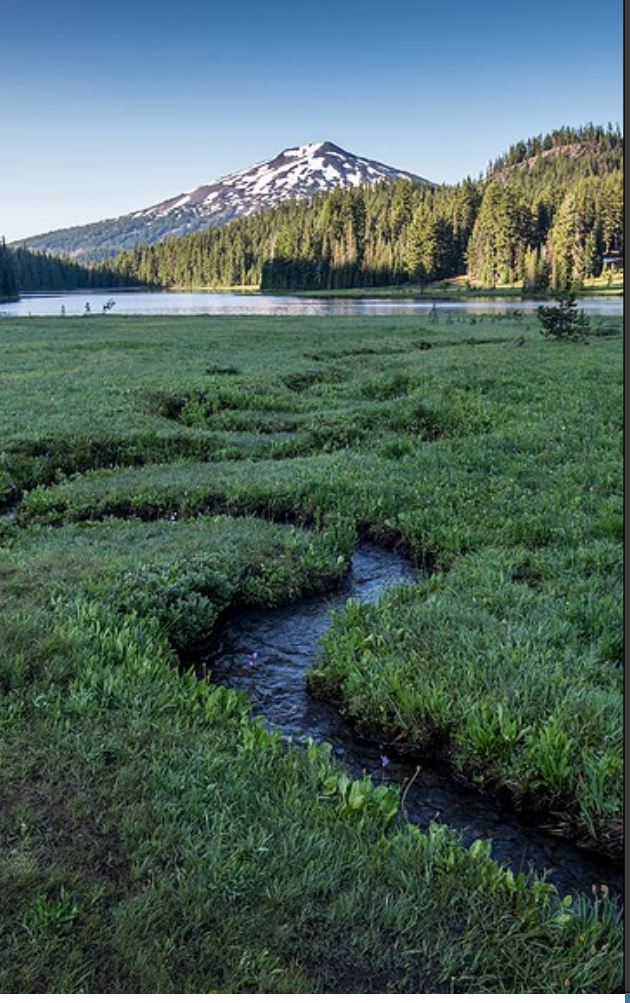

2020 Residential Wood Combustion Emission Inventory

Submitted to: Jeffery Stocum
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State of Oregon
DEQ Department of Environmental Quality

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Table of Contents

Executive Summary

The Oregon Department of Environmental Quality develops a comprehensive, statewide emissions inventory of air pollutants every three years and submits the data to the US Environmental Protection Agency as a part of the National Emission Inventory. This report summarizes emissions from the Residential Wood Combustion component of Oregon's 2020 NEI submittal. The NEI is based primarily on data provided by state, local and tribal air agencies and supplemented by data developed by the EPA.

RWC is the Sector of the NEI that includes emissions estimates from residential wood burning in all appliances (fireplaces, woodstoves, boilers, outdoor fire pits, etc.), including the burning of wood pellets and firelogs.

The preferred methodology for developing a State's RWC submission for the NEI is to conduct a local survey to determine number of appliances and fuel use. In the absence of local data, there are guidance documents and an emissions estimating database provided by the EPA. The 2020 Oregon RWC emissions inventory was developed using the results of a statewide survey and EPA wood density factors. The number of housing units, appliance use and fuel use was entered into templates provided by the EPA and the calculations were done using the Wagon Wheel database, also provided by the EPA.

1. Methodology

To develop an emissions inventory for Residential Wood Combustion, the EPA's preferred methodology is that states determine county level activity from local survey data. The Oregon emissions inventory for RWC, for the 2020 National Emission Inventory, is based on the "2021 Oregon Residential Wood Combustion Survey" conducted by the Center for Marketing & Consumer Insight at Oregon State University.

The number of appliances in use and amount of fuel combusted was estimated using the survey results and housing unit demographics on a US Census Block Group level. County level data was derived by summing the Block Groups in each county. Emissions were calculated by importing the county activity data into the EPA's Wagon Wheel database. Figure 1 shows a flow chart of the general methodology and data sources.

Figure 1. RWC NEI Flow Chart

US Census Block Groups are geographic areas with between 600 and 3000 people. Oregon is divided into 2,634 Block Groups (this is going to change due to the 2020 US Census work that is ongoing). The Block Groups range in size from 12 acres (very high population density) to 4.8 million acres (very low population density). Each housing unit was designated as urban, suburban or rural based on the population density of their Census Block Group. For this inventory, Block Groups that have greater than 3000 people per square mile were designated as urban. Block Groups with population density between 1000 and 3000 people per square mile were designated as suburban. And Block Groups that have less than 1000 people per square mile were designated as rural. Figure 2 visually shows the Block Group population density.

