Emissions Inventory Improvement Program (EIIP)
Residential Wood Combustion Coordination Project

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TABLE OF CONTENTS

1 Introduction

OMNI Consulting Services, Inc., working under contract for the Mid-Atlantic Regional Air Management Association (MARAMA), has prepared this report as an information resource for state, local and regional organizations that are planning or conducting residential wood combustion (RWC) surveys. Surveying is the method preferred by the Environmental Protection Agency (EPA) for data collection in the development of RWC emissions inventories. As part of this work, OMNI conducted a national search to identify U.S. RWC surveys and coordinated a conference call with an expert forum on the subject of RWC survey methodology. It is hoped that this work will provide information to improve RWC emissions inventories. This report contains a general discussion on survey preparation (Section 2) as well as specific recommendations for RWC survey contents (Section 3).

Unfortunately, many RWC surveys, including some of those listed here in Section 4, have been conducted for reasons other than emissions inventory development and it has been difficult to derive emissions inventory values from these surveys. In addition, there are many subtleties associated with RWC that require careful survey design. Moreover, many parts of the country have never been surveyed. Section 4 of this report is a compilation of all the identified RWC surveys conducted since 1981. For the surveys conducted in the last ten years contact information has been provided along with the survey sample size and survey area population. Section 5 contains a list of Internet resources and Section 6 contains some example questions.

2 Survey Preparation

Before designing a residential wood combustion survey, familiarization with general survey procedures and survey design for area source emissions inventories is recommended. Some background information on surveying techniques is worth discussing although it is not the primary focus of this report. The primary focus of this report is on the specifics of RWC surveys in developing emissions inventories. It should be noted that the EPA has provided guidance for general survey methodology in the EIIP Technical Report Series, Volume III, Area Sources and Area Source Method Abstracts, Chapter 24, Conducting Surveys for Area Source Inventories.

The first step in developing a RWC emissions inventory is to determine if a survey is necessary. If it is decided to conduct a survey, thorough planning is essential. Initial planning should include an evaluation of the data quality requirements and a project budget. Before starting to design the survey, the information needed to develop an emissions inventory should be identified. Typically RWC emissions inventories require: types of appliance at each residence, how many appliances each residence has, how much fuel is burned in each appliance and residence demographics for extrapolating survey results to the entire area's population. Useful demographic information includes the urban/rural distribution of a home's residential area, economic distribution of the residential area and the age of residences in the area. In addition to survey results, heating degree-day data for the survey area may be useful when extrapolating survey results.

2.1 Distribution of a Survey Questionnaire

Typically, RWC survey questionnaires have been either mailed or completed by telephone interviews. There are strong arguments for each method.

Positive aspects of mailing survey questionnaires are: (1.) mailing survey questionnaires is normally cheaper to administer than telephone surveys, (2.) survey questionnaires can use graphics to explain possible answers and (3.) they are self-administered on a homeowner's time at their own pace. Negative aspects of mailing survey questionnaires are: (1.) the survey period is longer, often much longer, (2.) addresses change, meaning that more survey questionnaires need to be sent in-order to have the required number completed and returned, (3.) incomplete forms can be unusable, (4.) administrators cannot ask questions to clarify answers, (5.) they bias results to people with interest in the subject and (6.) in populations with lower educational and literacy levels, response rates are often too small to be useful. Response rates are often as low as 3%.

A way of mitigating low response rates when mailing survey questionnaires is to mail a postcard either before or after the survey questionnaire is sent (or both) explaining why it is important that the survey questionnaire is completed and returned. Unfortunately, this doubles or triples mailing costs. Another way to increase response to a mailed survey questionnaire is to use an incentive. One possibility is to offer to donate money to a charity specified by the respondent. Another is to include the people who return completed survey questionnaires in a drawing for a prize. A third is to offer a copy of the (non-confidential) result highlights to those who complete the questionnaire. Any of these techniques will increase the response rate.

To determine the number of survey questionnaires that should be mailed, an estimate of the expected response rate should be made and the number of survey questionnaires sent adjusted accordingly. For example, if a sample of 1,000 respondents is desired as part of a mailing survey, and the estimated response rate is 5%, 20,000 questionnaires should be mailed. Bulk mail rates can save on postage expenses. However, most researchers do not use bulk mail because people may throw out bulk mailings without opening the envelope, lowering the response rate. Also, bulk mail moves slowly, increasing the time needed to complete the project.

Telephone surveys have the distinct advantage of utilizing an interactive interviewer who can explain stove types, wood use units and make sure the survey is complete. Interviewers can also often elicit longer or more complete answers than people will give on their own and if using a computer-assisted telephone interviewing system (CATI) the results can be available minutes after completing the last interview.

CATI software makes complex or lengthy questionnaires practical by offering many logic options; CATI can skip questions, perform calculations and modify questions based on the

answers to earlier questions. It can check the logical consistency of answers and can present questions or answer choices in random order.

Random sampling is easier with telephone interviews; a computer can dial random telephone numbers when there is not an actual list of telephone numbers of potential respondents.

Problems with telephone interviews are: (1.) the expense of a team of interviewers, (2.) the expense to train and supervise interviewers, (3.) biased results to women and seniors who have been shown to be more likely at home during evening hours, (4.) telemarketers have given telephone research a bad name (many people are reluctant to answer the phone to avoid telemarketers and use their answering machines to screen calls), (5.) the prime calling time is about 6-9 p.m. (a time many homeowners have planned activities) and (6.) an interviewer cannot show graphics or diagrams by phone.

2.2 Sample Size (Number of Households)

To get representative results, the sample size needs to be determined prior to surveying and an unbiased, random sampling procedure is needed. The first step in determining sample size is to define the target population. When developing a RWC emissions inventory the target population should be all households in the area for which the emissions inventory is being developed. The data quality requirements, the study budget and population characteristics should be taken into account when making a decision on the sample size. Large samples will provide better data but are more time consuming and are more costly. With very homogeneous populations a large sample size may not be worth the extra time and expense.

The number of responses needed to obtain data quality requirements can be calculated using basic statistics or with on-line calculators (http://www.surveysystem.com/sscalc.htm). For example, in a survey area with a population of 1 million households, a survey sample of 1066 respondents (only one respondent per household) will give a result with a 95% confidence level and 3% confidence interval, if the confidence interval is widened to 5% only 384 samples are needed. Often RWC surveys designed for emissions inventory development have a 95% confidence level and 3% confidence interval. Confidence level is how likely the value is within the confidence interval had the entire population been surveyed. The confidence interval is the range that the true value lies.

To calculate the number of survey questionnaires to be distributed, the desired number of samples should be divided by the expected response rate. (For example: 26,650 surveys would need to be mailed if a desired 1066 questionnaires are to be returned with an expected 4% return rate, 1066/0.04= 26,650.)

2.3 Preparation of Survey Questions

In general, it is recommended that the ultimate purpose of the survey be considered in any survey design. The information desired should be reviewed and questions should be designed to result in the data needed, in this case the development of a RWC emissions inventory. Questions should be kept simple and brief. Questions that will over complicate the survey should be avoided. It is advisable to keep in mind the audience who will receive the survey questionnaire and the language that they will understand when wording a survey questionnaire. Attention should be paid to the order of the questions to keep the survey streamlined. Questions should not be asked in a way to bias answers. Emotional buzzwords, i.e., pollution, dirty, etc. should be avoided. It is important to have an option for "none", "other", "don't know" or "not applicable." At the beginning of the survey it is helpful to confirm that the residence is in the area being surveyed and the type of residence being surveyed, this data is also included for extrapolating data (zip code and residence type) to the entire area's population. Personal questions, such as income level or educational background, are not needed for emissions inventories but if they are to be asked as part of a survey it is preferred to ask them at the end, so that the important data is obtained should the respondent become offended and discontinue the conversation.

After designing the survey questionnaire, instructions for the surveyor or a cover letter to be mailed with a written survey questionnaire should be prepared to explain the survey's purpose and how the data will be used. A cover letter will increase the returns on a mailed survey and an appropriate introduction script for telephone interviews will increase the number of people who will participate in the survey.

