School of Environmental and Forest Sciences

UNIVERSITY of WASHINGTON

College of the Environment

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CINTRAFOR

Center for International Trade in Forest Products

Avoided Impacts on Human Health by Recovering Wood Residues for Bioenergy and Bio-products in the Pacific Northwest

Presented by:

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U.S. DEPARTMENT OF ENERGY

HUMBOLDT STATE UNIVERSITY

Background – Harvest residue

Large mechanical DNR WA Naches piles.

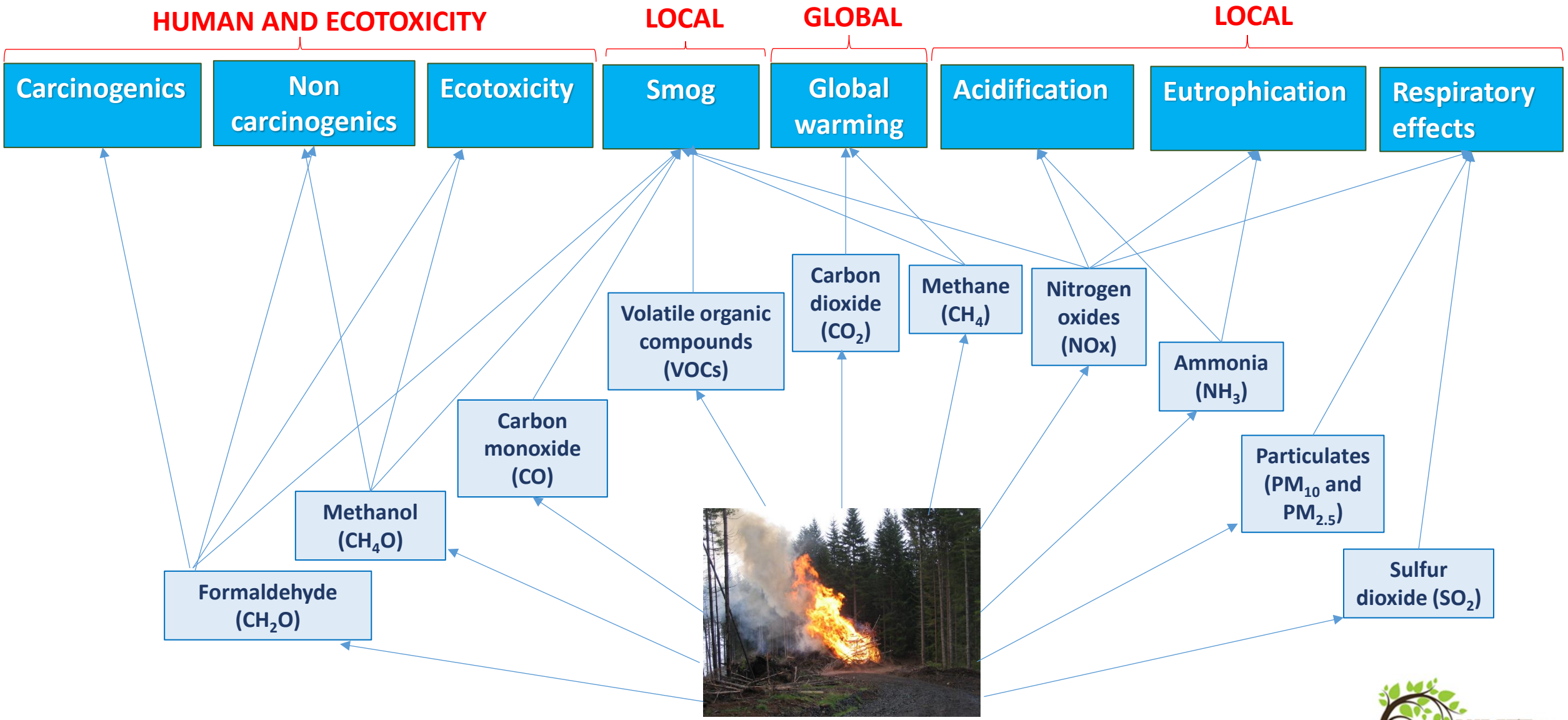
- In the U.S. Pacific Northwest a large volume of residue are produced by forest operations.
- Western Washington and Oregon are two of the largest timber producing regions in the US.
- Given the harvest practices and the species associated, on an average **18-22%** of the above ground woody biomass can be categorized as **harvest residue** (tops, branches and foliage).
- In this region, on an average **60%** of the overall harvest residue **gets piled** up at the primary landing and **burned**.

