 7 shows that for most appliance types, homes are more likely to use a wood-burning appliance if they are in a county that lacks natural gas service. Homes without natural gas access are nearly twice as likely to use a fireplace with an insert or a wood-burning boiler, and more than 75 percent more likely to use a woodstove, than homes with natural gas access.

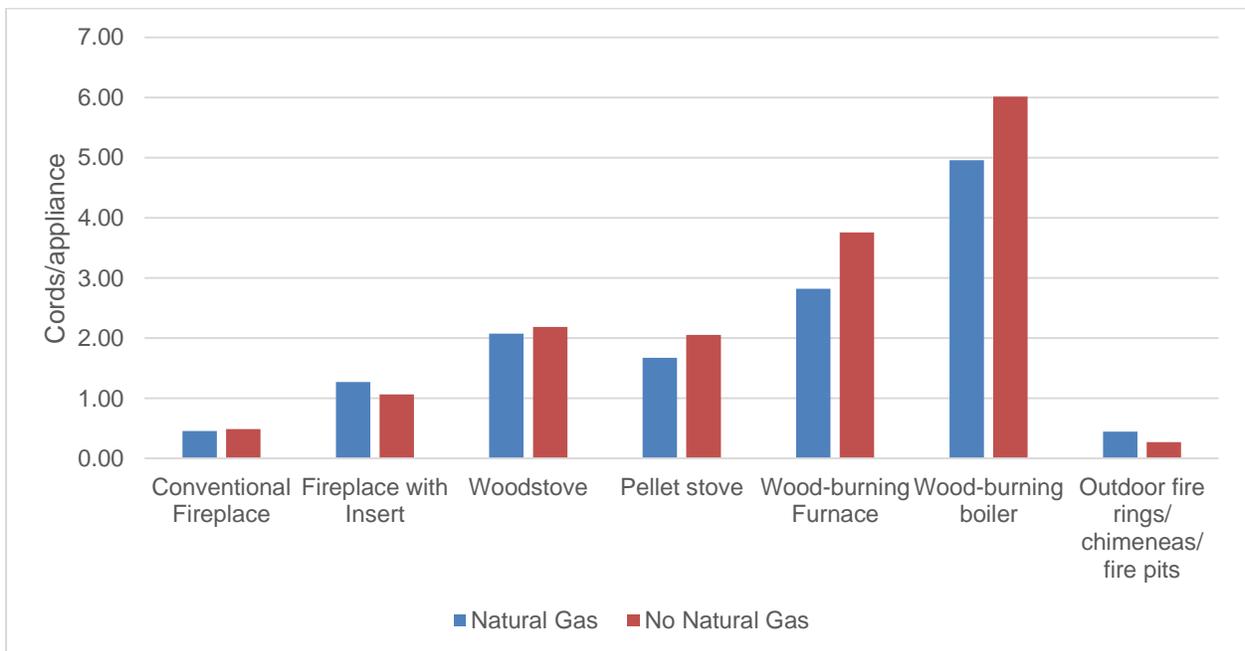
Homes without access to natural gas service are actually somewhat less likely to use a conventional fireplace or outdoor fire pit than homes with natural gas service. In the case of outdoor fire pits, one would not necessarily expect to see a relationship between appliance use and natural gas service, given that this type of appliance is not used for indoor heating. This survey has also shown that conventional fireplaces are rarely used for heating, and are more often used for pleasure/aesthetic burning. As a result, it may be that homes without natural gas service are less likely to use a conventional fireplace and more likely to use a more efficient heating source, such as a fireplace with an insert, a woodstove, or a wood-burning boiler.

Figure 8 shows relatively little difference in fuel consumption rate between homes with and without natural gas service. The exceptions are for pellet stoves, wood-burning furnaces, and wood-burning boilers, each of which has a fuel consumption rate more than 20 percent higher for homes without natural gas service compared to homes with natural gas service. All other appliances have similar fuel consumption rates regardless of natural gas access. Therefore, it appears that natural gas access is a stronger determinant of whether a home uses a particular type of appliance. However, once the occupant has decided to use the appliance, there is little difference in the amount of wood burned per appliance between homes with and without natural gas service.

**Figure 7. Percentage of Households Using Each Type of Appliance, by Natural Gas Access**



**Figure 8. Average Fuel Consumption Rate (Cords/Appliance), by Natural Gas Access**



### 3.5 Burn Activity in Urban, Suburban, and Rural Homes

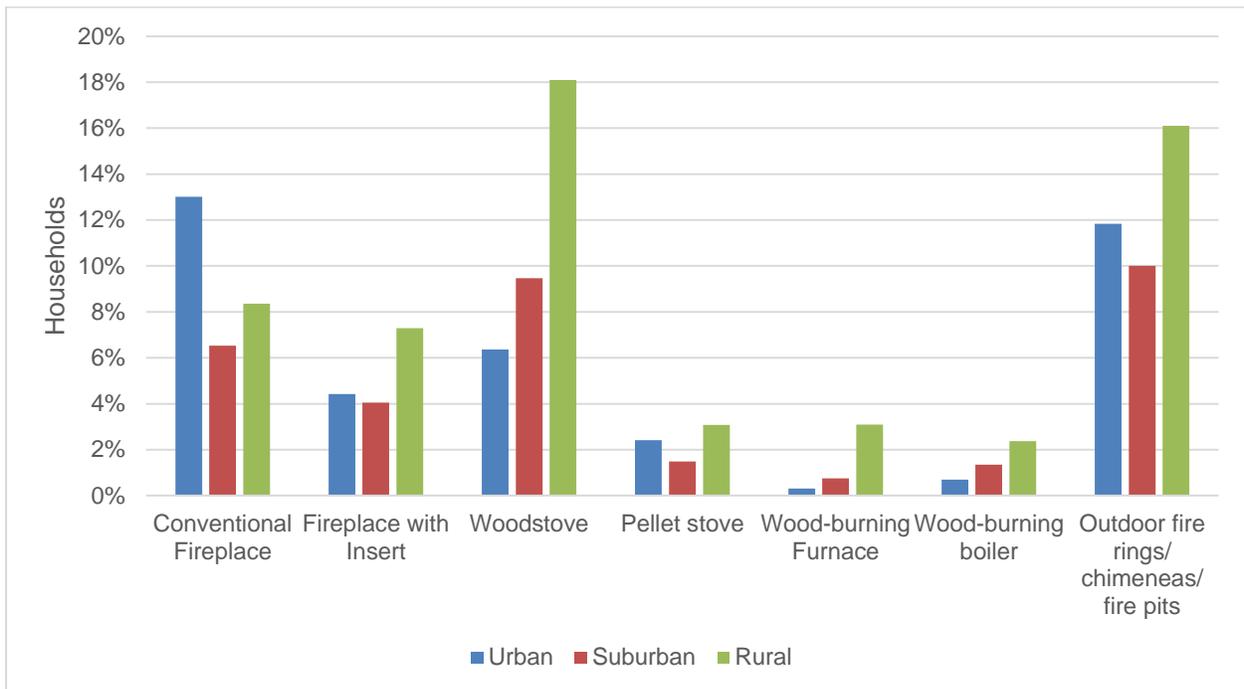
To estimate the difference in burn activity in urban, suburban, and rural homes, the project team matched the respondents' zip codes with spatial data from the Census Bureau on urban areas (with a population greater than 50,000) and urban clusters (with a population between 2,500 and 50,000) in the United States (U.S. Census Bureau, 2010). The project team overlaid the map of urban areas/urban clusters with a map of zip codes to determine which zip codes intersect with urban areas/urban clusters. The project team

considered zip codes that intersect with urban areas as “urban,” zip codes that intersect with urban clusters as “suburban,” and all other zip codes as “rural.” Table 5 shows the raw (unweighted) responses and the survey-weighted responses from urban, suburban, and rural areas. As discussed in Section 2.4, above, in the sample frame design rural areas were purposefully oversampled in an effort to ensure more responses from areas where wood-burning activity is more common. In order to analyze the responses, survey weights were developed to account for the fact that respondents did not have an equal chance of being selected for the survey. In the survey weights, the responses from urban or suburban areas were weighted more heavily, and the responses from rural areas were weighted less heavily. The survey-weighted responses can be interpreted as the number of homes represented by each survey response.

In estimates of burning activity, it is often assumed that wood burning is more common in rural areas than in urban or suburban areas, because wood is typically more plentiful in rural areas while other heat sources, such as natural gas, may not be available. The results in Figure 9 show that this assumption is true for nearly all appliance types, with the exception of conventional fireplaces, which are used more for pleasure/aesthetic burning than for heating. In other words, homes in rural areas mainly burn wood in appliances that provide primary or supplemental heating.

For some appliances, the differences are striking. For example, 18 percent of rural homes use a woodstove, compared to only six percent of urban homes and nine percent of suburban homes. Perhaps less surprising is the fact that less than one percent of urban homes use a wood-burning furnace or boiler, while approximately two to three percent of rural homes use one.