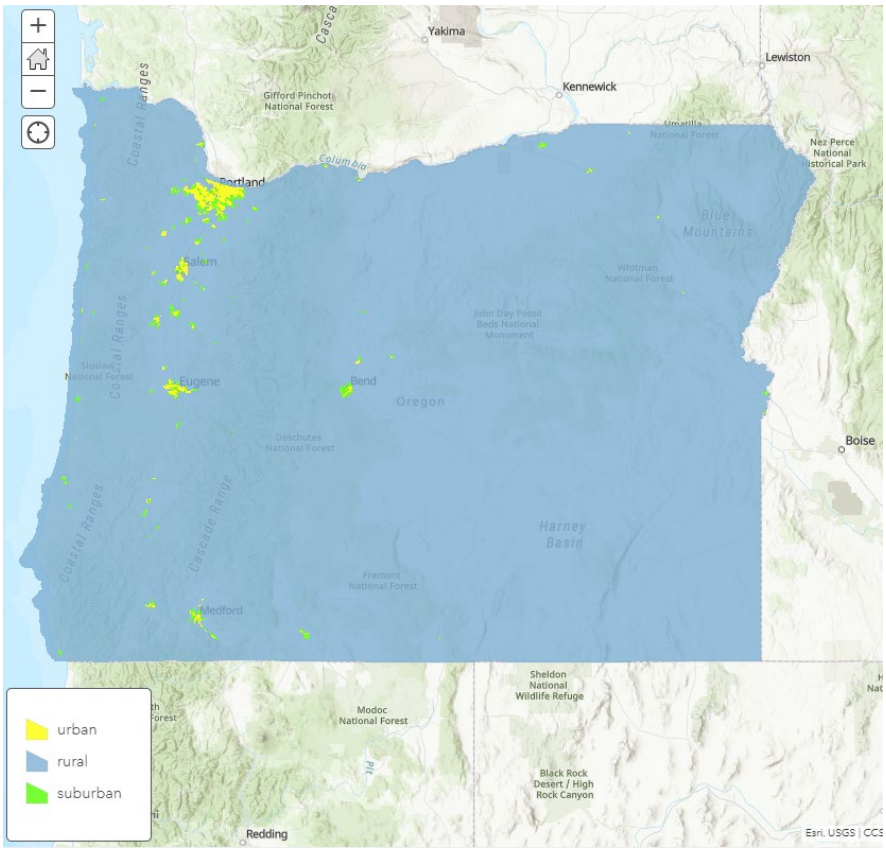

Figure 2. Block Group Population Density

Invitations to respond to the online survey were sent to established DEQ e-mail lists, purchased e-mail lists and homeowner's groups across the state to survey as many people as possible.

The survey yielded a total of 2,921 questionnaires that met criteria for analysis. Responses represented every county except Grant County (which represents 0.2% of Oregon's population). Multnomah County was overrepresented by about 7% (26% of total responses, 19% of population). However, the Portland Metro area as a whole, was only slightly overrepresented by about 3% (49% of responses, 46% of population). There was good representation of households on the east (11% of responses, 13% of Oregon's population) vs west (89% of responses, 87% of population) sides of the Cascade Mountains. Even if a survey response was deemed complete enough to be used for the analysis, many responses did not answer every question.

1.1 Housing Units

To generate a statewide emissions inventory, the number of housing units in the state must first be established. The number of housing units in each US Census Block Group for this inventory originated from the 2019 American Communities Survey, Table B25024. This 2019 data was adjusted for population change from 2019 to 2020 based on Portland State University's Population Research Center's 2020 Annual Population Report Tables, Revised 4/15/2021. This adjusted data was further refined by reducing the total number of housing units to only occupied housing units by applying vacancy rates from the US Census Table H1. The result was the total number of occupied housing units in each block group for the year 2020. Table 1 shows the occupied housing units by county used in the 2020 NEI calculation.

Since the 2017 NEI (the NEI is prepared every three years) there was an increase of over 19,000 housing units and a population gain of 127,000 people.

Table 1. 2020 Oregon Regional Occupied Housing Unit (HU) Estimates

County	Population	Occupied HU
Baker	16,910	7,591
Benton	94,665	35,930
Clackamas	426,515	158,834
Clatsop	39,455	17,153
Columbia	53,280	20,299
Coos	63,315	27,449
Crook	23,440	9,648
Curry	23,005	10,896
Deschutes	197,015	77,191
Douglas	112,530	46,446
Gilliam	1,990	894
Grant	7,315	3,515
Harney	7,280	3,304
Hood River	25,640	8,832
Jackson	223,240	90,498
Jefferson	24,105	8,641
Josephine	86,560	36,274
Klamath	68,075	29,306
Lake	8,075	3,637
Lane	381,365	154,193
Lincoln	48,305	22,345
Linn	127,320	48,205
Malheur	32,105	10,777
Marion	349,120	120,834
Morrow	12,825	4,186
Multnomah	829,560	329,638
Polk	83,805	30,815
Sherman	1,795	838
Tillamook	26,530	11,791
Umatilla	81,495	27,940
Union	26,840	10,946
Wallowa	7,160	3,294
Wasco	27,295	10,294
Washington	620,080	221,902
Wheeler	1,440	712
Yamhill	108,605	37,199
TOTAL	**4,268,055**	**1,642,248**

The housing unit data for this inventory was separated into two categories: detached, single residence and all others, including duplexes, multiplexes, condominium, etc. The division was made because it is widely accepted that household's burning activity is highly dependent on the type of housing unit. The American Community Survey data provided the structure type and showed the state's housing units were made up of 1,039,000 detached, single residences and 603,600 other housing types (or 63% DSR).

