

# Wildfires and Wood Stoves: Profiles in Woodsmoke toxicity

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# Project Goals

1. Evaluate the ambient air toxics associated with wood smoke in a suburban community
  - Focus on species associated with residential wood combustion: naphthalene, benzo(a)pyrene, formaldehyde, acetonitrile, and acrolein
  - Evaluate these toxics relative to PM2.5 NAAQS

# Project Outcomes

1. Illustrate differences in wildfire and wood stove smoke toxicity.
  - Compare these results with data from Beacon Hill NATTS site
  - Evaluate these toxics relative to PM2.5 and CO NAAQS

# Monitoring sites

## Mt. View Elementary, Lacey

- Suburban residential
- Residential wood heating is the primary PM<sub>2.5</sub> source
- Other sources include: light traffic, restaurants, roadwork (summer)



## Beacon Hill, Seattle

- Urban multipollutant monitoring site
- PM<sub>2.5</sub> sources include: vehicles, urban sources, residential home heating



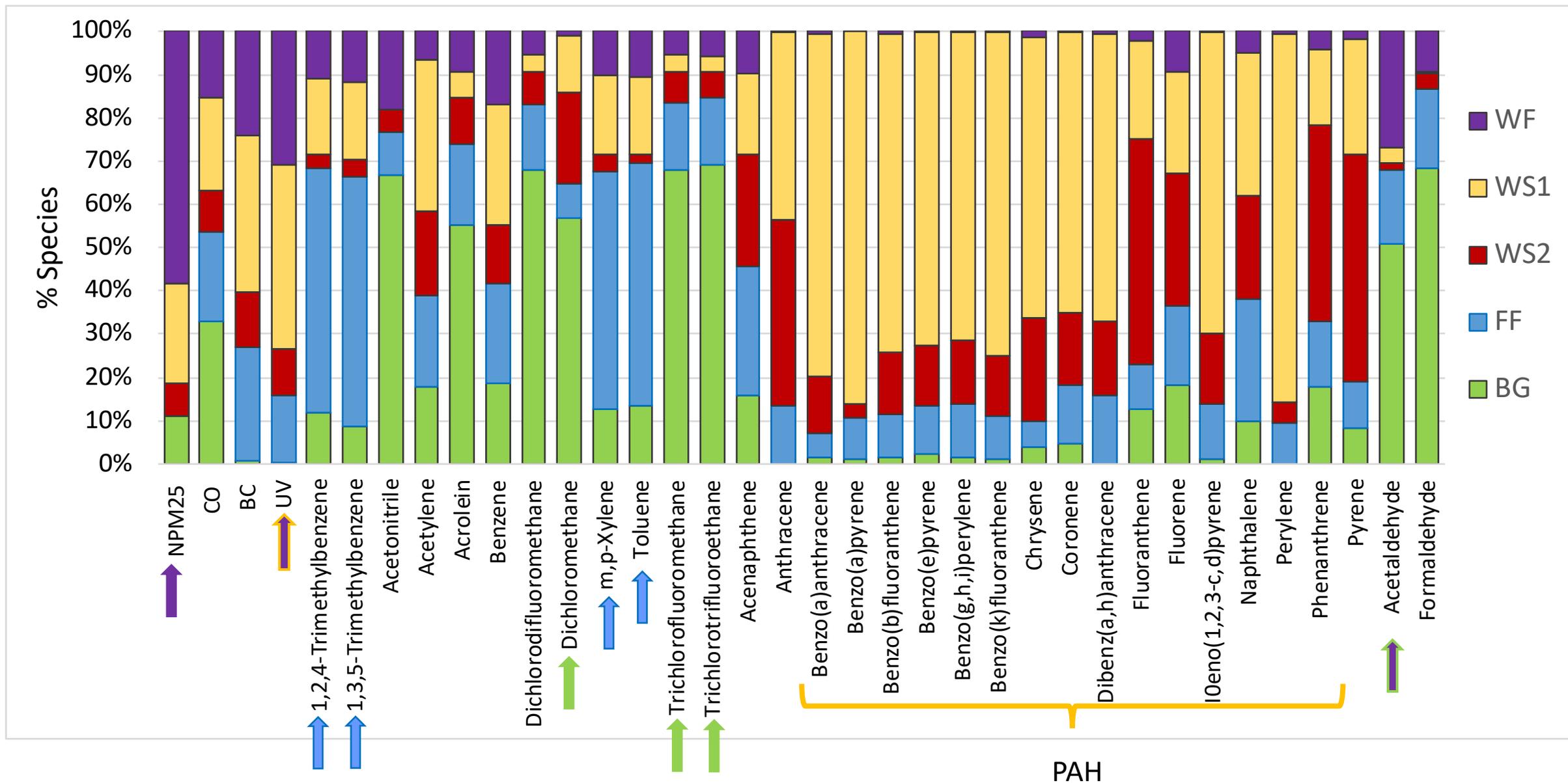
# Project overview

- Air samples collected at Mt. View Elementary School, Lacey WA
- 24-hour samples collected on every 6<sup>th</sup> day<sup>1</sup>
  - TO – method 11 – carbonyls (formaldehyde)
  - TO – method 13a – SVOC and PAH (naphthalene, benzo(a)pyrene)
  - TO – method 15 – VOC (acrolein, acetonitrile)
- Hourly:
  - Black carbon, ozone, carbon monoxide, PM2.5 (nephelometer)

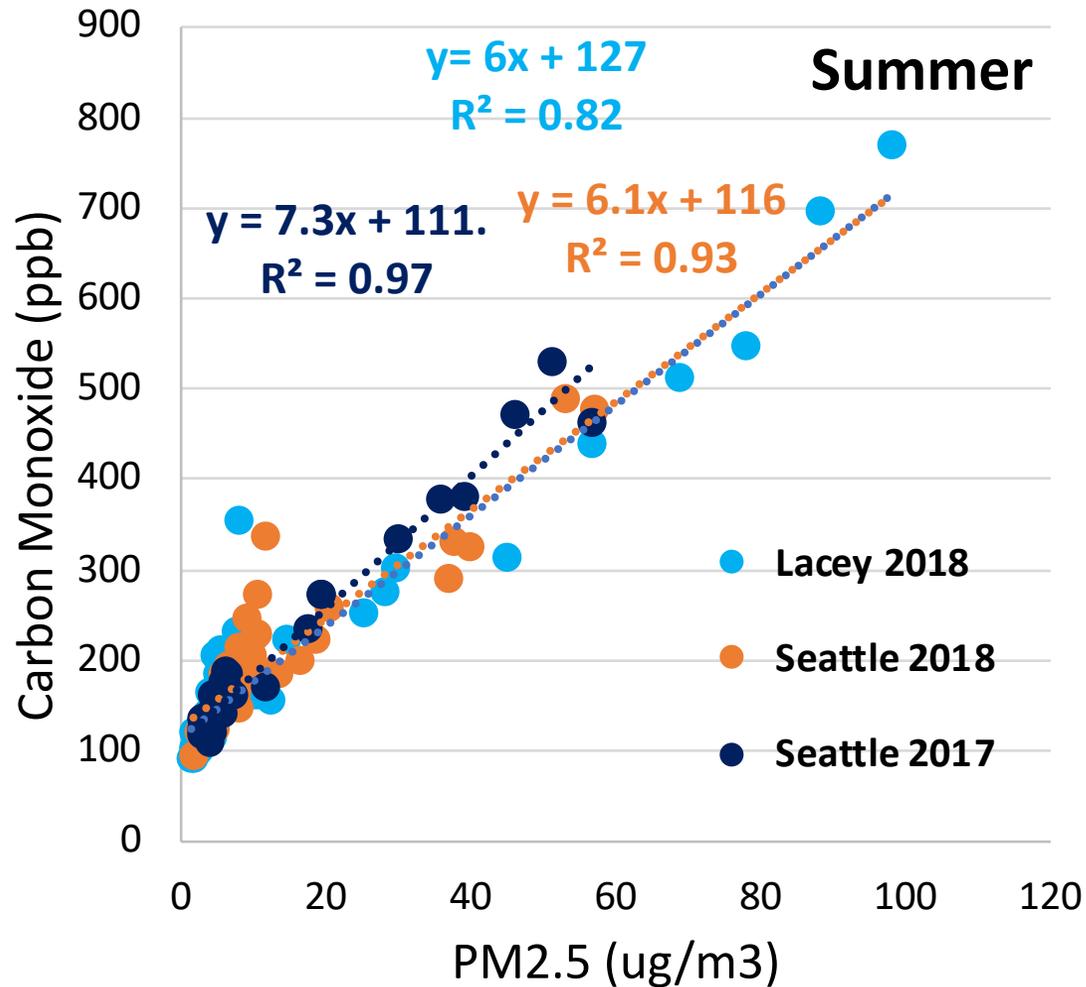
1. Additional sample days added when warranted by high PM2.5 forecasts