A pilot survey followed by a revision of questions is a valuable tool in assuring usable results. Care should be taken when mixing any results from a pilot test with the final survey as the questions may change.

2.4 Survey Participants

When collecting data by a survey, the information needs to be collected from an individual at the residence who is familiar with the information requested. For example, the data collected may not be reliable if it is from a child interviewed simply because they are the person who answered the telephone. Many of the surveys listed in Section 4 of this report gathered information on public opinion along with RWC emissions inventory data. Due to this extra data being collected (along with demographics of the person giving the opinion) special care needs to be taken to avoid bias. It has been documented that telephone surveys are often biased to women and seniors because they statistically tend to be home more often in the evenings to answer the telephone. As long as the person answering the questions is knowledgeable about wood use in the home, there is little concern of bias; the questions involved in RWC emissions inventory surveys should not require opinions.

3 Key Residential Wood Combustion Survey Contents

A successfully designed survey will return results that provide the necessary information to calculate an emissions inventory. The needed information is: types of appliance at each residence, how many appliances each residence has, how much fuel is burned in each appliance and residence demographics for extrapolating survey results to the entire area's population should that be necessary. This section of the report will discus each of these topics in detail.

Historically there have been some common problems with RWC surveys. These common problems include not distinguishing wood use in the different appliance types, which is important because they have different emission factors, over estimating wood use, confusion over the term "insert" and not properly addressing homes that do not have or do not use their wood burning appliance. It is hoped that the following discussion will help avoid or to mitigate these difficulties in future surveys.

3.1 Type of Appliance

Conventional (non-certified) woodstove, certified non-catalytic woodstove, certified catalytic woodstove, masonry fireplace, factory-built fireplace, advanced technology (EPA) fireplace, masonry heater, fireplace insert, pellet stove, wood burning furnace/boiler and cook stoves are the main wood burning appliance types in use in the U.S. The numerous types of appliances and subtle differences between types cause confusion in RWC surveys. Many homeowners, and some surveyors, cannot always tell the difference. If a survey questionnaire is to be mailed, drawings and a description will help homeowners know what type of appliance they have. If a survey is to be done by interview, the interviewer should understand the appliance types and be able to communicate the differences to the respondent.

Woodstoves are freestanding wood burning space heaters. Determining the type of woodstove (conventional woodstove, certified non-catalytic woodstove or certified catalytic woodstove) is not always straightforward as the EPA emission certification rules were phased in over several years. Care should also be taken when determining the woodstove type as most people in the air quality field use the term certified to denote a stove is EPA certified for low emissions, but homeowners may think certified means it was installed by a certified installer, was certified as installed correctly by the city or certified for safety by an accredited safety laboratory. Conventional woodstoves have no emissions control and have not been EPA certified for low emissions, generally these stoves were built before 1990. Catalytic woodstoves have a built in catalyst to reduce emissions and are EPA certified as low emissions. Certified non-catalytic woodstoves use design technology to lower emissions and are EPA certified as low emissions.

Conventional fireplaces, both factory built (zero-clearance) and masonry (site-built), are normally built into a wall but a small percent will be freestanding. Fireplaces are mostly for

decorative use, or at most supplemental heat, they may have no doors, screen doors or non-sealing glass doors (no gasket) and they may have "heatilator" tubes or other tubular grates to aid in heating the room.

Advanced technology fireplaces (sometimes referred to as EPA fireplaces) are uncommon as few have been sold. They are actually certified woodstoves built into a wall to look like a fireplace and they are air tight with gasketed doors.

Masonry heaters are also uncommon as few have been built due to the high cost of construction. They work under the principal of a short hot fire heating up a very large mass of masonry and long after the fire is out the masonry radiates heat into the room. They have small fireboxes but a very large overall mass.

Wood burning fireplace inserts are woodstoves that are installed into or partly into a conventional fireplace. Like woodstoves determining the type of wood burning fireplace insert is not always straightforward as the EPA emission certification rules were phased in over several years. Wood burning inserts are very commonly over estimated by surveys when residents incorrectly count a zero-clearance fireplace as a wood burning insert, because the unit is "inserted" into the wall. Survey questions regarding wood burning fireplace inserts should be worded carefully to also avoid any confusion regarding natural gas log sets, which are "inserted" into a fireplace, natural gas inserts and pellet stove inserts.

Pellet stoves can be free standing or inserted into a conventional fireplace, in which case they are referred to as pellet inserts. They burn small compressed wood pellets.

Wood burning furnaces and boilers are centralized units and have ducts or pipes to move the heat by either air or water. They are normally in the basement, utility rooms or outdoors.

There are a small number of wood burning cook stoves in the U.S. Besides being used as cook stoves they are used for supplemental heat.

There are specific EPA AP-42 emission factors for: fireplaces, conventional woodstoves, certified non-catalytic woodstoves, certified catalytic woodstoves (woodstoves include inserts), masonry heaters and pellet stoves. (EPA technical documents have been published on the emission factors of wood burning furnaces and boilers.) With so many categories and the sometimes-subtle distinction between the appliance types, there has been considerable confusion in many surveys. (An example of confusion would be a survey questionnaire that leads people with masonry fireplaces to respond that they have a masonry heater, the survey result would show an unlikely number of masonry heaters.) An option is to combine some of the categories to simplify the survey. Combining categories may not produce as precise data on the appliance type in a residence but a higher number of people will participate if they are not confused and they are more likely to answer correctly if it is kept simple.

Combining certified catalytic woodstoves with certified non-catalytic woodstoves can simplify the survey. (Similarly, combining certified catalytic inserts with certified non-catalytic inserts the survey will be simplified.) While the emission factors for new catalytic

woodstoves (and inserts) are lower than those of new non-catalytic woodstoves (and inserts), catalyst performances decreases with age and in actuality the difference in emission factors for appliances in homes is probably not significant enough to warrant their separation. By creating two categories for woodstoves, conventional (pre-1990) and certified (post-1990) woodstoves, much confusion can be eliminated. Unless the homeowner purchased the stove they may not know what type of woodstove it is, but they will probably have an idea of its age.

There is often confusion with the terms catalytic and certified, i.e., some homeowners that have certified non-catalytic woodstoves think that they are catalytic. If data is to be collected on catalytic woodstoves separately from non-catalytic woodstoves it is recommended that a series of simple questions be used. For example, it is not recommended to ask if the woodstove is a) conventional, b) certified non-catalytic, c) certified catalytic or d) do not know. Too many homeowners will not know what type of stove they have and stoves will end up in the "do not know" category. A better way to get the data is to determine if there is a woodstove (y/n), ask if the stove is conventional (pre July-1990) or certified (post July-1990), if they do not know a best guess is fine, and finally ask if the appliance is catalytic (y/n). If the homeowner does not know if the woodstove is catalytic or not it probably is not because the operation of a catalytic woodstove requires the operation of a by-pass damper.

Appliance types that are uncommon in the U.S. can be grouped together or into the "other" category, this will simplify the survey without much risk of losing data quality because there are so few of these in homes. These appliance types that are often grouped together are masonry heater, advanced technology (EPA) fireplace, wood burning furnace/boiler and wood burning cook stove. These appliances represent very small numbers in the U.S. For example, if a homeowner knows they have a masonry heater they can fill out the "other" category, otherwise they will most likely use the fireplace or woodstove category. Though this may be technically incorrect the small number of these appliances will make the point insignificant, while at the same time the simpler form will often encourage residence to complete the survey.

If categories are not grouped together or if they are not added to the "other" category, it should be noted that masonry fireplaces are often confused with masonry heaters. Masonry heaters although similar in appearance to masonry fireplaces have quite different emission factors, and in fact are listed in section 1.10 of AP-42 along with woodstoves not in section 1.9 with fireplaces. Therefore, their activity data needs to be kept separate from woodstoves and fireplaces. Because they are superficially similar in appearance to fireplaces special attention needs to be made to designing survey questionnaires to identify them. Drawings will help explain the differences. However, as noted previously, there are so few masonry heaters as compared to masonry fireplaces that combining them into one category will have an insignificant effect on an emissions inventory.