Sources: (Wiedinmyer et al. 2006), (Annenberg et al. 2012)

Objective

- The goal of the study is to develop an objective, data driven, and geo-spatially nuanced assessment of the environmental and health **benefits associated with avoiding/reducing slash** by recovering forest residues to produce biofuels instead of burning them in prescribed fires in the western forests.

Background: Emissions from slash piles burn



Method: TRACI 2.1

Source: (NETL Life Cycle Inventory Data, 2013)

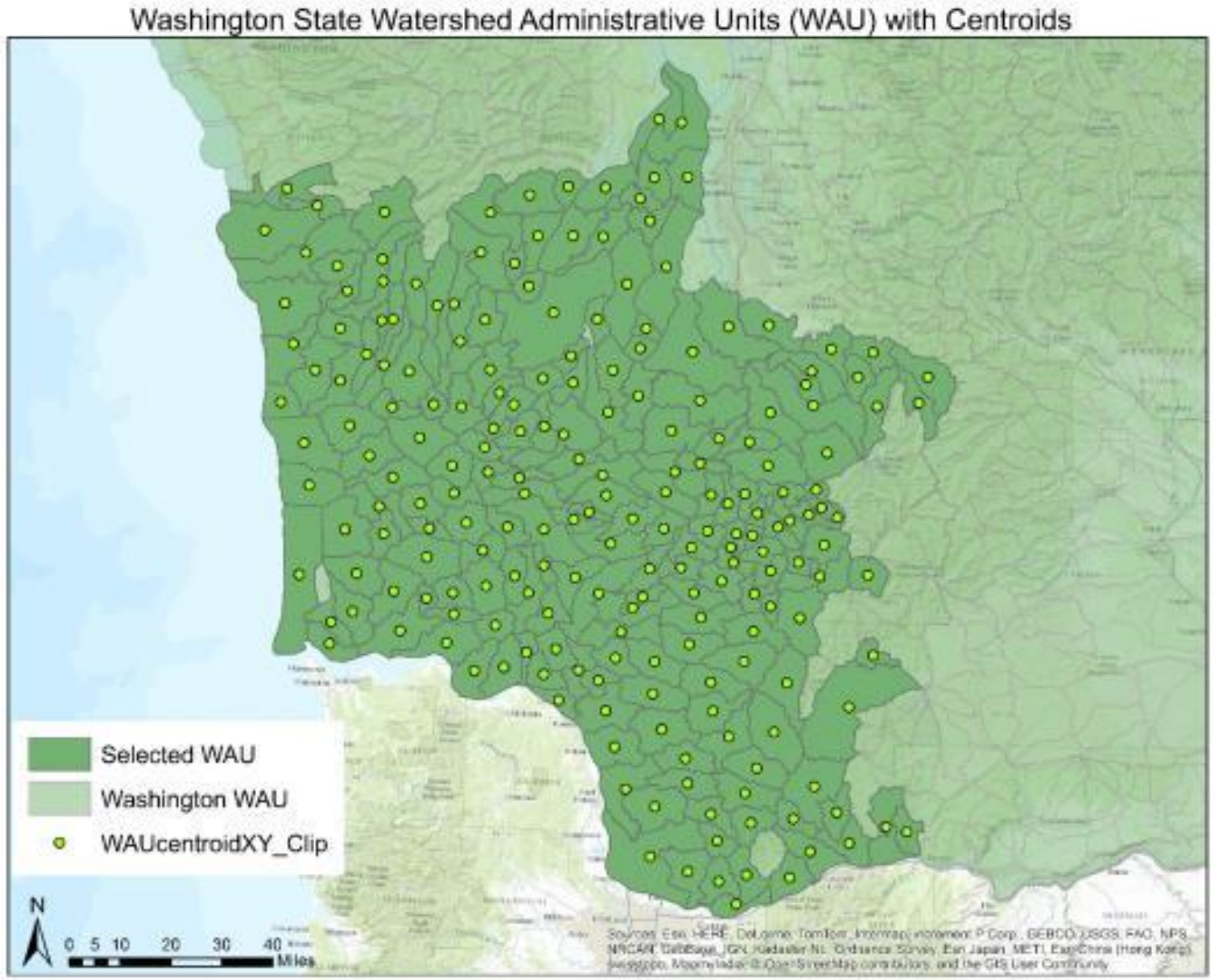
Main Steps of the assessment

1	2	3	4	5	6
					
Biomass calculator	Piles modeling	Piles emissions	Pollutants concentration	Human intake	Impact on population
Washington State Biomass Calculator	Data collection on field	Bluesky Playground online tool	AIRPACT	USEtox 2.0	2010 Census data

