Bernalillo County Wood Burning Assessment

Dan Gates

City of Albuquerque, Environmental Health Department

Overview

- **Definitions**
- **What we know about wood burning**
  - Local impacts
  - Wood Burning Pollutants
  - Hazardous Air Pollutants
- **National Emission Inventory (NEI) Data**
  - Using the NEI to evaluate pollutants and pollution sources
- **Local Monitoring Data**
  - The Local Network
  - What do we see in the data?
- **Conclusion**
- **Potential next steps**
- **Open Discussion**

Definitions

- **What is Biomass?**
  - Biomass is fuel that is developed from organic materials. Some examples of biomass fuels are:
    - **scrap lumber;**
    - **forest debris;**
    - certain crops;
    - manure; and
    - some types of waste residues.

https://www.reenergyholdings.com/renewable-energy/what-is-biomass/

- **For this Assessment biomass includes burning:**
  - wood for heat, cooking or ambiance
  - trash and construction waste
  - yard waste such as leaves, branches

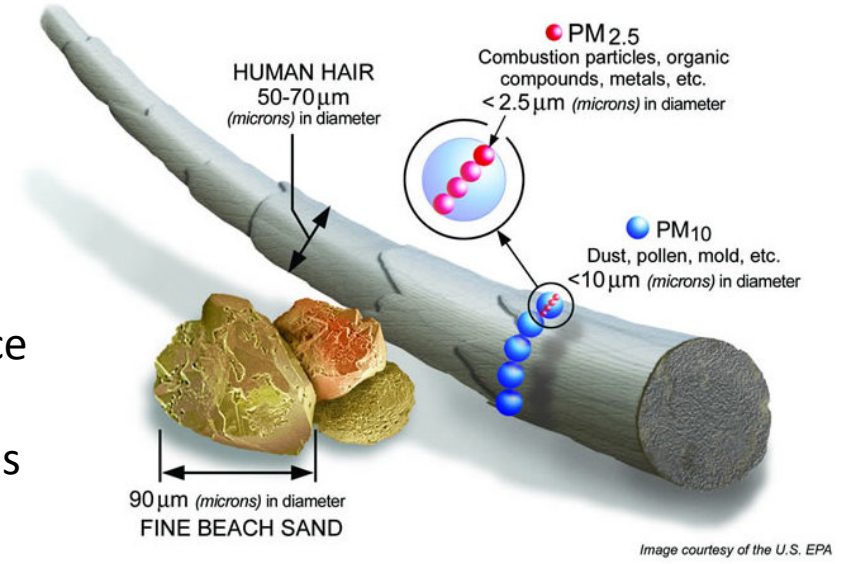


Image courtesy of the U.S. EPA

- **What is $PM_{2.5}$?**
  - $PM_{2.5}$ is particulate matter 2.5 microns and smaller

What we know about Wood Burning

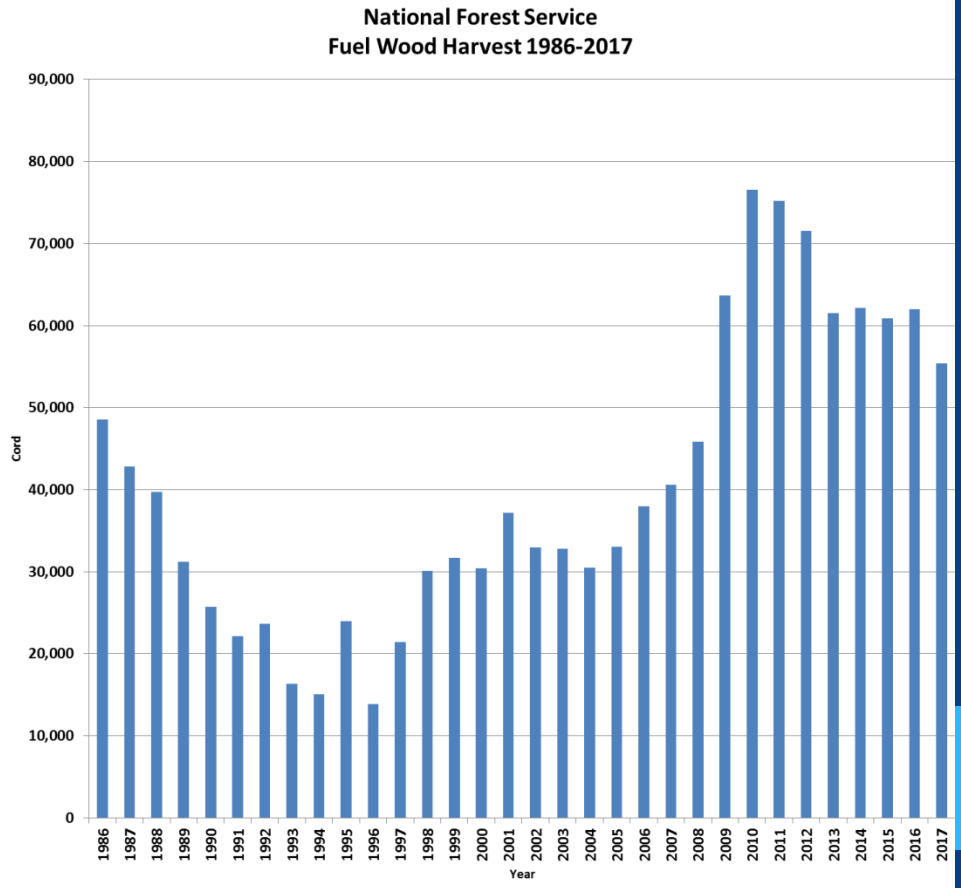
- **Wood burning impacts indoor air quality**
  - The NM Department of Health notes that "[d]uring the wintertime, residential wood smoke is the main source of fine particle pollution causing poor air quality inside the home." [1]
  - California ARB and EPA Study: ". . . Indicates that the indoor environment is not highly effective at reducing exposures to black carbon from residential wood smoke. . ."(page 93-94)[2]
- **Local data show increases in**
  - Pollutant values as the temperature decreases
    - Starts in October/November, Ends by April
  - Markers of biomass burning in the winter
    - Black Carbon (BC)
    - Potassium (K)
    - $PM_{2.5}$

1. NM Department of Health, What You Burn Matters: Minimize the Risk, January 23, 2014, https://nmhealth.org/news/safety/2014/1/?view=32
2. "Assessing Near-Field Exposures from Distributed Residential Wood Smoke Combustion Sources", California Air Resources Board and California Environmental Protection Agency, Tracy Thatcher, Stella Tan, Christopher Malejan, and Courtney Ward, Civil and Environmental Engineering California Polytechnic State University. Thomas Kirchstetter Environmental Energy Technologies Division Lawrence Berkeley National Laboratory, September 2011.

Human Activities

- Wood burning
  - In 1985, 35,000-40,000 cords of wood were burned in Albuquerque[1]
    - Based on average weight = 100,000,000 to 184,000,000 lbs/season in 1985.
    - In 1986, 197,198 cords of wood were harvested in New Mexico[2]
  - National Forest Service alone saw a 12.3% increase in fuelwood harvested from 1986 to 2017[2]