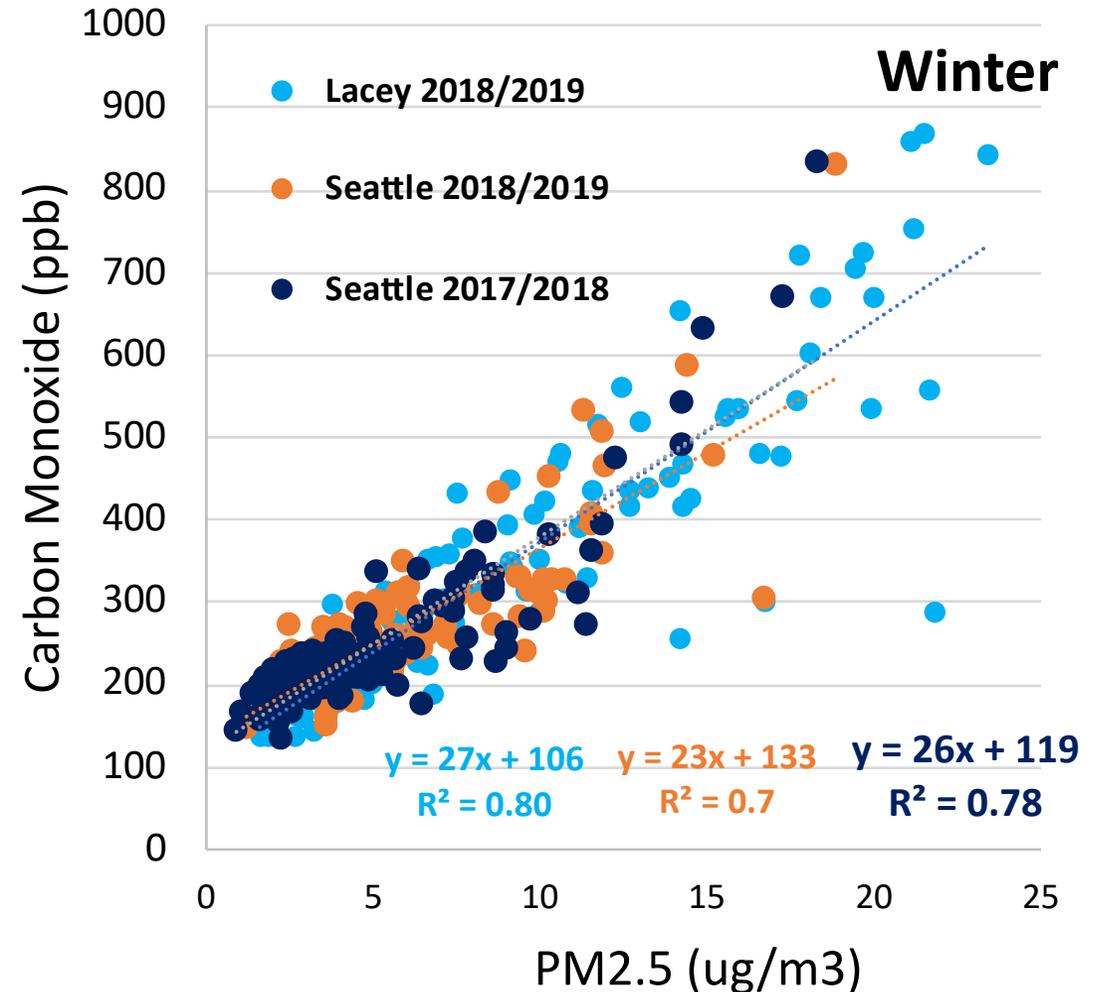
# EPA PMF 5.0 – Source profiles



# $\Delta\text{CO}/\Delta\text{PM}_{2.5}$ is higher in woodsmoke from residential burning compared to wildfires



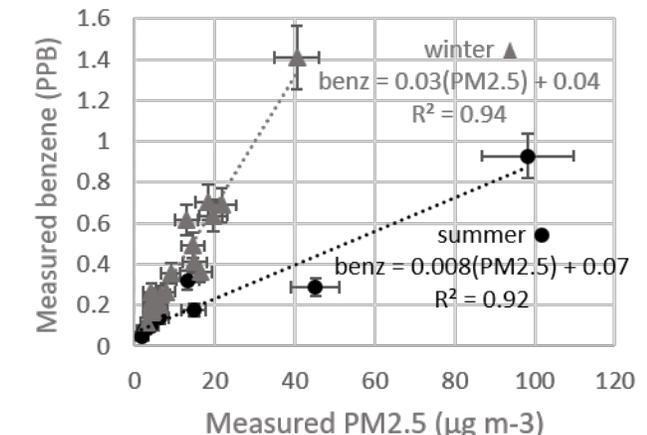
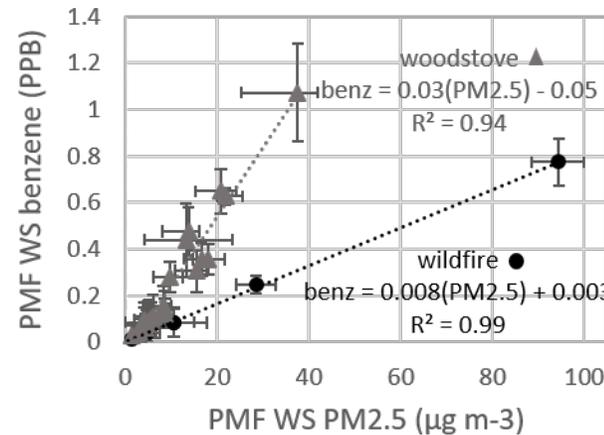
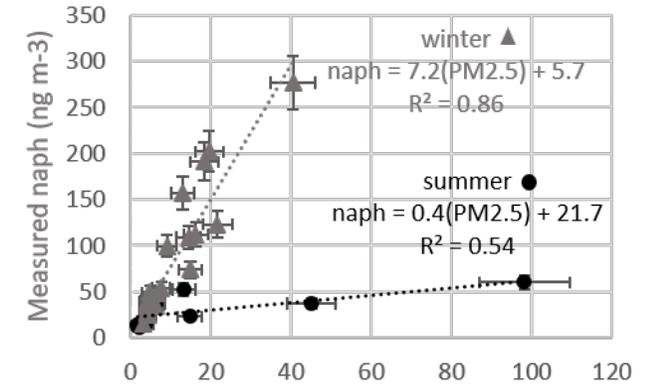
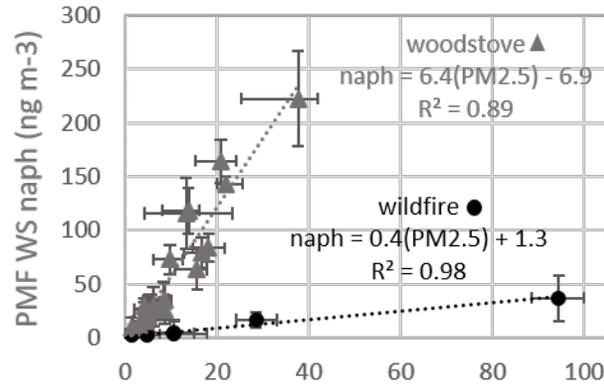
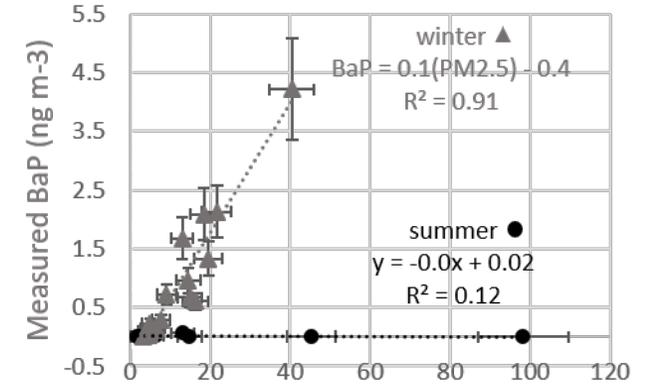
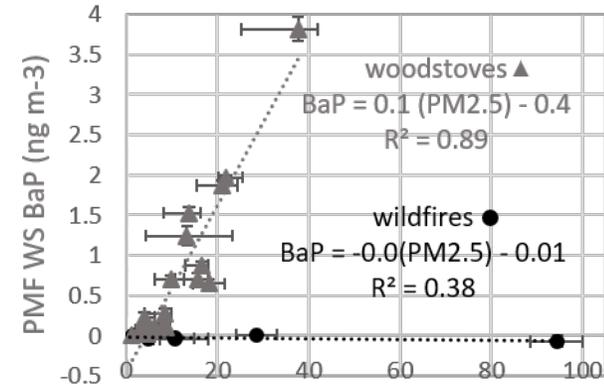
EF CO/PM2.5 ratio\_WF: 5.8 ppb/ug m<sup>3</sup> (Urbanski 2014)  
 7.5 ppb/ug m<sup>3</sup> (Kim et al 2018)