**Figure 9. Percentage of Urban, Suburban, and Rural Households Using Each Type of Appliance**



**Figure 10. Average Fuel Consumption Rate (Cords/Appliance) by Type of Appliance in Urban, Suburban, and Rural Homes**

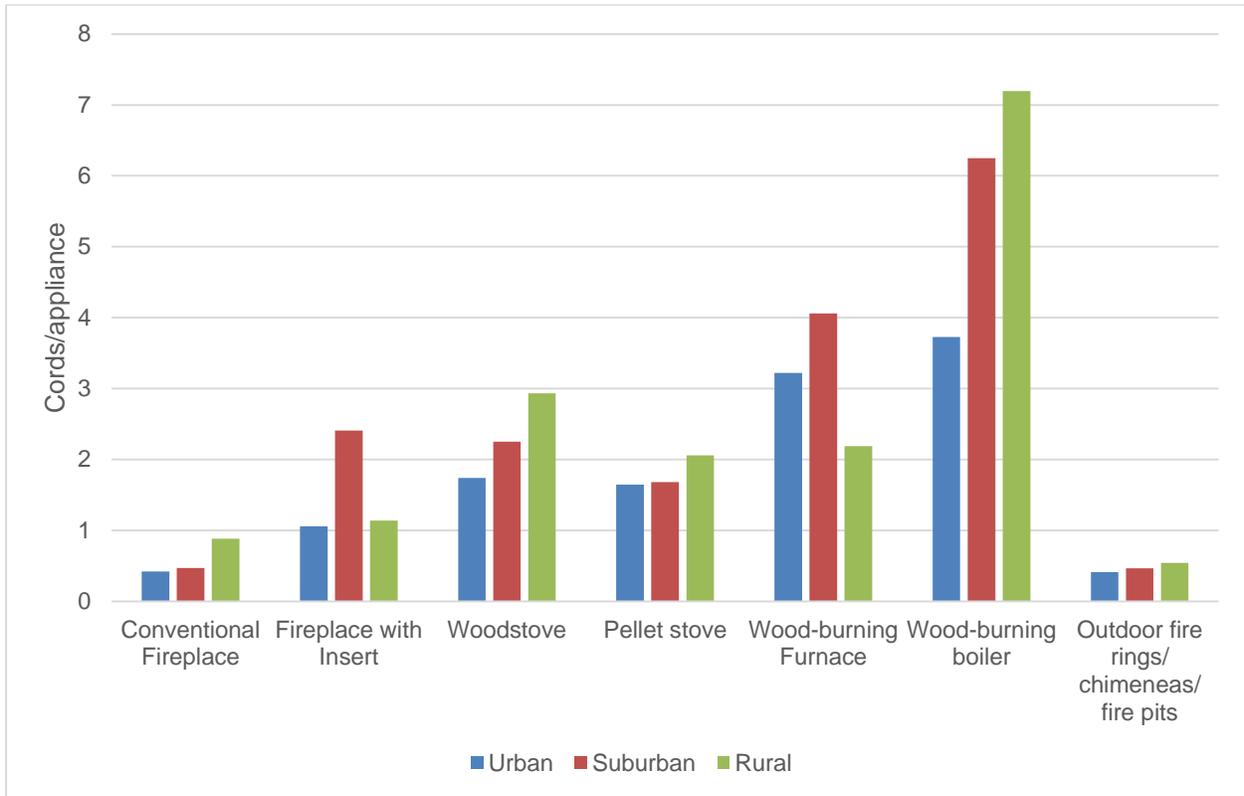


Figure 10 shows that there are differences among urban, suburban and rural households in average fuel consumption rates for some appliances, but not others. Woodstoves have a higher fuel consumption rate in rural homes, meaning that not only do more rural homes use woodstoves than urban and suburban homes, but they also burn more wood per stove. The fuel consumption rate for conventional fireplaces in rural homes is approximately double the fuel consumption rate in urban and suburban homes. Therefore, even though fewer rural homes use their fireplaces, when they do use them they burn more wood than urban and suburban homes.

The fuel consumption rates for fireplaces with inserts and wood-burning furnaces suggest that these two types of appliances are more popular in suburban homes than in urban and rural homes. There is relatively little difference in fuel consumption rates between urban, suburban, and rural homes for pellet stoves and outdoor fire pits.

### 3.6 Burn Activity by Type of Dwelling

The survey asked respondents to state the type of dwelling in which they live. Table 5 lists the different types of dwelling, along with the raw responses and total survey-weighted responses by dwelling type. The overwhelming majority of survey responses came from detached single-family homes (85 percent), with relatively few responses coming from residents of apartment buildings. Table 5 also shows how the survey weights adjust for differences in type of dwelling, based on data from the Census Bureau’s ACS. While the survey sample design differentiated between urban and rural homes, it did not take into account different home types. As discussed in Section 2.4, above, part of the process for developing the survey weights included calibrating the weights to account for differences between the responses and known data

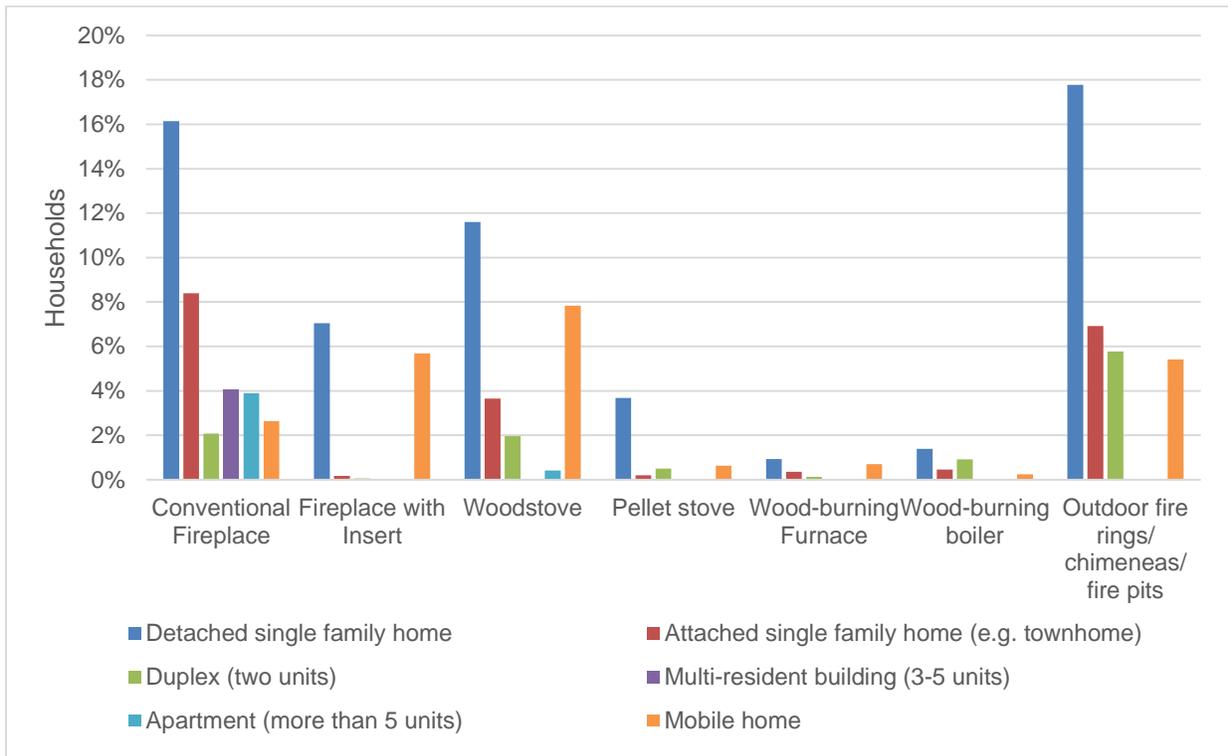
about the area surveyed. Therefore, since the survey received a higher proportion of responses from detached single-family homes than the actual proportion of detached single-family homes in the surveyed states, survey responses from detached single-family homes were calibrated to have slightly less weight. Similarly, the survey received a lower proportion of responses from apartments and therefore these responses were calibrated to have a slightly higher weight.

**Table 5. Response by Type of Dwelling**

Type of Dwelling	Unweighted Responses	% of Unweighted Responses	Survey-Weighted Households	% of Weighted Households
Detached single-family home	2,537	85%	31,603,605	62%
Attached single-family home (e.g. townhome)	88	3%	3,178,564	6%
Duplex (two units)	56	2%	2,593,272	5%
Multi-resident building (3-5 units)	58	2%	3,733,047	7%
Apartment (more than 5 units)	102	3%	7,613,637	15%
Mobile home	151	5%	2,525,702	5%

Figure 11 shows that for most appliance types, burning activity is more common in detached-single family homes. Burning activity is relatively uncommon in multi-resident buildings that have 3-5 units, or more than 5 units. While there is some activity in these homes from conventional fireplaces, there were almost no responses for any of the other appliances. Mobile homes also use certain appliances nearly as much as detached single-family homes, particularly fireplaces with inserts and woodstoves.

**Figure 11. Percentage of Households Using Each Type of Appliance, by Dwelling Type**



**Figure 12. Average Fuel Consumption Rate (Cords/Appliance), by Dwelling Type**

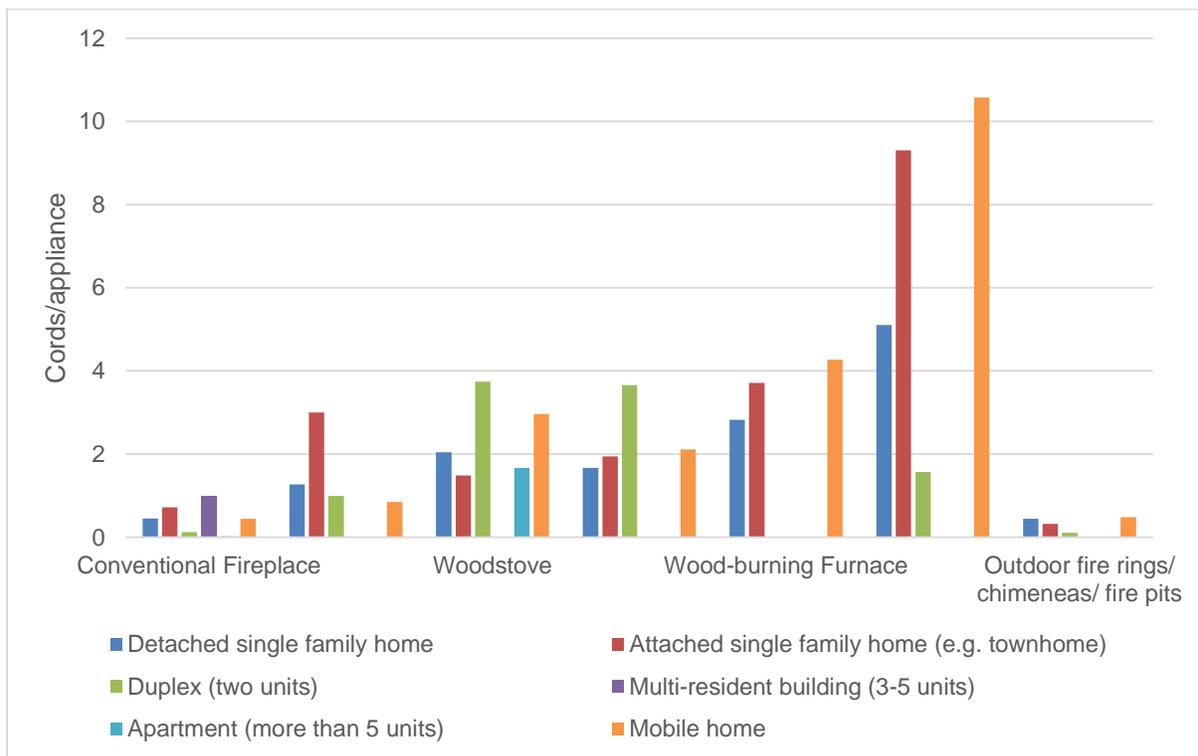
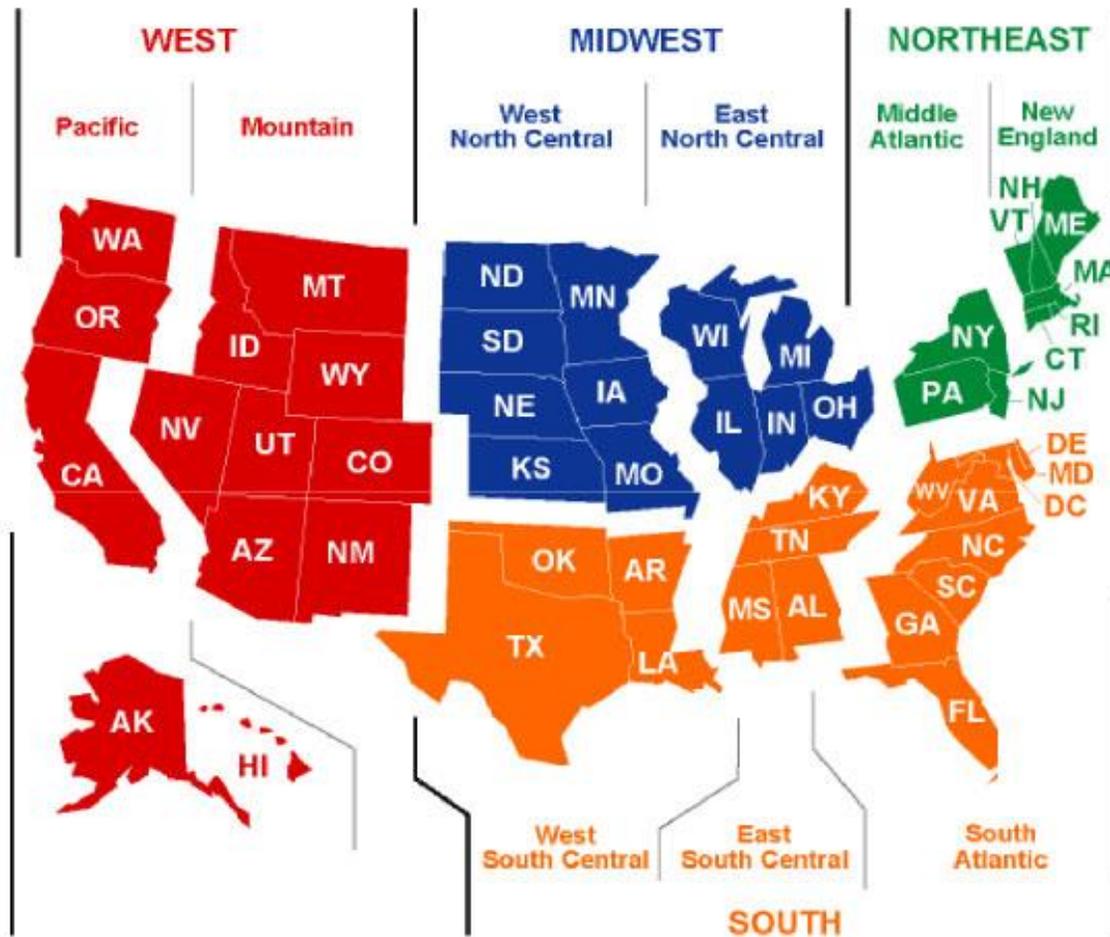