There is often confusion caused by wood burning fireplace inserts and wood burning fireplaces without inserts. Wood burning fireplace inserts have emission factors similar to woodstoves not wood burning fireplaces, therefore fuel use in fireplaces with and without

inserts need to be kept separate. A user friendly script needs to be prepared to make sure that fireplace inserts and fireplaces are not double counted because a fireplace is needed for a fireplace insert to be installed. Also the definition of what constitutes a fireplace insert needs to be developed because there are some fireplace appliances that are in a "gray area." Additionally, many originally wood burning fireplaces have had natural gas inserts, pellet inserts or have had natural gas log sets installed in them. Care must be taken not to count them as wood burning fireplace inserts or wood burning fireplaces without inserts.

3.2 Number of Appliances

One of the first questions should be whether or not the household has a wood burning appliance. If it does not then that survey still needs to be counted. Zero is an important number since the percent of homes with a wood burning appliance is fundamental when developing an emissions inventory. When reviewing some of the surveys listed in Section 4 it was suspected that some interviewers just ended a call when the house did not have a wood burning appliance. Similarly, a mailed survey must explain why someone should send in their questionnaire even if they have no wood burning appliances. It cannot be over emphasized that for RWC emissions inventories it is necessary to know how many homes have and how many do not have wood burning appliances.

As many as 10 percent of homes that have wood burning appliances have more than one wood burning appliance. This has caused considerable confusion when, for example, fuel use per appliance is calculated or when the percentage of homes with a wood burning appliance is calculated. Multiple appliances should be taken into consideration when designing a questionnaire.

3.3 Wood Use

For an accurate emissions inventory, how much wood is burned in each appliance type will have to be determined.

Due to the considerable work associated with cutting, splitting, transporting and stacking a cord of wood, it is believed that wood usage is generally overestimated. In addition, since there are a number of inexact methods of measuring wood (cord, face cord, fireplace cord, rick, pick-up truck, and bundle) and manufactured firelogs are sold in different weights and package sizes, there are a number of questions that need to be asked to ensure that the mass of fuel burned is accurately obtained.

The homeowner needs to be clear on the wood use measurement units. Through drawings or clear definition it is key that they understand the units. They also need to understand that they are answering how much wood they burned not how much they bought or stacked.

It is preferred to ask the homeowner the amount of wood they burned in cords with a clear understanding how to convert any unit of wood use into cords. Some surveys have a blank

next to each unit and allow the homeowner to pick the units they are most comfortable with and fill out only that blank, but some people will fill out their use converted to more than one unit. If this is not caught on data entry their use will be over estimated.

A cord of wood is a stack of split wood measuring 4 feet high by 4 feet wide by 8 feet long and has a volume of 128 cubit feet. A face cord, or a fireplace cord, is a stack of split wood 4 feet high by eight feet long and is as wide as the individual firewood pieces, normally 16 inches. A face cord is equal to one-third of a full cord. A full size pick-up truck load (8 foot box) is one-half of a full cord. If the wood is neatly stacked one-half of a cord will be up to the truck box sides, if it is thrown in it will be piled up to the top of the cab. A compact pick-up truck load (6 foot box) is about one-quarter of a cord. If the wood is neatly stacked one-quarter of a cord will be up to the truck box sides, if it is thrown in it will be piled up to the top of the cab. A bundle of firewood purchased at a grocery or mass merchandise store is typically 1 foot by 1 foot by 2 feet and would represent $1/64^{th}$ of a cord.

It may be desirable to calculate the wood use, as a double check of the amount the resident gave in cords. Calculating wood use from number and duration of fires can be done. To do this the appliance type needs to be known to estimate burn rate, and survey questions need to be designed appropriately to provide the needed information. The number of fires per month needs to be broken down over the heating season. It should be noted that the number of fires can be deceiving as many people keep their appliances going for days or weeks at a time and they may consider this only one fire. Another check on the amount of fuel burned can be obtained by asking how many pieces of fuel are typically burned during each fire. This information combined with the number of fires allows an estimate of wood use.

Manufactured logs are widely used. There are two kinds of manufactured logs: wax/sawdust firelogs primarily for use in fireplaces and densified firelogs primarily for use in woodstoves. The two types of logs are often confused. Because they have different emission factors from each other and both have different emission factors from cordwood their activity data needs to be kept separate. As many as 30% of fireplace users, use wax/sawdust firelogs some of the time, consequently their contribution to emissions cannot be ignored. Emission factors for manufactured fuels have been published and are available. As noted, the emission factors are different for wax/sawdust firelogs used in fireplaces and for densified firelogs manufactured for use in woodstoves, so survey questions need to be worded to keep the two fuel type's usage separate.

Many appliances are not used. For example, approximately 35% of fireplaces are not used in a given 12-month period. When cordwood (and manufactured firelog) usage per appliance is determined, the survey should be designed so that the results are clear on whether the average is fuel use per appliance installed or per appliance used.

3.4 Other Considerations

If a survey area is heterogeneous and the sample collection is unbiased, extrapolating the survey results to the entire survey area is simple. In many cases a survey area has distinctly

different areas or demographics, this could be a rural region, a mountainous region, suburban, inner city, etc. In this case it is desirable to collect samples in the same proportion of the population of the different regions. For example: if in the survey area of 1 million households, 700,000 households are in an urban area located in a valley and 300,000 households are in a rural mountainous region, then it is recommended that 70% of the surveys are from the urban valley and 30% from the rural mountainous region. If a survey is taken with 50% of the samples collected from each region then it is recommended that some adjustments be made when extrapolating the data to the entire survey area. Typically, zip code or county information can be used to "scale up" survey data. In the preceding example, if 50% of the samples where taken in each of the two regions it may be necessary to weight the results by region when extrapolating the results to the entire population. This information, along with household type (single family, apartment, etc.), can also be helpful in future emissions modeling should the need arise.

4 Compilation of Residential Wood Combustion Surveys and Related Studies

The following is a list by geographical area of residential wood combustion surveys, reports containing the results of surveys and related publications. Reports have included or compiled survey information for use in air quality evaluations, for marketing considerations and for energy utilization studies. The surveys conducted in the last ten years include contact information as well as the survey sample size and the survey area population.

Alaska

Developing a Residential Wood Combustion Emissions Inventory and a Profile of Wood Burning Practices for Fairbanks, Alaska, Environmental Services Division of the Fairbanks North Star Borough, 1984.

Arizona

1994 Regional PM_{10} Emission Inventory Study: Residential Wood Combustion Survey, report prepared by CSI Santa Rita Research Center for Systems Applications International, Inc., August 30, 1996.
Contact: Maricopa Association of Governments, Air Pollution Control, 302 North 1st Ave., Suite 300, Phoenix, AZ 85003. (602) 254-6300.
n = 278, population was not given, current Maricopa County population is 3,296,250.

MAG 1999 Serious Area Particulate Plan for PM10 for the Maricopa County Nonattainment Area, Appendix A, Exhibit 6, Section 4, Stationary Area Sources, Maricopa Association of Governments, February 2000.
Contact: Maricopa Association of Governments, Air Pollution Control, 302 North 1st Ave., Suite 300, Phoenix, AZ 85003. (602) 254-6300.
n = 1,416, population was not given, current Maricopa County population is 3,296,250.

California

Analysis of Carbon Monoxide and Inhalable Particulate Emissions from Woodburning Devices in Fresno, California, report prepared by Engineering Science for U.S. Environmental Protection Agency, Region IX, 1982.

Installation of Fireplaces, Stoves and Inserts in New and Existing Houses, report prepared by Housing Industry Dynamics, Inc. for Wood Heating Alliance, 1982.

Estimated 1984 Residential Wood Burning in the South Coast Air Basin, South Coast Air Quality Management District, Engineering Division Report, 1985.

Estimation of Carbon Monoxide and Particulate Emissions from Woodburning Devices in the Fresno/Clovis Metropolitan Area, D. Inouye, Fresno State University, 1985.

Healdsburg Wood Heating Survey, Northern Sonoma County Air Pollution Control District, 1987.

The California Residential Wood Consumption Survey, report prepared by Northern California Research Associates for California Air Resources Board, 1988.

Residential Wood Use in California, report prepared by Sierra Research for U.S. Environmental Protection Agency, 1989.