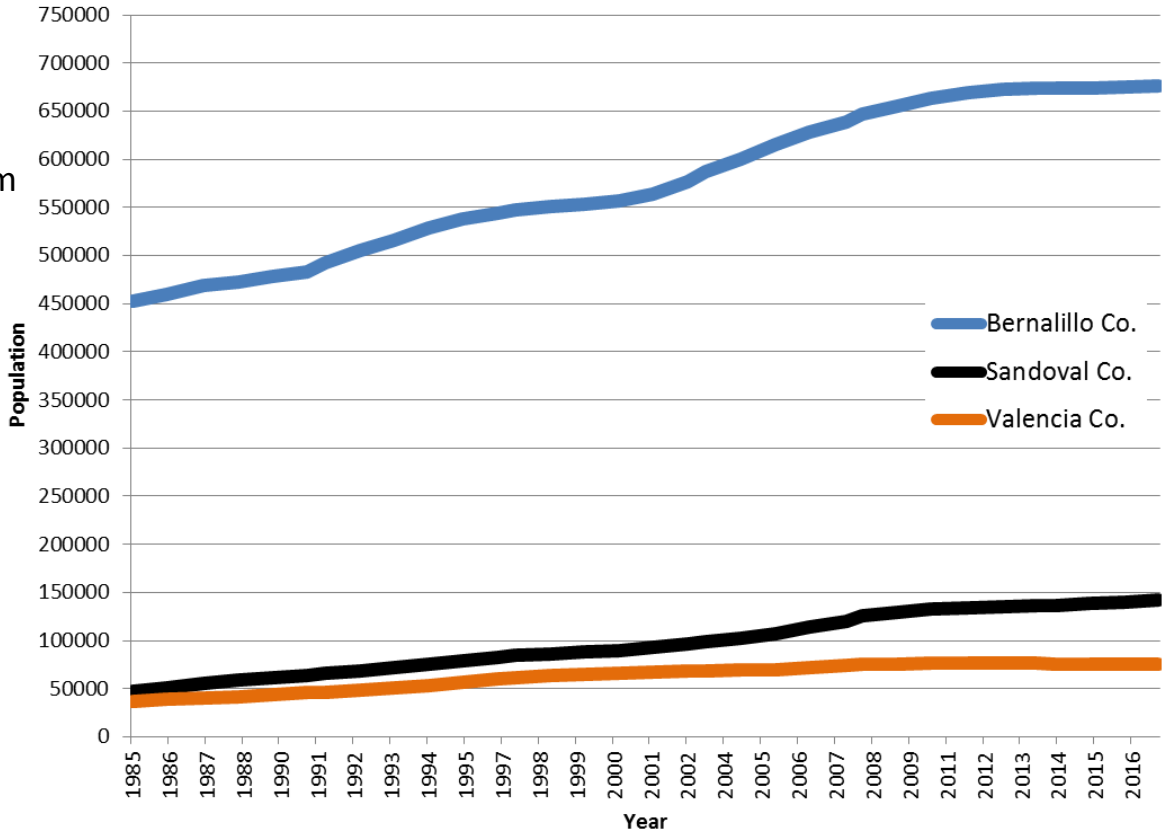
Total cord harvest calculated from New Mexico forests only, Cibola, Gila, Lincoln, and Santa Fe National Forests.



1. Residential Space Heating with Wood: Efficiency and Environmental Performance, Urban Consortium Energy Task Force, City of Albuquerque, Energy Management Division, December 1985.
2. New Mexico's 1986 Fuelwood Harvest., McLain, William H., United States Department of Agriculture Forest Service, Intermountain Research Station, April 1989, https://archive.org/stream/newmexicos1986fu60mcla#page/n3/mode/2up

Population Growth

- 1985-2017 Bernalillo County grew 49.5%, Sandoval County grew 203.8%, Valencia County grew 107.3%
- The three counties added 359,147 residents from 1985-2017[1], growing from 536,073 to 895,220
  - Commuting Time & Vehicle traffic
  - Transport
    - what's coming in from outside the county
  - Agricultural burning
  - Other?
  - If we use the Federal average the 3 Counties would have 86,836 wood burning households.[2]



1. https://factfinder.census.gov
2. https://www.eia.gov/todayinenergy/detail.php?id=15431

Wood Burning Pollution

- Molds* such as Thermoactinomyces vulgaris, Aspergillus fumigatus and Cladosporium herbarium
- 1993 EPA identified over 70 pollutants from wood burning[1]
  - **Trace elements including heavy metals such as chromium and lead**
  - **Polycyclic Aromatic Hydrocarbons (PAHs)**

(PAHs) are a group of more than 100 different chemicals that are released from burning coal, oil, gasoline, trash, tobacco, wood, or other organic substances such as charcoal-broiled meat. (https://toxtown.nlm.nih.gov)

- A Univ. of Stockholm, Sweden study found that ". . . wood-burning homes had . . . roughly 4 times the total PAH cancer potency, compared to non-wood-burning homes."[2]

* Interstitial Lung Disease and Domestic Wood Burning: Ramage, Roggli, bell and Piantadosi, AM REV RESPIR DIS 1988; 137:1229-1232

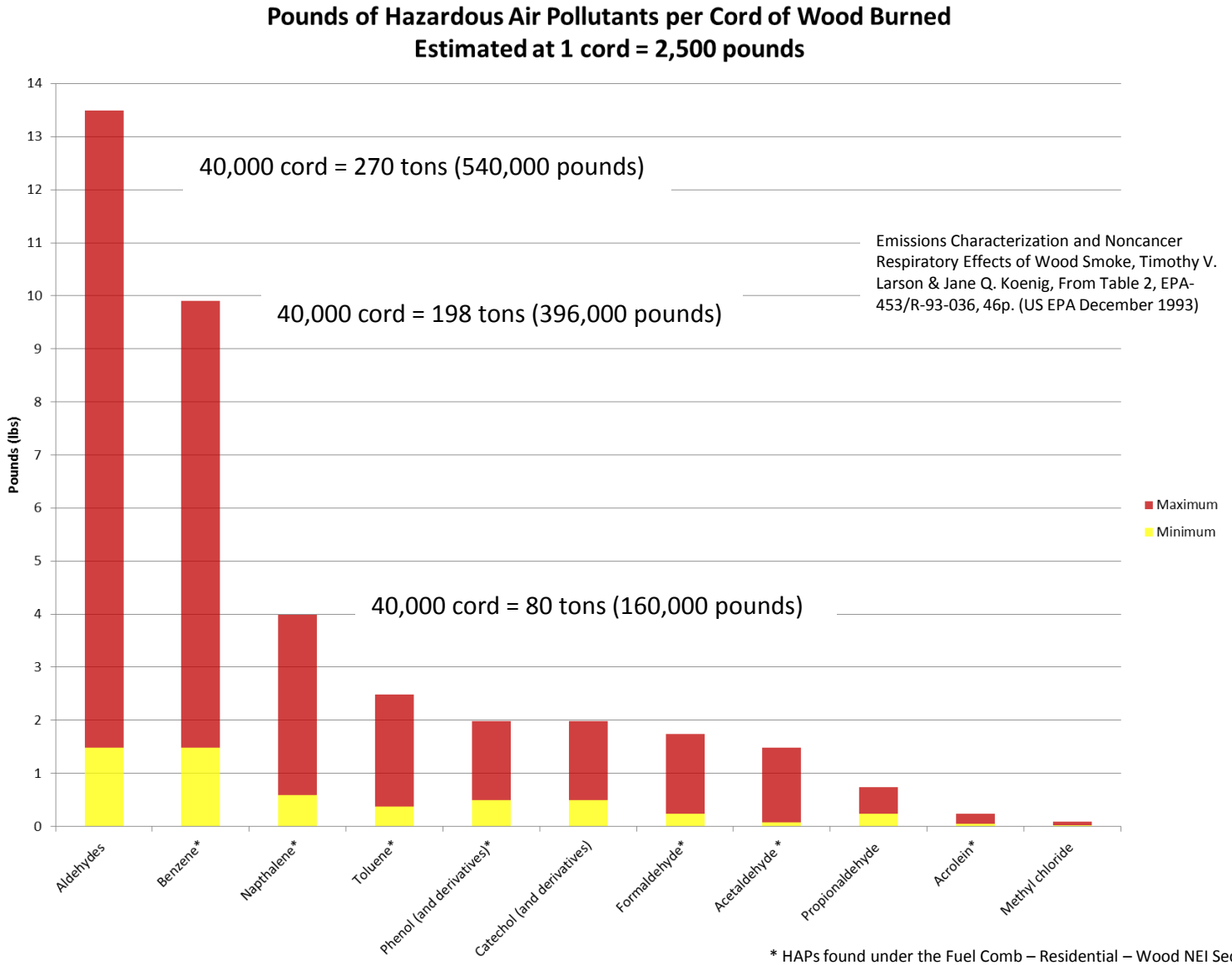
1. Emissions Characterization and Noncancer Respiratory Effects of Wood Smoke, Timothy V. Larson & Jane Q.Koenig, From Table 2, EPA-453/R-93-036, 46p. (US EPA December 1993)
2. Indoor Levels of Polycyclic Aromatic Hydrocarbons in Homes with or without Wood Burning for Heating, Pernilla Gustafson, Conny Östman and Gerd Sällsten, Department of Occupational and Environmental Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden, and Department of Analytical Chemistry, Stockholm University, Stockholm, Sweden, 2008

More about PAH

- One primary PAH is **Benzo(a)pyrene** which is produced from the incomplete combustion of organic matter.
  - A Norwegian Institute of Public Health study states: “Benzo(a)pyrene is the most carcinogenic PAH. . . the higher content of PAHs in the wood smoke particles indicates a higher mutagenic potential compared to vehicle exhaust.”[1]
  - An EPA study estimates that wood stoves, on average, emit 432 µg/hour of benzo[a]pyrene.[2]
  - You would have to light 27,333 cigarettes to emit as much benzo(a)pyrene as burning one kilogram (2.2 lbs) of wood.[3] If you smoked one pack per day it would take 3.75 years to smoke 27,333 cigarettes.