To make sure survey responses represented the whole state, housing units were designated as eastern or western based on their county's location in Eastern or Western Oregon. The Cascade Mountain range splits the state of Oregon, each side has differing topography and meteorology, as well as cultural and socio-economics. Figure 3 shows a map of how counties were designated as on the east or west side of the state. In 2020 there were 212,700 households (13%) on the eastern side and 1,430,000 households (87%) on the western side of the state. The survey response rates of 11% from the eastside and 89% from the westside represented the split well.

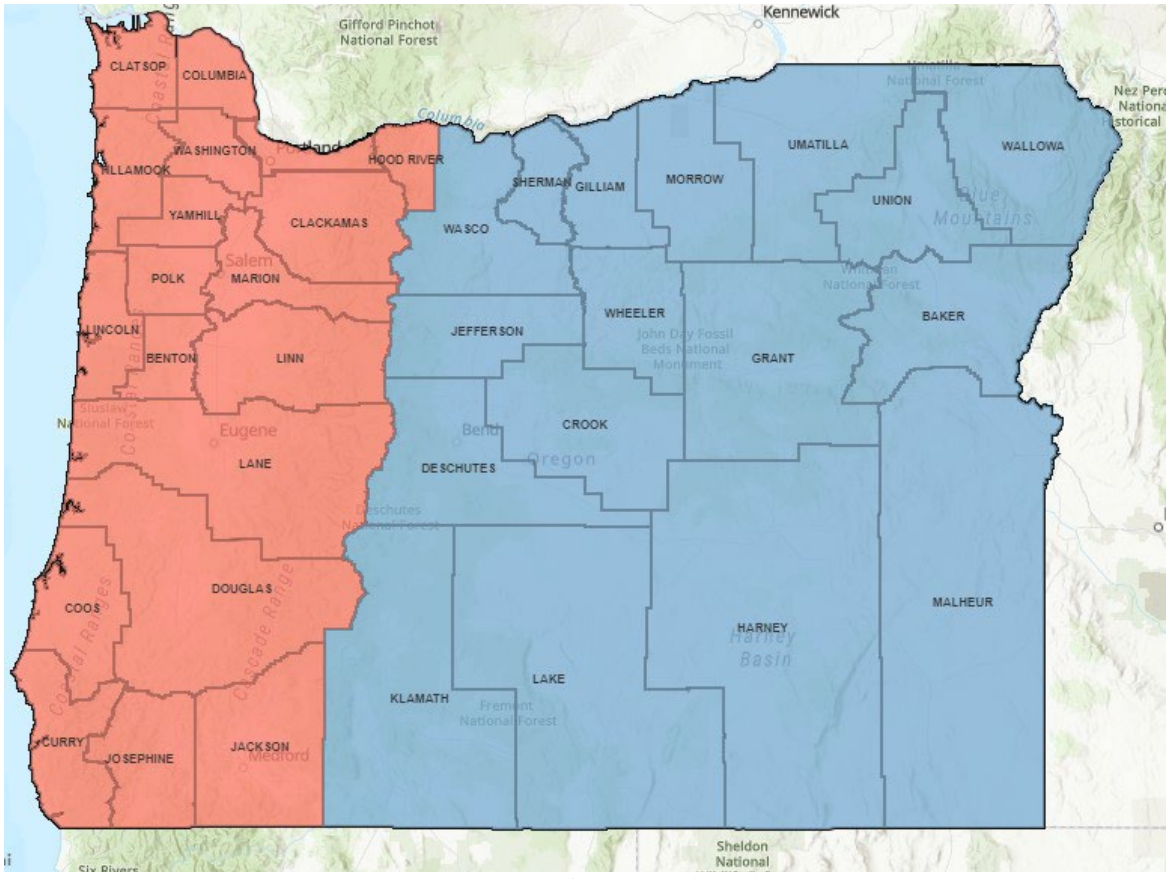

Figure 3. East/West Designation

The designation of housing unit demographics by Block Group improves the emissions inventory when the survey data (roughly 2900 questionnaires) are applied over a large population. Table 2 shows the details of housing unit designations in Oregon used for this inventory.

Table 2. 2020 Oregon HU Structure Type Demographics

HU Demographics	SumOf#HU	%HU
Rural/DSR	376,798	23%
Rural/OTHER	133,845	8.2%
Suburban/DSR	170,920	10%
Suburban/OTHER	93,339	5.7%
Urban/DSR	490,902	30%
Urban/OTHER	376,443	23%
Total	1,642,248	100.0%

1.2 Appliance Profile

The 2021 OSU survey results generated an appliance profile (the percentages of each appliance type that are used in Oregon homes) for each of the housing unit demographic categories. Table 3 lists the appliance types, and the corresponding Source Classification Code (SCC), covered by this emissions inventory. The EPA's Wagon Wheel database is set up to accept the appliance profiles as general categories, and then for each category provide further detail breakdown on a separate table. For example, the calculation asks for percent of housing units that have woodstoves. On a secondary table the woodstove appliance category is divided into non-certified, certified catalytic, and certified non-catalytic stoves. Results are shown in Table 4. These results were used statewide, based on the demographics of the housing unit described in the previous Section.