Air Quality Management Plan for the Town of Mammoth Lakes, Great Basin Unified Air Pollution Control District and The Town of Mammoth Lakes, November 30, 1990.

Emission Inventory Procedure Manual, Volume III, Methods for Assessing Area Source Emissions, Section 7.1 Residential Wood Combustion, California Environmental Protection Agency, Air Resources Board, October 1997.

San Joaquin Valley Unified Air Pollution Control District Baseline Survey, job number 8E3213, report prepared by META Information Services for the SJVUAPCD, 1999.
Contact: Cynthia Echavarria, SJVUAPCD, 1990 E. Gettysburg Ave., Fresno, CA 93726-0244.
n = 1,075, the population was not given, current population of represented counties is 595,324.

San Joaquin Valley District Survey, report prepared by McGuire Research Services for Duraflame, Inc., November 2002.
Contact: Chris Caron, Duraflame, Inc., 2894 Mount Diablo Blvd., Stockton, CA 95203.
n = 300, population was not given, current population of represented counties is 595,324.

Results of Wood Burning Survey – Sacramento, San Joaquin, and San Francisco Airsheds, UC Berkeley/California Air Resources Board – GIS Study, analysis of survey by OMNI Consulting Services, Inc, 2002.
Contact: David Broderick, OMNI, PO Box 743, Beaverton, OR 97075.
n = 680, population was not given, current population of represented counties is 10,741,955.

Model Development for Spatial Allocations of PM2.5 Emissions Including Residential Wood Combustion, report prepared by the University of California Berkeley for the California Air Resource Board, May 2002.
Contact: Ray Asregadoo, CARB, 2020 L Street, Sacramento, CA 95814.
n = 731, population was not given, current population of represented counties is 10,741,955.

Winter 2002/2003 Spare the Air Tonight Campaign Survey Summary Report, report prepared by Godbe Research and Analysis for the BAAQMD, May 2003.
Contact: Administrative Services, BAAQMD, 939n Ellis Street, San Francisco, CA 94109.
n = 400, current population of BAAQMD is 6,460,856.

Canada

1993 Survey of Household Energy Use, National Results, Efficiency and Alternative Energy Branch, Natural Resources Canada, November 1994.

Residential Fuelwood Combustion in Canada, Canadian Facts report to National Emissions Inventory and Projections Task Group, April 1997.

Étude Sur le Marché du Chauffage D'appoint, Hydro Québec report, Montreal, Quebec, 1997.

1995 Criteria Air Contaminants Emission Inventory Guidebook (Draft Final) report to National Emissions Inventory and projections Task Group (NEIPTG), February 2000.

Colorado

Survey for Home Heating Patterns, Survey Questionnaire, State of Colorado, 1984.

A Survey of Residential Combustion of Wood and Coal in Colorado, report prepared by TRC Environmental Consultants, Inc. for the U.S. Environmental Protection Agency, Region VIII and Colorado Department of Health, January 1985.

Denver Metro Woodburning Survey, report prepared by Community Response, Inc. for the Colorado Department of Health, June 1988.

Metropolitan Denver Woodburning Survey, report prepared by R.B. Hutton and S.W. Hartley for the Colorado Department of Health, December 1991.

Carbon Monoxide Woodburning Inventory for Colorado Springs, Air Pollution Control Division, Colorado Department of Health, November 1992.

Carbon Monoxide Woodburning Inventory for Ft. Collins, Air Pollution Control Division, Colorado Department of Health, November 1992.

Grand Junction Woodburning: Citizen Attitudes about Environmental Quality, University of Colorado at Denver, November 1993.
Contact: Department of Sociology, University of Colorado at Denver, Campus Box 105, PO Box 173364, Denver, CO 80217-3364.
n = 200, population was not given, current population of Grand Junction is 41,986.

Technical Support Document for the Colorado State Implementation Plan for PM_{10} : Steamboat Springs Element, Woodburning Emissions Inventory for the Steamboat Springs Metropolitan Area, Colorado Department of Public Health and Environment, March 1995.

Improving Air Quality in Delta County, A County-Wide Survey, Colorado Department of Public Health and Environment, June 1995.
Contact: Delta County Air Quality Advisory Committee.
n = 250, population was not given, current population of Delta County is 28,421.

General Air Quality Survey Report July 1997, City of Fort Collins, Natural Resources Department, July 1997.
Available at http://www.ci.fort-collins.co.us/airquality/pdf/1997.pdf.
n value was not given, current population of Fort Collins is 126,848.

Wood Smoke Survey – May 1998 (1998 survey with references to 1996,1994 and 1990 surveys), City of Fort Collins, Colorado, 1998.
Contact: Fort Collins Natural Resources Department, 281 North College, Fort Collins, CO 80521
Available at http://www.ci.fort-collins.co.us/airquality/survey.php.
n = 812, population was not given, current population of Fort Collins is 126,848.

General Air Quality Survey June 1999, City of Fort Collins, Natural Resources Department, June 1999.
Available at http://www.ci.fort-collins.co.us/airquality/pdf/aq99-report2.pdf.
n = 670, population was not given, current population of Fort Collins is 126,848.

Outdoor Air Quality Survey 2001 Report: City of Fort Collins, report prepared by Environmental Behavior Consulting for the City of Fort Collins, Natural Resources Department, August 2001. *Available at http://www.ci.fort-collins.co.us/airquality/pdf/oaq-survey-2001-report2.pdf.*
n = 725, population was not given, current population of Fort Collins is 126,848.

Metropolitan Denver Woodburning Study, report prepared by Market Analysis Professionals for the Colorado Department of Public Health and Environment, August 2002.
Contact: Mike Silverstein, Colorado Department of Public Health and Environment, 4300 Cherry Creek Dr., Denver, CO, 80220-1530.
n = 1,190, population was not given, current population of the Metropolitan Denver area is 2,160,841.

Delaware

Report on the 1995 Delaware Fuelwood Survey, Delaware Forest Service, Delaware Department of Agriculture, May 1995.
Contact: Delaware Forest Service, 2320 S. Dupont Hwy., Dover, DE 19901.
n = 879, population given is 666,168.

Idaho

Evaluation of Residential Wood Energy Use in Idaho, Idaho Department of Water Resources, October 1985.

Pocatello Air Quality RWC Device Usage, Survey Results, Field Services, Inc. for Marketing Research, August 1991.

Illinois

Wood Combustion Survey [Southeast Chicago], report prepared by Manuel D. Plotkin Research and Planning Co. for U.S. Environmental Protection Agency, Region V, March 1989.

Indiana

Residential Fuelwood Consumption and Production in Indiana, 1996, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, 1997.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=449.
n value was not given, current population of Indiana is 6,115,000.

Kansas

Residential Fuelwood Consumption and Production in Kansas, 1994, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=434.
n value was not given, current population of Kansas is 2,695,000.

Maine

Residential Fuelwood Use in Maine, Results of 1998/1999 Fuelwood Survey, Maine State Planning Office, November 1999.
Contact: Donna Bradstreet, Maine State Planning Office, 38 State House Station, Augusta, Maine 04333-0038.
n = 407, population was not given, current Maine population is1,286,670.

Michigan

Residential Fuelwood Consumption and Production in Michigan, 1992, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, 1993.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=415.
n value was not given, current population of Michigan is 9,991,000.

Minnesota

Minnesota Residential Fuelwood Study, 1986, Minnesota Pollution Control Agency.

Minnesota Residential Fuelwood Survey, 1988-1989, Minnesota Department of Natural Resources.

Minnesota Residential Fuelwood Survey, 1995-1996 Heating Season, Minnesota Department of Natural Resources.
Contact: Keith Jacobson, Minnesota Pollution Control Agency, 520 Lafayette Rd. N., St. Paul, MN 55155-4194.
n = 1,278, population was not given, current Minnesota population is 4,972,294.

Missouri

Missouri Residential Fuelwood Survey, Missouri Department of Conservation, Forestry Division, 1982.

Residential Fuelwood Production and Sources from Roundwood in Missouri, 1987, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, 1991.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=402.