1. Physicochemical characterisation of combustion particles from vehicle exhaust and residential wood smoke Anette Kocbach1, Yanjun Li, Karl E Yttri, Flemming R Cassee, Per E Schwarze1 and Ellen Namork, Division of Environmental Medicine, Norwegian Institute of Public Health, http://www.particleandfibretoxicology.com/content/3/1/1
2. LONG-TERM PERFORMANCE OF EPA-CERTIFIED PHASE 2 WOODSTOVES, KLAMATH FALLS AND PORTLAND OREGON: 1998-1999, EPA/600/R-00/100, November 2000
3. https://woodsmokepollution.org/toxins.html

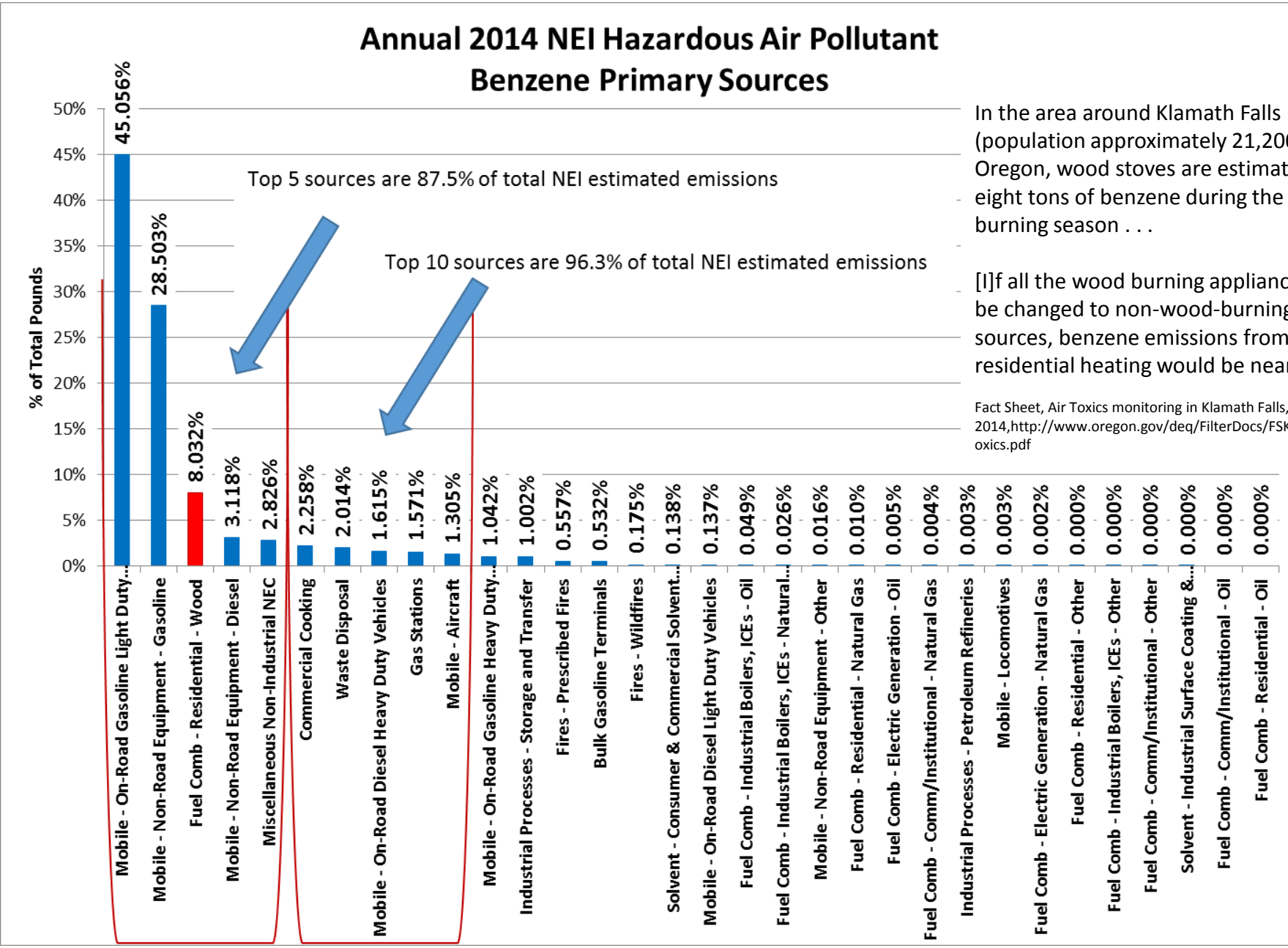
Hazardous Air Pollutants



* HAPs found under the Fuel Comb – Residential – Wood NEI Sector

The National Emission Inventory (NEI)

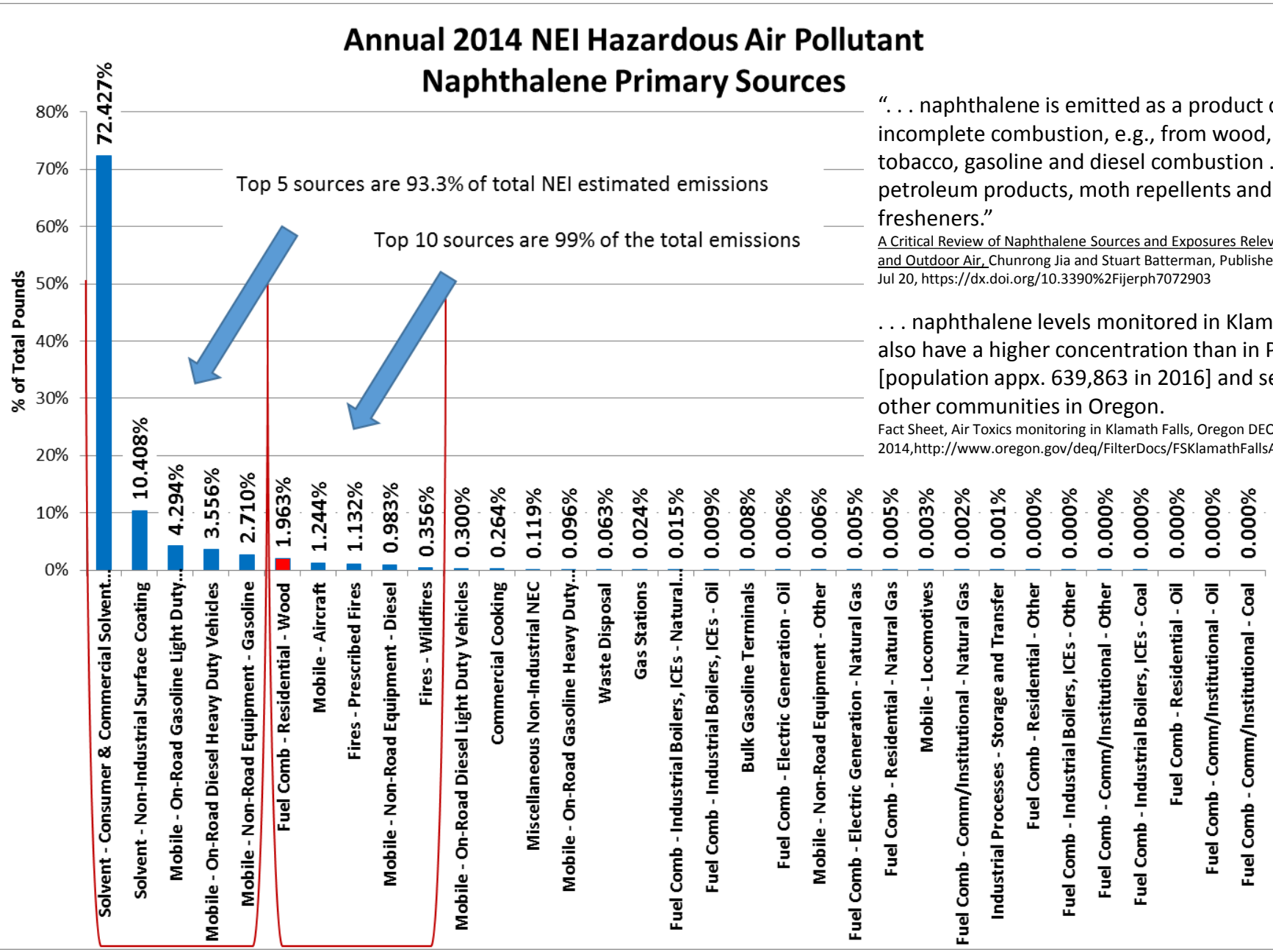
- **What is the NEI**
  - a comprehensive and detailed estimate of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emission sources.
  - Available to everyone at:
    - https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data
  - We can use the NEI to evaluate sources to help prioritize efforts to reduce pollutants from those sources.
    - For example, under Benzene, Agricultural Burning is a source category for Valencia and Sandoval but not for Bernalillo County.
  - The NEI identifies 33 hazardous air pollutants associated with Residential Wood fuel combustion.
  - Of the 17 fuel combustion sector sources Residential wood burning is 60.8% of the total sector.