Table 3. SCCs and Appliances

SCC	Appliance
21-04-008-100	Fireplace
21-04-008-210	Insert Not Certified
21-04-008-220	Insert Certified NonCatalytic
21-04-008-230	Insert Certified Catalytic
21-04-008-310	Woodstove Not Certified
21-04-008-320	Woodstove Certified NonCatalytic
21-04-008-330	Woodstove Certified Catalytic
21-04-008-400	Pellet Stove
21-04-008-510	Central Furnace
21-04-008-530	Furnace Pellet-fired
21-04-008-610	Outdoor Boiler
21-04-008-620	Indoor Boiler
21-04-008-630	Boiler Pellet-fired
21-04-008-700	Outdoor Fire-pit
21-04-009-000	Residential Firelog Total: All Combustor Types

Table 4. Appliance Profile by HU Demographics

Density Designation	Structure Type	Fireplace	Insert	Woodstove	Central Heater	Pellet	Wax Log	Outdoor Recreational
Rural	DSR	3.5	5.8	16	0.50	2.27	0.50	32
Rural	Other	1.7	1.0	7.9	0.69	0.00	3.8	27
Suburban	DSR	6.0	5.2	4.9	0.31	0.47	2.7	31
Suburban	Other	2.8	0.57	2.3	0.00	0.00	0.85	13
Urban	DSR	2.6	1.8	2.0	0.39	0.26	1.4	42
Urban	Other	1.7	0.62	0.41	0.62	0.21	0.62	19

From the survey data, fireplace inserts and woodstoves were determined to be 33% non-certified, 33% certified, non-catalytic, and 34% certified, catalytic. The central heater column of Table 4 was further described as 73% of all central heaters to be indoor furnaces and 23% of them as outdoor boiler heaters.

Outdoor, recreational appliances were reduced by 6% to account for unclear questionnaire wording. The survey asked if the respondent had an outdoor, recreational appliance. The question should have asked if the household used the appliance. The survey design was very deliberate when asking about fireplaces and woodstoves to differentiate ownership of an appliance and use of an appliance. The 6% is based on the number of people who said they had vs used all other appliance types. The survey also did not attempt to capture the type of outdoor appliance. It is unknown if households have a rock ring/campfire, chiminea, burn barrel or some other outdoor fireplace. The emissions are potentially vastly different from these different appliances. Future surveys will be designed to collect this data.

1.3 Activity

Activity, in the form of amount fuel burned per year, was calculated based on the results of the 2021 OSU survey and attributed to wood burning households throughout Oregon. For the emissions calculations, wood density was used as provided in the EPA's Wagon Wheel database.

Table 5 shows activity survey results in cords per year. Activity was extrapolated from the survey to Block Groups based only on appliance type and the urban, suburban rural designation. East or west and housing unit structure type was not further divided because there were too many null (empty, not zero) responses for the survey question regarding the amount of wood used in the last year.

Table 5. Wood Used by Appliance, Cords/year

Density Designation		Fireplace	Insert	Woodstove	Central Heater	Pellet, ton/yr	Wax Log, ton/yr	Outdoor Recreational
Rural		2.6	1.9	2.5	5.0	2.2	0.016	1.2
Suburban		1.5	2.5	2.8	5.0	1.5	0.061	0.73
Urban		1.5	2.4	2.5	5.0	0.90	0.016	0.88

This is an example of how fuel use weighting was calculated: Multnomah County has 521 Census Block Groups. Based on population density, there were 21 Block Groups designated as rural (or 4%), there were 30 suburban block groups (or 6%) and 470 urban Block Groups (or 90%). The County's total wood use was weighted based on these density groups, for fireplaces in Multnomah County it would be as follows: (4% rural x 2.6 cords/yr) + (6% suburban x 1.5 cords/yr) + (90% urban x 1.5 cords/yr) = 1.54 cords/yr used in fireplaces for Multnomah County.

Table 6 shows the total estimated tons of fuel used for the last 7 NEI reports. Figure 4 shows the calculated fuel use by county for NEI reporting years from 2005 to 2020. For the mass calculation, firelogs were assumed to weigh 8 pounds each and pellets are assumed to be sold in 40-pound bags. Activity data from survey responses that reported over 10 cords per year were deemed unreasonable and not included.

