United States Environmental Protection Agency

Pile Burning Emissions Estimates for the 2023 National Emissions Inventory

Source: https://forestry.nv.gov/uploads/hero-backgrounds/Spooner_Rx_Burn_-_202220220115_0021.JPG

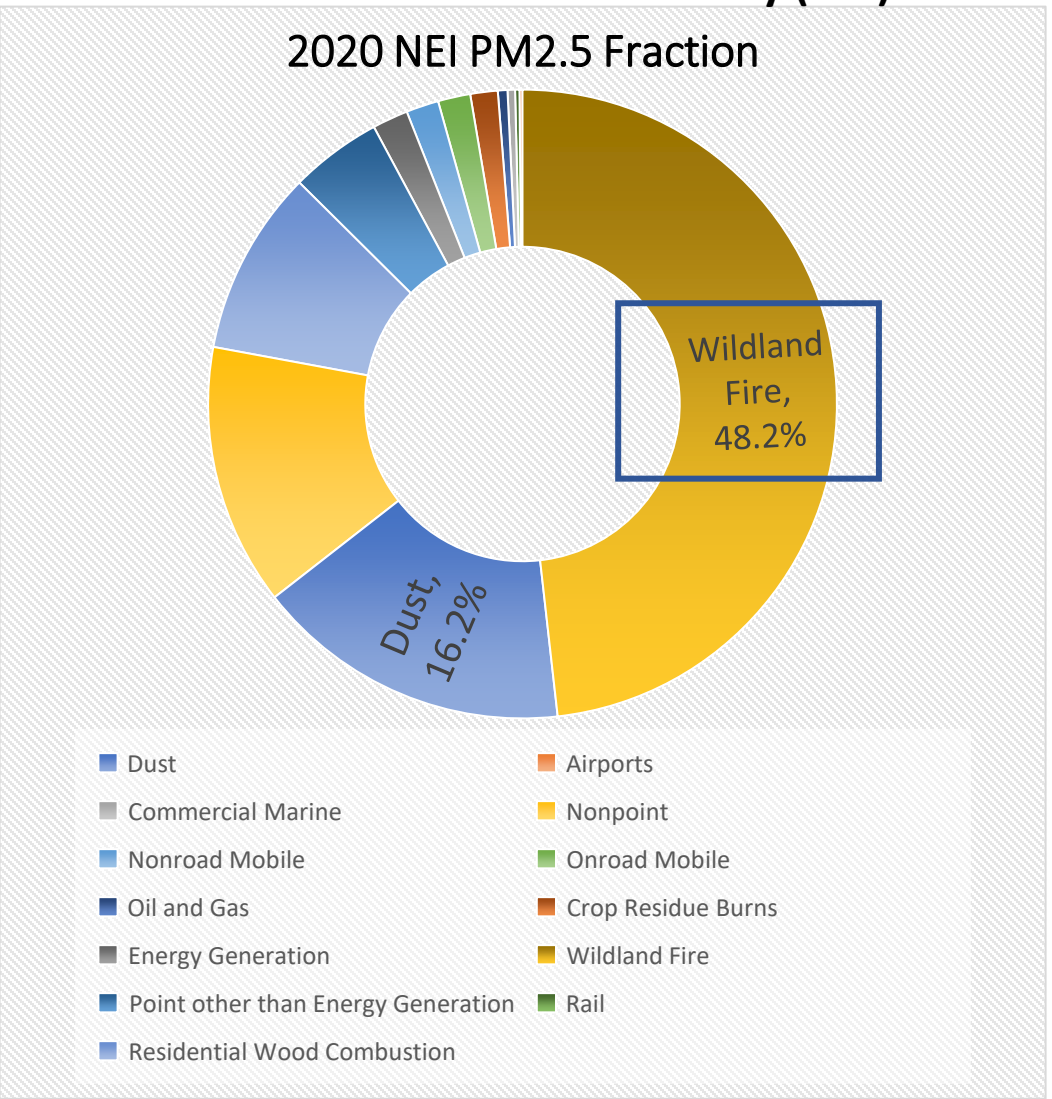
Questions? Send email to NEI_Help@epa.gov

Presented at the 2025 Emissions Inventory Conference - Advancing Emissions Inventories through Innovation and Collaboration

9/15/2025

Introduction

Wildland fires are consistently the largest emitter of Particulate Matter < 2.5 microns ($PM_{2.5}$) in the National Emissions Inventory (NEI)



Prescribed fires (Rx) like this broadcast burn annually account for 25-75% of the wildland fire $PM_{2.5}$ in EPA inventories[1]

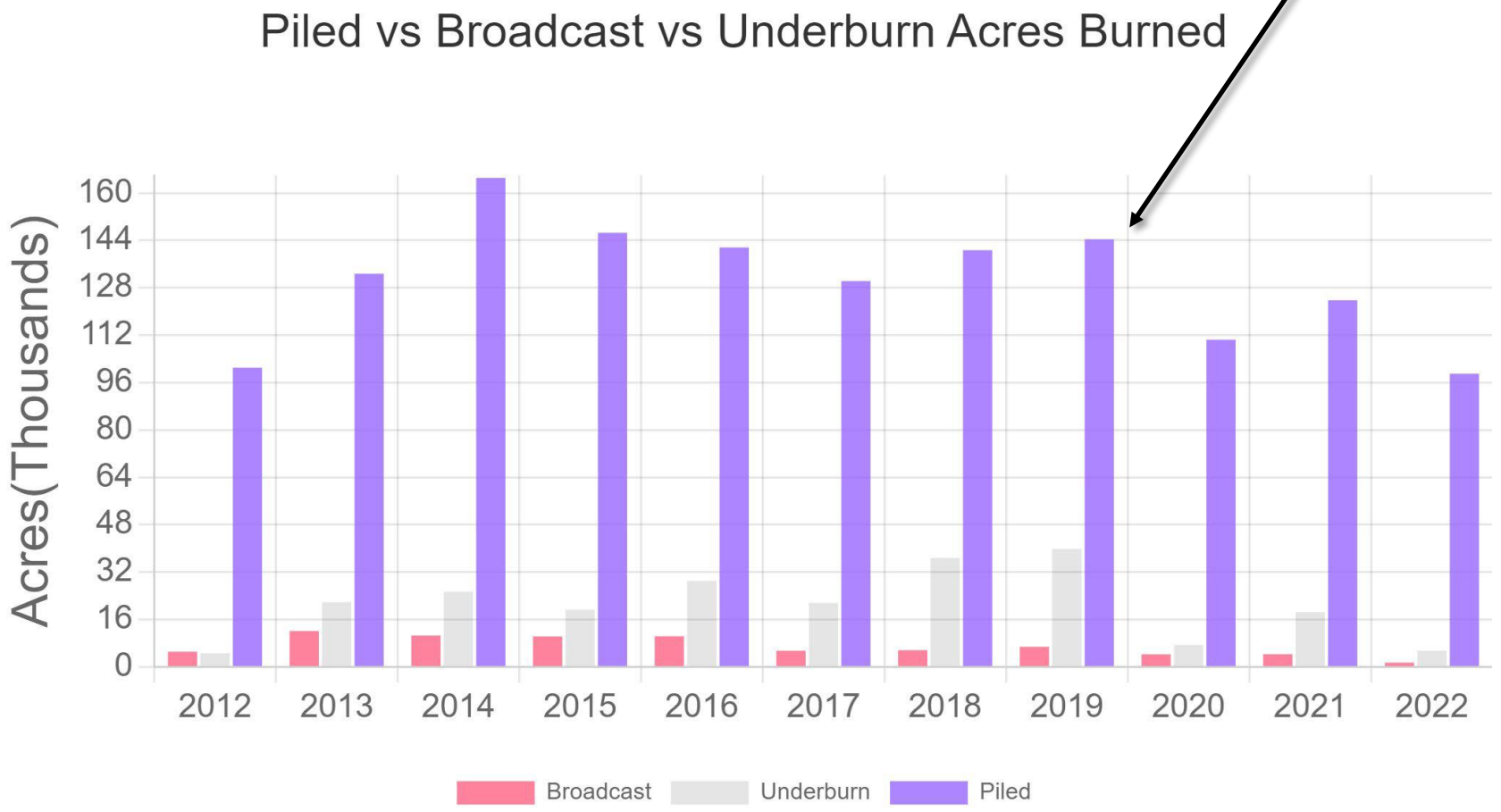
USFS: https://www.fs.usda.gov/sites/default/files/styles/scale_880/public/2023-04/prescribed-burn-on-hornet.jpg?itok=IwXcZl0w