1. Biomass supply - Washington State Biomass Calculator

- Biomass supply from 3 timbersheds in Southwest Washington where numerous facilities can be used in the scenario
- Comprised of 11 counties
- The project area includes 214 Watershed Administrative Units (WAU)

2. Piles modeling – Data collection on field



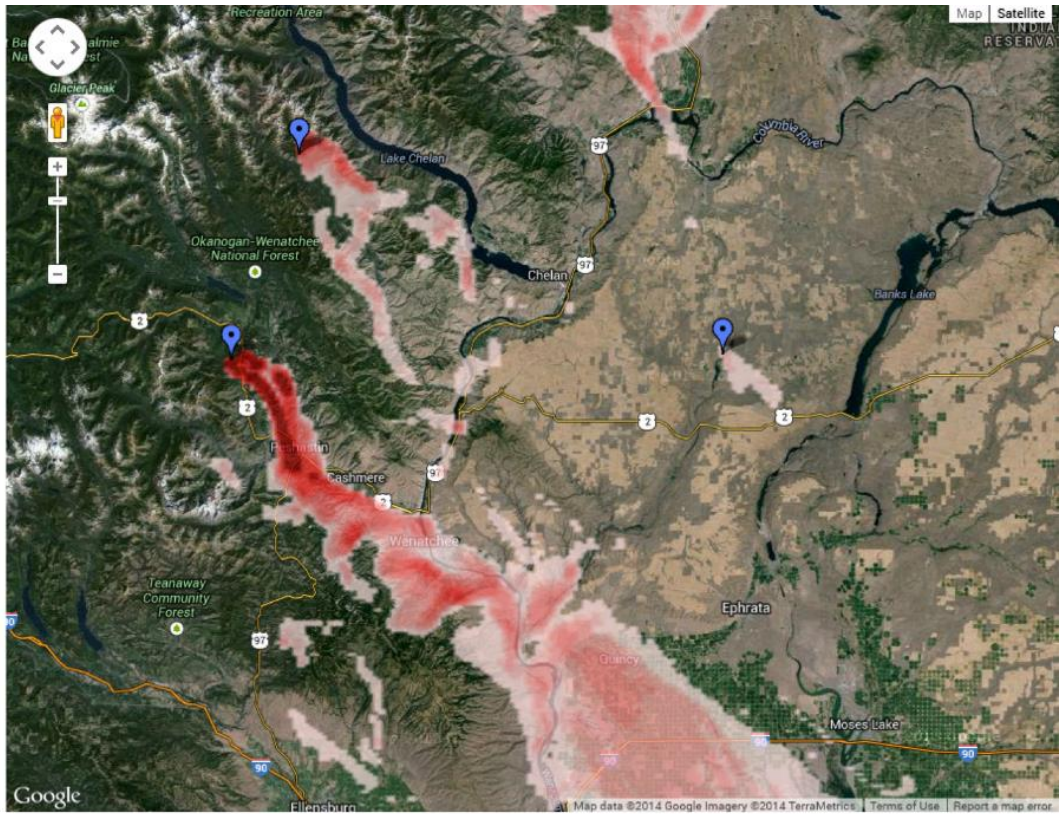
AIRPACT requires location coordinates for the pile burns so locations for the inputs were created in ArcMap

New coordinates become burn locations for AIRPACT input

- Pile sizes:
  - **large** (~**50-60 tons/pile**) (25%),
  - **medium** (~**20 tons/pile**) (50%),
  - **small** (**10 tons/pile**) (25%)
  - **small hand pile** (~**0.05 tons/pile**).