Table 6. Tons of Wood Fuel by Year

Surveyed Appliances	
year	tons per year
2002	3,082,147
2005	1,550,941
2008	1,109,810
2011	1,173,686
2014	507,382
2017	545,454
2020	1,288,475

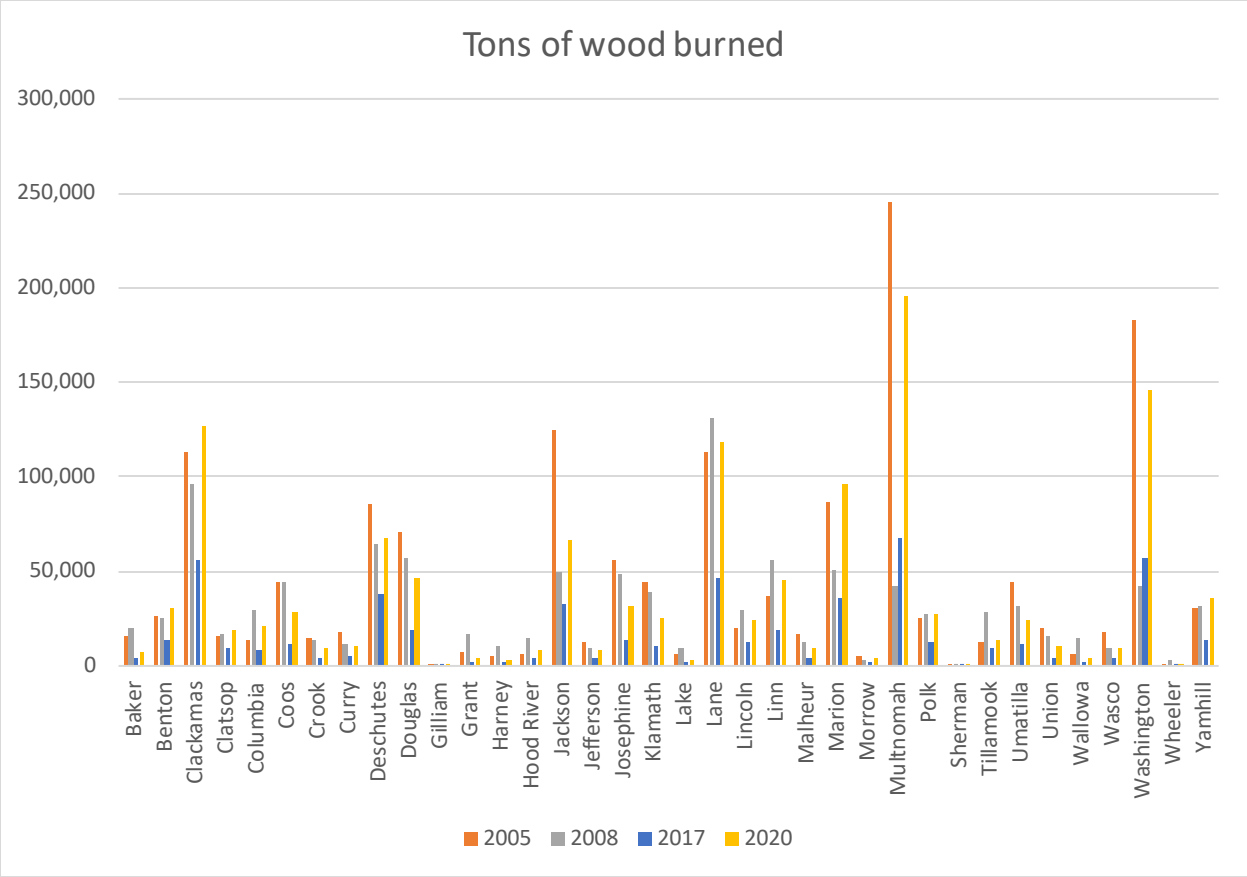

Figure 4. Mass of Wood Burned by County

1.4 Emission Factors

Emission factors used to calculate total emissions were provided in the EPA's Wagon Wheel database. Emissions are a calculation of total fuel burned in tons multiplied by the emission factors. Emission factors are specific for each appliance type (each SCC).

1.5 Calculations

A DEQ MS Access database was used to extrapolate the 2021 OSU survey data to create the input files for the EPA's Wagon Wheel database. The number of occupied housing unit, appliance profiles (percent of HU that use an appliance) and burn rate data, outlined in the previous sections of this report, were imported into the EPA's Wagon Wheel database. The Wagon Wheel database calculates emissions based on that imported data, wood density defaults and emission factors.

2. Results

2.1 2020 Residential Wood Combustion Emissions Inventory

Results in this summary are primarily shown as PM2.5, because of the health risk, but the full emissions inventory includes a complete list of pollutants. A full dataset can be found at: Oregon.gov/deq/aq/pages/ei-data.aspx. Figure 5 shows the total PM2.5 by appliance type for the 2020 and 2017 RWC NEI. Table 8 is a detailed summary of the PM2.5 and CO emissions. Figure 6 compares the RWC PM2.5 by county for the 2017 and 2020 NEI.