Not all prescribed fires are broadcast burns!

[1] https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data

Why are pile burns important?

~75-90% of area treated with fire in **Oregon** each year are in the form of pile burns.



Pile burns are common in many parts of the U.S., particularly the western U.S.

Source: Oregon Department of Forestry 2022 Oregon Smoke Management Report

Motivations

Large piles of woody biomass are burned as part of fuel treatments or to dispose of downed wood. These are pile burns (PB).

- Satellites can detect pile burns but they were previously categorized as higher emitting broadcast burns (or perhaps ignored)
- We recognized an emissions difference with pile burns but no suitable NEI had been developed

- What magnitude of criteria air pollutants do pile burns emit across the United States and where do these emissions occur?
- Develop a method for estimating pile burn emissions in the 2023 NEI that:
  - Accommodates state-submitted activity
  - Integrates into the NEI workflow
  - Provides daily emissions totals by location

Pile Burn Activity

- 2023 pile activity data for 14 states, 2 Federal agencies, and 1 tribe
- Activity basis varied across these data sets:

Area	Pile Volume	Pile Geometry	Piled Mass	Burned Mass
5	4	3	3	3

- Each form of activity requires a different calculation method to get to the burned mass

- 2023 final pile burn data gap-filled with satellite fire detections over recent known logging activity on USFS land in CO and SD

Estimating Pile Burn Emissions

Pile Burning Emissions = Biomass Burned * Emission Factor

Biomass burned

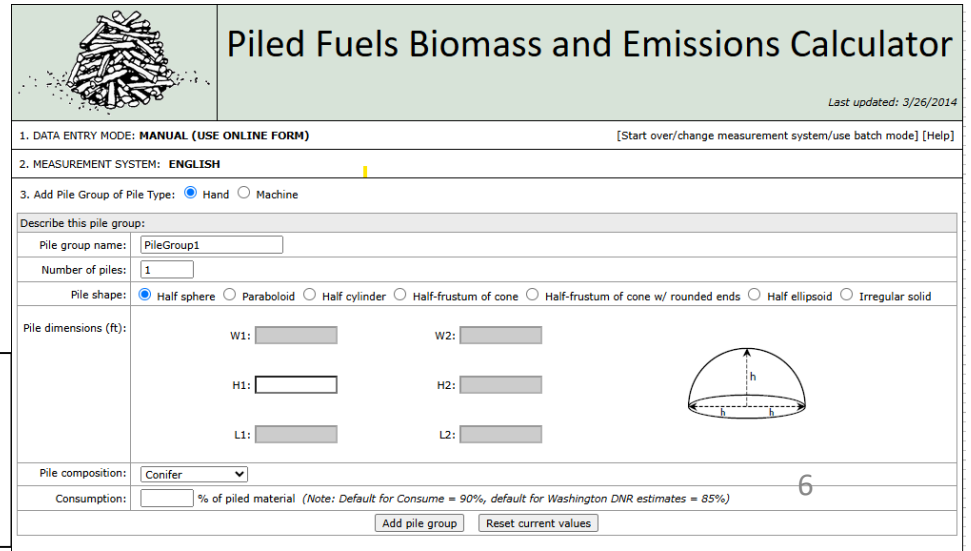
- Can be estimated with 5 different calculations depending on the information provided
  - $\boldsymbol{Mass\ consumed}$ *or*
  - $\boldsymbol{Mass\ of\ piled\ material} \times consumption\ fraction\ (CF)$ *or*
  - $\boldsymbol{Pile\ volume(geometry)} \times biomass\ density \times packing\ ratio \times CF$ *or*
  - $\boldsymbol{Pile\ volume} \times biomass\ density \times packing\ ratio \times CF$ *or*
  - $\boldsymbol{Area} \times fuel\ loading \times CF$

Activity reported in the **bolded** forms

Emission factors

- Smoke Emissions Reference Application (SERA) pile burn emission factors (EFs)
- EFs by combustion phase where possible: flaming vs. smoldering vs. residual