Figure 12 shows the average fuel consumption rates by type of dwelling. In general, there is not much variation in fuel consumption rates across dwelling types. The two outlier rates for wood-burning boilers in attached single-family homes and mobile homes are due to relatively low response rates for those dwelling types. In the case of attached single-family homes, the survey received two responses from residents using boilers, one of whom stated that the boiler uses 25 cords per year. For mobile homes, the survey received three responses from residents using boilers, one of whom stated the boiler uses 17 cords per year.

### 3.7 Burn Activity by Census Division

To examine regional differences in burn activity, the project team calculated the percentage of homes using each type of appliance, and the average fuel consumption rate for homes by Census Division. The survey was mailed to homes in each of the nine Census Divisions, with the exception of the East South Central Census Division (Figure 13).

Figure 13. U.S. Census Divisions



Source: Energy Information Administration

**Figure 14. Percentage of Households Using Each Appliance Type, by Census Division**

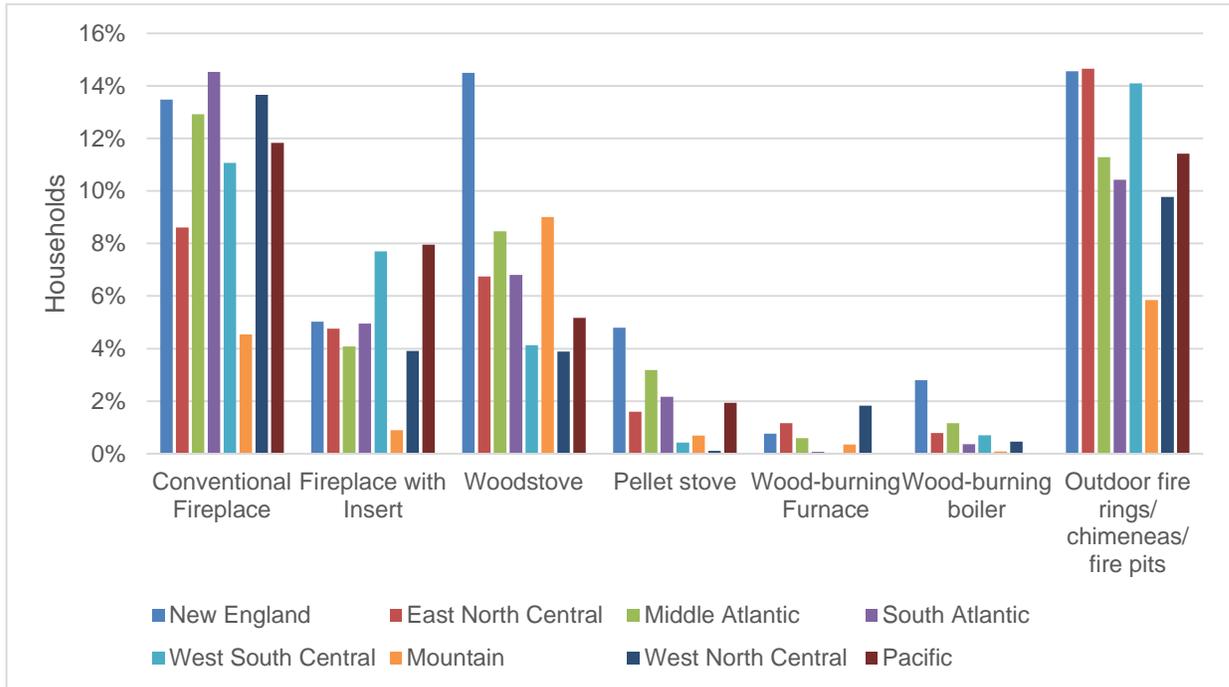
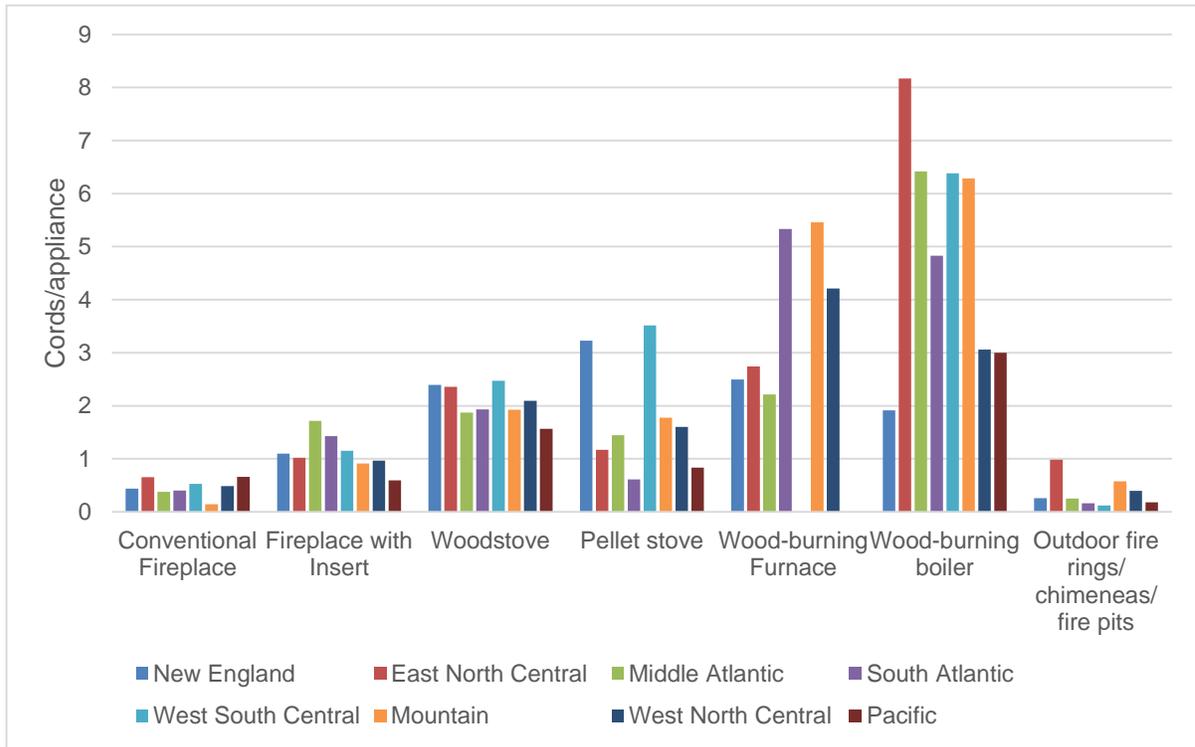


Figure 14 shows that wood-burning activity is more common in eastern U.S. Census Divisions, for most appliance types. For example, in the New England, East North Central, and Middle Atlantic Census Divisions, more than 10 percent of homes use woodstoves. In the other Census Divisions to the south and west, less than 10 percent of homes use woodstoves.

In some Census Divisions, certain appliances are less common. For example, in the South Atlantic, Mountain, West North Central, and Pacific Census Divisions, less than 0.5 percent of homes use wood-burning boilers, while in the New England Census Division three percent use that type of appliance. Similarly, there were no survey responses from homes that use wood-burning furnaces in the West South Central or Pacific Divisions.

The average fuel consumption rates by Census Division shown in Figure 15, below, illustrate that there are not large regional differences in the wood consumption rate for certain appliances, such as conventional fireplaces, fireplaces with inserts, and woodstoves. As discussed in Section 3.2, these appliances are often used for pleasure/aesthetic burning. Other appliances that are used more for primary or supplemental heating, such as pellet stoves, wood-burning furnaces, and wood-burning boilers, do have larger regional differences in fuel consumption rates, with the colder Census Divisions typically burning more wood.