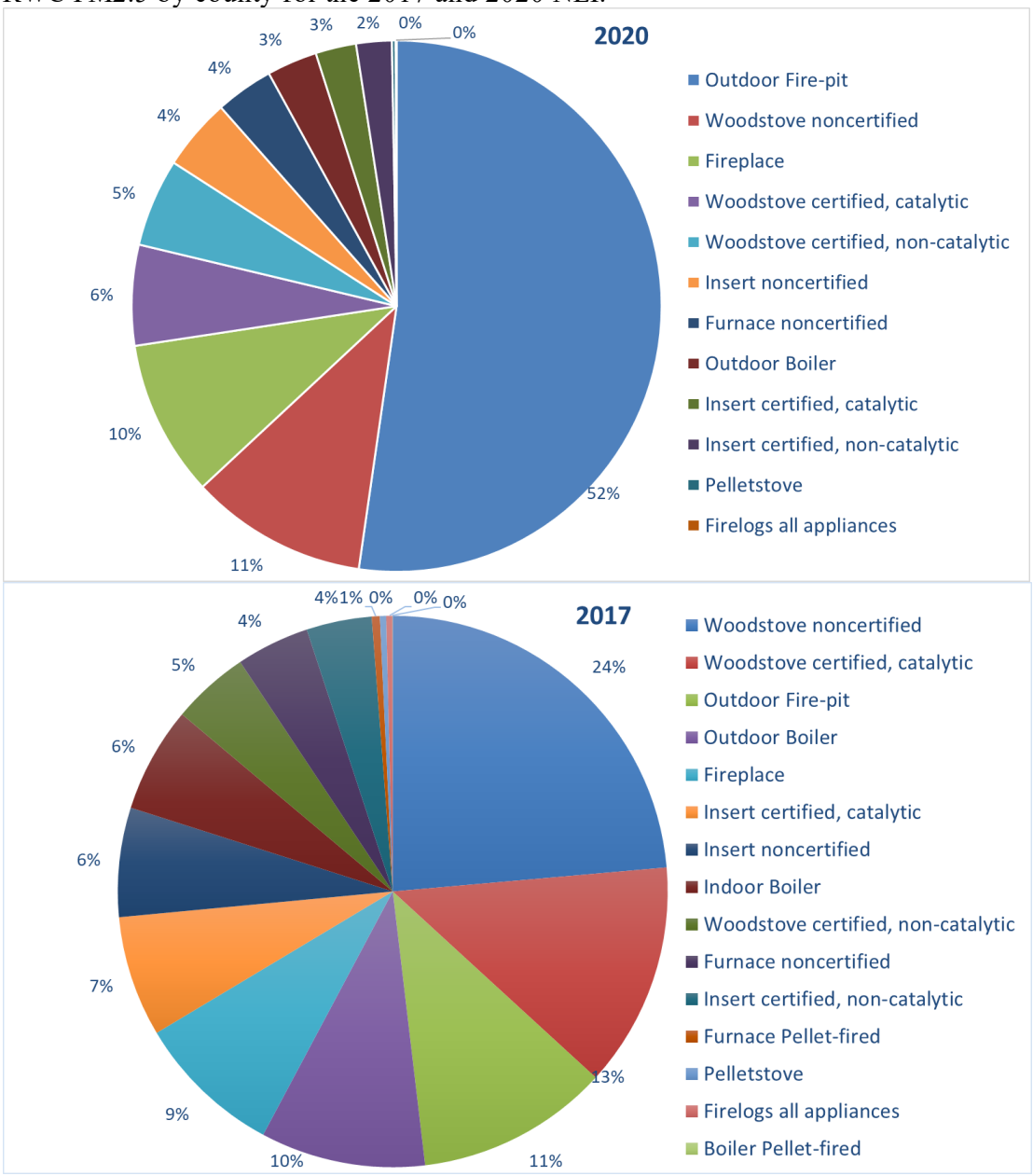

Figure 5. PM2.5 by Appliance Type

TABLE 7. PM2.5 and CO Emissions Details

Appliance Type		CO tons		PM2.5 tons
Fireplace		**8,853**		**1,402**
Certified Woodstoves/Inserts		**15,904**		**2,286**
Insert certified, non-catalytic	2,583		308	
Insert certified, catalytic	2,003		352	
Woodstove certified, non-catalytic	6,374		759	
Woodstove certified, catalytic	4,944		868	
Noncertified Woodstoves/Inserts		**16,862**		**2,236**
Insert noncertified	4,862		645	
Woodstove noncertified	12,000		1591	
Pelletstove		**173**		**33**
Furnaces		**3,471**		**521**
Furnace noncertified	3,471		521	
Furnace Pellet-fired	-		0	
Boiler/Hydronic		**2,546**		**453**
Outdoor Boiler	2,546		453	
Indoor Boiler	-		0	
Boiler Pellet-fired	-		0	
Outdoor Fire-pit		**48,622**		**7,701**
Firelogs all appliances		**37**		**8**
Total		**96,468**		**14,640**