EF CO/PM2.5 ratio\_WS: 20 +/- 4 ppb/ug m<sup>-3</sup> (Li, Env. Canada)  
<https://www3.epa.gov/ttnchie1/conference/ei16/session5/victor.pdf>

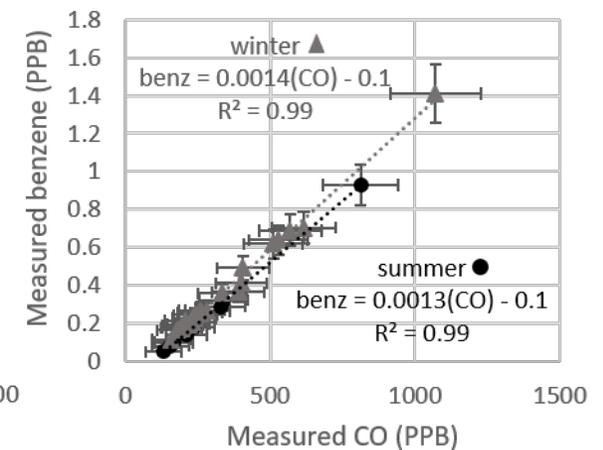
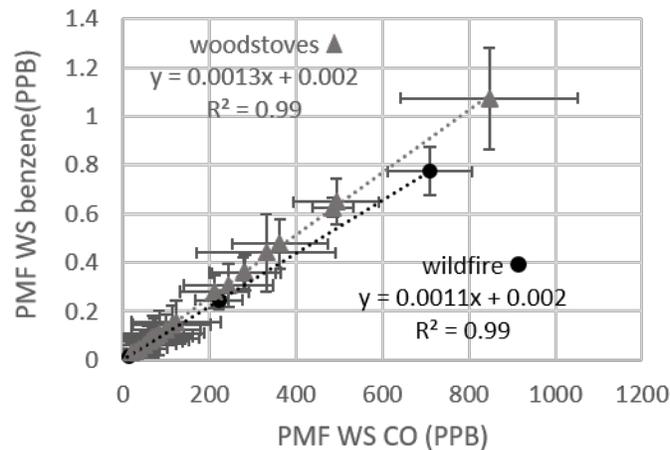
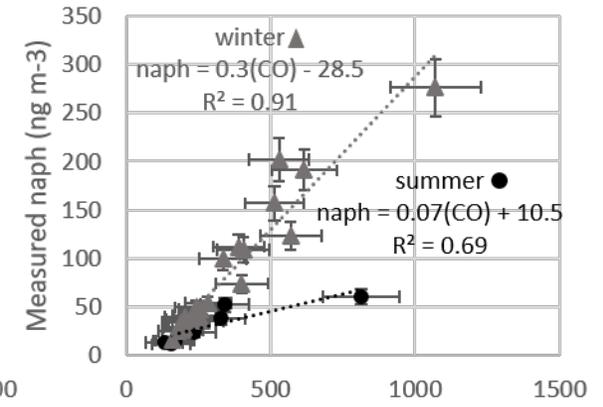
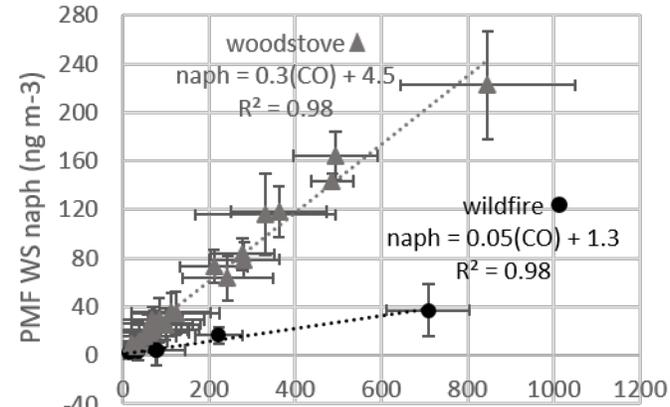
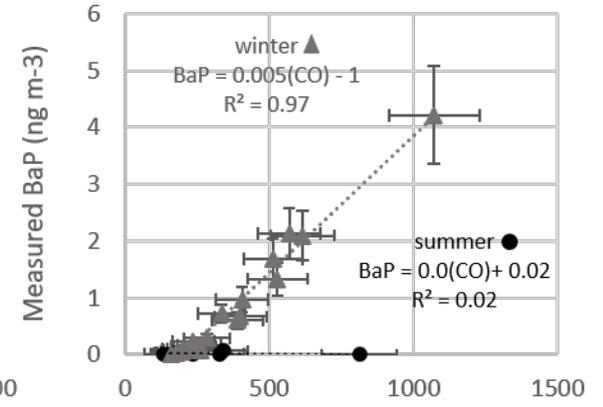
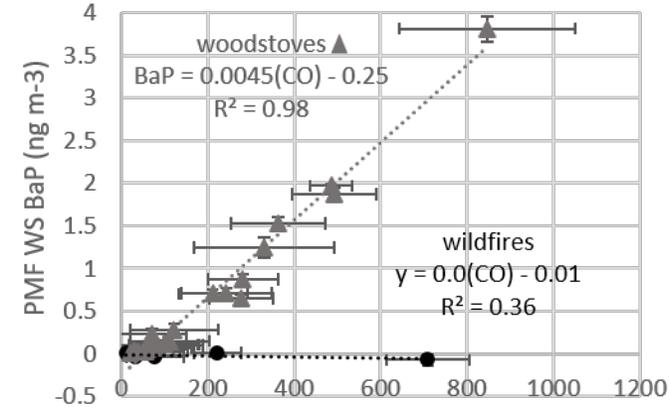
# Toxic compounds vs. PM2.5