- These shapes and sizes are later used as an input for Bluesky to estimate emissions

3. Calculation of piles emissions - BlueSky



BlueSky smoke modeling example for July 29 2014 over Eastern WA.

BlueSky modularly links a variety of independent models of fire information, fuel loading, fire consumption, fire emissions, and smoke dispersion, enabling:

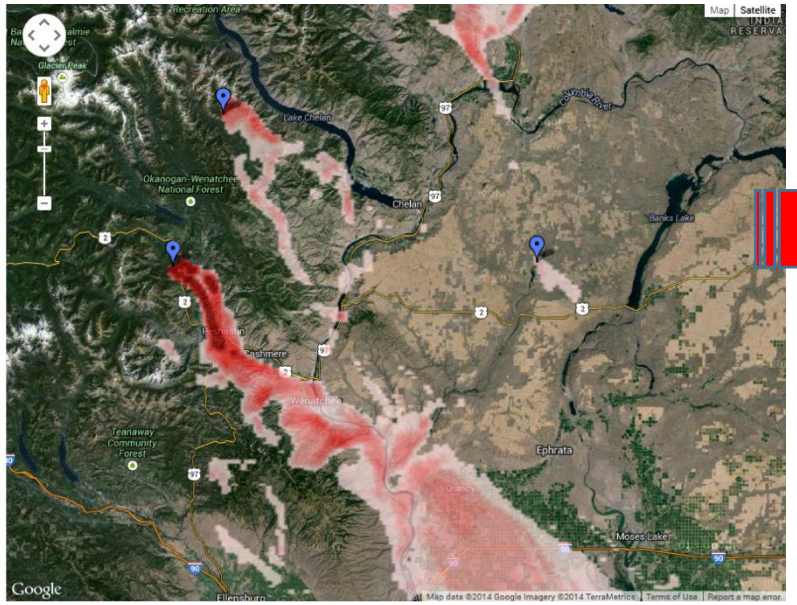
- ✓ the calculation of total and hourly fire consumption based on fuel loadings and weather information;
- ✓ the calculation of specific emissions (such as CO_2 or $PM_{2.5}$) from a fire;
- ✓ the calculation of vertical plume profiles.

(http://www.airfire.org/emissions/)