In the area around Klamath Falls (population approximately 21,200), Oregon, wood stoves are estimated to emit eight tons of benzene during the wood burning season . . .

[I]f all the wood burning appliances were to be changed to non-wood-burning heating sources, benzene emissions from residential heating would be near zero.

Fact Sheet, Air Toxics monitoring in Klamath Falls, Oregon DEQ, 2014,http://www.oregon.gov/deq/FilterDocs/FSKlamathFallsAirToxics.pdf



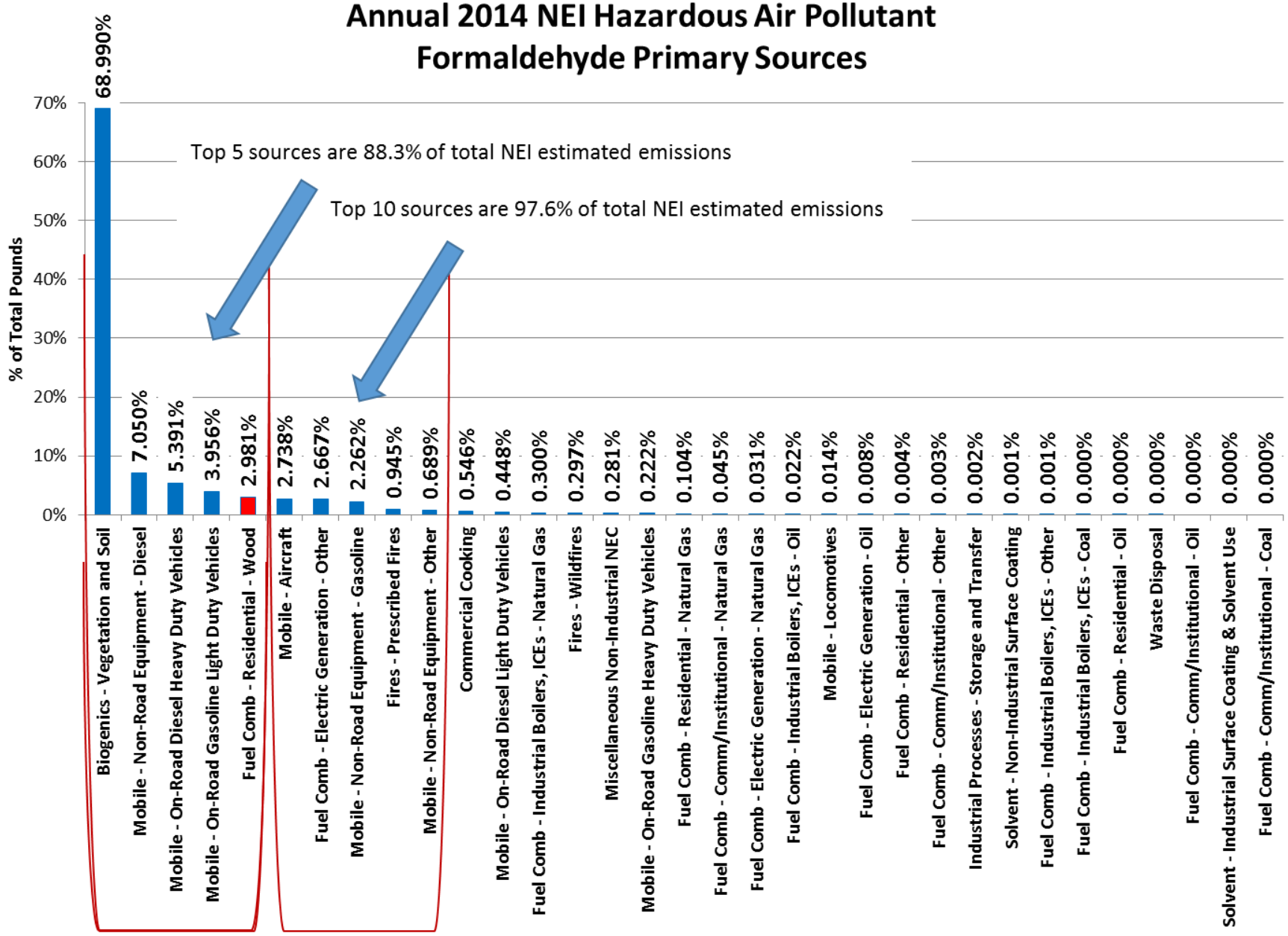
". . . naphthalene is emitted as a product of incomplete combustion, e.g., from wood, straw, tobacco, gasoline and diesel combustion . . . petroleum products, moth repellents and air fresheners."

A Critical Review of Naphthalene Sources and Exposures Relevant to Indoor and Outdoor Air, Chunrong Jia and Stuart Batterman, Published online 2010 Jul 20, https://dx.doi.org/10.3390%2Fijerph7072903