- Look at toxics relative to PM2.5 because
  - Commonly monitored
  - Has a NAAQS
- 100% less BaP in wildfire PM2.5 relative to wood stove PM2.5 (5 rings)
- 93% less naphthalene (2 rings)
- 73% less benzene (1 ring)



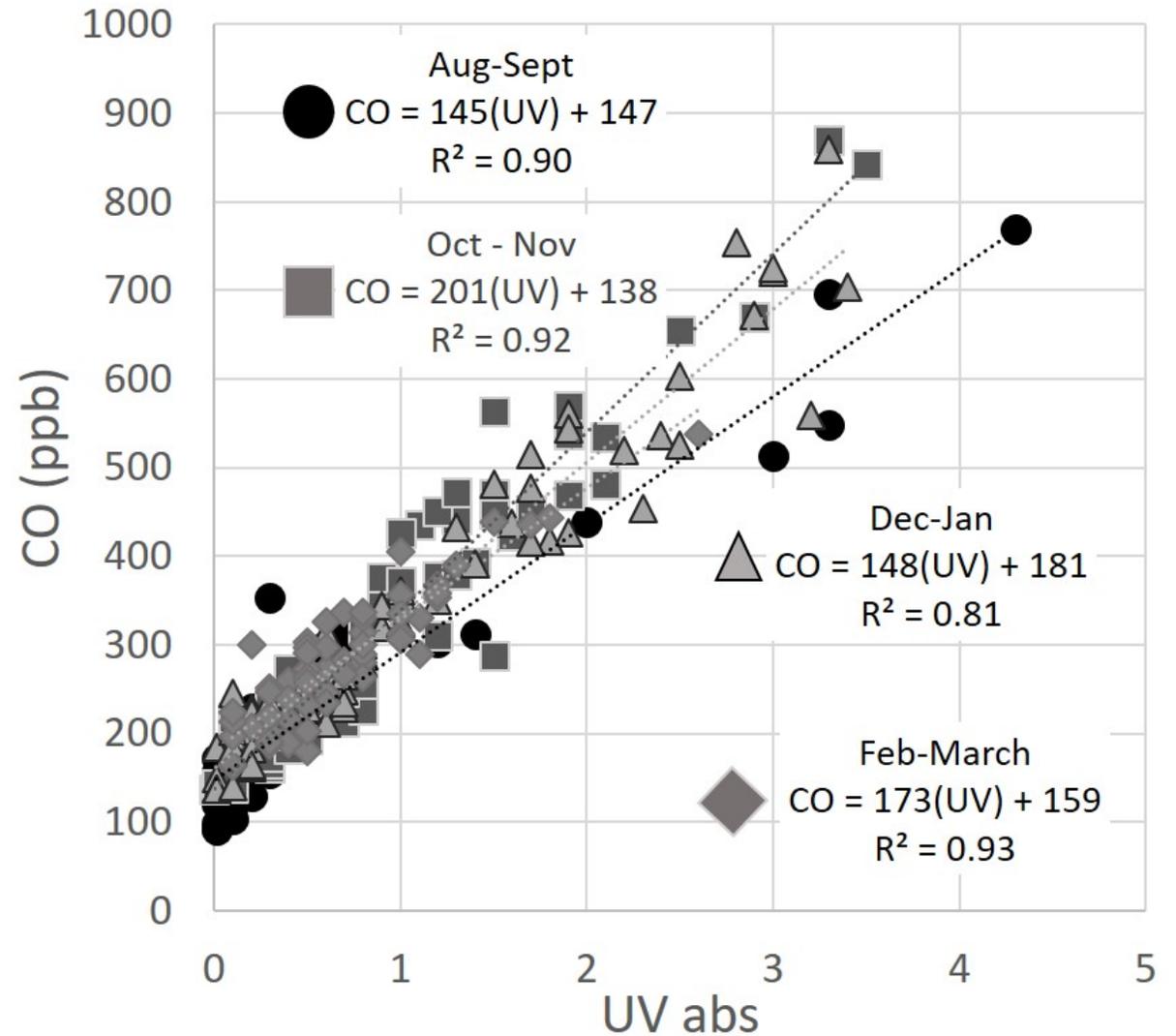
# Toxic compounds vs. CO

- Look at toxics relative to CO because
  - Commonly monitored
  - Has a NAAQS
  - Atmospheric tracer ?
- 100% less BaP (5-rings) in wildfire plume
- 73 - 82% less naphthalene (2-rings)
- 0 - 15% less benzene (1-ring)

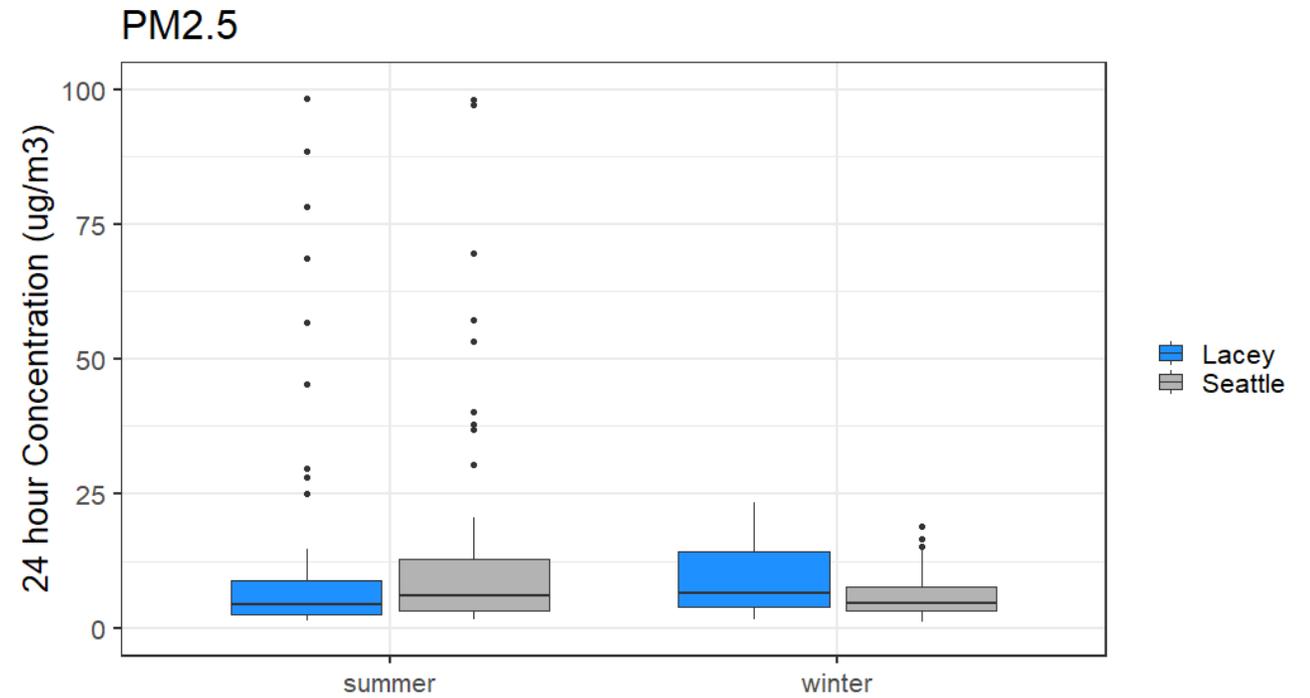
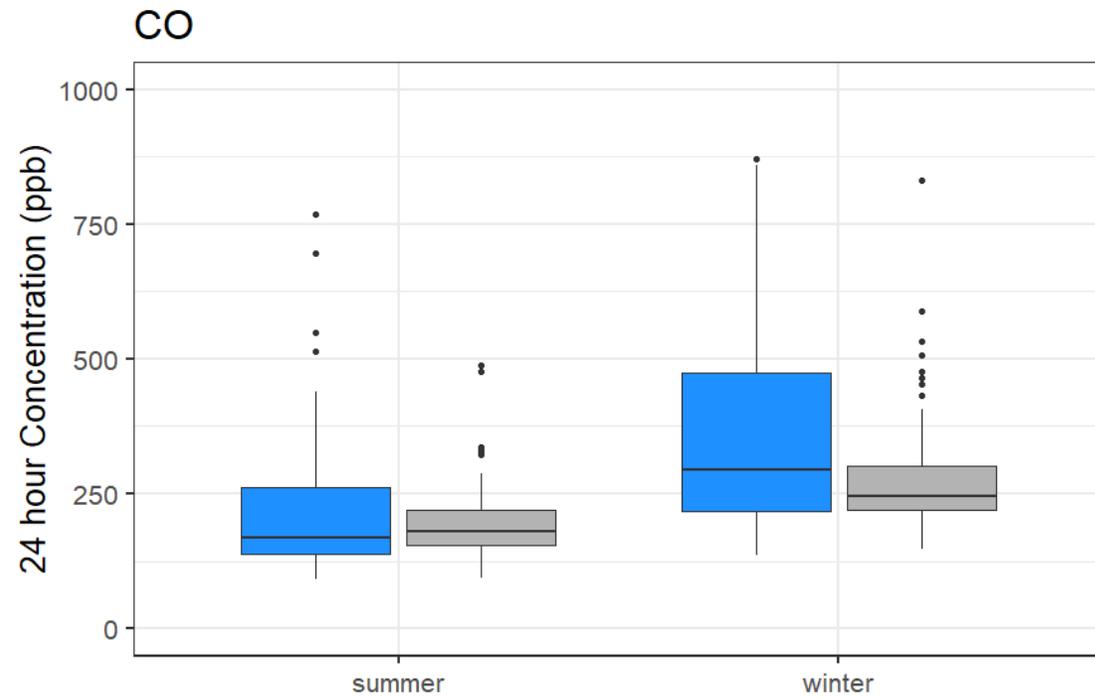