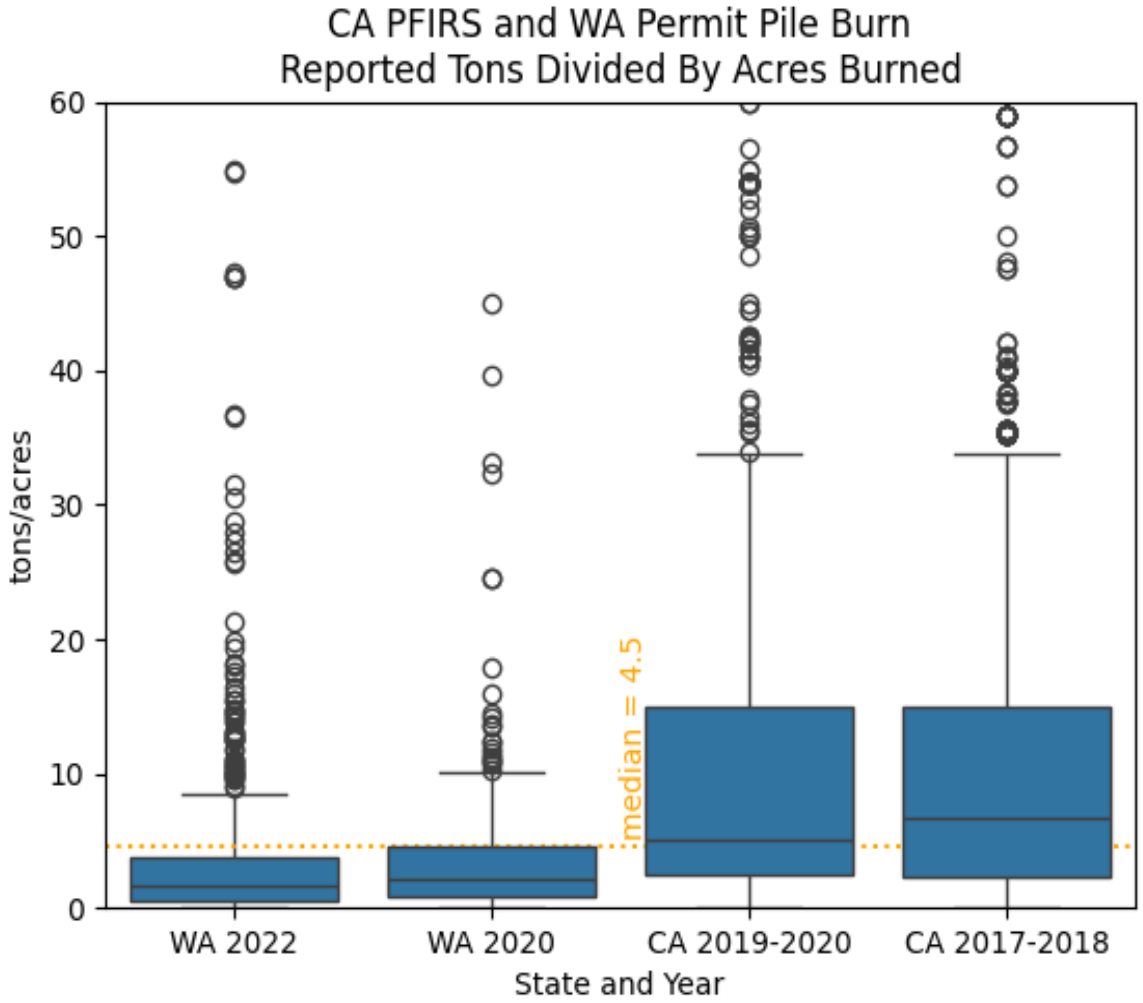
https://depts.washington.edu/nwfire/piles/



Pile geometry consumption equations from USFS/UW Pile Burn Calculator and CONSUME for hand (Wright 2009) and machine piles (Hardy 1996)

Estimating Biomass Burned from Area

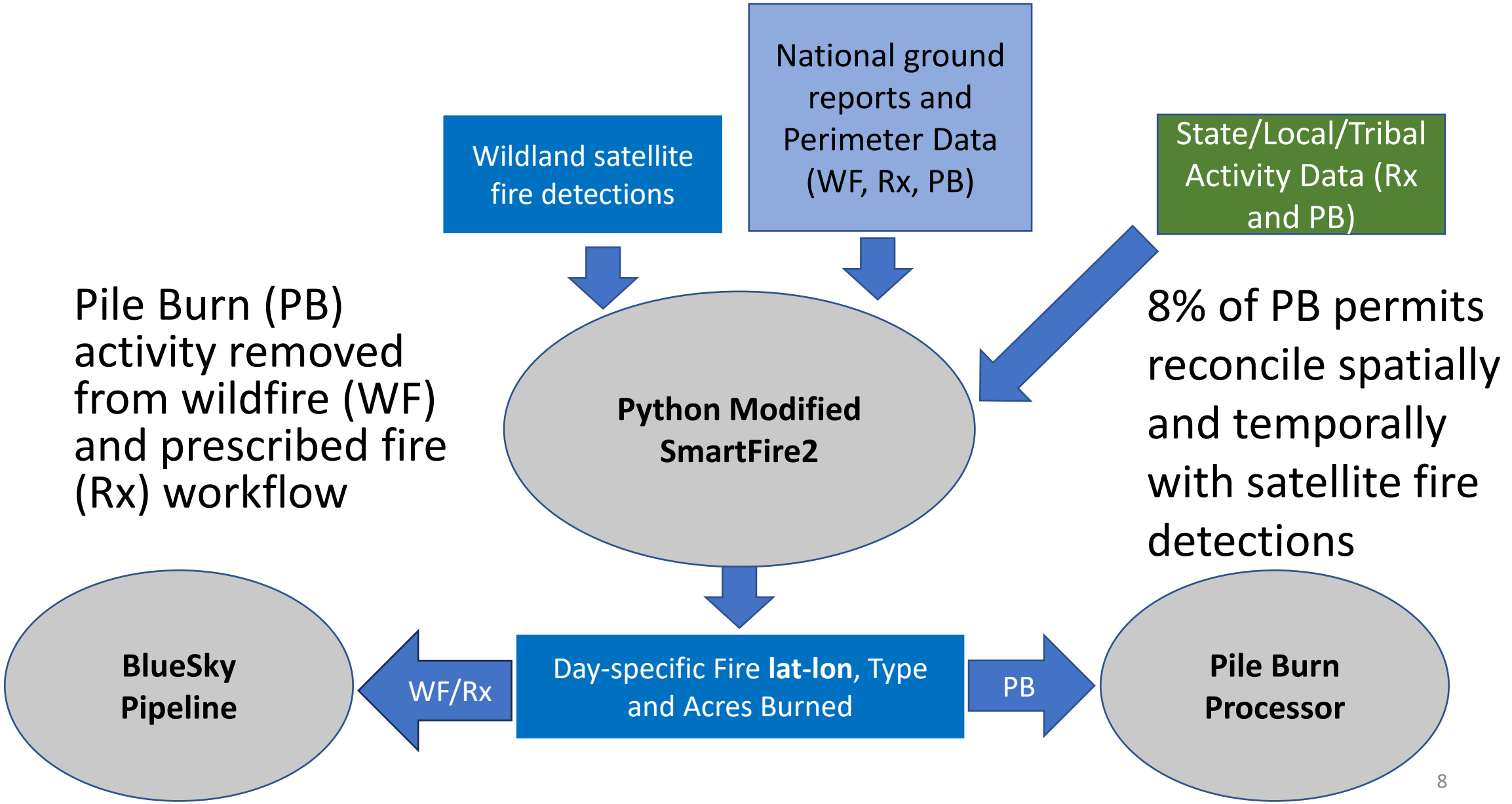
4.5 tons/acre median value derived from CA and WA permit data