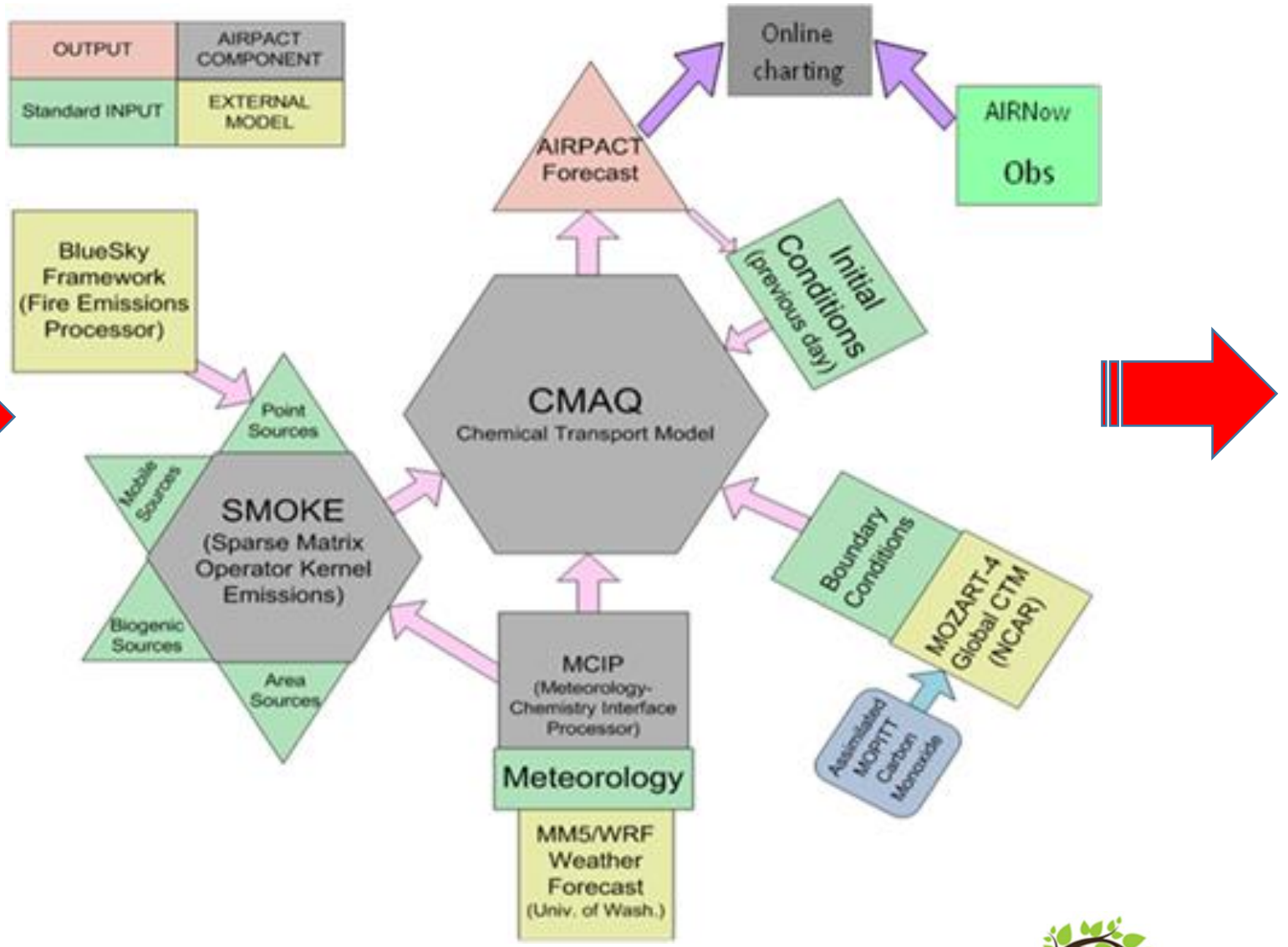
4. Pollutants concentrations – AIRPACT

We modeled ~ **800,000 tons** of biomass

burned over a **29 days period in 2011.**

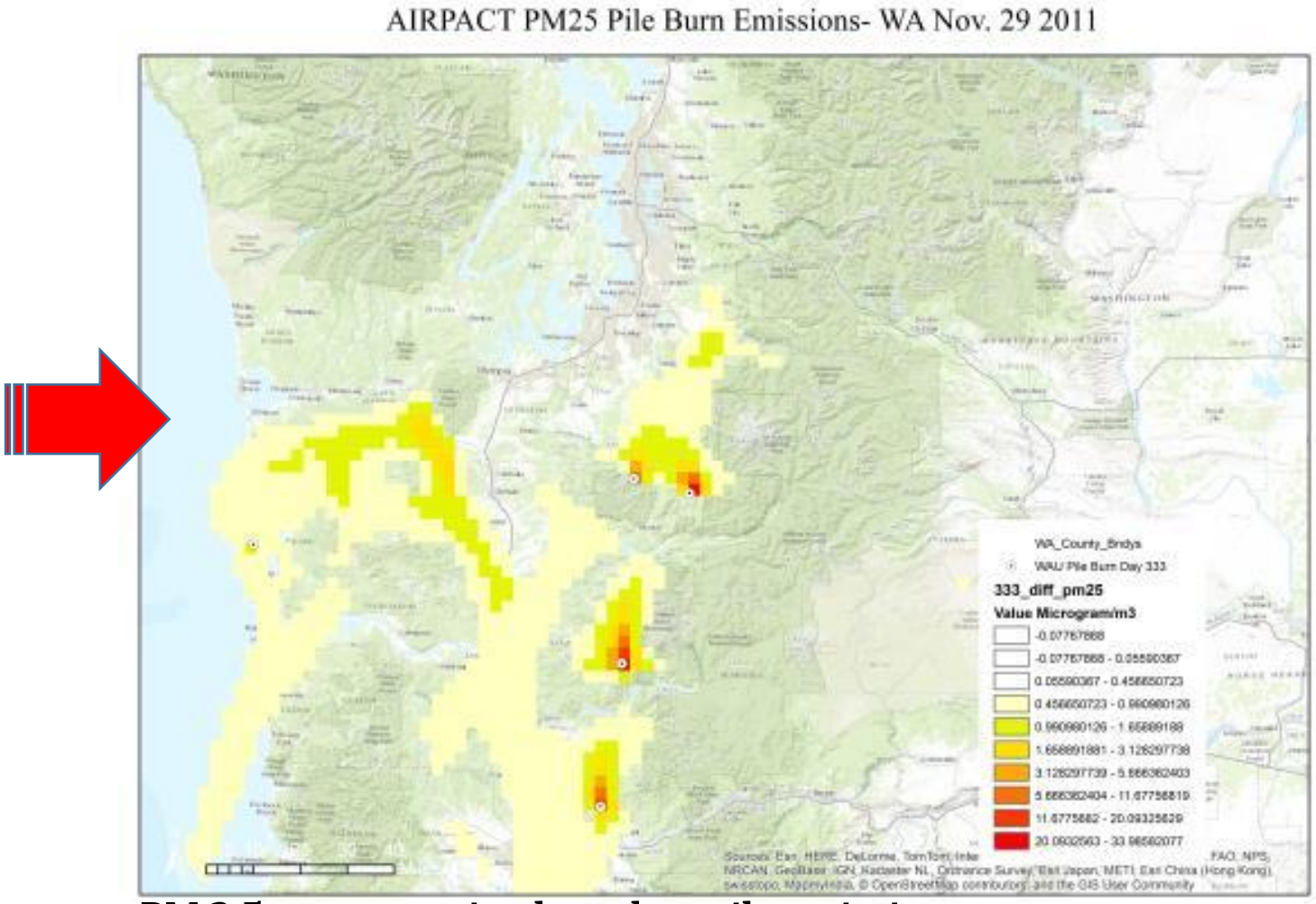


BlueSky smoke modeling example for July 29 2014 over Eastern WA.



AIRPACT model displaying the various model integrations. Graphic: Ravi V. et al. 2016

4. Pollutants concentrations – AIRPACT



PM 2.5 concentration based on pile emissions

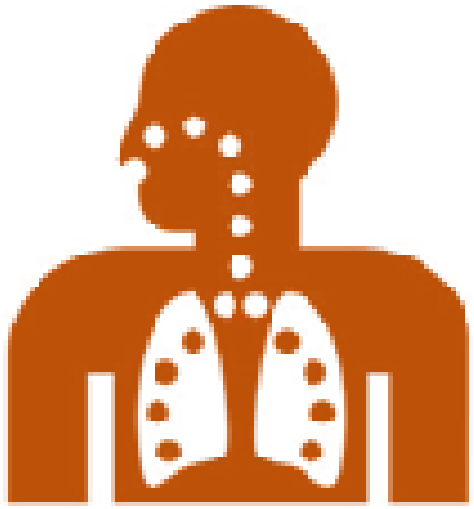
AIRPACT predicts air quality by calculating the chemistry and physics of air pollutants within the context of the background, natural air chemistry and predicted meteorology.