# So what happened to the PAHs??

- PAHs and other organic compounds strongly absorb UV
- The  $\Delta\text{CO}/\Delta\text{UV}_{\text{abs}}$  is highly correlated and has no seasonal dependence
  - $\Delta\text{CO}/\Delta\text{UV} = 167 (+/- 26)$  ppb
- Indicates PAHs were oxidized, but retained their absorptive properties (i.e. toxic compounds undetected, but present in WF smoke)
  - Oxidized PAH may have higher toxicity (ref)

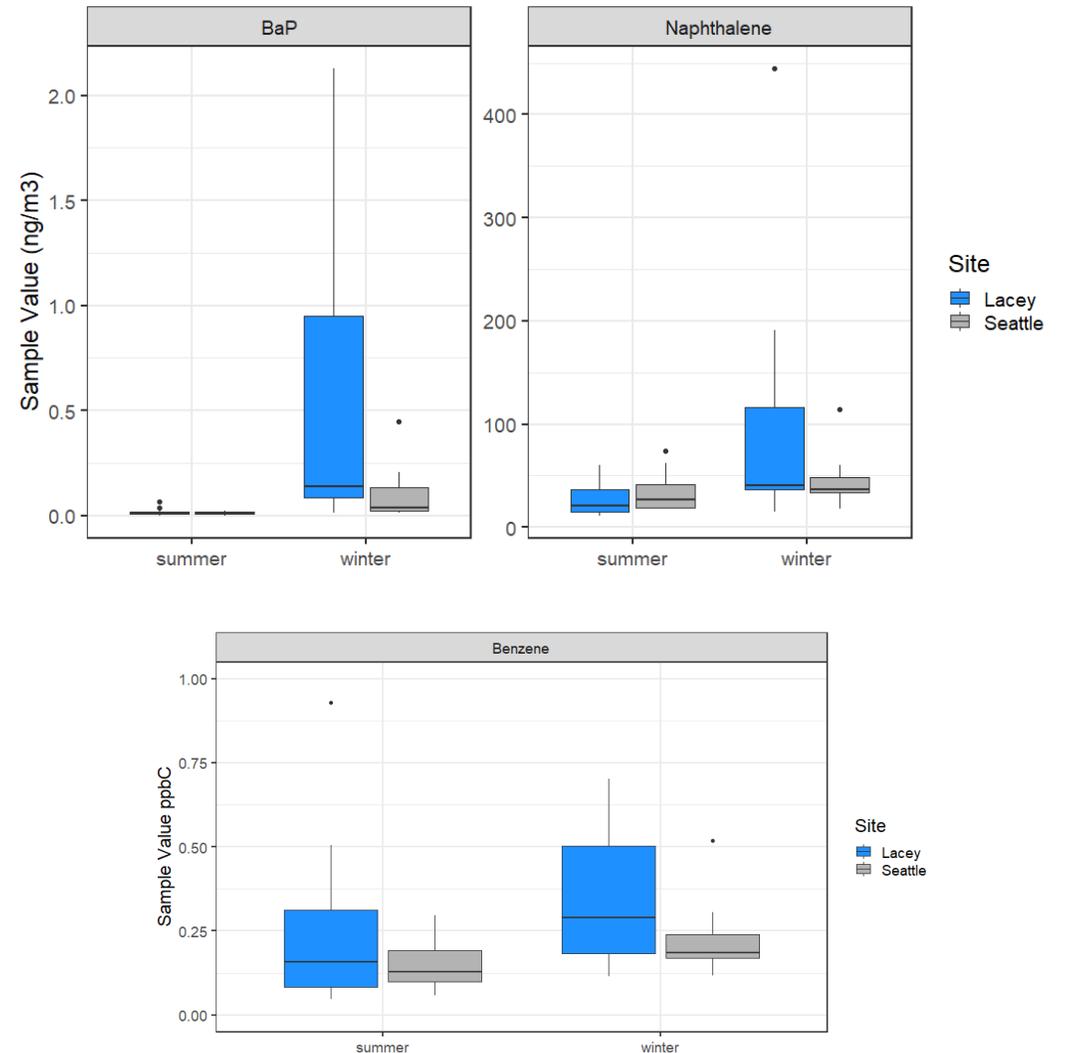


# Wintertime PM2.5 and CO: Seattle vs. Lacey



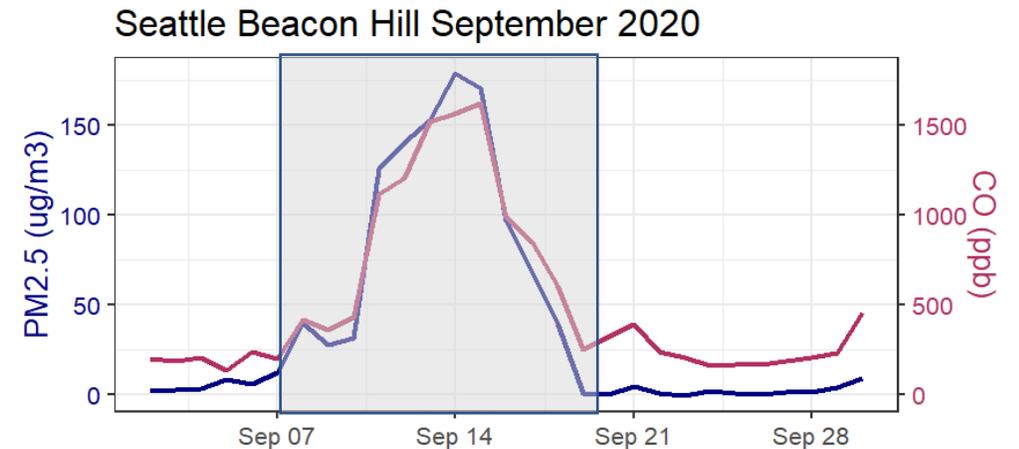
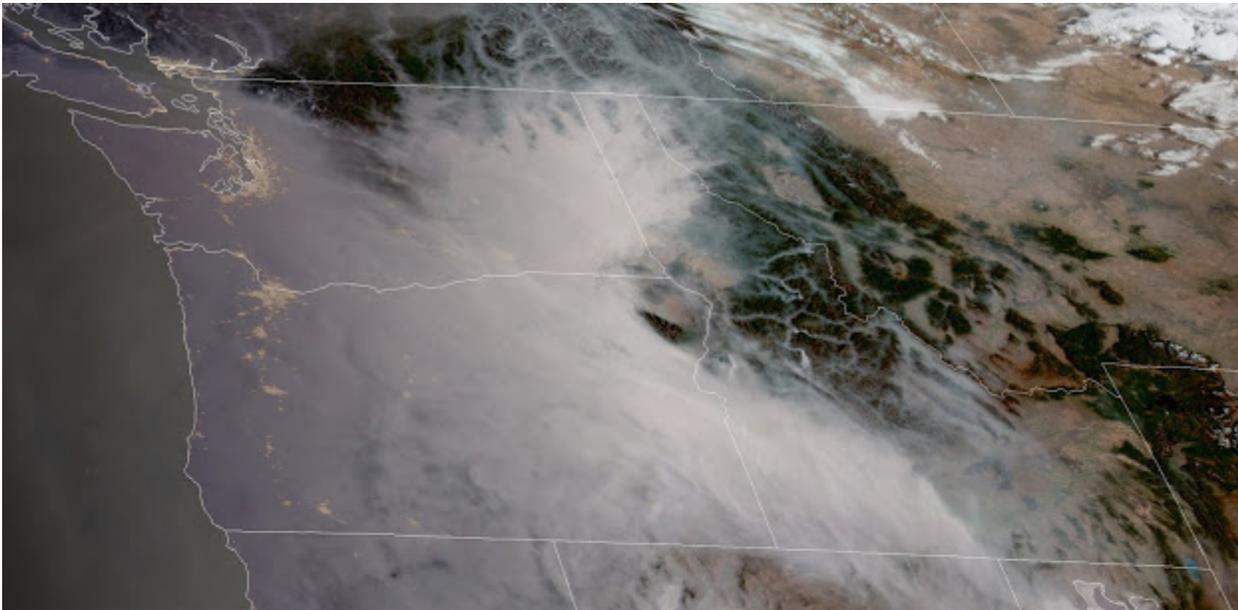
# Wintertime toxic compounds: Seattle vs. Lacey

- Seattle wintertime BaP, naphthalene, and benzene are 40-80% less than Lacey wintertime.
- PMF residential wood smoke factor in Seattle only comprised 11% of wintertime PM<sub>2.5</sub> (compared to 77% in Lacey)