For states and agencies that only provide **area**:

$$Biomass\ burned\ = \mathbf{4.5}\ \boldsymbol{tons/acre} \times\ acres\ (treated)\ \times\ CF$$

2023 Pile Burn Workflow



Pile Burn (PB) activity removed from wildfire (WF) and prescribed fire (Rx) workflow

8% of PB permits reconcile spatially and temporally with satellite fire detections

2023 Pile Burn Emissions

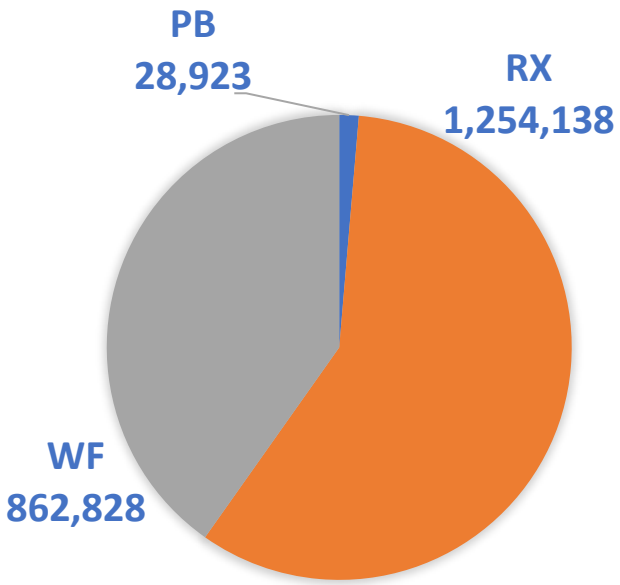