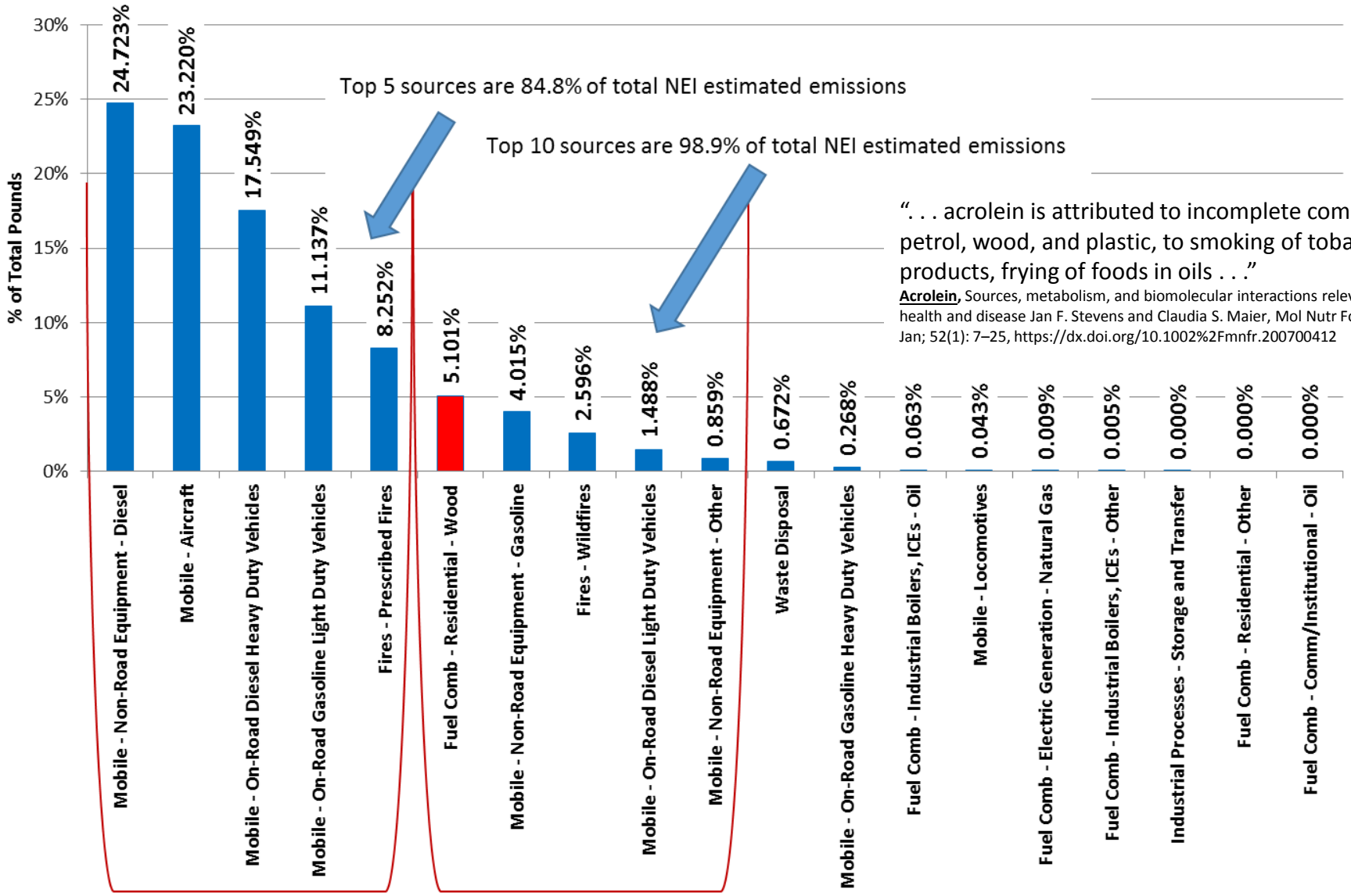
. . . naphthalene levels monitored in Klamath Falls also have a higher concentration than in Portland [population appx. 639,863 in 2016] and several other communities in Oregon.

Fact Sheet, Air Toxics monitoring in Klamath Falls, Oregon DEQ, 2014,http://www.oregon.gov/deq/FilterDocs/FSKlamathFallsAirToxics.pdf

Annual 2014 NEI Hazardous Air Pollutant
Formaldehyde Primary Sources



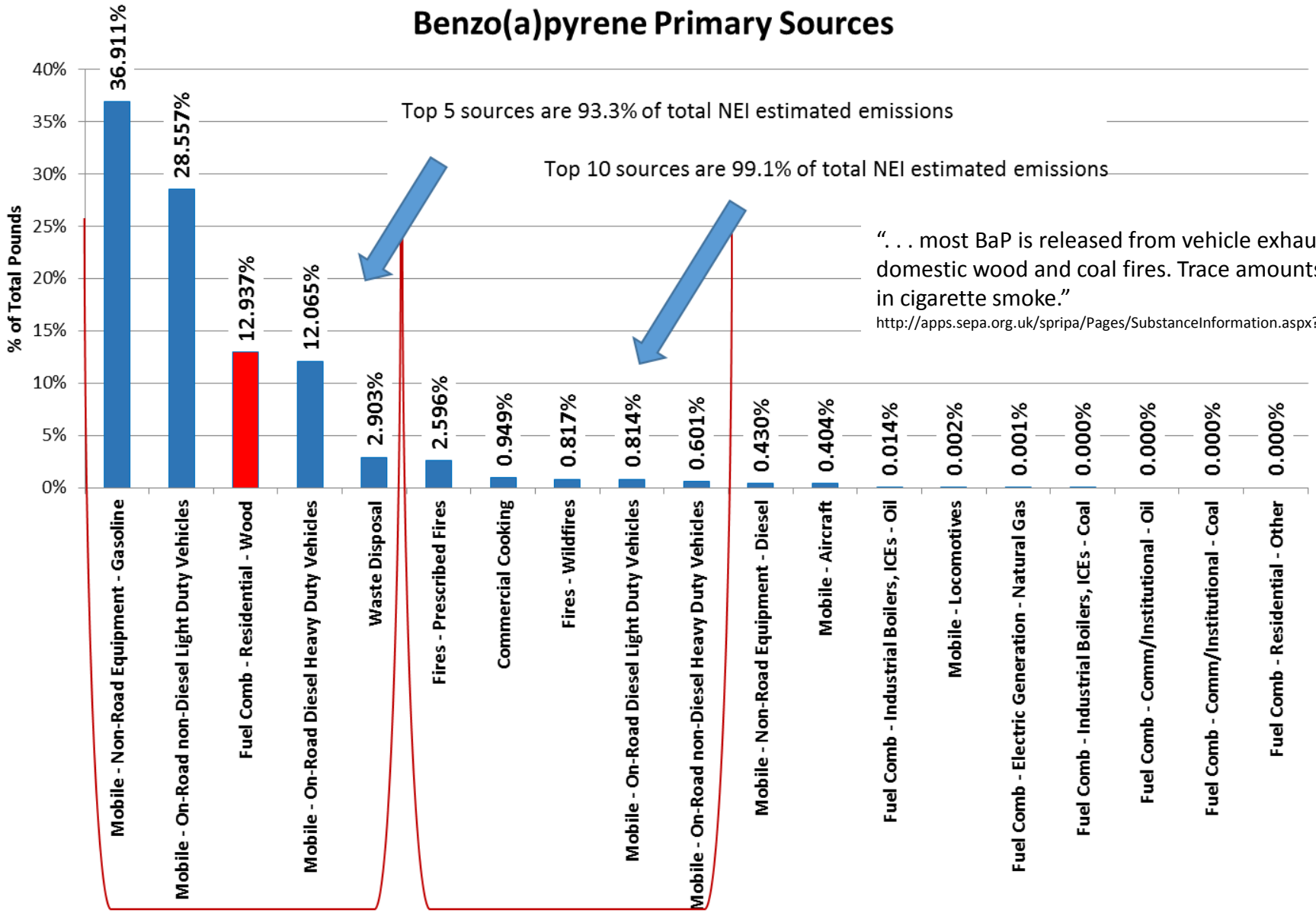
Annual 2014 NEI Hazardous Air Pollutant
Acrolein Primary Sources



". . . acrolein is attributed to incomplete combustion of petrol, wood, and plastic, to smoking of tobacco products, frying of foods in oils . . ."