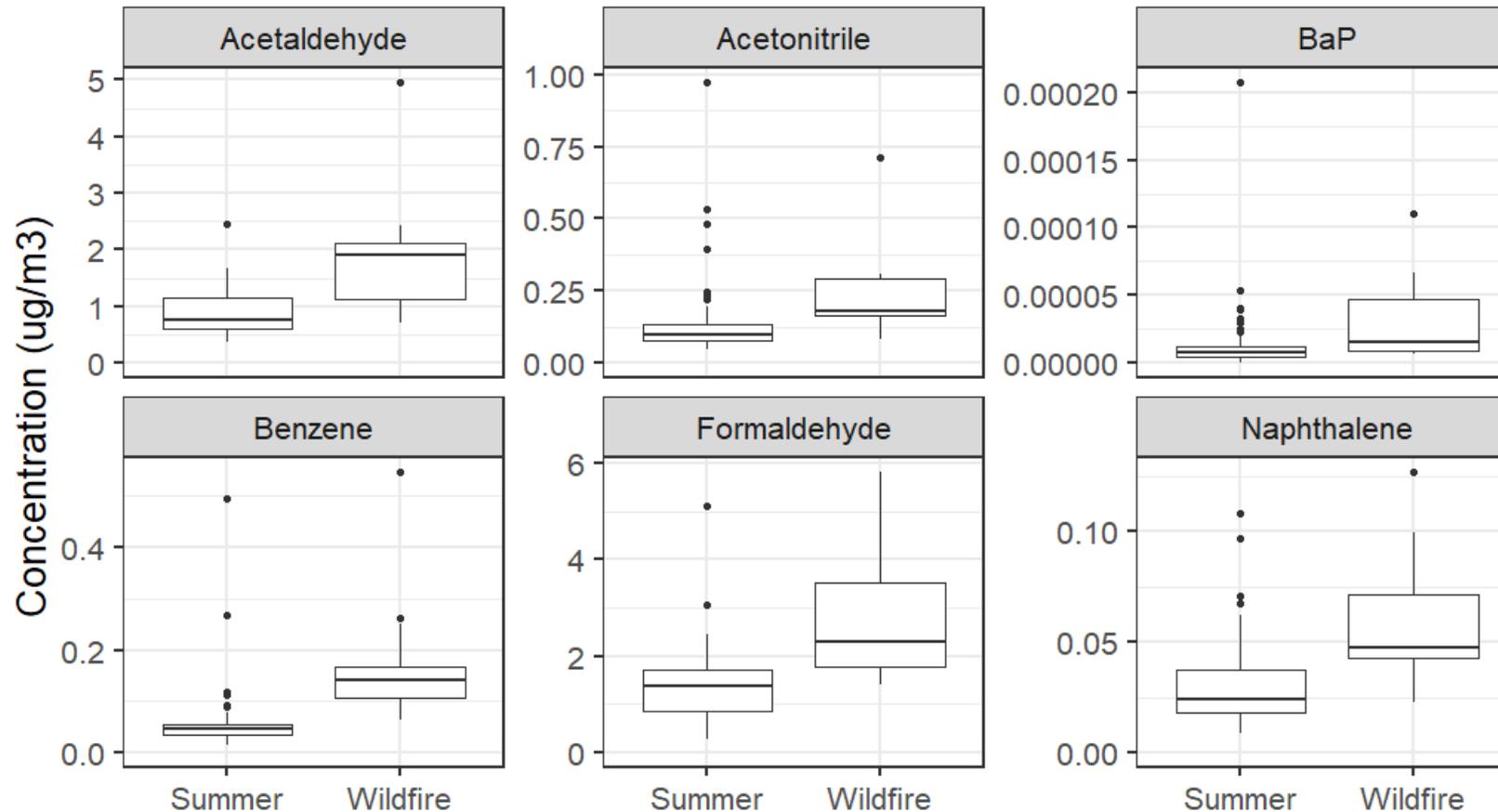


# The last few years: hazardous air pollutants in wildfire smoke

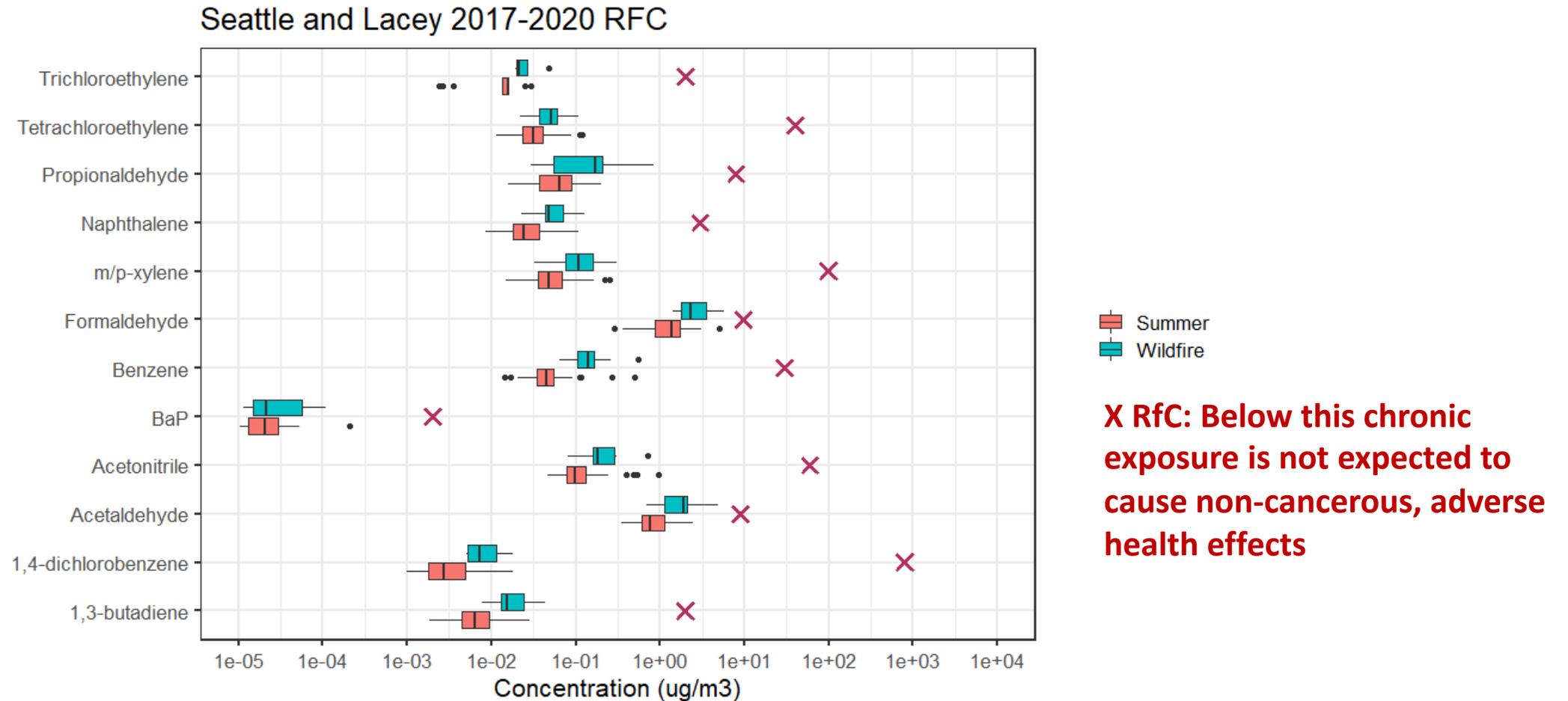
- Which HaPs are enhanced in wildfire smoke?
- What are their associated health impacts?