2023 Draft Pile Burn County $PM_{2.5}$

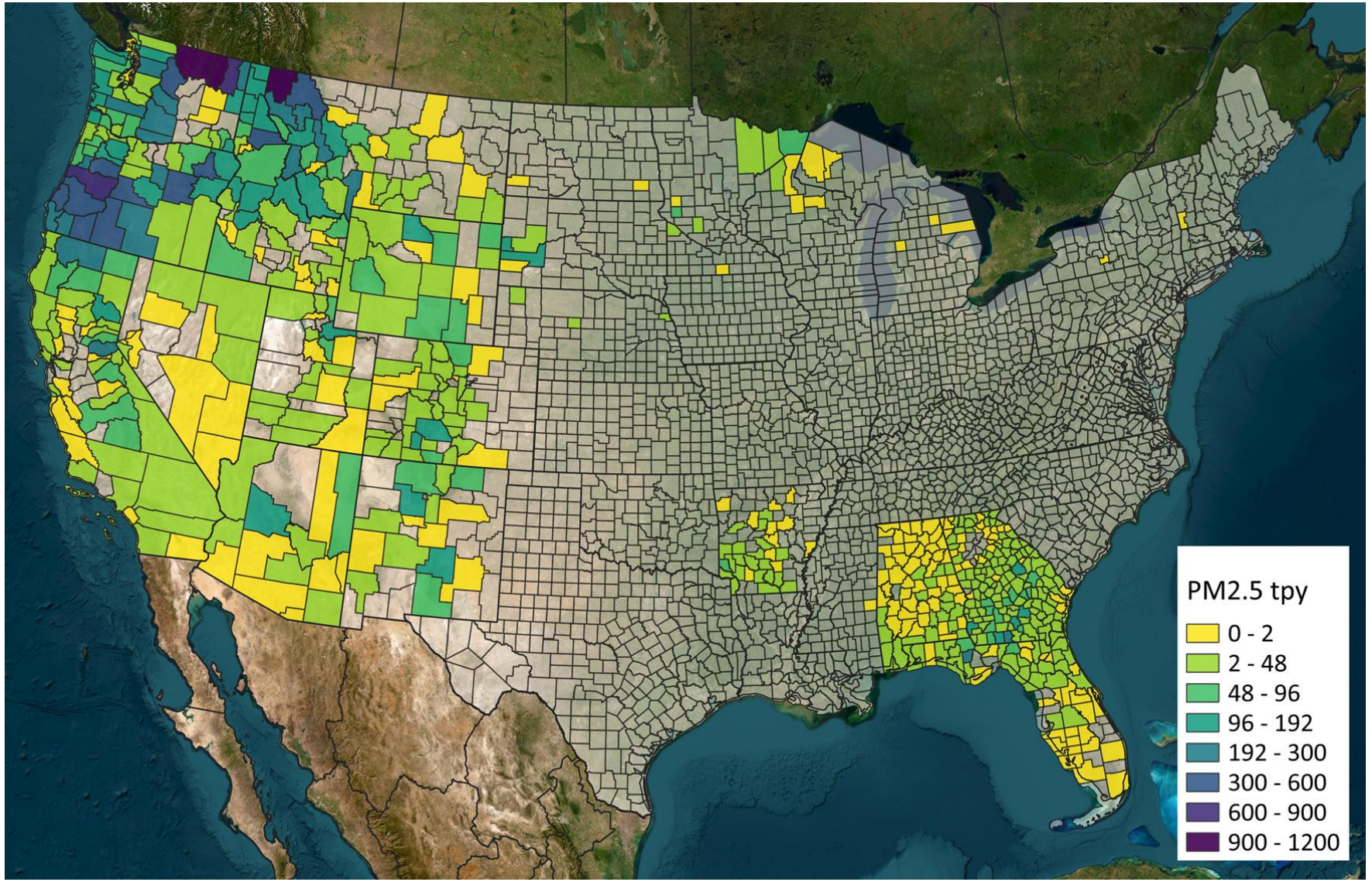
Submissions from

- 15 States
- 1 Tribe
- 2 Federal Agencies

2023beta NEI Wildland Fire

$PM_{2.5}$ Tons per year





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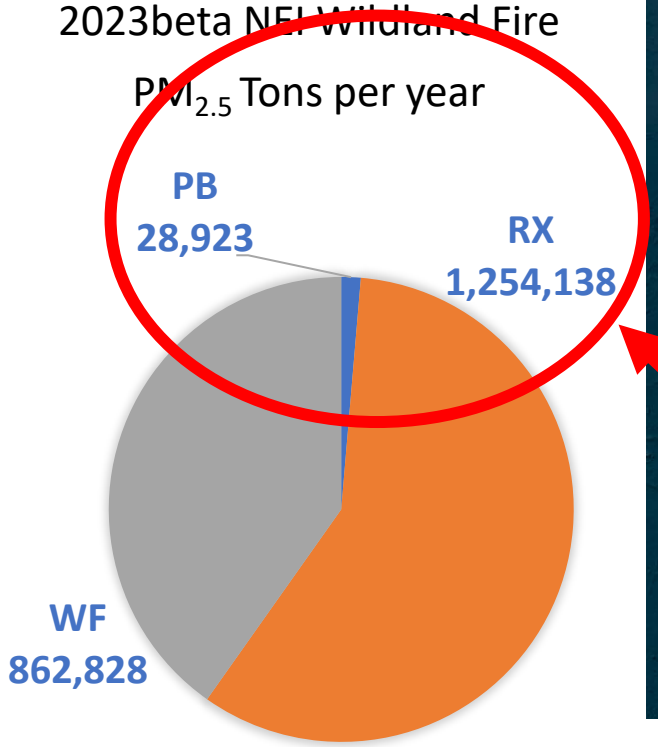
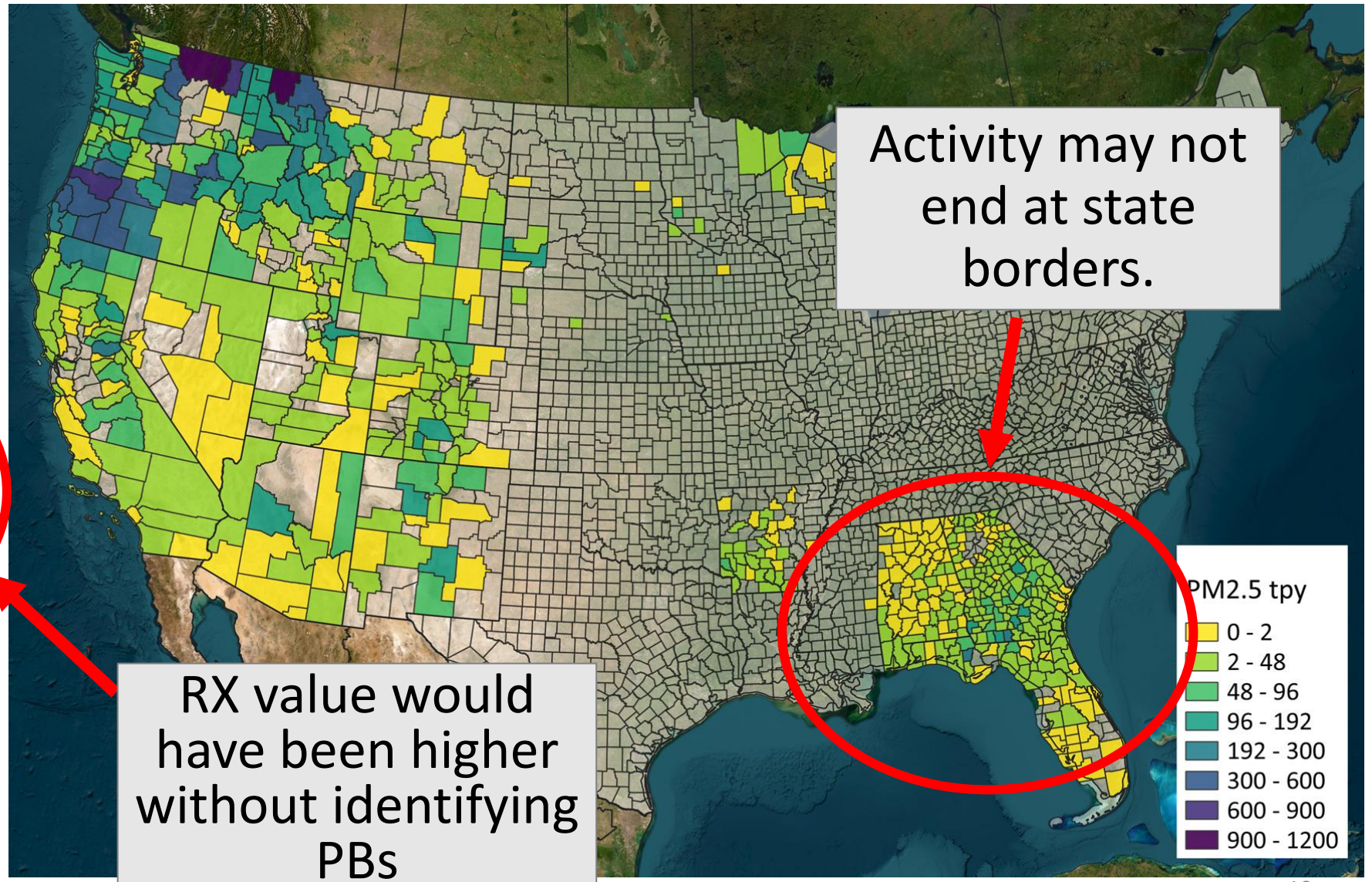
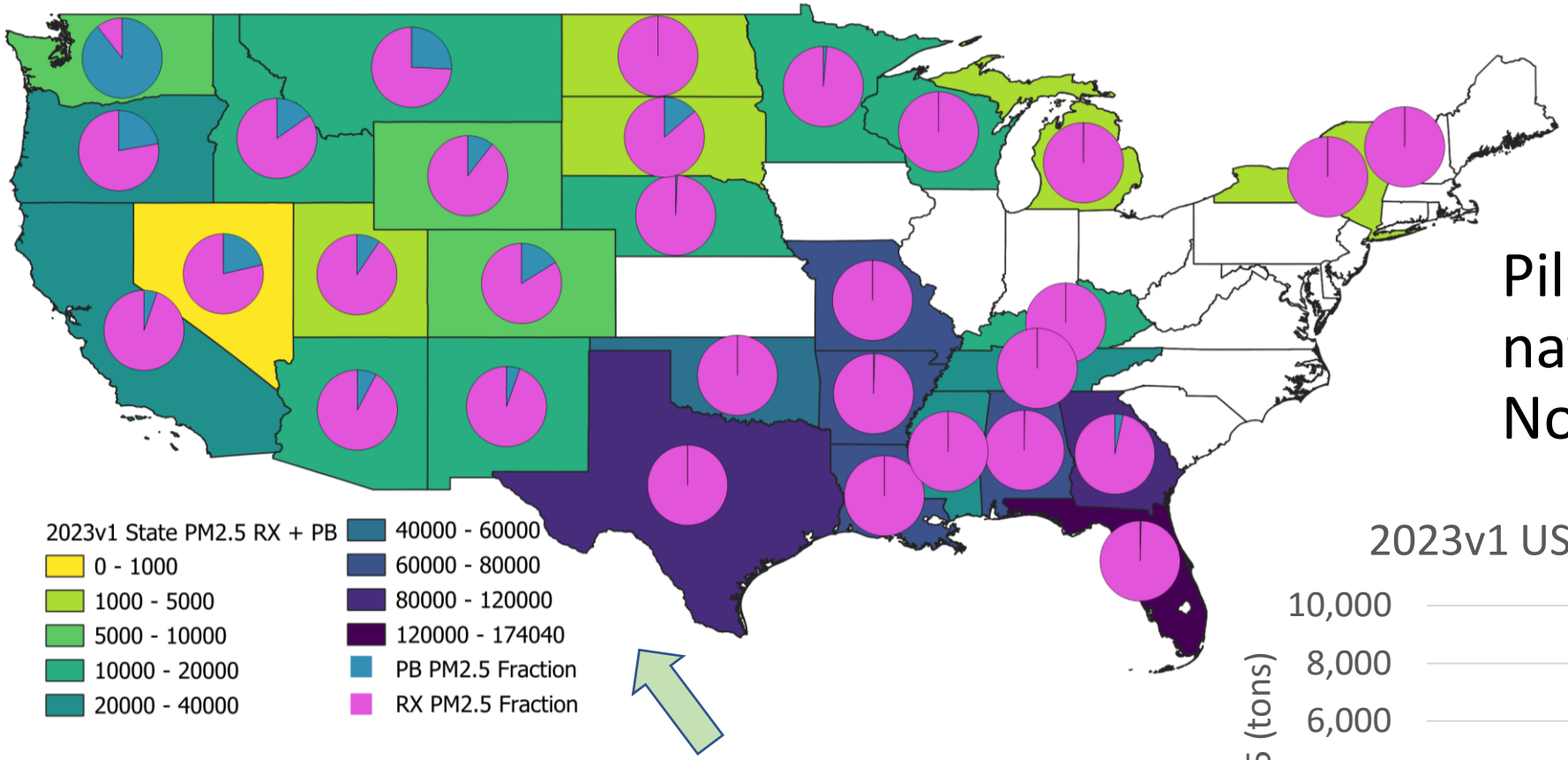