Acrolein, Sources, metabolism, and biomolecular interactions relevant to human health and disease Jan F. Stevens and Claudia S. Maier, Mol Nutr Food Res. 2008 Jan; 52(1): 7–25, https://dx.doi.org/10.1002%2Fmnfr.200700412

Annual 2014 NEI Hazardous Air Pollutant Benzo(a)pyrene Primary Sources



". . . most BaP is released from vehicle exhausts and domestic wood and coal fires. Trace amounts are found in cigarette smoke."

http://apps.sepa.org.uk/spripa/Pages/SubstanceInformation.aspx?pid=22

Additional Hazardous Air Pollutants

- There are 28 additional Hazardous Air Pollutants found under the **Fuel Comb–Residential–Wood** NEI Sector

NEI Pollutant	Rank of Fuel Comb - Residential - Wood	% of all Source Categories
Cresol/Cresylic Acid (Mixed Isomers)	1	90.9%
o-Xylene	1	59.8%
Phenol	1	45.8%
Acenaphthylene	1	31.1%
Benzo[e]Pyrene	2	35.7%
Perylene	2	31.2%
Benzo(a)Fluoranthene	2	23.6%
Phenanthrene	2	16.5%
Anthracene	3	12.8%
1,3-Butadiene	3	6.8%
Methylchrysene	3	1.8%
Benzo[b]Fluoranthene	4	6.5%
Benzo[k]Fluoranthene	4	5.5%
Dibenzo[a,h]Anthracene	5	11.1%
Fluorene	5	9.3%
Acenaphthene	5	8.6%
Indeno[1,2,3-c,d]Pyrene	5	3.1%
Mercury	5	2.4%
Benz[a]Anthracene	6	3.1%
Acetaldehyde	6	1.5%
Manganese	6	0.3%
Cadmium	6	0.1%
Chrysene	7	3.6%
Benzo[g,h,i,]Perylene	7	0.6%
Fluoranthene	11	0.6%
Pyrene	11	0.4%
Nickel	12	0.1%
Toluene	14	0.4%

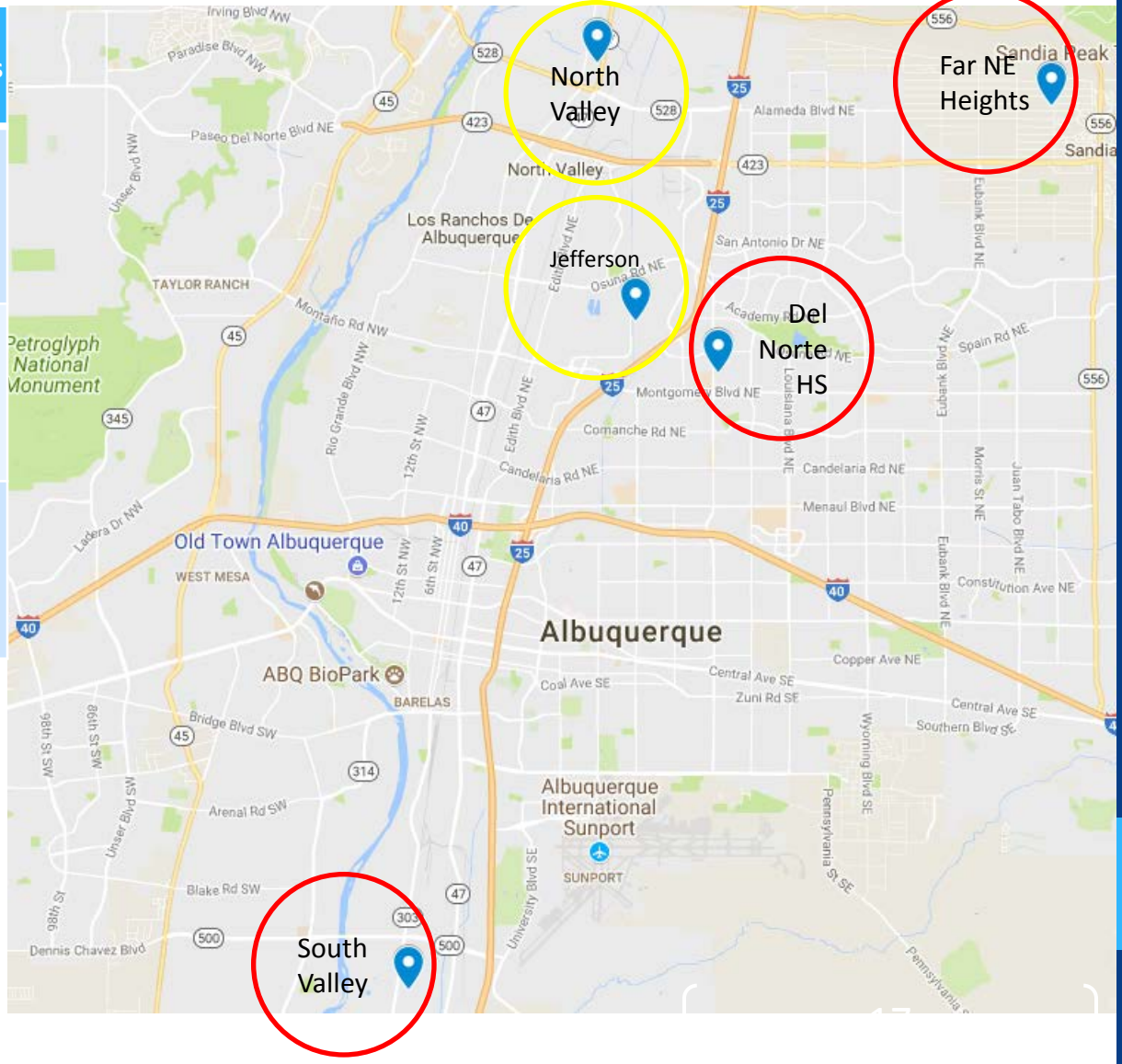
18 are in the top 5

24 are in the top 10

Local Monitoring Data

Site	Del Norte (2ZM)	South Valley (2ZV)	Far NE Heights (2ZF)
PM2.5 Hourly	X	X	X
Black Carbon Hourly	X	X	X
Potassium 24 hour, one sample every 3rd day	X		

- North Valley and Jefferson started $PM_{2.5}$ this year.
- As of 2018 Bernalillo County has 5 $PM_{2.5}$ sites, this is **50%** of all the $PM_{2.5}$ monitors in New Mexico.