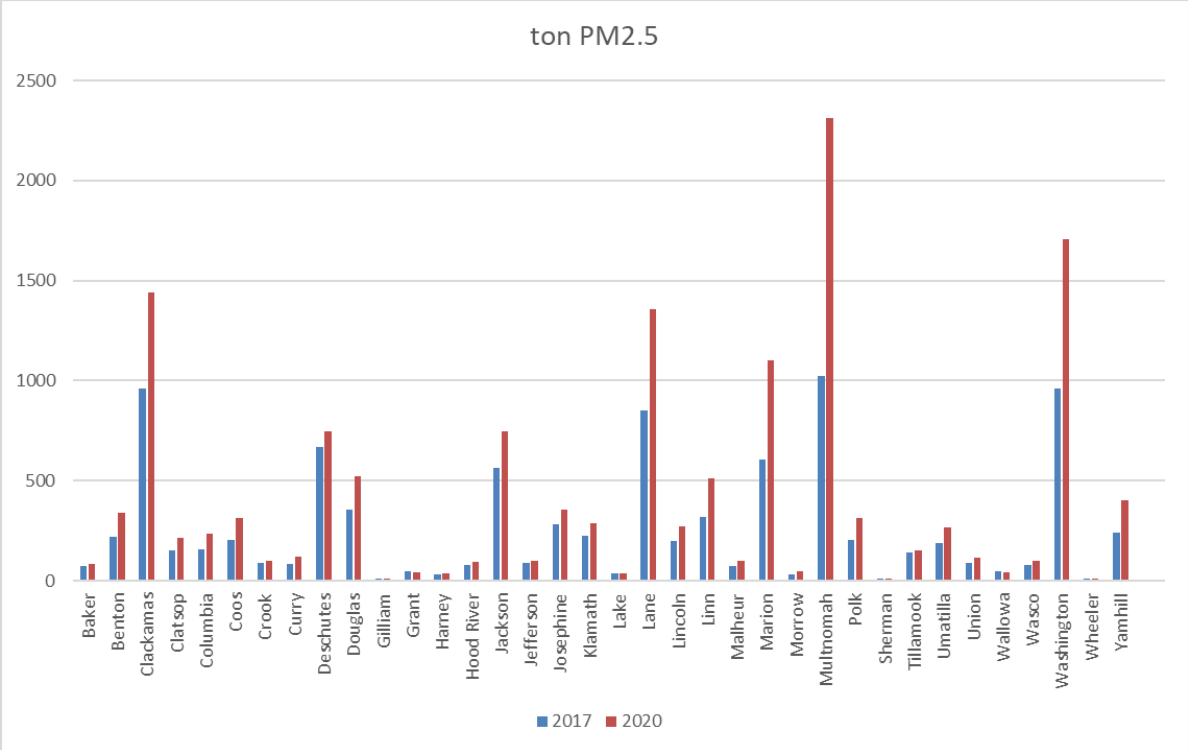

Figure 6. County Level PM2.5 emissions

2.2 Range Check: State Survey vs. EPA's Tool

Running the EPA's Wagon Wheel database without the data derived from the 2021 OSU survey, the total tons of PM2.5 would be 18,439-ton PM2.5, or 26% more than the calculation with Oregon specific data. One of the largest overestimates in the EPA default data is the use of the central heater appliance category. In 2014 the old EPA "Tool" calculated emissions based on national defaults to be 47% of what was calculated with Oregon data (2014 NEI was based on the PATS RWC survey). The old "Tool" underestimated both activity and number of appliances.

2.3 Heating Degree Day Data Comparison

The 2021 OSU survey was conducted for the winter of 2020-2021, the previous two NEI submissions (2014 and 2017) were based on the PATS survey conducted for the winter of 2013-2014. A Heating Degree Day is a calculation based on a specific place's daily temperature to quantify the demand for energy needed to heat a building. It is the number of degrees that a day's average temperature is below a set point (usually 65° F), which is the temperature below which buildings are normally heated. HDD is a good way to compare the need for heating between specific years, in this case comparing the need to use RWC to heat a home based on different survey years. Table 8 shows a data summary for the Portland International Airport to compare the severity of the winter during the PATS vs OSU survey years. Additionally, the Redmond Airport data is shown to help show winter severity outside of the Portland Metro area. The data shows that the years in which surveys were completed are in the 'normal' range and should represent average weather years well.

TABLE 8. Heating Degree Days

		Portland Airport	Redmond Air Port
		HDD	HDD
PATS Survey	2013-2014	4312	6431
OSU Survey	2020-2021	3824	5686
Mean	1999-2021	4121	6465
St Dev	1999-2021	334	373

2.4 Historic Oregon Residential Wood Combustion NEI Data

Figure 7 is a graph of PM2.5 emissions inventories for Oregon's RWC from 2002 to present. The large drop in annual emissions after 2005 was due to methodology improvements.

The 2002 RWC NEI was based on 1993 and 2000 statewide surveys. Data was collected in 5 Oregon regions. The Emission inventory did not account for the fact that some owners of appliances did not use them, all appliances were attributed with the same wood use. This biased the results high.

The 2005 inventory was based on a reinterpretation of the 2000 survey data. Accounting for nonusers of appliances and correcting a calculation for wood density. Noted results in the 2005 summary were that there is a higher occurrence of woodstove use in Eastern Oregon and more fireplace use in northwest Oregon.

The 2008 inventory was based on a 2009 statewide survey. Better survey questions around wood and appliance use, as compared to 1993 and 2000 surveys, yielded better data. Methodology still used 5 regions. Summary confirms that the eastern region users burn more wood than Western Oregon users.

The 2011 inventory was also based on a 2009 statewide survey.

The 2014 and 2017 RWC inventories were based on the 2014 Portland Air Toxics Solutions RWC survey of the Portland metro three county area. The methodology changed and was based on defining household types in Block Groups and building up county data. The 2017 NEI included EPA supplemental data for the furnace, boiler and outdoor, recreational appliance types.