Activity may not end at state borders.

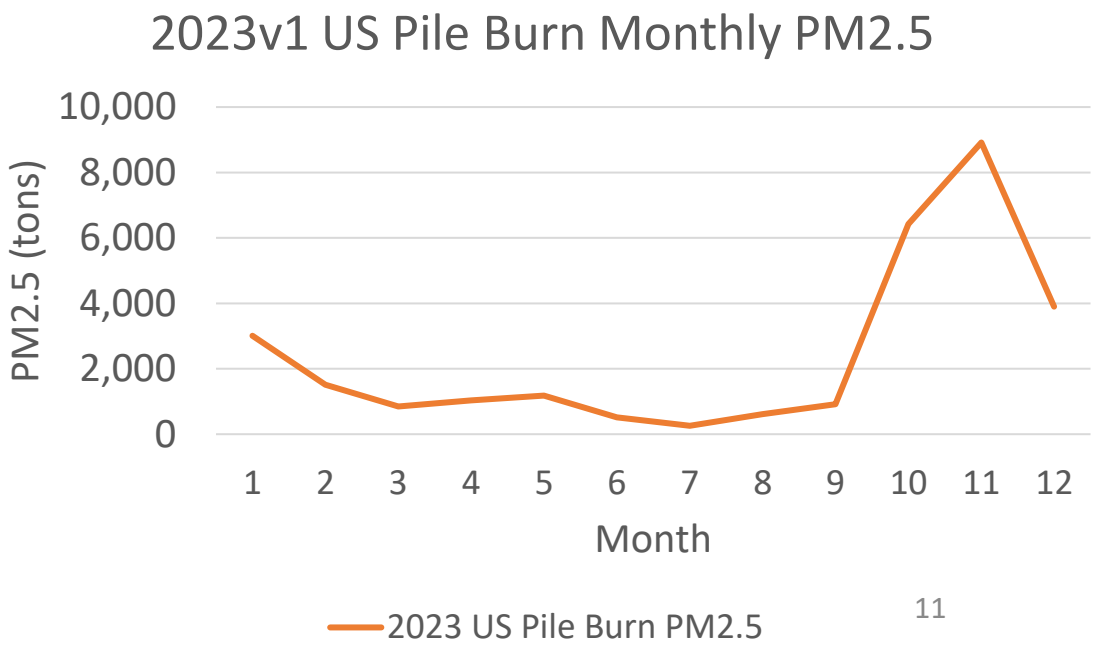
RX value would have been higher without identifying PBs

2023 Final Pile Burn Emissions

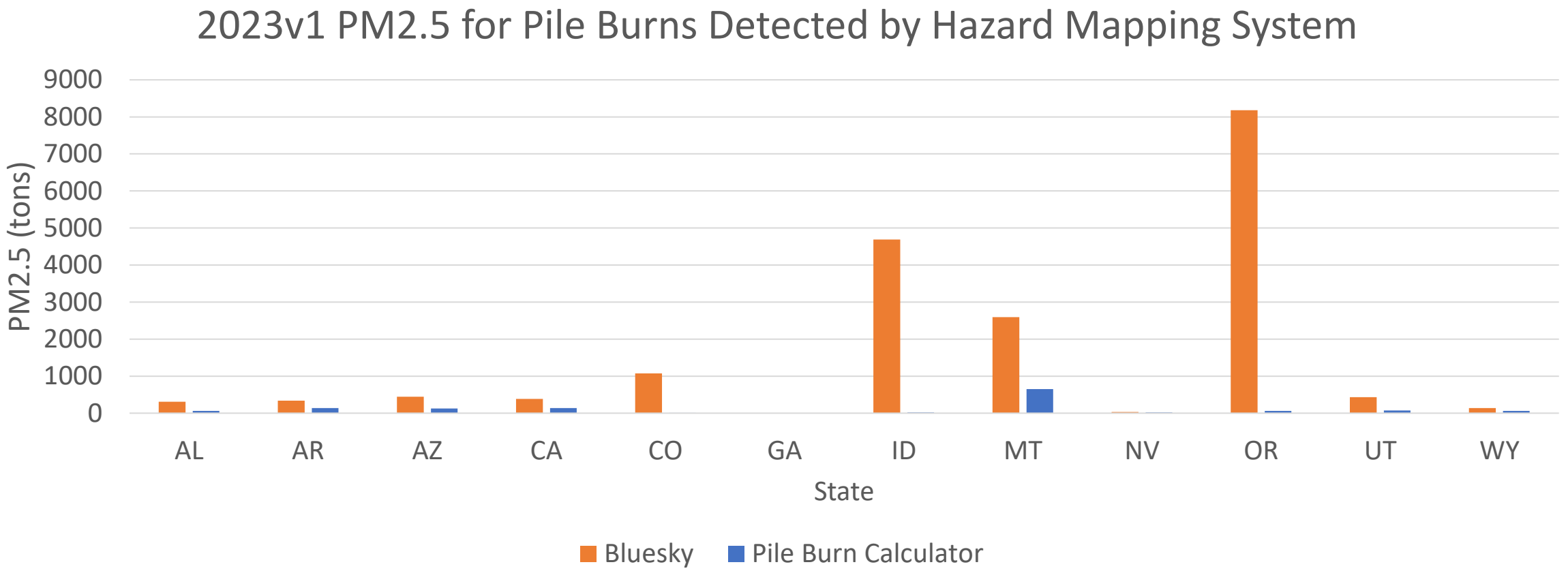


For states with PB data, fraction of total prescribed fire $PM_{2.5}$ from PB higher in Northwest