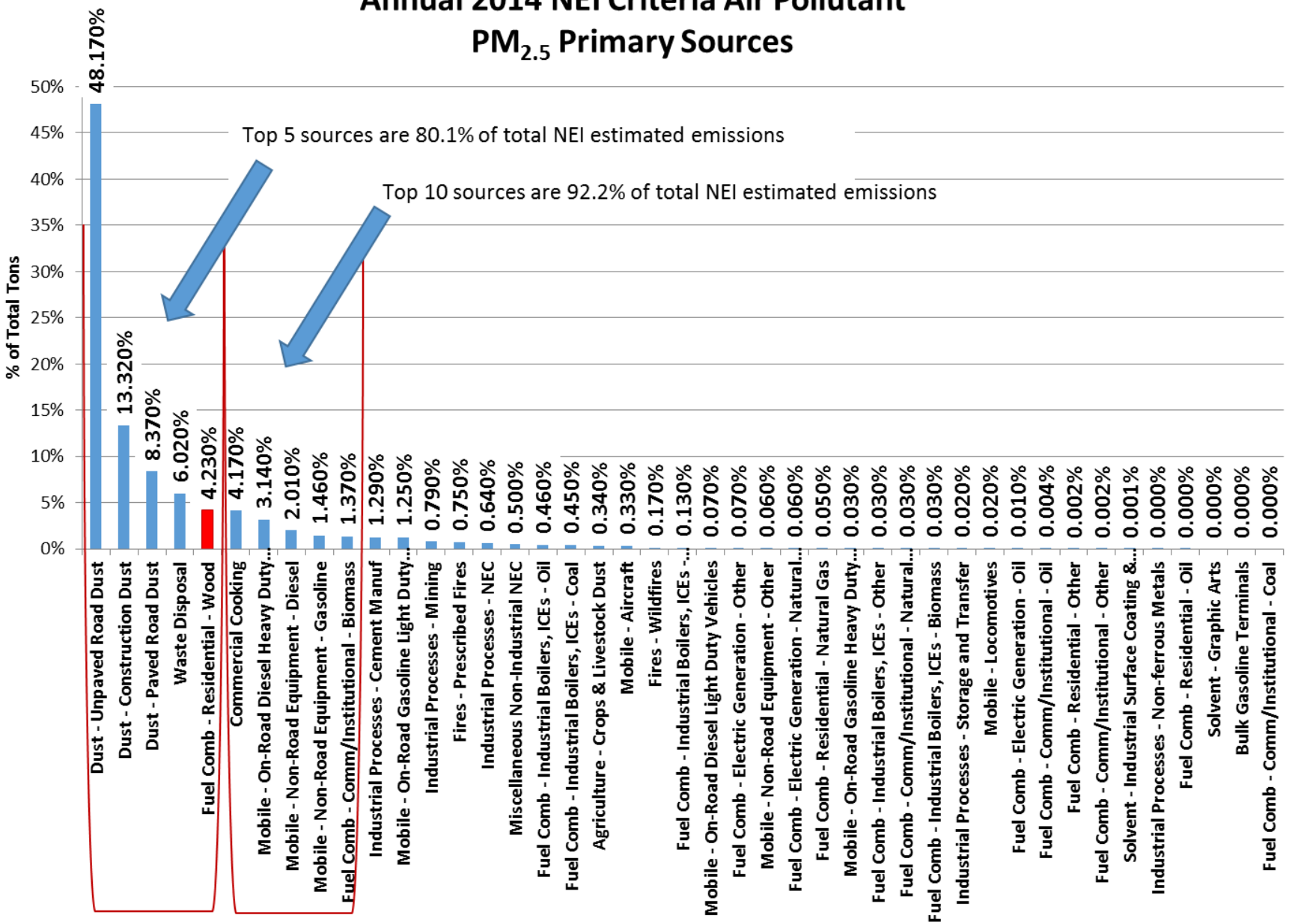
What We Are Looking For

- Increased markers of $PM_{2.5}$, Black Carbon and Potassium during the winter time wood burning season

- Late evening and early morning increases in these wood burning markers
  - Indicates wood burning activities after the evening and before the morning commuting time period

- Increased frequency in EHD's email alerts
  - winter period (Dec. 2016-Jan. 2017) EHD had 165 email alerts
  - summer period (June-July 2017) EHD had 50 email alerts.

Annual 2014 NEI Criteria Air Pollutant $PM_{2.5}$ Primary Sources



What did we see in the data

- **44.6% average increase in $PM_{2.5}$** from summer to winter (excl. Foothills)

2015-2016 data	Del Norte HS Average µg/m³	South Valley Average µg/m³	Foothills Average µg/m³
Summer (Mar-Aug)	4.7	5.5	5.3
Winter (Sep-Feb)	6.5	8.3	4.7
% Increase	**38.3%**	**50.9%**	**-11.3%**

- **104% average increase in Black Carbon** from summer to winter (excl. Foothills)

2015-2016 data	Del Norte HS Average µg/m³	South Valley Average µg/m³	Foothills Average µg/m³
Summer (Mar-Aug)	0.280	0.406	0.144
Winter (Sep-Feb)	0.567	0.835	0.223
% Increase	**102.5%**	**105.6%**	54.9%

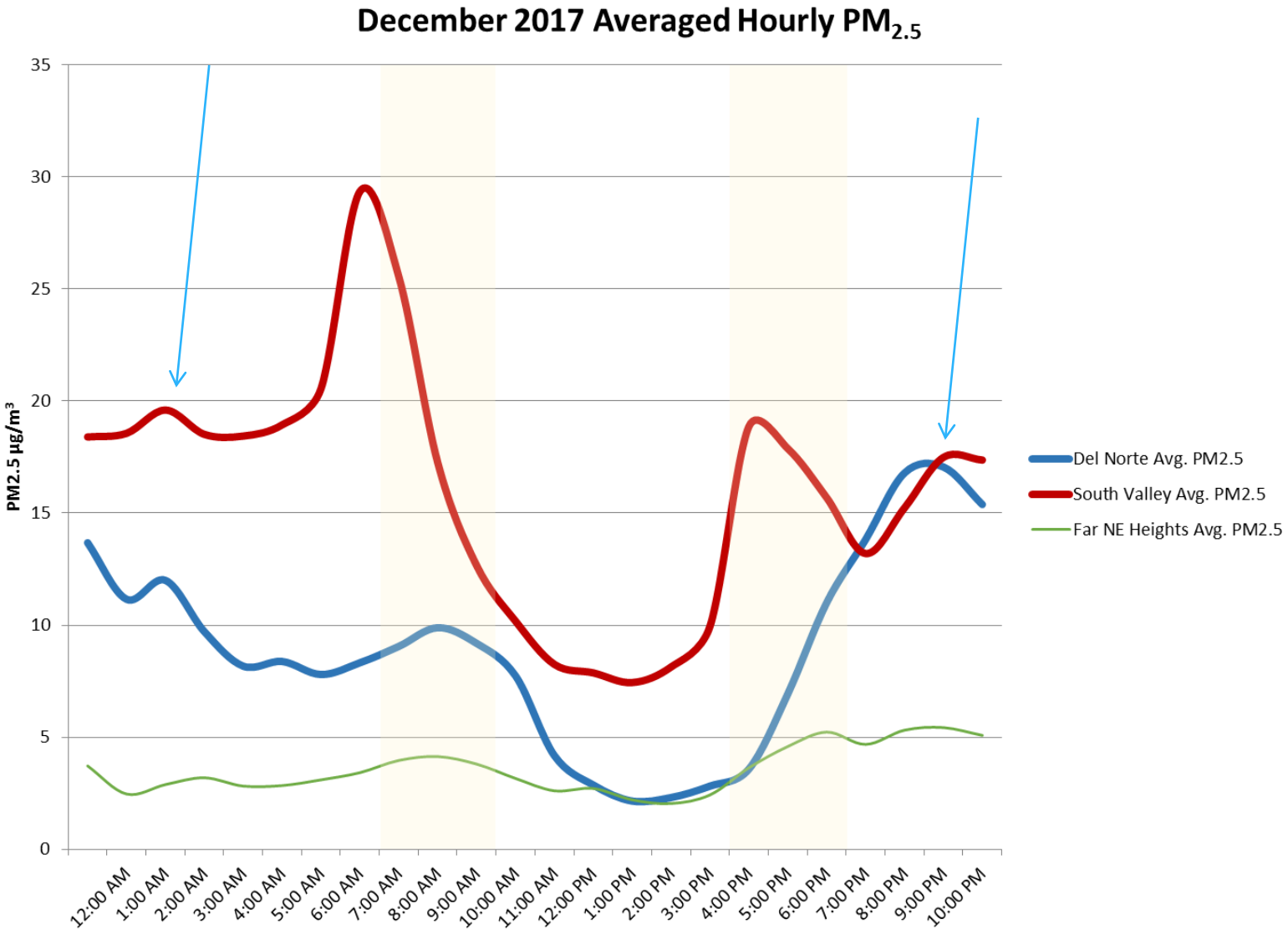
- **101.3% increase** in **Potassium** from summer to winter

2015-2016 data, Del Norte HS	Average Potassium µg/m³
Summer (Mar-Aug)	0.0169
Winter (Sep-Feb)	0.0339
% Increase	**101.3%**