Montana

PM-10 and Carbon Monoxide Emissions from Wood Burning in Butte, Montana, Department of Environmental Engineering, Montana College of Mineral Science and Technology and State Air Quality Bureau, Department of Health and Environmental Sciences, undated.

PM-10 and Carbon Monoxide Emissions from Wood Burning in Libby, Montana, Department of Environmental Engineering, Montana College of Mineral Science and Technology and State Air Quality Bureau, Department of Health and Environmental Sciences, undated.

PM-10 and Carbon Monoxide Emissions from Wood Burning in Thompson Falls, Montana, Department of Environmental Engineering, Montana College of Mineral Science and Technology and State Air Quality Bureau, Department of Health and Environmental Sciences, undated.

1986 Missoula Wood-Use Survey, Residential Wood Burning and Pollutant Emissions, report prepared by Eco-Resource Systems for The Missoula City-County Health Department, June 1986.

Billings Air Quality Survey, report prepared by Economic Consultants Northwest for Montana Department of Health and Environmental Sciences, January 1992.

Great Falls Air Quality Survey, report prepared by Economic Consultants Northwest for Montana Department of Health and Environmental Sciences, January 1992.

Missoula Air Quality Survey, report prepared by Economic Consultants Northwest for State of Montana Department of Health and Environmental Sciences, January 1992.

White Fish Air Quality Survey, report prepared by Dodge Data Systems, Inc. for Montana Department of Health and Environmental Sciences, May 1993.
Contact: Montana Air Quality Bureau, Cogswell Bldg., 1400 Broadway, Helena, Montana 59620.
No information on the n value nor was the population given.

Residential Wood-Burning Survey in Columbia Falls, Montana, report prepared by the Department of Environmental Engineering, Montana Tech of the University of Montana for the Montana Department of Environmental Quality, August 1996.
Contact: Montana DEQ, Planning, Prevention and Assistance Division, (406) 444-6697.
n = 241, population was not given, current population of Columbia Falls is 3,645.

Multiple States

Residential Fuelwood Demand Assessments, A Status Report, U.S. Department of Agriculture, Forest Service, Northeastern Area, 1981.

Burn Rate Frequency Distributions for Portland, Oregon; Waterbury, Vermont; and Warrensburg, New York, OMNI Environmental Services, Inc. internal report, 1986.

Residential Fuelwood Consumption in the Southeastern United States, report prepared by The Gallup Organization, Inc., for the Tennessee Valley Authority, Southeastern Regional Biomass Energy Program, August 1991.

Study of Firewood Sources and Costs in Klamath Falls, Oregon and Sandpoint, Idaho, report prepared by OMNI Environmental Services, Inc. for the Air & Waste Management Association, Pacific Northwest International Section, April 1992.

Residential Fuelwood Consumption and Production in the Plains States, 1994, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Resource Bulletin NC-173, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=437.
n = 3,600, population was not given, current population of North Dakota, South Dakota, Nebraska and Kansas is 5,798,924.

Woodburning survey for Idaho, Oregon and Washington State, report prepared by Social and Economic Sciences, Washington State University for the Idaho Department of Environmental Quality, August 2001.
Contact: Idaho DEQ, Boise, ID 83706-1255.
n = 2,251, population not given, current population on Idaho, Oregon and Washington is 10,781,846.

National

Pickup Trucks as Units for Measuring Firewood, A.P.C. Marsinko and T.E. Wooten, Forest Products Journal, vol.33, no.1, pp.43-44, January 1983.

Residential Firewood Use in the United States, F.W. Lipfert and J.L. Dungan, Science, vol. 219, pp.1425-1427, March 25, 1983.

Estimates of U.S. Wood Energy Consumption 1980-1983, Energy Information Administration, November 1984, DOE/EIA-0341(83).

Room Heating Equipment Exposure Survey, U.S. Consumer Product Safety Commission, Washington, D.C., March 1989.

Estimates of U.S. Biomass Energy Consumption 1990, Energy Information Administration, October 1991, DOE/EIA-0548(90).

Household Energy Consumption and Expenditures 1990, Energy Information Administration, February 1993, DOE/EIA-0321(90).

Household Energy Consumption and Expenditures 1990, Supplement: Regional, Energy Information Administration, February 1993, DOE/EIA-0321(90)S.

1993, 1990 and 1987 residential energy use data available as ASCII files at http://www.eia.doe.gov/emeu/recs/public.html#other.

Estimates of U.S. Biomass Energy Consumption 1992, Energy Information Administration, May 1994, DOE/EIA-0548(92).

Household Energy consumption and Expenditures 1993, EIA, 1995.
Available at http://tonto.eia.doe.gov/ftproot/consumption/032193.pdf

Housing Characteristics in 1993, EIA, 1995.
Available at http://tonto.eia.doe.gov/ftproot/consumption/031493.pdf

Renewable Energy Annual 1995, EIA, 1995.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

U.S. Fireplace Fuel Usage and Fireplace Usage Frequency, 1994/95 Fall/Winter Season, report prepared by Vista Marketing Research for Duraflame, Inc., March 1996.
Contact: Chris Caron, Duraflame, Inc., 2894 Mount Diablo Blvd., Stockton, CA 95203.

U.S. Household Fireplace Penetration and Fuel Use, report prepared by Nichols Research for Duraflame, Inc., December 1996.
Contact: Chris Caron, Duraflame, Inc., 2894 Mount Diablo Blvd., Stockton, CA 95203.

Consumer Research Results, Duraflame Firelogs, Winter 1997/98, report prepared by Perry Lawson & Associates for Duraflame, Inc.
Contact: Chris Caron, Duraflame, Inc., 2894 Mount Diablo Blvd., Stockton, CA 95203.

Renewable Energy Annual 1996, EIA, 1997.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

Residential Use of Fireplaces, Andrew Kochera, Housing Economics, pp. 10-11, March 1997.

Residential Wood Combustion, Volume III, Chapter 2, report prepared by Radian Corporation for Emission Inventory Improvement Program, U.S. Environmental Protection Agency, September 1997.

Renewable Energy Annual 1997, EIA, 1998.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

Renewable Energy Annual 1998 With Data for 1997, EIA, 1998, DOE/EIA-0603(98).
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

A Look at Residential Energy Consumption in 1997, EIA, 1999.
Available at http://www.eia.doe.gov/pub/pdf/consumption/063297.pdf

American Housing Survey for the United States 1997, Current Housing Reports, issued September 1999, U.S. Department of Housing and Urban Development and U.S. Department of Commerce, HISO/97.

Simmons Study of Media and Markets, annual reports 1987-1999, Simmons Market Research, New York, NY.
Contact: Simmons Market Research, http://www.smrb.com.

Mediamark Research, appliances, climate control, annual reports, 1989-1999, Mediamark Research Inc.
Contact: Mediamark Research Inc., http://www.mediamark.com.

Recommended Procedure for Compiling Emission Inventory National and County Level Activity Data for the Residential Wood Combustion Source Category, draft report prepared by Eastern Research Group, Inc. and Omni Environmental Services, Inc. for the U.S. Environmental Protection Agency, September 2000.

Renewable Energy Annual 1999 With Data for 1998, EIA, 2000.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

Renewable Energy Annual 2000 With Data for 1999, EIA, 2001.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/pubs.html

American Housing Survey, US Census Bureau:
2001 http://www.census.gov/prod/2002pubs/h150-01.pdf
1999 http://www.census.gov/prod/2000pubs/h150-99.pdf
1997 http://www.census.gov/prod/99pubs/h150-97.pdf
1995 http://www.census.gov/prod/2/constr/h150/h15095rv.pdf
1993 http://www.census.gov/prod/1/constr/h150/h150-93m.pdf
1991 http://www2.census.gov/prod2/ahsscan/h150-91.pdf
1989 http://www2.census.gov/prod2/ahsscan/h150-89.pdf
1987 http://www2.census.gov/prod2/ahsscan/h150-87.pdf
1985 http://www2.census.gov/prod2/ahsscan/h150-85.pdf

Renewable Energy Annual 2001, EIA, 2002.
Available at http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/rea.pdf

2002 Hearth Retail Sales, Hearth and Home magazine, pp.32-40, March 2003.

Residential Energy Consumption Survey 2001, EIA, 2003.
Available at http://www.eia.doe.gov/emeu/recs/contents.html

Nebraska

Residential Fuelwood Consumption and Production in Nebraska, 1994, North Central Forest Experiment Station, U.S. Forest Service, U.S. Department of Agriculture, Resource Bulletin NC-168, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=433.
n value was not given, current population of Nebraska is 1,713,000.