**Figure 15. Average Fuel Consumption Rate (Cords/Appliance) by Census Division**



In some cases, the results by Census Division may be sensitive to data submitted by only a few respondents, especially for appliance types that are less common. This appears to be the case for the fuel consumption rate for pellet stoves in the West South Central Division (3.5 tons/year), which is higher than the fuel consumption rate for pellet stoves in any other Census Division—but also based on only two responses. The fuel consumption rates for pellet stoves in the New England Census Division, by contrast, are based on 69 responses.

### 3.8 Burn Activity by Heating Degree Days

In addition to differences attributable to U.S. Census Division, there are also likely differences in burn activity by climate regions. The National Oceanic and Atmospheric Administration (NOAA)’s Earth System Research Laboratory (ESRL) has identified 344 climate zones in the United States. The project team used data from ESRL to identify the climate zone of each respondent, based on the respondent’s county. The team then identified the number of heating degree days in each climate zone. Heating degree days are a measurement designed to quantify the amount of demand for energy needed to heat a building. It is calculated as the number of degrees that a day’s average temperature is below 65 degrees Fahrenheit – with colder climate zones having a higher number of heating degree days than warmer climate zones. Colder climate zones would also be expected to have more burn activity than warmer climate zones.

Rather than summarize survey responses individually for each climate zone, the project team aggregated the results into bins based on the number of heating degree days in each respondent’s climate zone. Homes in the lowest bin (0-10%) have the fewest number of heating degree days among respondents; homes in the highest bin (90-100%) have the highest number of heating degree days.

Figure 16 shows the percentage of homes using each type of appliance, by heating degree day bin. The relationship between heating degree days and wood-burning activity is more obvious for some types of appliances than for others. For woodstoves, wood-burning furnaces, and wood-burning boilers, there is a clear, increasing relationship between heating degree days and percentage of homes using each appliance type. However, the relationship is not as clear for other appliances used for heating, including fireplaces with inserts and pellet stoves. There is also not a clear relationship for conventional fireplaces and outdoor fire pits, but this may be expected because these appliances are used more for aesthetic/pleasure burning than for heating.

**Figure 16. Percentage of Households Using Each Appliance Type, by Heating Degree Day Bin**

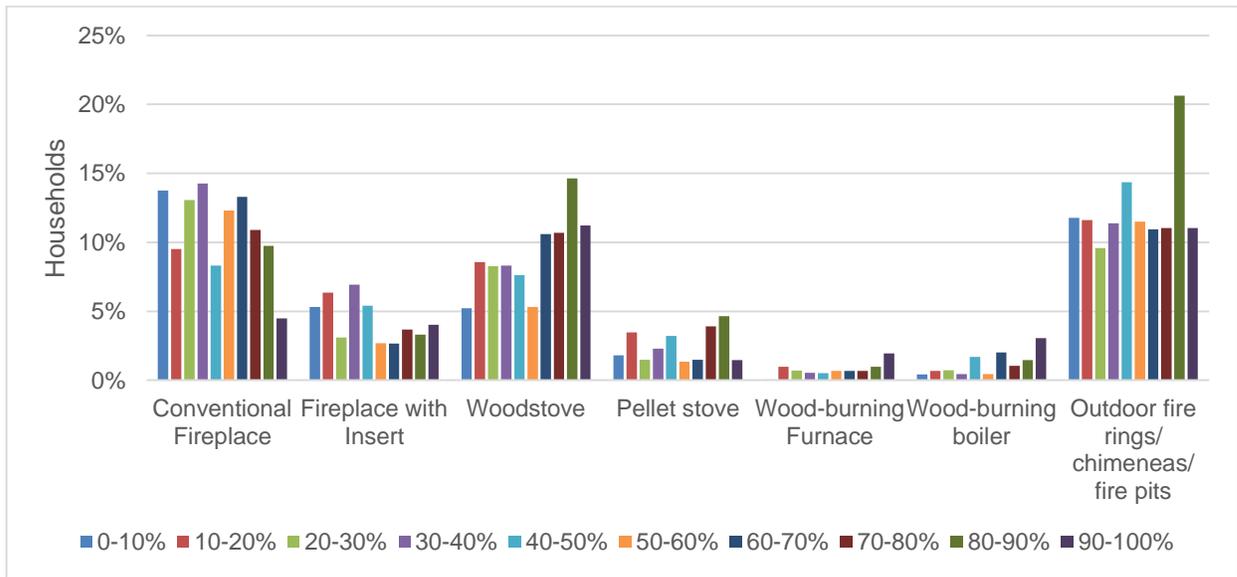
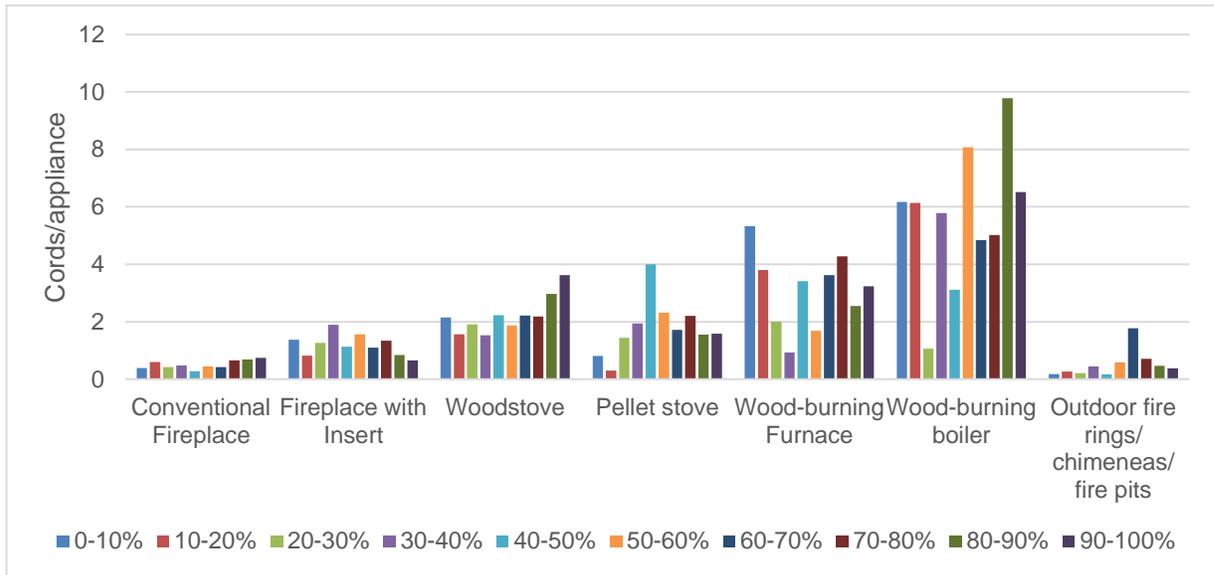


Figure 17 also shows an increasing relationship between heating degree days and the number of cords burned per appliance for woodstoves, wood-burning furnaces, and conventional fireplaces. However, as for Figure 16, above, there is no clear relationship between heating degree days and fuel consumption rate for the other appliance types.

**Figure 17. Average Fuel Consumption Rate (Cords/Appliance), by Heating Degree Day Bin**

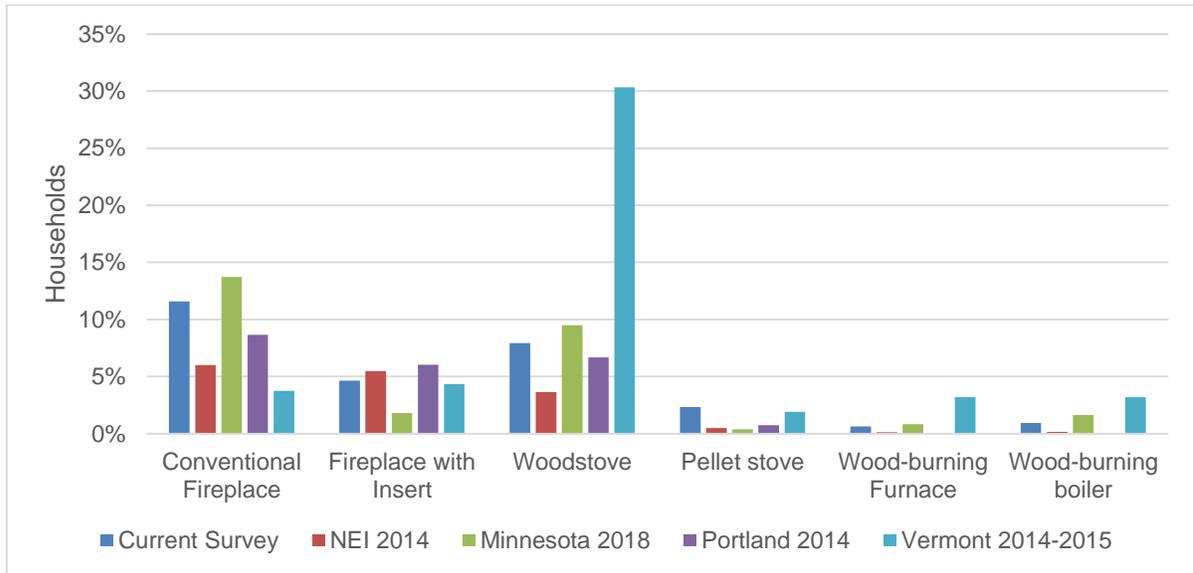


### 3.9 Comparison to Other Surveys

The project team compared the results of this project survey to other surveys of wood burning activity, including those from Minnesota (Wilder Research, 2016); Vermont (Frederick and Jaramillo, 2016); and Portland, Oregon (ODEQ, 2014). The team also compared the results of the survey to the U.S. EPA’s 2014 NEI (US EPA, 2019), which estimates wood burning activity for all counties in the United States, based on a combination of data from the EIA RECS and the Census Bureau’s ACS, and expert judgment. The results of these other surveys differ in terms of how easily they are comparable to the results of the current survey. For example, each of the above-mentioned surveys allows estimation of the percentage of homes having most of the appliances covered in the present survey. However, only the Minnesota survey reports the average fuel consumption rate by appliance. The NEI includes estimates of both the percentage of homes using each appliance and the fuel consumption rates. The project team also reviewed a survey of wood burning activity in Alaska, but those results do not include the percentage of homes using each appliance type and the average fuel consumption rates in ways that are comparable to the results of the current survey (Nicholls et al., 2010).