Pile burn emissions peak nationally in October and November



2023 Method Comparison



2023v1 Pile Burn Activity Associated with HMS Detects

BlueSky Processed through BlueSky as Broadcast Burns

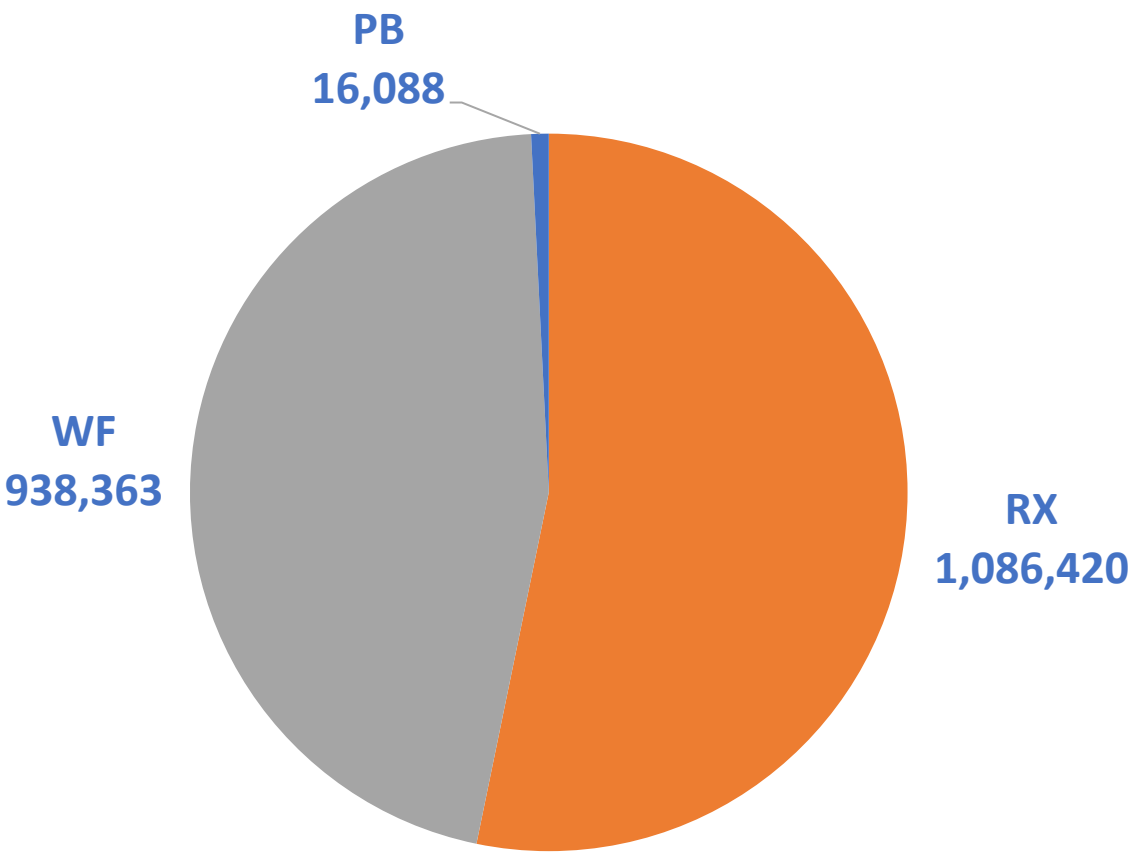
Pile Burn Calculator Processed as piles using the draft pile burn method

Area treated is equivalent between methods

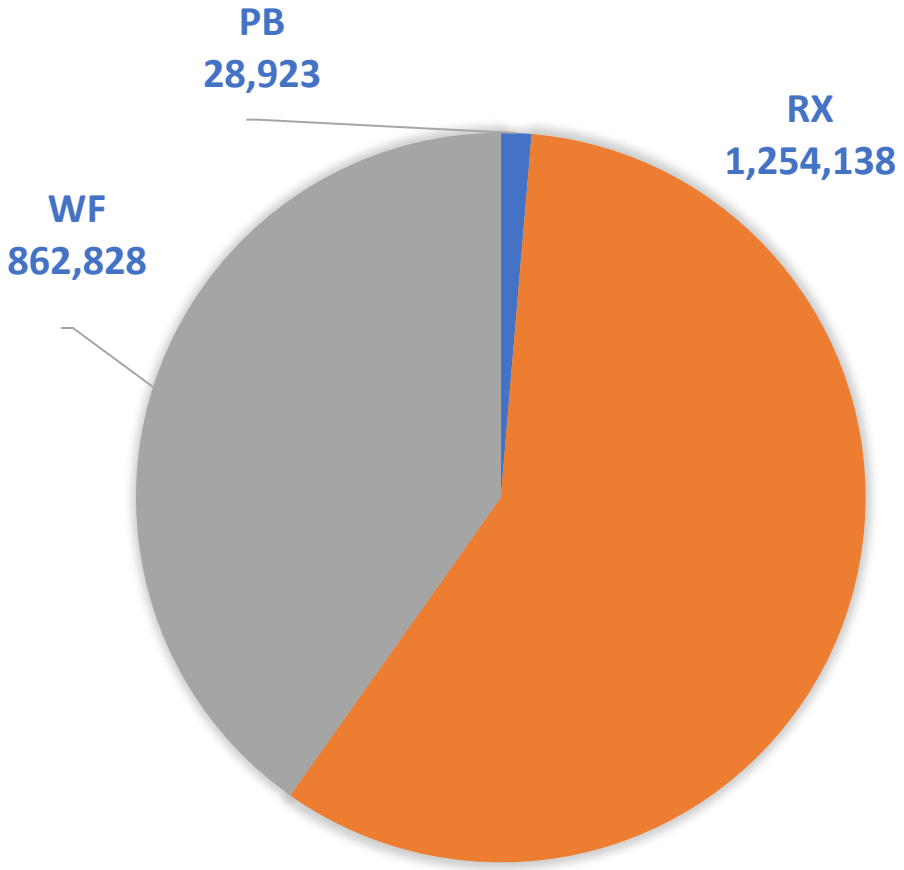
93% Reduction in $PM_{2.5}$ for activity seen by satellite