Nevada

Washoe County, Nevada, Residential Wood Use Survey, 1995-1996, Washoe County District Health Department, August 1996.
Contact: Washoe County Air Quality Management Division, 401 Ryland St., Suite 331, Reno, NV 89502-1643.
n = 392, population was not given, current Washoe County population is 353,336.

Washoe County, Nevada, Residential Wood Use Survey, 1999-2000, Washoe County District Health Department, 2000.
Contact: Washoe County Air Quality Management Division, 401 Ryland St., Suite 331, Reno, NV 89502-1643.
n = 1,131, population was not given, current Washoe County population is 353,336.

New Mexico

Report on Woodburning in Bernalillo County, November 1996 through January 1997, City of Albuquerque Environmental Health Department, Air Quality Planning Section, August 1998.
Contact: Dan Warren, Albuquerque Environmental Health Department, PO Box 1293, Albuquerque, NM 87103.
n = 1000, population not given, current population of Bernalillo County is 562,458.

City of Albuquerque/ Wood Burning Survey May 1998, report prepared by Research & Polling, Inc. for the City of Albuquerque Environmental Health Department.
Contact: Dan Warren, Albuquerque Environmental Health Department, PO Box 1293, Albuquerque, NM 87103.
n = 1000, population not given, current population of Bernalillo County is 562,458.

North Dakota

Residential Fuelwood Consumption and Production in North Dakota, 1994, North Central Forest Experiment Station, U.S. Forest Service, U.S. Department of Agriculture, Resource Bulletin NC-167, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=432.
n value was not given, current population of North Dakota is 634,000.

Oregon

Medford Area Wood Heating Survey, 1981, Oregon Department of Environmental Quality and Oregon Department of Energy, March 1982.

Portland Area Wood Heating Survey, 1982, Oregon Department of Environmental Quality, September 1982.

Report on the 1987 Klamath Falls Area Wood Heating Survey, Oregon Department of Environmental Quality, March 1989.

Klamath Falls Wood Heating Survey, 1991, Klamath County Department of Health Services and Oregon Department of Environmental Quality, July 1991.

Medford Area Wood Heating Survey, 1985, Oregon Department of Environmental Quality, October 1985.

Portland Area Wood Heating Survey, 1985, Oregon Department of Environmental Quality, October 1985.

Executive Summary, 1993 Woodheating Survey, Oregon Department of Environmental Quality, December 1994.

Bend, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 652, population is not given, current population is 52,029.

Klamath Falls, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 565, population is not given, current population is 19,462.

La Grande, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 706, population is not given, current population is 12,327.

Lakeview, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 166, population is not given, current population is 2,474.

Medford-Ashland, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 659, population is not given, current population is 82,676.

Pendleton, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 553, population is not given, current population is 16,354.

Prineville, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 357, population is not given, current population is 7,356.

Portland, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 699, population is not given, current population is 529,121.

Roseburg, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 553, population is not given, current population is 20,017.

Sisters, 1993 Oregon Woodheating Survey, Overview Report, Oregon Department of Environmental Quality, December 1994.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 152, population is not given, current population is 959.

Klamath Falls, 1999 Oregon Woodheating Survey, Overview Report, report prepared by the Oregon Institute of Technology for the Oregon DEQ, 1999.
Contact: David Collier, Oregon DEQ, 811 SW 6th Ave., Portland, OR 97204.
n = 499, population is not given, current population is 19,462.

South Dakota

Residential Fuelwood Consumption and Production in South Dakota, 1994, North Central Forest Experiment Station, U.S. Forest Service, U.S. Department of Agriculture, Resource Bulletin NC-171, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=435.
n value was not given, current population of South Dakota is 757,000.

Utah

Air Pollution and Heating Methods, report prepared by the Paria Group for the Utah Division of Air Quality, 1993.
Contact: Steve Parkin, Utah DAQ, 150 North 1950 West, Salt Lake City, Utah 84116.
n value was not given, current population of Utah is 2,270,000.

Vermont

Vermont Residential Fuel Wood Assessment, 1997-1998, Department of Public Service, December 2000.
Available at http://www.state.vt.us/psd/DPSLibrary/R98report.PDF.
n = 482, population was not given, current Vermont population is 613,090.

Washington

Residential Wood Stove Emissions in Yakima and Olympia, State of Washington Department of Ecology, 1984.

Woodsmoke Education Evaluation Survey, report prepared by Carolyn Browne for the Puget Sound Clean Air Agency, June 1988.

Evaluating Effects of Wood Smoke Control Legislation in Washington State on Electrical Customers, report prepared by Mike Nelson, Washington State Energy Office, and Stewart Kaufman, Gilmore Research Group, for the Washington Dept. of Ecology, June 1990.
Contact: WDOE, PO Box 47600, Olympia, WA 98504-7600.
n = 2078, population was given as 4,866,663.

Public Opinion Survey, report prepared by Alliance Pacific, Inc. for Spokane County Air Pollution Control Authority, 1993.
Contact: SCAPCA, West 1101 College Ave., Suite 403, Spokane, WA 99201.
n = 511, population was not given, current population of Spokane County is 423,261.

Public Opinion Survey for the Puget Sound Clean Air Agency, report prepared by Pacific Rim Resources, Inc. for PSCAA, September 1993.
Contact: Naydene Maykut, PSCAA, 110 Union St., Suite 500, Seattle, WA 98101.
n = 1,200, population was not given, current population of King, Pierce, Snohomish and Kitsap counties is 3,317,464.

Wood Combustion Study, Summary Report, report prepared by Market Trends, Inc. for the Puget Sound Clean Air Agency, July 1993.
Contact: Naydene Maykut, PSCAA, 110 Union St., Suite 500, Seattle, WA 98101.
n = 1,500, population was not given, current population of King, Pierce, Snohomish and Kitsap counties is 3,317,464.

PSCAA Air Pollution Awareness Study, Executive Summary, report prepared by Edmunds Research Services for Strategic Environmental Management Group, October 1995.
Contact: Naydene Maykut, PSCAA, 110 Union St., Suite 500, Seattle, WA 98101.
n = 800, population was not given, current population of King, Pierce, Snohomish and Kitsap counties is 3,317,464.

Island, Skagit and Whatcom County Public Awareness Research, prepared by Cole Geyer Research for the Northwest Air Pollution Authority, June 1996.

Contact: Laura Curley, Northwest Air Pollution Authority, 1600 South Second Street, Mount Vernon, WA 98273-5202.
n = 301, population was not given, current population of Island, Skagit and Whatcom Counties is 350,210.

Puget Sound Air Quality, report prepared by The Gilmore Research Group for the Puget Sound Clean Air Agency, March 1998.
Contact: Naydene Maykut, PSCAA, 110 Union St., Suite 500, Seattle, WA 98101.
n = 901, population was not given, current population of King, Pierce, Snohomish and Kitsap counties is 3,317,464.

Public Opinion Study, Key Findings Study, Key Findings Summary Report, prepared by Robinson Research, Inc. for Spokane County Air Pollution Control Authority, June 1999.
Contact: Lisa Woodard, SCAPCA, West 1101 College Ave., Suite 403, Spokane, WA 99201.
n = 500, population was not given, current population of Spokane County is 423,261.

Puget Sound Air Quality, report prepared by The Gilmore Research Group for the Puget Sound Clean Air Agency, April 2002.
Contact: Naydene Maykut, PSCAA, 110 Union St., Suite 500, Seattle, WA 98101.
Available at http://www.pscleanair.org/news/other/2002_survey.pdf.
n = 900, current population of King, Pierce, Snohomish and Kitsap counties is 3,317,464.