- How does toxicity change with fresh vs. aged wildfire smoke?



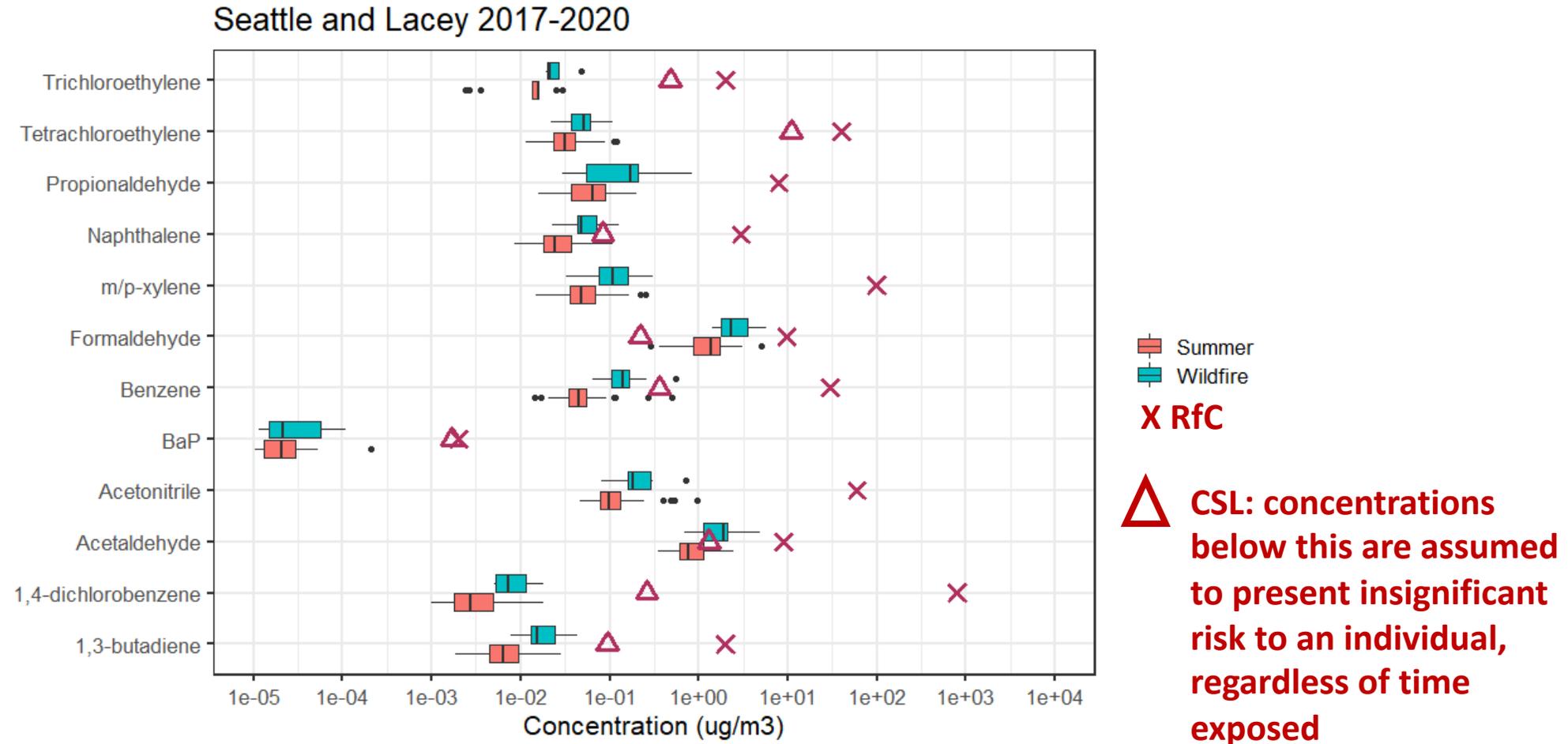
# Hazardous air pollutants enhanced in wildfire smoke compared to summer concentrations