The comparison of the percentage of homes using each appliance type is shown in Figure 18. The results show roughly similar percentages across surveys for the different appliance types, with some exceptions. The percentage of homes using woodstoves in each survey was as follows: Vermont: 30 percent; Minnesota: 9 percent; Portland: 7 percent; and the current survey: 8 percent. The current survey estimates a higher percentage of fireplace usage, at 12 percent, than any other survey except for Minnesota (14 percent). The Portland survey shows the use of fireplaces to be 9 percent, while the Vermont survey and the NEI indicate 4 percent and 6 percent, respectively.

**Figure 18. Percentage of Households Using Each Appliance Type: Comparison of Multiple Survey Results**

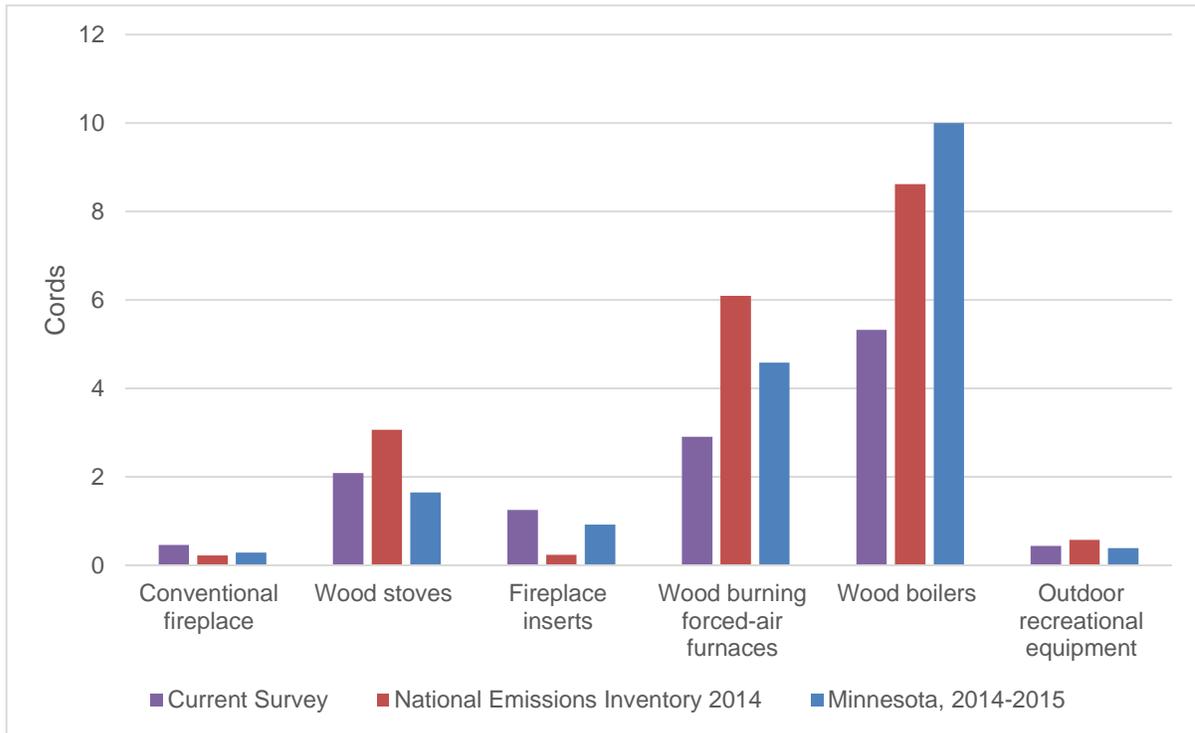


Not all appliance types are represented in each survey. The Portland survey did not include results for wood-burning furnaces, wood-burning boilers, or outdoor fire pits. The Vermont survey grouped wood-burning boilers and furnaces together, with the total percentage of homes with one of these appliances adding up to 6 percent (for the comparison shown in Figure 18, the team split the results from the Vermont survey evenly between furnaces and boilers). The Vermont survey did not include results for outdoor fire pits.

The Minnesota survey is the only one that included outdoor fire pits. However, the results are not shown in Figure 18 because they are so much higher than the rest of the results—up to 90 percent of homes in Minnesota reported using an outdoor fire pit or other recreational wood-burning appliance. This is compared to the current survey, which estimates that 12 percent of homes use an outdoor fire pit. The NEI, which is largely based on expert judgment, estimated that two percent of homes use an outdoor fire pit.

The comparison of the average cords of wood burned per type of appliance is shown in Figure 19. These results are roughly similar across appliance types, particularly the most common ones, including conventional fireplaces and outdoor fire pits. The results tend to differ for the less common appliances, including wood-burning boilers. The estimates from the NEI and the Minnesota survey are 8.6 and 10.0 cords per boiler, respectively, whereas the value from the current survey is 5.3 cords per boiler.

Figure 19. Average Cords Burned per Appliance Type: Comparison of Multiple Survey Results



It is also important to point out the differences in the methods used in each of the surveys. The current survey was conducted as an online survey, with invitation letters mailed to respondents. There is some concern, however, that homes that do not burn wood may be less likely to respond to such a survey—even though the letter clearly requested responses from households even if they do not burn wood. This suggests the potential for positive bias – that is, for the survey to predict that more homes burn wood than actually do. In contrast, the Vermont survey was conducted by phone. There is less concern about positive bias in a phone survey, as respondents can simply state that they do not burn wood. For this reason, the Vermont survey could be regarded as an upper bound. Therefore, it is encouraging to note that in comparison to the Vermont survey, the results of the present survey show less wood burning activity, for most appliances.

## 4 Conclusions

The present survey represents the most comprehensive national assessment of wood-burning activity in the United States to date. While several state-level surveys have been undertaken, they have not provided information on large parts of the country, including the southeastern states. The national surveys, including the EIA RECS and the Census Bureau’s ACS, have broader geographic coverage, but the questions in those surveys are far less detailed with respect to wood-burning activity.

This survey improves upon the existing data for wood-burning activity by asking more detailed questions of homes throughout the United States, including in eight of the nine Census Divisions. It asks questions relative to seven appliance types, unlike the other national surveys, which tend to ask only about fireplaces and woodstoves. The current survey also asks about outdoor fire pits for which there are almost no other data on burn activity. It also asked more detailed questions about the amount

of wood burned. For example, the EIA RECS asks respondents only about the number of cords burned in whole numbers. However, the survey for the present project gives respondents more options than whole cords for reporting the amount of wood burned, including face cords and wood bundles. The RECS also focuses on energy consumption and, unlike this survey, does not ask questions about the amount of wood burned for pleasure/aesthetics.

The results of the present survey indicate that the most commonly used appliances are conventional fireplaces and outdoor fire pits. These appliance types also have the lowest average fuel consumption rates, each with less than half a cord per year. By contrast, the appliances with the highest average fuel consumption rates (wood-burning furnaces and boilers, at 3.8 and 5.3 cords per year, respectively) are also much less common, used by less than one percent of households.

While there are regional differences in the use of certain appliance types, there is not a large regional variation in the fuel consumption rates, especially for conventional fireplaces and fireplace inserts, which are used for pleasure/aesthetic burning rather than heating. The appliances that tend to be used for primary or supplemental heating, such as pellet stoves, wood-burning furnaces, and wood-burning boilers, demonstrate more regional variation, with homes in colder Census Divisions burning more wood per year per appliance. This suggests that the fuel consumption rates for appliances that are mainly used for pleasure/aesthetic burning are somewhat independent of climate.

There are notable differences for urban, suburban, and rural homes in the percentage of households using each appliance type, and the fuel consumption rates. In general, rural homes are more likely to use wood-burning appliances and are more likely to burn larger quantities of wood.

There are relatively few other surveys of wood-burning activity to compare to the present survey, and all are in colder climates: Minnesota, Vermont, and Portland, Oregon. Of these states, the current survey only includes Vermont. The data compare reasonably well overall, with some exceptions: in comparison with the others, this survey found a higher percentage of homes using fireplaces and outdoor fire pits. As discussed above, the RECS survey, which is used as the basis for the NEI, does not ask respondents about pleasure/aesthetic burning, and the NEI estimates for outdoor fire pits are based on expert judgment. Therefore, the present survey appears to be capturing burn activity that is not currently accounted for in the NEI.

While this survey provides information about wood-burning activities in more U.S. states than any other survey, it has some limitations. Due to resource constraints, the project team was only able to sample 21 states. As a result, information from these states will be used as a proxy to estimate wood-burning activity in the remaining contiguous U.S. states.

In addition, care must be taken when analyzing subsets of the data, due to low response rates for some categories. As discussed above, some of the average fuel consumption rates appear to be skewed by outlier data, particularly in cases where few responses were received (such as for wood-fired boilers in attached-single family homes).

Lastly, it is possible that the results of the survey have been skewed by those people who chose to respond – i.e., perhaps the people who do not burn wood chose not to complete the survey. While there were many responses from people stating that they do not burn wood, resulting in an estimate of 70 percent of homes with no burn activity, it is possible that this percentage could be even higher. In a future survey, this issue could be addressed by following up with homes from the sample that did not complete the survey, to determine why they did not respond. Such an analysis could determine whether a disproportionate number of non-responsive households do not burn wood. Although this follow-up step was not undertaken for this project, due to resource limitations, it has been done in other state-level wood burning surveys, such as the Minnesota survey, where non-respondent households were sent a paper copy of the survey to encourage their participation.

Albeit the above limitations, the results of this survey provide important information about the use of wood-burning appliances and the amount of wood burned throughout the United States. This information can be used to make detailed national estimates of wood-burning activity and associated air pollution emissions. In the NEI, black carbon is computed as a speciation factor from inventory  $PM_{2.5}$  and is thus directly-correlated to  $PM_{2.5}$  estimates. Any improvement in activity data resulting from the appliance profiles and burn rates established through this survey will lead to direct improvements in estimates of  $PM_{2.5}$  and thus BC, emissions.