Wisconsin

Residential Fuelwood Consumption and Production in Wisconsin, 1994, North Central Forest Experiment Station, U.S. Forest Service, U.S. Department of Agriculture, Resource Bulletin NC-172, 1996.
Contact: North Central Forest Experiment Station, U.S. Forest Service, 1992 Folwell Ave., St. Paul, Minnesota 55108.
Available at http://www.ncrs.fs.fed.us/pubs/viewpub.asp?key=436.
n = 2,436, population was given as 5,401,906.

Residential Wood Heat Research, report prepared by Matousek & Associates for North Central Hearth Products Association, January 2000.
Contact: North Central Hearth Products Association, PO Box 259282, Madison, WI 53725-9282.
n = 1,207, current population of Wisconsin is 5,401,906.

5 Internet Resources For Residential Wood Combustion Surveys

California Energy Commission information on RWC and woodstoves
http://www.energyloans.org/EnergyReference/body_woodstove.html

California Energy Commission energy site links
http://www.energy.ca.gov/links/index.html

Creative Research Systems' on-line sample size calculator
http://www.surveysystem.com/sscalc.htm

EPA Technology Transfer Network Clearinghouse for Inventories & Emission Factors
http://www.epa.gov/ttn/chief/eiinformation.html

Hearth, Patio & Barbecue Association
http://www.hpba.org/

Mid-Atlantic Regional Air Management Association
http://www.marama.org/

OMNI Consulting Services, Inc. publication list
http://www.omni-test.com/Publications.htm

US Census Bureau housing statistics
http://www.census.gov/prod/www/abs/cons-hou.html#house

US Census Bureau population QuickFacts
http://quickfacts.census.gov/qfd/

US Energy Information Agency, DOE, publications list
http://www.eia.doe.gov/emeu/consumption/reports.html

US Forest Service publication list
http://www.ncrs.fs.fed.us/pubs/search.asp

6 Example Questions

The following is an example of a poorly written question. The question leaves out catalytic stoves and inserts, virtually all conventional woodstoves are noncatalytic (this will confuse many people), and it lists three categories of fireplaces (very confusing and unneeded for a RWC emissions inventory). In addition, the term "facility" is an industrial source emissions inventory term that will not be understood by most homeowners.

> What type of wood burning facility do you have?
> 1=Conventional Woodstove 3=Regular Fireplace 5=Pellet Stove
> 2=Noncatalytic Woodstove 4=Furnace 6=Fireplace
> 7=Masonry Heater 8=Modified Fireplace 9=don't know

The survey did not ask if there were multiple appliances or provide a way to answer for multiple appliances. The survey went on to ask:

> Is your burning facility (appliance) certified?

This will confuse homeowners, many of which had to get the installation of their woodstove certified by the city. The survey would be much better asking:

> Was your woodstove built before July 1990?

Stoves sold in the U.S. after July 1990 had to be EPA certified as low emissions.

One survey asks for wood use as follows:

> How much wood do you burn in an average winter week? ____cords

Wood use by week in cords is a hard question to answer; this sounds ok but most people do not burn enough of a cord during a one-week period to make this a usable question. On average 1.75 cords of wood are burned in woodstoves, in the U.S., per year, if the wood is burned over a four-month period that would be about 1/10 of a cord per week. Homeowners cannot be expected to estimate 10ths of a cord use accurately. A better question would be:

> How much wood do you burn in an average winter? ____cords

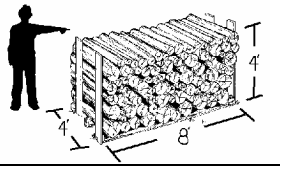
Remember to add some definitions of wood use units; drawings will help with the explanation.

The following page is from a residential wood burning survey questionnaire provided by Environment Canada; it is a good example of explaining wood use units.

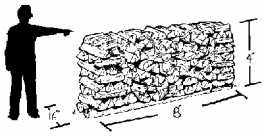
ESTIMATING HOW MUCH FIREWOOD YOU USE

Firewood quantities are sometimes difficult to estimate. The official measurement of firewood is a "cord". To help you make an accurate estimate, some other units of firewood measurement are compared to the full cord below.

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

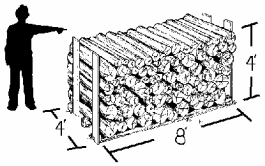


A **face** cord of wood is four feet high by eight feet long and is as wide as the individual firewood pieces, but averages 16 inches wide. A 16-inch wide **face** cord is equal to one-third of a **full** cord.



Face cord (16")

x times 3 three = equals

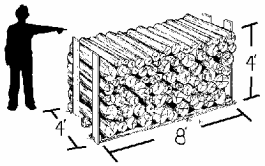


One full cord

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.

Full-size pick-up truck (8')

x times 2 two = equals

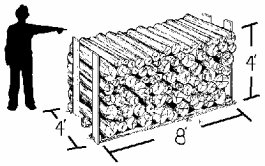


One full cord

Four compact pick-up truck loads (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.

Compact pick-up truck (6')

x times 4 four = equals



One full cord

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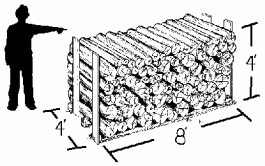
64 bags or bundles of firewood that measure about one foot by one foot by two feet (1' x 1' x 2') equal **one full cord**.

Bag or bundle
(1' x 1' x 2')

x times 64 sixty four = equals



One full cord

The following is an example survey designed to be a telephone interview:

Survey Questionnaire

Part 1 Introduction

Surveyor's Name_____ Date_____ Contact Phone Number_____

No answer, hang-up or refuse to participate _____

Household or Business? _____, terminate if business

Key points to discuss with potential interviewee:

Surveying home heating practices for air quality research

Not a sales call, research only

All information confidential

Would like to speak with person most familiar with home heating practices

If the interviewee is not sure of an answer request that they make their best guess or estimate

If the interviewee is willing to participate, assign a home code ID number_____

Part 2 Household Questions

1. Type of Household *(circle one*)

house
duplex or triplex
townhouse, apartment, or condominium (4 or more units)
mobile home

2. Tenure *(circle one)*

owner
renter

3. Age of housing unit *(circle one)*

1939 or before
1940 to 1949
1950 to 1959
1960 to 1969
1970 to 1979
1980 to 1989
1990 to 1994
1995 or after

4. Value of Residence *(circle one)*

less than $ 50,000
$ 50,001 - $ 100,000
$ 100,001 - $ 200,000
$ 200,001 - $ 300,000
$ 300,001 - $ 400, 000
$ 400,001 - $ 500,000
greater than $500,001

5. Zip Code _____ *(This is to allow for the determination of urban/rural status, i.e., rural, town, city, or suburban)*

Part 3 General Questions

1. Do you have a wood burning appliance (e.g., a fireplace, a woodstove, or a fireplace insert) in your home? Y/N *(It is very important to ask this question and record the answer even if the home occupant reports that they don't have a wood burning device since the determination of the fraction of homes having a wood burning device is one of the key objectives of the survey.)*

2. Do you have a wood burning-fireplace? Y/N How many? ___ *Fill out a part 4 for each fireplace.*

3. Do you have a woodstove? Y/N How many?____ *Fill out a part 5 for each woodstove.*

4. Do you have a woodstove-like fireplace insert? Y/N How many? _____*(Fill out a part 6 for each fireplace insert. Explain that a fireplace insert is really a type of woodstove designed to fit into an existing fireplace cavity. It is not a fireplace that is built-in or simply inserted in the wall nor is it a fireplace with a simple heat circulating device. Be careful not to double count a fireplace insert as both a fireplace and a fireplace insert, i.e., a home needs a fireplace to install a fireplace insert but don't count it as a fireplace if it is counted as a fireplace insert.)*

5. Do you have any other wood burning appliances in your home? Y/N If so, what kinds?_____*(Likely responses may include: pellet stove, furnace, boiler, cook stove or masonry heater. Do not bring up the term masonry heater as there are very few installed in homes and the home occupant may confuse masonry fireplaces, which are very common, with them. However, if the home occupant volunteers the term "masonry heater" without prompting and it is not already listed as a fireplace, record it. Because the overwhelming majority of wood is burned in fireplaces, woodstoves and fireplace inserts, no further questions will be asked for the "other" wood burning devices.)*