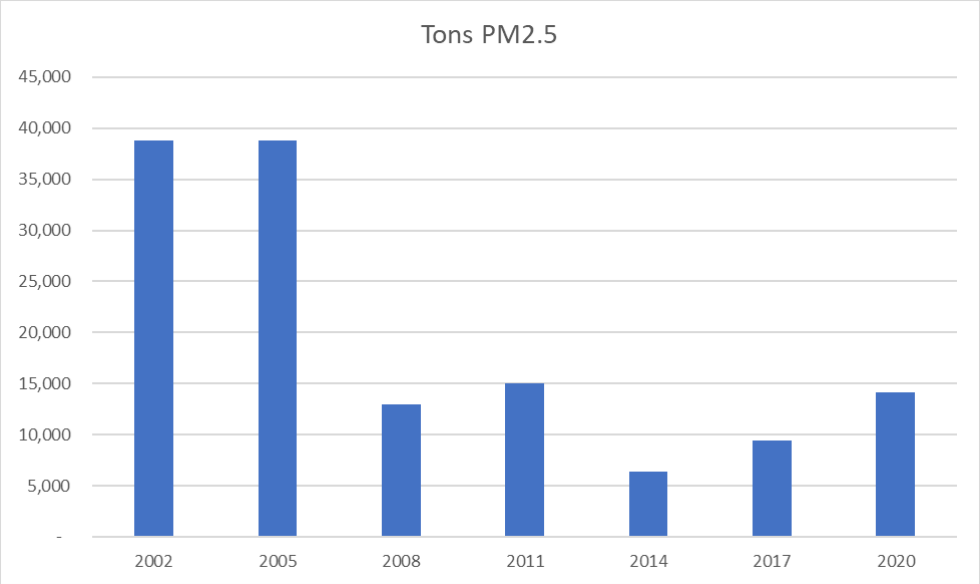

Figure 7. Historic PM2.5 tons by NEI Year

3 Comments and Recommendations

There were 2,921 responses used in the analysis. The survey responses did a good job of representing the whole state. There was good representation from both the east and west sides of Oregon (the only county that was not represented was Grant, but they represent only 0.2% of population). The survey utilized an online survey questionnaire, which was easy to execute and cost effective. However, this method biased the results due to the demographic of the type of person who would do (or not do) an online, voluntary survey. The overall affect is unknown, but indicators, such as east/west coverage indicate that the survey is valid.

Ways to improve the survey in the future would be to conduct a hybrid survey, where 80% of responses are voluntary, online and 20% are targeted to the demographics who are underrepresented. The first step would be to identify the groups or areas that are underrepresented. Set goals for each category or area and focusing the 20% on these groups or areas. This would require more resources (effort, cost, time).

A future survey tool could have improved logic that would preclude "unrealistic" data and require an answer/data before moving on. For example, a popup screen that explains how big a cord of wood is could open if someone enters 75 cords (which is not realistic). Other logic that would question if someone put in data that doesn't seem plausible. For example, a screen with appliance photos and descriptions could popup if a respondent indicates they have an outdoor boiler and an indoor furnace. Additionally, prompting respondents for missing data before they move on to the next section; the survey could highlight in red the questions not answered, with the option to enter a response or "prefer not to answer." The open text boxes are hard to utilize. Design future questions to avoid open text answers. Adding photos to more questions will make the questionnaire easier to use, for example a photo of what a cord of wood looks like. The questions on appliance type that used photos to click on were nice and that technique could be used for woodstoves being certified or non-certified, catalytic or not catalytic, amount of wood, type of house, etc. The wood species data did not record correctly and was not useable, the logic will need to be fixed for future surveys; EPA default data from the Wagon Wheel database was used. Logic that will not allow text in number boxes (and vice versa) would be a good improvement.

2020 was the first year of the Covid-19 lockdown and that certainly influenced many aspects of RWC and survey responses. Stove purchases, outdoor, recreational burning, gathering firewood, staying home, more heat during day, etc. all make 2020 a unique year.

Outdoor burning was the most significant change from past RWC emissions inventories. Two reasons that account for the increase are better survey questionnaire and Covid-19. The questionnaire used photos respondents could click on to signify that they had a similar appliance. Outdoor appliances were included instead of being a separate question, often at the end of the survey. As for the affect of Covid lockdowns, when John Crouch, of the HPBA, was asked about the state of the hearth industry on a 9/24/21 EPA Residential Wood Heat Zoom call, he commented "Over the last 2 years, many of our stores shut down due to the pandemic. But the consumers that stayed home and had jobs started spending money on their homes, on things like firepits." The conversation was not specifically about outdoor burning, so the unsolicited comment about that appliance group demonstrates that the manufactures have noted an increase in outdoor burning. Similarly, backyard fire pits and roasting marshmallows were featured on numerous national media ad campaigns in 2021-2022.

The EPA has changed some of the Wagon Wheel calculations since 2017. They have added a SEDS wood use adjustment (Oregon was not affected because actual survey data was used) and a 27% increase in wood density data is going to increase every state's emissions who uses the default data.