Potassium corrected to remove crustal portion

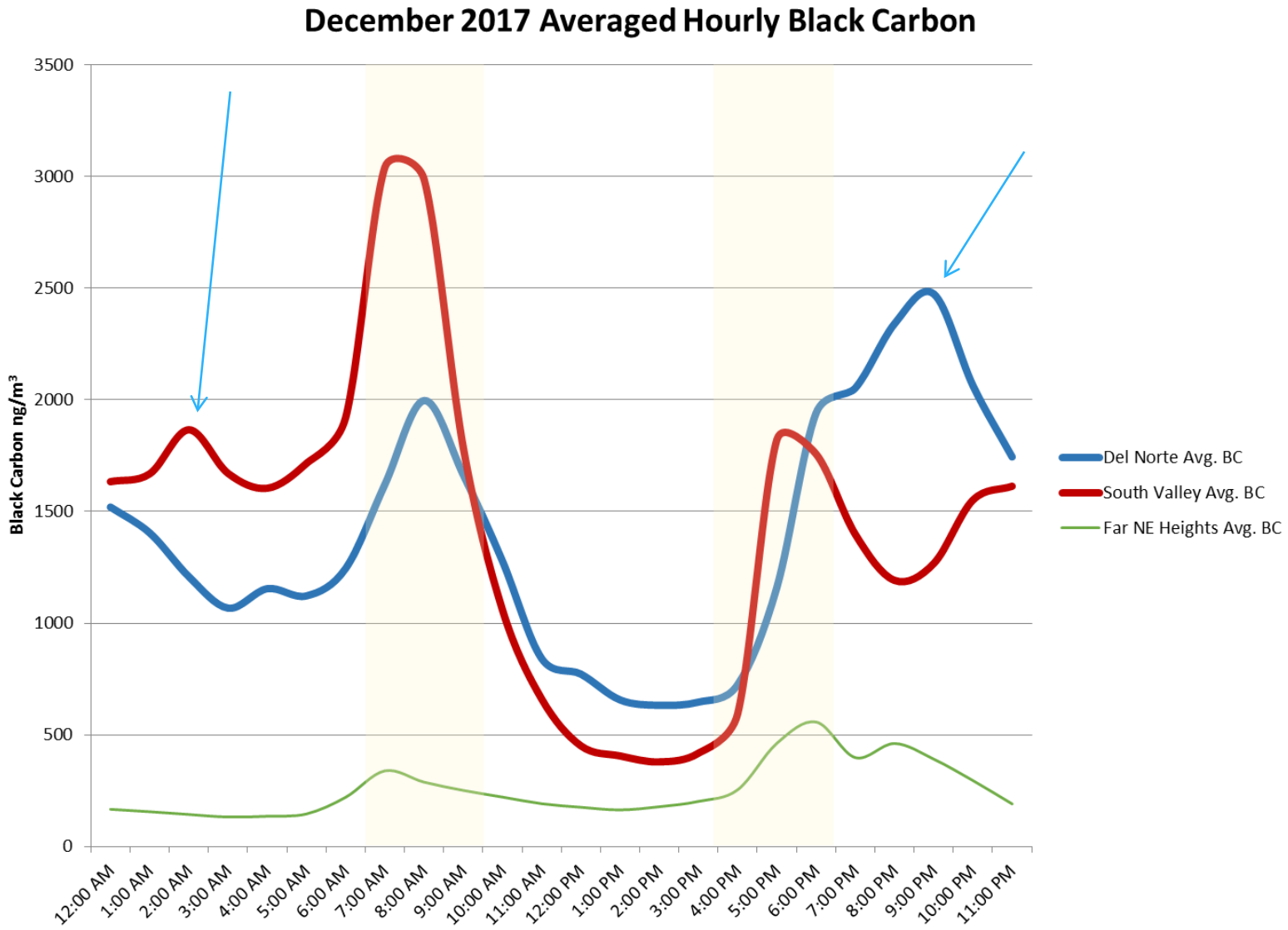
What did we see in the data

- Evening and early morning impact on fine particulates

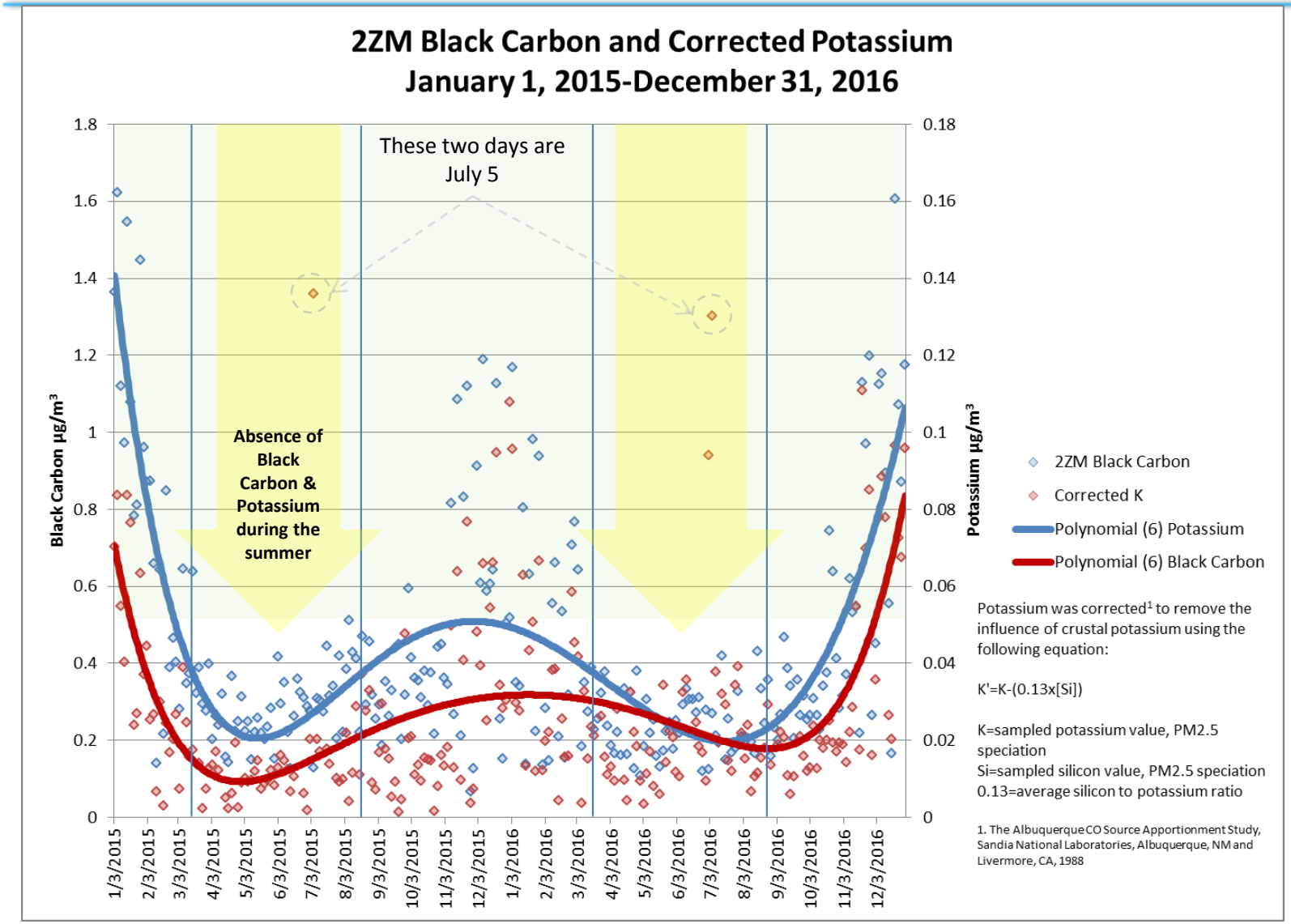


What did we see in the data

- Evening and early morning impact on Black Carbon



Seasonal Variations



Potassium was corrected[1] to remove the influence of crustal potassium using the following equation:

K'=K-(0.13x[Si])

K=sampled potassium value, PM2.5 speciation
Si=sampled silicon value, PM2.5 speciation
0.13=average silicon to potassium ratio

1. The Albuquerque CO Source Apportionment Study, Sandia National Laboratories, Albuquerque, NM and Livermore, CA, 1988

Conclusions

- **The NEI and the local monitoring data point toward wood burning as an impact on area residents**
- **Black Carbon and Potassium show wood burning activity**
- **NEI data clearly identifies the Fuel Comb–Residential–Wood Sector as a significant source of air pollutants**
  - Due to the seasonality of wood burning the impact could be more significant than the NEI data presents

Potential Next Steps

- Wood Burning Activity Survey
- Levoglucosan, Mannosan, Galactosan (anhydrous sugars)
  - Organic compounds closely related to biomass burning
  - Ratios can help determine wood/biomass types burned
  - Able to use existing sampling equipment
  - Laboratory analysis by Gas Chromatograph

- Spectrum Wavelength Aethalometer
  - instrument measuring concentrations of light absorbing particles
  - 7 different wavelength channels based on differences in particle size and material, including black carbon and CO_2 (additional sensor).
  - Potential for identifying particulate sources based on wavelength UV absorption
  - This could help differentiate wood burning and traffic contributions

- Mobile autoGC monitoring
  - Provide data on up to 57 different hydrocarbon pollutants including benzene, toluene, and formaldehyde (https://cas-en.com/turn-key-systems/pams/)
  - Some systems are easy to set up and easy to use

Open Discussion