# Health impacts of wildfire-enhanced HaPs: Reference concentrations



# Health impacts of wildfire-enhanced HaPs: Carcinogenic Screening Levels

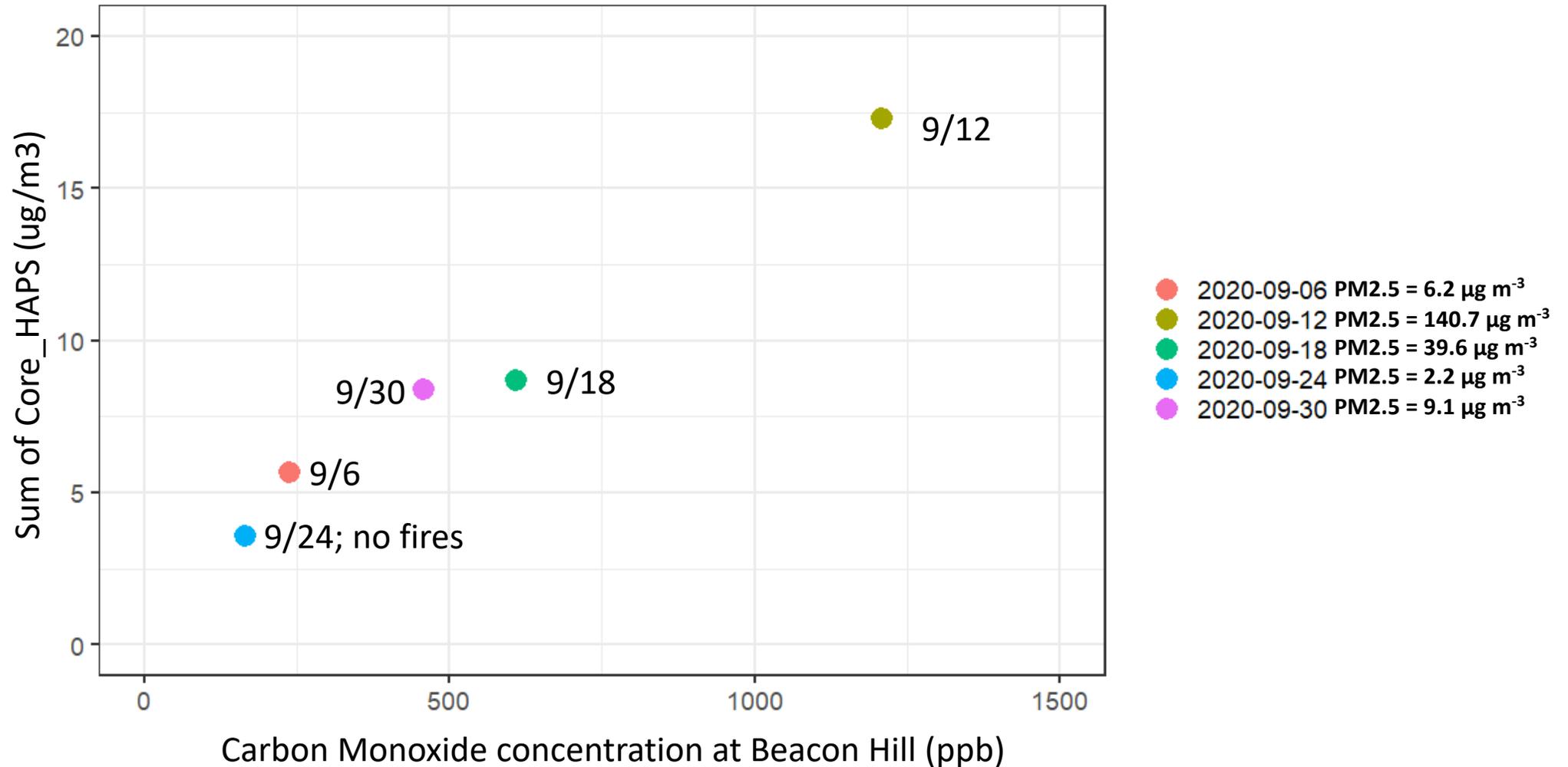


# Health Impacts and PM2.5 NAAQS

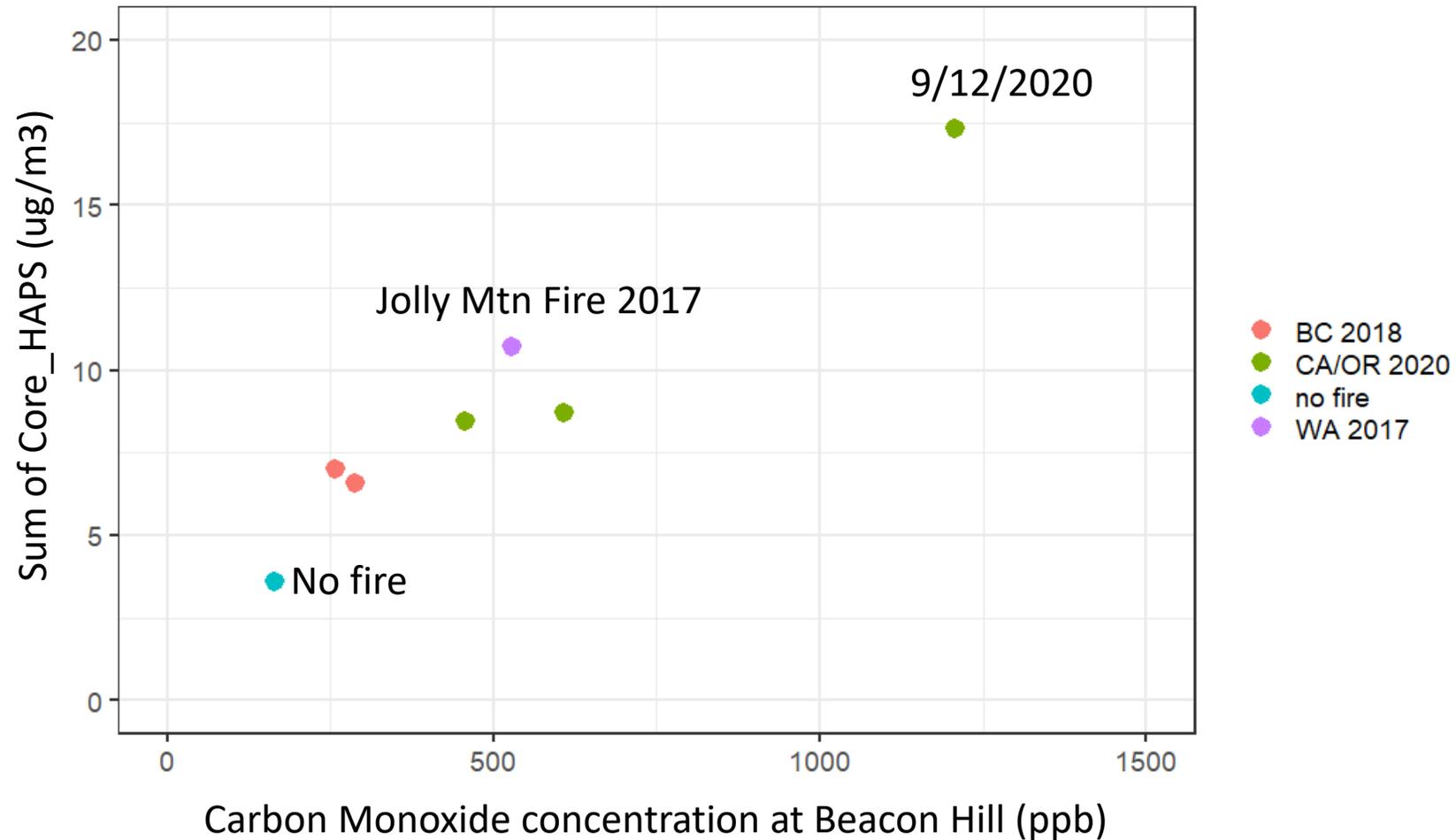
- Annual NAAQS for PM2.5 are meant to protect against chronic exposure
- CSL (carcinogenic screening levels) and RfC (non-carcinogenic reference concentrations) set ambient concentrations at which there are insignificant health risks after a lifetime of chronic exposure

compounds	Benzo(a)pyrene	Naphthalene	Benzene	PAH (BaP TEF)
RfC	2 ng m <sup>-3</sup>	3 µg m <sup>-3</sup>	30 µg m <sup>-3</sup>	2 ng m <sup>-3</sup>
CRSL	1.8 ng m <sup>-3</sup>	83 ng m <sup>-3</sup>	0.36 µg m <sup>-3</sup>	1.8 ng m <sup>-3</sup>
@ PM2.5 NAAQS	1.2 ng m <sup>-3</sup>	77 ng m <sup>-3</sup>	3 µg m <sup>-3</sup>	2 ng m <sup>-3</sup>

# HaPs in Wildfire Smoke: September 2020



# HaPs in Wildfire Smoke: 2017-2020



# Summary

- Seattle observes lower concentrations than Lacey of toxic compounds from residential wood smoke emissions
- HaPs enhanced in wildfire smoke are mostly below reference concentrations and carcinogenic screening levels
- Toxicity of smoke impacted by the age of the wildfire plume
  - Larger PAHs oxidized more rapidly than smaller volatile VOC
  - UV absorption indicates oxidized PAH in same proportion to CO as parent compounds