## Bibliography

- Bond, T.C., Doherty, S.J., Fahey, D.W., Forster, P.M., Berntsen, T., DeAngelo, B.J., Zender, C.S. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. *Journal of Geophysical Research: Atmospheres*, 118(11), 5380-5552. doi:10.1002/jgrd.50171
- Center for Climate and Energy Solutions. (2010). *What is Black Carbon?* [Fact sheet]. Retrieved from <https://www.c2es.org/site/assets/uploads/2010/04/what-is-black-carbon.pdf>
- Commission for Environmental Cooperation. (2015). *North American Black Carbon Emissions: Recommended Methods for Estimating Black Carbon Emissions*. Retrieved from <http://www3.cec.org/islandora/en/item/11629-north-american-black-carbon-emissions-recommended-methods-estimating-black>
- Di, Q., Dai, L., Wang, Y., Zanobetti, A., Choirat, C., Schwartz, J.D., Dominici, F. (2017). Association of short-term exposure to air pollution with mortality in older adults. *JAMA*, 318(24), 2446-2456. doi:10.1001/jama.2017.17923
- Di, Q., Wang, Y., Zanobetti, A., Wang, Y., Koutrakis, P., Choirat, C., Schwartz, J.D. (2017). Air pollution and mortality in the Medicare population. *New England Journal of Medicine*, 376(26), 2513-2522. doi:10.1056/NEJMoa1702747
- Frederick, P. and Jaramillo, D. (2016). *Vermont Residential Fuel Assessment for the 2014-2015 Heating Season*. Retrieved from Vermont Department of Forests, Parks, and Recreation: [https://fpr.vermont.gov/sites/fpr/files/About\\_the\\_Department/Library/Library/FINAL\\_2015%20Residential%20Fuel%20Assessment%20Report.pdf](https://fpr.vermont.gov/sites/fpr/files/About_the_Department/Library/Library/FINAL_2015%20Residential%20Fuel%20Assessment%20Report.pdf)
- Nicholls, D.L, Brackley, A.M., & Barber, V. (2010). *Wood Energy for Residential Heating in Alaska: Current Conditions, Attitudes, and Expected Use* (General Technical Report PNW-GTR-826). Retrieved from U.S. Department of Agriculture: [https://www.fs.fed.us/pnw/pubs/pnw\\_gtr826.pdf](https://www.fs.fed.us/pnw/pubs/pnw_gtr826.pdf)
- Oregon Department of Environmental Quality. (2015). *Summary of results: 2014 Portland Residential Wood Combustion Survey*. Retrieved from <https://www.oregon.gov/deq/FilterDocs/WoodburningSurvey.pdf>
- U.S. Census Bureau. (2010). 2010 Census Urban and Rural Classification and Urban Area Criteria. Retrieved from <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>
- U.S. Environmental Protection Agency. (2017). Black Carbon Research. Retrieved from <https://www.epa.gov/air-research/black-carbon-research>
- U.S. Environmental Protection Agency. (2019). National Emissions Inventory. Retrieved from <https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei>
- Wilder Research. (2016). *Minnesota Residential Wood Fuel Use: Minnesota Residential Wood Fuel Survey: Results from 2014-2015*. Retrieved from <https://www.pca.state.mn.us/sites/default/files/aq-ei4-46.pdf>

## **Appendix A – Survey Instrument**

The survey instrument developed and implemented for this project is presented on the following pages.

**Abt Associates Inc.  
Wood Usage Survey**

**Study # 24297  
FINAL Survey**

Thank you for your help with this important survey. We value your time and appreciate your participation. The survey will take 10-15 minutes.

**Even if you do not have wood-burning equipment or did not burn any firewood, fireplace logs or wood pellets, please complete the appropriate portions of the survey; that information is also important.**

The objective of this survey is to help understand how much wood is being used for fuel at homes throughout the United States. This survey will show how many homes use wood heating and the amount of wood people use for both heating and recreational burning.

The survey asks about any **wood-burning appliance(s)** you use. **Wood-burning appliance** includes wood-burning fireplaces, fireplace inserts, woodstoves, wood-burning furnaces, wood boilers, outdoor fire pits, chimeneas, etc. Wood is a renewable and local energy source. Through this survey, we are seeking information to help us better understand the role wood plays as an alternative to fossil fuels such as oil and natural gas.

This survey is being conducted by Abt Associates Inc., in conjunction with the Northeast States for Coordinated Air Use Management (NESCAUM) and the Commission for Environmental Cooperation of North America (CEC).

If you need help with this survey, please contact Chris Hardtke, Senior Analyst at Abt Associates, at 888-735-0199, or [NESCAUMhelp@abtassoc.com](mailto:NESCAUMhelp@abtassoc.com).

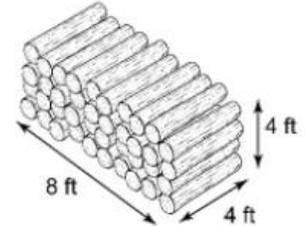
## Estimating Wood Use

If you use firewood, there are questions about the amount of firewood used in a typical year. Please note, this survey uses the cord (unit) to measure firewood.

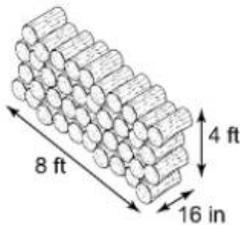
The information below can help you estimate the amount you use in cords:

### ESTIMATING HOW MUCH FIREWOOD YOU USE.

**A full cord** is a large amount of wood. It measures 4 feet high by 4 feet wide by 8 feet long (4' x 4' x 8') and has a volume of 128 cubic feet.



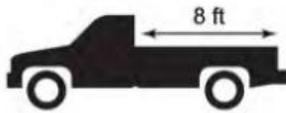
**A full cord**



**A face cord**

**x3**

**A face cord of wood** is 4 feet high by 8 feet long and is as wide as the individual firewood pieces, but averages 16 inches wide. A 16-inch wide face cord (sometimes called a **fireplace cord**) is equal to one-third of a full cord.



**Full-size pick-up**

**x2**

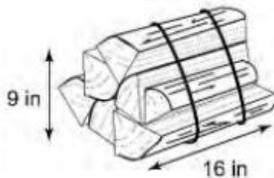
**Two full-size pick-up truck loads** (8 foot box) equals **one full cord**, whether the wood is stacked carefully so it is about level with the truck box sides, or is thrown into the truck box with the top of the pile about as high as the cab.



**Compact pick-up**

**x4**

**Four compact pick-up truckloads** (6 foot box) equals **one full cord of wood**, whether the wood is stacked carefully so it is about level with the truck box sides, or is thrown into the truck box with the top of the pile about as high as the cab.



**x170**

**Bundles of wood** sold at gas stations, hardware stores and state parks are often 0.75 cubic feet. They often measure about 16 inches x 9 inches x 9 inches. 170 bundles equals **one full cord**.

I1: To begin, what is the zip code for your primary residence?

\_\_\_\_\_

I2: Do you burn wood for heating or aesthetic purposes at your primary residence?

- Yes
- No

I3: Which of the following type(s) of appliance(s) do you have in your **primary residence**?  
(Please select all that apply.)

To see an example of each appliance type, please hover your mouse over each option below.

- Conventional fireplaces (without an insert)
- Conventional fireplaces (with an insert)
- Woodstoves (firewood/ cordwood)
- Woodstoves (wood pellets or corn pellets)
- Wood-burning furnaces (firewood/ cordwood or pellets)
- Wood-burning boilers (firewood/ cordwood or pellets)
- Outdoor fire rings/ chimeneas/ fire pits

### **Conventional Fireplaces**

This next group of questions asks about conventional fireplaces at your primary residence.

Please keep in mind, a conventional fireplace:

- May or may not have doors;
- May burn wood, natural gas, or propane;
- Includes fireplaces known as “heatilators”;
- Includes fireplaces with tubular grates or other devices intended to increase heat flow;
- Includes freestanding fireplaces.

Q1: How many conventional fireplaces are in your **primary residence**?

- # of conventional fireplaces that **burn wood**
- # of conventional fireplaces that **burn natural gas**
- # of conventional fireplaces that **burn propane**

Q2: What is the **primary purpose** of your wood-burning fireplace?

- Pleasure/aesthetics
- Primary source of heat
- Back-up, room heating or supplemental heating
- I do not use my wood-burning fireplace

Q3: Please indicate the amount of wood that you use in your fireplace in a typical year. For any of the following that apply, please put the amount in the space provided. (If you do not know the exact amounts, please give us your best estimate.):

- # of full cords
- # of face cords
- # of wood bundles
- # of wax logs (such as Duraflame, Enviro-log, Pine Mountain, etc.)
- I use something else. (Please specify: \_\_\_\_\_)

Q4: Which of the following months do you typically use your wood-burning fireplace? (Please select all that apply.)

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

Q5: Thinking about the months you use your wood-burning fireplace, approximately how many days per month is it used?

- Less than 5 days per month
- 5-15 days per month
- More than 15 days per month

### **Woodstoves**

This next group of questions asks about woodstoves at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Woodstoves are freestanding space heaters often used to heat a specific room or zone of a house.
- Woodstoves have either conventional or EPA-certified air pollution control technology. Most conventional woodstoves were sold or installed prior to 1989, whereas most EPA-certified woodstoves were sold or installed beginning in 1989. Some EPA-certified woodstoves have a ceramic catalytic element that improves combustion of particles in the woodsmoke.

Q6: How many woodstove(s) are in your **primary residence**?

# of **woodstoves**

Q7: Thinking about your woodstove, what is the **primary purpose** of your woodstove?

- Pleasure/aesthetics
- Primary source of heat
- Back-up, room heating or supplemental heating

I do not use my woodstove

Q8: Thinking about your woodstove, which of the following months do you typically use your woodstove? (Please select all that apply.)

January  
February  
March  
April  
May  
June  
July  
August  
September  
October  
November  
December

Q9: Thinking about the months you use your woodstove, approximately how many days per month is it used?

Less than 5 days per month  
5-15 days per month  
More than 15 days per month

Q10: What is the brand or model of your woodstove?

Brand or model: \_\_\_\_\_  
Don't know/ not sure

Q12: Thinking about your woodstove, how much wood, in cords, do you typically burn each year in your woodstove?

# of full cords  
# of face cords  
# of wood bundles  
# of wax logs (such as Duraflame, Enviro-log, Pine Mountain, etc.)  
I use something else. (Please specify: \_\_\_\_\_)

Q13: Thinking about your woodstove, how long have you owned your woodstove?

0-5 years  
6-10 years  
11-15 years  
16-20 years  
21-25 years  
More than 25 years

Q14: Thinking about your woodstove, is your woodstove EPA certified?

Yes

No  
Don't know

Q15: Thinking about your woodstove, does your woodstove have a catalytic element?

Yes  
No  
Don't know

### **Fireplace Inserts**

This next group of questions asks about fireplace inserts at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Fireplace inserts are space heaters designed to fit into an existing fireplace opening.
- Fireplace inserts have either conventional or EPA-certified air pollution control technology. Most conventional inserts were sold or installed prior to 1989, whereas most EPA-certified inserts were sold or installed beginning in 1989. Some EPA-certified inserts have a ceramic catalytic element that improves combustion of particles in the woodsmoke.

Q16: How many fireplace inserts are in your **primary residence**?

# of **fireplace inserts**

Q17: Thinking about your fireplace insert, what is the **primary purpose** of your fireplace insert?