6. Do you have a gas burning fireplace? Y/N How Many?_____*(Many wood burning fireplaces have been converted to gas burning units and many new homes have them directly installed in lieu of a wood burning one. By asking this questions it helps insure that they home occupant is not getting a gas- fired unit confused with a wood burning one.)*

Part 4 Wood burning Fireplace Questions

1. Did you use your wood burning fireplace during the last 12 months? Y/N

2. How much wood fuel (not counting artificial fireplace logs) did you use? *(Review the wood use options listed below and allow the home occupant to use the units that they choose. The average weight of a cord on a dry basis is 1.163 tons.)*

_____ number of full cords *(stack of wood 4 ft X 4 ft X 8 ft = 128 cubic feet)*

_____ number of face cords or "fireplace" cords *(stack of wood 2 ft X 4 ft X 8 f = 64 cubic feet = ½ of a full cord)*

_____ number of pick-up truck loads *(average pick-up truck load = 0.35 full cords)*

_____number of bundles of wood *(usually bought at a grocery store, typically 1 ft X 1 ft X 2 ft or 1/64 of a full cord)*

3. Did you use artificial fireplace logs? Y/N How many did you use during the last 12 months? _____ *(Provide some common manufacturing names (e.g., Duraflame, Pine Mountain, and Hearthlogg) to the interviewee to help them understand the term artificial fireplace logs. Artificial fireplace logs range in weight from 2.5 lbs. to 6 lbs. The weighted average value based on national sales estimates is 4.95 lbs.)*

4. How many times did you have a fire using wood fuel (not counting artificial fireplace logs) in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

5. How many times did you have a fire using artificial fireplace logs in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

6. When you had a fire using wood fuel (not counting artificial fireplace logs), how long did the fire last?_____hrs. *(Note weekday fires are generally shorter in duration than weekend or holiday fires since weekday fires are often only in the evening. Work with the interviewee to come up with a reasonable weighted average fire duration. For post-survey data reduction it is worth noting that the national average fireplace burn rate is 5.6 dry kg/hr with a standard deviation of 3.2, this corresponds to 6.72 kg/hr with a standard deviation of 3.8 for typical firewood with a 20% moisture content.)*

7. When you had a fire using wood fuel (not counting artificial fireplace logs), how many pieces of wood did you on the average use? _____ *(It is estimated, that on the average, 444 typical- sized wood pieces make up a cord.)*

8. When you had a fire using artificial fireplace logs, how long did the fire last?_____hrs. *(Small (2.5 lbs. to 3.2 lbs.) artificial fireplace logs are designed to last about 2 hrs or less. Large (5 lbs. to 6 lbs.) artificial fireplace logs are designed to last about 4 hours or less.)*

9. When you had a fire using artificial fireplace logs how many logs did you use on the average? _____ *(The weighted average artificial fireplace log weight is 4.95 lbs.)*

10. Is your fireplace a masonry fireplace (stone, brick, concrete) or a metal factory manufactured fireplace?_____ *(Note: a masonry fireplace may have a metal frame and a metal factory manufactured fireplace may be built into the wall or free standing.)*

11. Does your fireplace have a solid glass or metal door? Y/N *(Don't count screen doors)*

Part 5 Woodstove Questions

1. Did you use your woodstove during the last 12 months? Y/N

2. How much wood fuel did you use? *(Review the wood use options listed below and allow the home occupant to use the units that they choose. The average weight of a cord of wood on a dry basis is 1.163 tons. Artificial compressed sawdust logs are also used in woodstoves. They are generally sold by the 3, 6 or 9 log packs or by the pallet. Two major name brands that could be used to familiarize the interviewee with what is meant by artificial compressed sawdust logs are "Pres-to-Logs" and "High Energy Firelogs". These are different than the individually wrapped artificial wax/sawdust fireplace logs discussed in the fireplace section although some compressed sawdust logs are burned in fireplaces, albeit the number is small as compared to the individually wrapped wax/sawdust logs.*

_____ number of full cords *(stack of wood 4 ft X 4 ft X 8 ft = 128 cubic feet)*

_____ number of face cords or "fireplace" cords *(stack of wood 2 ft X 4 ft X 8 ft=64 cubic feet = ½ of a full cord)*

_____ number of pick-up truck loads *(average pick-up truck load = 0.35 full cords)*

_____number of bundles of wood *(usually bought at a grocery store, typically 1 ft X 1 ft X 2 ft or 1/64 of a full cord)*

_____number of artificial compressed sawdust logs *(typical logs weigh 5 lbs.)*

_____ number of pallets of compressed sawdust logs *(A typical pallet contains about 400 logs and weighs 2000 lbs.)*

3. How many times did you have a fire using real wood in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

4. How many times did you have a fire using artificial compressed logs in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

5. How many pieces of real wood did you on the average use for each fire? _____ *(It is estimated, that on the average, 444 typical-sized wood pieces make up a cord.)*

6. How many pieces of artificial compressed sawdust logs did you on the average use for each fire?_____*(Compressed sawdust logs typically weigh 5 lbs. per log.)*

7. How old is the woodstove? _____ Was it purchased after July 1990? Y/N *(Ask the interviewee to make their best guess if they don't know for sure. If it was purchased after July 1990 it is probably an EPA certified stove.)*

8. Is it a catalytic stove? Y/N *(If the interviewee doesn't know if it is a catalytic stove, it probably isn't and record it as no.)*

8. What is the brand and model of the stove_____ *(If the interviewee doesn't know ask them to take a minute to look.)*

9. Is the woodstove your primary source of heat or a supplemental source of heat?_____

Part 6 Fireplace Insert Questions

1. Did you use your wood burning fireplace insert during the last 12 months? Y/N

2. How much wood fuel did you use? *(Review the wood use options listed below and allow the home occupant to use the units that they choose. The average weight of a cord of wood on a dry basis is 1.163 tons. Artificial compressed sawdust logs are also used in inserts. They are generally sold by the 3, 6 or 9 log packs or by the pallet. Two major name brands that could be used to familiarize the interviewee with what is meant by artificial compressed sawdust logs are "Pres-to-Logs" and "High Energy Firelogs". These are different than the individually wrapped artificial wax/sawdust fir place logs discussed in the fireplace section although some compressed sawdust logs are burned in fireplaces, albeit the number is small as compared to the individually wrapped wax/sawdust logs.*

_____ number of full cords *(stack of wood 4 ft X 4 ft X 8 ft = 128 cubic feet)*

_____ number of face cords or "fireplace" cords *(stack of wood 2 ft X 4 ft X 8 ft= 64 cubic feet = ½ of a full cord)*

_____ number of pick-up truck loads *(average pick-up truck load = 0.35 full cords)*

_____number of bundles of wood *(usually bought at a grocery store, typically 1 ft X 1 ft X 2 ft or 1/64 of a full cord)*

_____number of artificial compressed sawdust logs *(typical logs weigh 5 lbs.)*

_____ number of pallets of compressed sawdust logs *(A typical pallet contains about 400 logs and weighs 2000 lbs.)*

3. How many times did you have a fire using real wood in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

4. How many times did you have a fire using artificial compressed logs in the following months?

___Jan.
___Feb.
___March
___April
___May
___June
___July
___Aug.
___Sept.
___Oct.
___Nov.
___Dec.

5. How many pieces of real wood did you on the average use for each fire? _____ *(It is estimated, that on the average, 444 typical-sized wood pieces make up a cord.)*

6. How many pieces of artificial compressed sawdust logs did you on the average use for each fire?_____*(Compressed sawdust logs typically weigh 5 lbs. per log.)*

7. How old is the insert?_____ Was it purchased after July 1990? Y/N *(Ask the interviewee to make their best guess if they don't know for sure. If it was purchased after July 1990 it is probably an EPA certified stove.)*

8. Is it a catalytic insert? Y/N *(If the interviewee doesn't know if it is a catalytic insert, it probably isn't and record it as no.)*

9. What is the brand and model of the insert_____ *(If the interviewee doesn't know ask them to take a minute to look.)*

10. Is the insert your primary source of heat or a supplemental source of heat?_____

11. Do you have a gas-fired fireplace insert? Y/N