2022 Pile Burn Emissions Comparison

2022 Emissions Modeling Platform (v2) had 16,088 tons $PM_{2.5}$ from 13 states, 2 Federal agencies, and 1 tribe



2023 Draft NEI has 28,923 tons $PM_{2.5}$ from 14 states, 2 Federal agencies, and 1 tribe



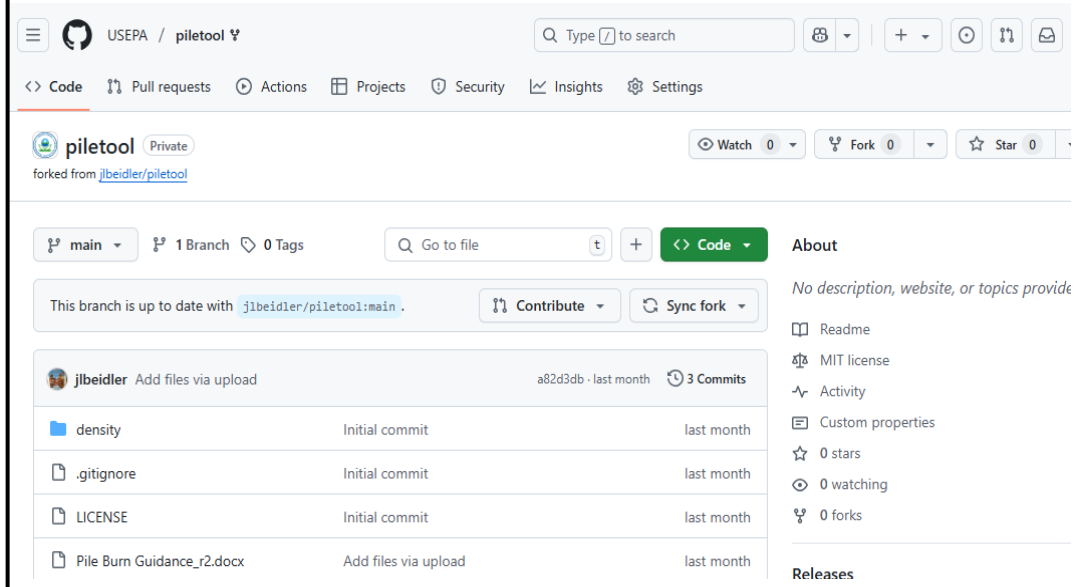
More activity and more complete activity is resulting in greater pile burn emissions as this method continues to be implemented.

Impacts and Next steps

- PBs are a relatively minor source of emissions nationally, but locally important in the Pacific Northwest
- Previous NEIs may have overpredicted prescribed fire emissions in regions with pile burn activity
- Directly applicable to air quality modeling for State Implementation Plans (SIP) as a source of winter PM

- Data are missing: acquire more data from states, land managers, and practitioners
- Identify data sources and methods to differentiate pile burns
- Expand the emission factors to include hazardous air pollutants (HAPs)
- Evaluate updated pile burn calculator in BlueSky

Draft Python tool available on internal EPA GitHub: https://github.com/USEPA/piletool



EPA United States Environmental Protection Agency

Contact: NEI_Help@epa.gov

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Estimating Biomass Burned From Activity

- Activity supplied as a **mass**
  - If it is burned or consumed – great! Nothing more to do.
  - If it is total mass in pile – apply the consumption fraction (75-95% Hardy 1996) (90-95% Wright 2019)
- Activity supplied as a **pile volume**
  - Determine packing ratio to calculate effective volume (0.1-0.3 Hardy 1996/CONSUME v3) for machine piles
  - Determine wood species to calculate mass using biomass density (Miles 2009) or regression formula (Wright 2010)
- Activity supplied as a **geometry**
  - Determine best volume formula to calculate pile volume
  - Follow the pile volume method above

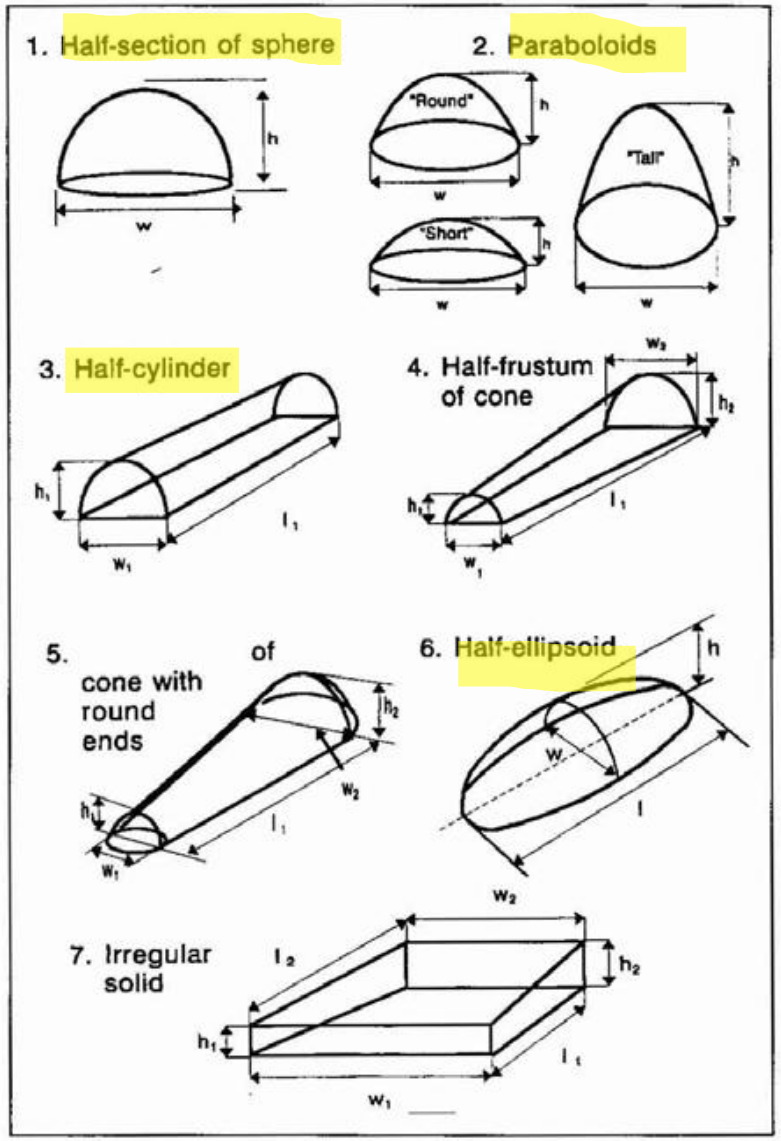

Image source: Hardy 1996