Pleasure/aesthetics  
Primary source of heat  
Back-up, room heating or supplemental heating  
I do not use my fireplace insert

Q18: Thinking about your fireplace insert, which of the following months do you typically use your fireplace insert? (Please select all that apply.)

January  
February  
March  
April  
May  
June  
July  
August  
September  
October  
November  
December

Q19: Thinking about the months you use your fireplace insert, approximately how many days per month is it used?

- Less than 5 days per month
- 5-15 days per month
- More than 15 days per month

Q20: What is the brand or model of your fireplace insert?

- Brand or model of your fireplace insert \_\_\_\_\_
- Don't know/ not sure

Q22: Thinking about your fireplace insert, how much wood, in cords, do you typically burn each year in your fireplace insert?

- # of full cords
- # of face cords
- # of wood bundles
- # of wax logs (such as Duraflame, Enviro-log, Pine Mountain, etc.)
- I use something else. (Please specify: \_\_\_\_\_)

Q23: Thinking about your fireplace insert, how long have you owned your fireplace insert?

- 0-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21-25 years
- More than 25 years

Q24: Thinking about your fireplace insert, is your fireplace insert EPA certified?

- Yes
- No
- Don't know

Q25: Thinking about your fireplace insert, does your fireplace insert have a catalytic element?

- Yes
- No
- Don't know

### **Pellet stoves**

This next group of questions asks about pellet stoves at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Pellet stoves burn small compressed fuels, typically using a hopper to hold the fuel. This enables pellet stoves to burn for a long time without reloading.
- Pellet stoves rely on electricity to release pellets into the combustion chamber and to operate fans.
- Pellets can be made from a variety of biomass products such as wood, corn or pits.

- Pellet stoves have either conventional or EPA-certified air pollution control technology. Most conventional pellet stoves were sold or installed prior to 1989, whereas most EPA-certified pellet stoves were sold or installed beginning in 1989. Some EPA-certified pellet stoves have a ceramic catalytic element that improves combustion of particles in the woodsmoke.

Q26: How many pellet stoves are in your **primary residence**?

# of **pellet stoves**

Q27: Thinking about your pellet stove, what is the **primary purpose** of your pellet stove?

Pleasure/aesthetics  
Primary source of heat  
Back-up, room heating or supplemental heating  
I do not use my pellet stove

Q28: Thinking about your pellet stove, what type of pellets do you burn in your pellet stove?  
(Please select all that apply.)

Wood  
Corn  
Other, please specify: \_\_\_\_\_

Q29: Thinking about your pellet stove, how many bags of pellets do you typically burn each year in your pellet stove? Pellets are usually sold in 40 lb bags; 50 bags = 1 ton.

# of full bags

Q30: The Pellet Fuel Institute (PFI) has developed a voluntary pellet fuel certification program. Are the pellets you burn in your pellet stove PFI certified?

Yes  
No  
Don't know

Q31: Thinking about your pellet stove, which of the following months do you typically use your pellet stove? (Please select all that apply.)

January  
February  
March  
April  
May  
June  
July  
August  
September  
October  
November  
December

Q32: Thinking about the months you use your pellet stove, approximately how many days per month is it used?

- Less than 5 days per month
- 5-15 days per month
- More than 15 days per month

Q33: What is the brand or model of your pellet stove?

- Brand or model \_\_\_\_\_
- Don't know/ not sure

Q35: Thinking about your pellet stove, how long have you owned your pellet stove?

- 0-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21-25 years
- More than 25 years

Q36: Thinking about your pellet stove, is your pellet stove EPA certified?

- Yes
- No
- Don't know

Q37: Thinking about your pellet stove, does your pellet stove have a catalytic element?

- Yes
- No
- Don't know

### **Wood-burning furnace**

This next group of questions asks about wood-burning furnaces at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Wood-burning furnaces provide central heating and can be controlled with thermostats.
- Indoor wood-burning furnaces are usually installed in basements or utility rooms. They heat air directly and are connected to ducts that move warmed air around the building.
- "EPA-qualified" or "EPA-certified" appliances are typically labeled "Qualified at EPA" or "EPA Certified" on the permanent label.

Q39: For what purposes do you use your wood-burning furnace?

- Heat my house or other buildings at my residence (e.g., garage, workshop, etc.)
- Other, please specify: \_\_\_\_\_
- I do not use my wood-burning furnace

Q40: How does your wood-burning furnace distribute heat?

Forced hot air system  
Other, please specify: \_\_\_\_\_

Q41: Where is your wood-burning furnace located?

Inside your house  
Inside your garage or outbuilding  
Outside

Q42: What is the rated heat output of your wood-burning furnace?

BTU (British Thermal Unit) per hour:  
Don't know/Not sure

Q43a: Which of the following fuels do you burn in your wood-burning furnace?

Firewood/Cordwood  
Pellets

Q43b: Please indicate the amount of fuel burned in your wood-burning furnace in a typical year. For any of the following that apply, please put the amount in the space provided. (If you do not know the exact amounts, please give us your best estimate.)

# of full cords  
# of face cords  
# of logs 16" or shorter  
# of logs 17" or longer  
Tons of pellets (pellets are usually sold in 40 lb bags; 50 bags = 1 ton)  
I use something else. (Please specify: \_\_\_\_\_)

Q44: Which of the following months do you typically use your wood-burning furnace? (Please select all that apply.)

January  
February  
March  
April  
May  
June  
July  
August  
September  
October  
November  
December

Q45: How long have you owned your wood-burning furnace? (Your best estimate is fine.)

0-5 years

- 6-10 years
- 11-15 years
- 16-20 years
- 21-25 years
- More than 25 years

Q46: Is your wood-burning furnace EPA qualified/certified?

- No
- Yes
- Don't know/Not sure

Q47: What is the brand or model of your wood-burning furnace?

- Brand or model: \_\_\_\_\_
- Not sure/don't know

### **Wood-burning boiler**

This next group of questions asks about wood-burning boilers at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Wood-burning boilers provide central heating and can be controlled with thermostats.
- Wood-burning boilers heat water that moves through pipes to where the heat is used.
- Wood-burning boilers can be located inside or outside a house.
- "EPA-qualified" or "EPA-certified" appliances are typically labeled "Qualified at EPA" or "EPA Certified" on the permanent label.

Q49: For what purposes do you use your wood-burning boiler?

- Heat my house or other buildings at my residence (e.g., garage, workshop, etc.)
- Heat water for my house
- Heat water for my swimming pool or hot tub
- Other, please specify: \_\_\_\_\_
- I do not use my wood-burning boiler

Q50: How does your wood-burning boiler distribute heat?

- Forced hot water system
- Other, please specify: \_\_\_\_\_

Q51: Where is your wood-burning boiler located?

- Inside your house
- Inside your garage or outbuilding
- Outside

Q52: What is the rated heat output of your wood-burning boiler?

- BTU (British Thermal Unit) per hour:

Don't know/Not sure

Q53a: Which of the following fuels do you burn in your wood-burning boiler?

Firewood/Cordwood  
Pellets

Q53b: Please indicate the amount of fuel burned in your wood-burning boiler in a typical year. For any of the following that apply, please put the amount in the space provided. (If you do not know the exact amounts, please give us your best estimate.)

# of full cords  
# of face cords  
# of logs 16" or shorter  
# of logs 17" or longer  
Tons of pellets (pellets are usually sold in 40 lb bags; 50 bags = 1 ton)  
I use something else. (Please specify: \_\_\_\_\_)

Q54: Which of the following months do you typically use your wood-burning boiler? (Please select all that apply.)

January  
February  
March  
April  
May  
June  
July  
August  
September  
October  
November  
December

Q55: How long have you owned your wood-burning boiler? (Your best estimate is fine.)

0-5 years  
6-10 years  
11-15 years  
16-20 years  
21-25 years  
More than 25 years

Q56: Is your wood-burning boiler EPA qualified/certified?

No  
Yes  
Don't know/Not sure

Q57: What is the brand or model of your wood-burning boiler?

Brand or model: \_\_\_\_\_  
Not sure/don't know

**Outdoor wood-burning fire pits, Chimeneas or fire rings**

This next group of questions asks about wood-burning firepits, Chimenea, or fire rings at your primary residence.

Please keep in mind the following while going through this section of the survey:

- Wood-burning firepit(s), Chimenea(s), or fire ring(s) can be above the ground or dug into the ground.
- Wood-burning firepit(s), Chimenea(s), or fire ring(s) are located outside of the house.
- When completing this section, please answer only for your firepit(s), Chimenea(s), or fire ring(s) that burn wood.

Q58: Which of the following types of outdoor wood-burning appliances do you use at your **primary residence**? (Please select all that apply.)

- Fire pit(s)
- Chimenea(s)
- Fire ring(s)
- Other, please specify: \_\_\_\_\_

Q59: Please indicate the amount of wood or biomass burned in your firepit(s), Chimenea(s), or fire ring(s) in a typical year. For any of the following that apply, please put the amount in the space provided. (If you do not know the exact amounts, please give us your best estimate.)

- # of full cords
- # of face cords
- # of wood bundles
- # of wax logs (such as Duraflame, Enviro-log, Pine Mountain, etc.)
- # of wood pallets
- # of full cord slabs (the round parts of a log cut off to make milled wood such as boards)
- # of bags of yard waste (such as sticks, twigs, leaves, etc.)
- I use something else. (Please specify: \_\_\_\_\_)

Q60: Which of the following months do you typically use outdoor wood-burning appliances? (Please select all that apply.)

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November

December

Q61. Thinking about the months you use outdoor wood-burning appliances, how many times do you typically use them per month?

- Less than 5 days per month
- 5-15 days per month
- More than 15 days per month

### Secondary Residences

This next group of questions asks about any additional residence, known as a secondary residence (second home, cabin, trailer or other vacation property), that you might have. If you have more than one secondary residence, please consider only the most frequently used secondary residence.

Q62. Do you own a secondary residence/second home? (Please do not include a rental property, only a home that you reside in sometimes.)

- No
- Yes

Q63. What is the zip code for your secondary residence/second home?

\_\_\_\_\_

Q64. Which of the following type(s) of appliance(s) do you have in your **secondary residence**? (Please select all that apply.)

- Conventional fireplaces (without an insert)
- Conventional fireplaces (with an insert)
- Woodstoves (firewood/ cordwood)
- Woodstoves (wood pellets or corn pellets)
- Wood-burning furnaces (firewood/ cordwood or pellets)
- Wood-burning boilers (firewood/ cordwood or pellets)
- Outdoor fire rings/ chimeneas/ fire pits

Q65. Please indicate the amount of wood or yard waste you burn **in all wood-burning appliances at your secondary residence** in a typical year. For any of the following that apply, please put the amount in the space provided. (If you do not know the exact amounts, please give us your best estimate.)

- # of full cords
- # of face cords
- # of wood bundles
- # of wax logs (such as Duraflame, Enviro-log, Pine Mountain, etc.)
- # of pellets in tons (pellets are usually sold in 40 lb bags; 50 bags = 1 ton)
- # of wood pallets
- # of full cord slabs (the round parts of a log cut off to make milled wood such as boards)
- # of bags of yard waste (such as sticks, twigs, leaves, etc.)
- I use something else. (Please specify: \_\_\_\_\_)

**Other**

The following questions are about other wood-burning appliances.

Q66a. Are there any other appliances not captured in the questions prior that burn wood in your primary residence?

Yes  
No

Q66b. Please describe the other appliances not captured and tell us how much wood (in cords) you typically use in the devices. Please indicate whether the wood-burning appliance is located at your primary residence.

Q67. For your **primary residence**, which of the following fuels do you use for heating? (Please select all that apply.)

Electricity  
Natural gas  
Oil  
Propane  
Wood  
Other, please specify: \_\_\_\_\_

Q68. For your **primary residence**, which of the following fuels do you use most often for heating? (Please select one.)

Electricity  
Natural gas  
Oil  
Propane  
Wood  
Other, please specify: \_\_\_\_\_

Q69. What is the approximate square footage of your primary residence?

\_\_\_\_\_

**Demographics**

These final questions are for classification purposes only. Your answers will be kept completely confidential, and the responses you give will be grouped with those of other participants and used only for the analysis of the survey data.

Q70: Which of the following best describes your **primary residence**?

Detached single family home  
Attached single family home (e.g. townhome)  
Mobile home  
Duplex (two units)

Multi-resident building (3-5 units)  
Apartment (more than 5 units)

Q71: Which of the following best describes your **secondary residence**?

Detached single family home  
Attached single family home (e.g. townhome)  
Mobile home  
Duplex (two units)  
Multi-resident building (3-5 units)  
Apartment (more than 5 units)  
Cabin or camp

Q72: Please provide the number of people in the following age ranges, including yourself, who live in your primary home.

# of people in household **ages 17 or younger**  
# of people in household **ages 18-35**  
# of people in household **ages 36-50**  
# of people in household **ages 51-65**  
# of people in household **ages 66 or older**  
I do not wish to answer.

Q73: What is your total household income, before taxes? (Please select the response that represents the annual gross income of all the people who live in your primary residence.)

Less than \$25,000  
\$25,001 to \$60,000  
\$60,001 - \$100,000  
\$100,001 – \$150,000  
\$151,001 - \$200,000  
Greater than \$200,000  
I do not wish to answer.

**Thank you for taking the time to complete this survey! Your responses have been recorded. You may close your browser, or to learn more about the Commission for Environmental Cooperation (CEC) and the Northeast States for Coordinated Air Use Management (NESCAUM), please follow the links to [www.cec.org](http://www.cec.org) and [www.nescaum.org](http://www.nescaum.org).**

## Appendix B – Survey Results Tables

This appendix contains detailed tables with the results of the survey, by appliance type.

**Table B-1. Total Responses by Appliance Type**

Appliance Type	Number of Unweighted Responses	% of Unweighted Responses	Survey Weighted Households	% of Weighted Households
Conventional Fireplace	378	13	5,937,714	12
Fireplace with Insert	228	8	2,376,373	5
Woodstove	694	23	4,063,255	8
Pellet stove	149	5	1,195,949	2
Wood-burning Furnace	86	3	324,210	1
Wood-burning boiler	119	4	486,244	1
Outdoor fire rings/ chimeneas/ fire pits	580	19	6,123,422	12
Use any wood-burning appliance	1,500	50	15,229,857	29.7
Do not burn wood	1,484	50	36,023,061	70.3
Total	2,984	100	51,252,918	100.0

*Note:* The percentage of Unweighted Responses and percentage of Weighted Households are calculated by dividing the number of unweighted responses or survey-weighted households for each appliance by the total number of unweighted responses (2,984) or survey-weighted households (51,252,918). The sum of percentages across appliance types will not equal 100% because some respondents use more than one appliance type.

**Table B-2. Percentage of Households Using Each Appliance Type, by Census Division**

Appliance Type	New England	East North Central	Middle Atlantic	South Atlantic	West South Central	Mountain	West North Central	Pacific
Conventional Fireplace	13.5%	16.4%	35.2%	19.2%	5.6%	2.9%	5.7%	5.7%
Fireplace with Insert	5.0%	9.1%	11.1%	6.6%	3.9%	0.6%	1.6%	3.8%
Woodstove	14.5%	12.8%	23.0%	9.0%	2.1%	5.7%	1.6%	2.5%
Pellet stove	4.8%	3.0%	8.7%	2.9%	0.2%	0.4%	0.0%	0.9%
Wood-burning Furnace	0.8%	1.2%	0.6%	0.1%	0.0%	0.3%	1.8%	0.0%
Wood-burning boiler	2.8%	0.8%	1.2%	0.4%	0.7%	0.1%	0.5%	0.0%
Outdoor fire rings/ chimeneas/ fire pits	14.6%	27.9%	30.7%	13.8%	7.1%	3.7%	4.1%	5.5%

**Table B-3. Average Fuel Consumption Rate (Cords/Appliance), by Census Division**

Appliance Type	New England	East North Central	Middle Atlantic	South Atlantic	West South Central	Mountain	West North Central	Pacific
Conventional Fireplace	0.43	0.65	0.38	0.40	0.53	0.14	0.49	0.66
Fireplace with Insert	1.10	1.02	1.72	1.43	1.15	0.91	0.97	0.60
Woodstove	2.39	2.36	1.87	1.93	2.47	1.93	2.09	1.56
Pellet stove	3.23	1.17	1.45	0.61	3.52	1.78	1.60	0.83
Wood-burning Furnace	2.50	2.74	2.21	5.33	na	5.46	4.21	na
Wood-burning boiler	1.92	8.17	6.42	4.83	6.38	6.29	3.06	3.00
Outdoor fire rings/ chimeneas/ fire pits	0.26	0.99	0.25	0.16	0.12	0.57	0.39	0.18

**Table B-4. Unweighted Responses by Census Division**

Appliance Type	New England	East North Central	Middle Atlantic	South Atlantic	West South Central	Mountain	West North Central	Pacific
Conventional Fireplace	138	65	71	37	14	11	20	22
Fireplace with Insert	55	55	47	23	13	7	10	18
Woodstove	293	115	110	51	12	52	20	41
Pellet stove	69	24	28	7	2	8	2	9
Wood-burning Furnace	27	41	8	1	0	2	7	0
Wood-burning boiler	35	41	26	8	3	2	3	1
Outdoor fire rings/ chimeneas/ fire pits	187	154	114	30	16	27	19	33

**Table B-5. Responses by Urban, Suburban and Rural Areas**

Appliance Type	% of Households with Appliance			Average Burn Rate (cords/appliance)			Unweighted Responses			Survey-Weighted Households		
	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural	Urban	Suburban	Rural
Conventional Fireplace	13	7	8	0.42	0.47	0.88	209	76	93	5,027,623	511,844	398,246
Fireplace with Insert	4	4	7	1.06	2.41	1.14	113	53	62	1,710,823	317,792	347,758
Woodstove	6	9	18	1.74	2.25	2.94	249	163	282	2,458,438	741,922	862,895
Pellet stove	2	1	3	1.65	1.68	2.06	61	33	55	932,686	116,684	146,580
Wood-burning Furnace	0.3	0.8	3.1	3.22	4.06	2.19	14	25	47	117,323	59,316	147,571
Wood-burning boiler	0.7	1.3	2.4	3.73	6.25	7.19	29	36	54	267,948	105,288	113,008
Outdoor fire rings/ chimeneas/ fire pits	12	10	16	0.41	0.46	0.54	249	134	197	4,570,989	784,609	767,824

**Table B-6. Percentage of Homes Using Each Type of Appliance, by Dwelling Type**

<b>Appliance Type</b>	<b>Detached single family home</b>	<b>Attached single family home (e.g. townhome)</b>	<b>Duplex (two units)</b>	<b>Multi-resident building (3-5 units)</b>	<b>Apartment (more than 5 units)</b>	<b>Mobile home</b>
Conventional Fireplace	16.1%	8.4%	2.1%	4.1%	3.9%	2.6%
Fireplace with Insert	7.0%	0.2%	0.1%	0.0%	0.0%	5.7%
Woodstove	11.6%	3.7%	2.0%	0.0%	0.4%	7.8%
Pellet stove	3.7%	0.2%	0.5%	0.0%	0.0%	0.6%
Wood-burning Furnace	0.9%	0.4%	0.1%	0.0%	0.0%	0.7%
Wood-burning boiler	1.4%	0.5%	0.9%	0.0%	0.0%	0.2%
Outdoor fire rings/ chimeneas/ fire pits	17.8%	6.9%	5.8%	0.0%	0.0%	5.4%

**Table B-7. Average Fuel Consumption Rate (Cords/Appliance), by Dwelling Type**

<b>Appliance Type</b>	<b>Detached single family home</b>	<b>Attached single family home (e.g. townhome)</b>	<b>Duplex (two units)</b>	<b>Multi-resident building (3-5 units)</b>	<b>Apartment (more than 5 units)</b>	<b>Mobile home</b>
Conventional Fireplace	0.45	0.72	0.13	1.00	0.02	0.45
Fireplace with Insert	1.27	3.00	1.00	na	na	0.85
Woodstove	2.04	1.48	3.74	na	1.67	2.96
Pellet stove	1.67	1.94	3.66	na	na	2.11
Wood-burning Furnace	2.82	3.71	0.00	na	na	4.27
Wood-burning boiler	5.10	9.30	1.57	na	na	10.57
Outdoor fire rings/ chimeneas/ fire pits	0.45	0.32	0.11	na	na	0.48

**Table B-8. Unweighted Responses by Dwelling Type**

<b>Appliance Type</b>	<b>Detached single family home</b>	<b>Attached single family home (e.g. townhome)</b>	<b>Duplex (two units)</b>	<b>Multi-resident building (3-5 units)</b>	<b>Apartment (more than 5 units)</b>	<b>Mobile home</b>
Conventional Fireplace	341	8	2	4	3	6
Fireplace with Insert	211	1	1	0	0	7
Woodstove	635	6	4	0	1	27
Pellet stove	131	3	2	0	0	7
Wood-burning Furnace	77	3	1	0	0	3
Wood-burning boiler	103	3	2	1	0	3
Outdoor fire rings/ chimeneas/ fire pits	525	12	6	0	0	18