Variables included:

- Wind speed
- Temperature and precipitation affecting dilution
- Chemical reaction rates
- Removal of pollutants through rain-out

(http://www.lar.wsu.edu/airpact)

5. Human intake

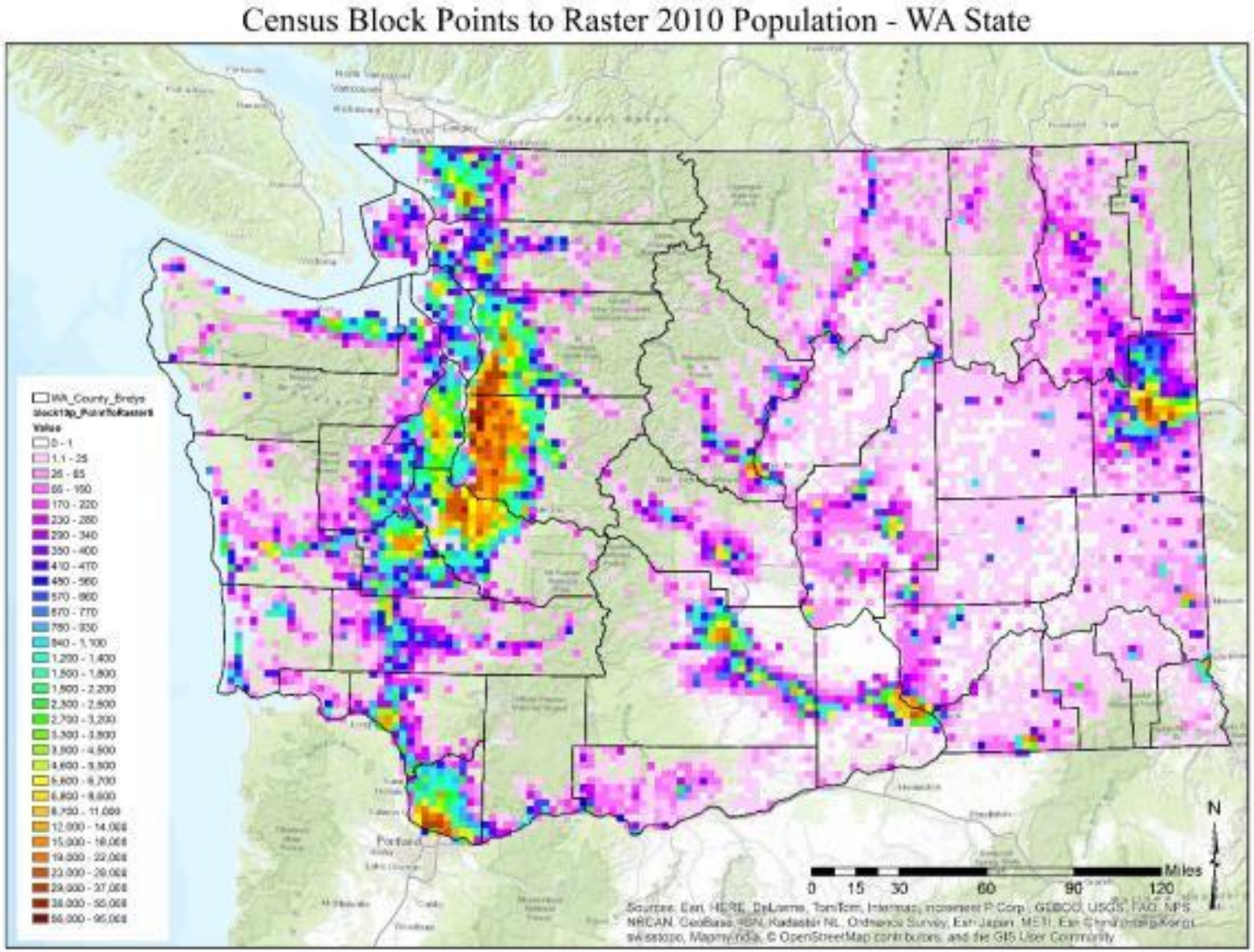


Human intake

Human intake was estimated by multiplying the concentrations by the breathing rate (**Human breathing rate** =**13 m^3/pers.d**, USEtox 2.0), then by the population for each pixel

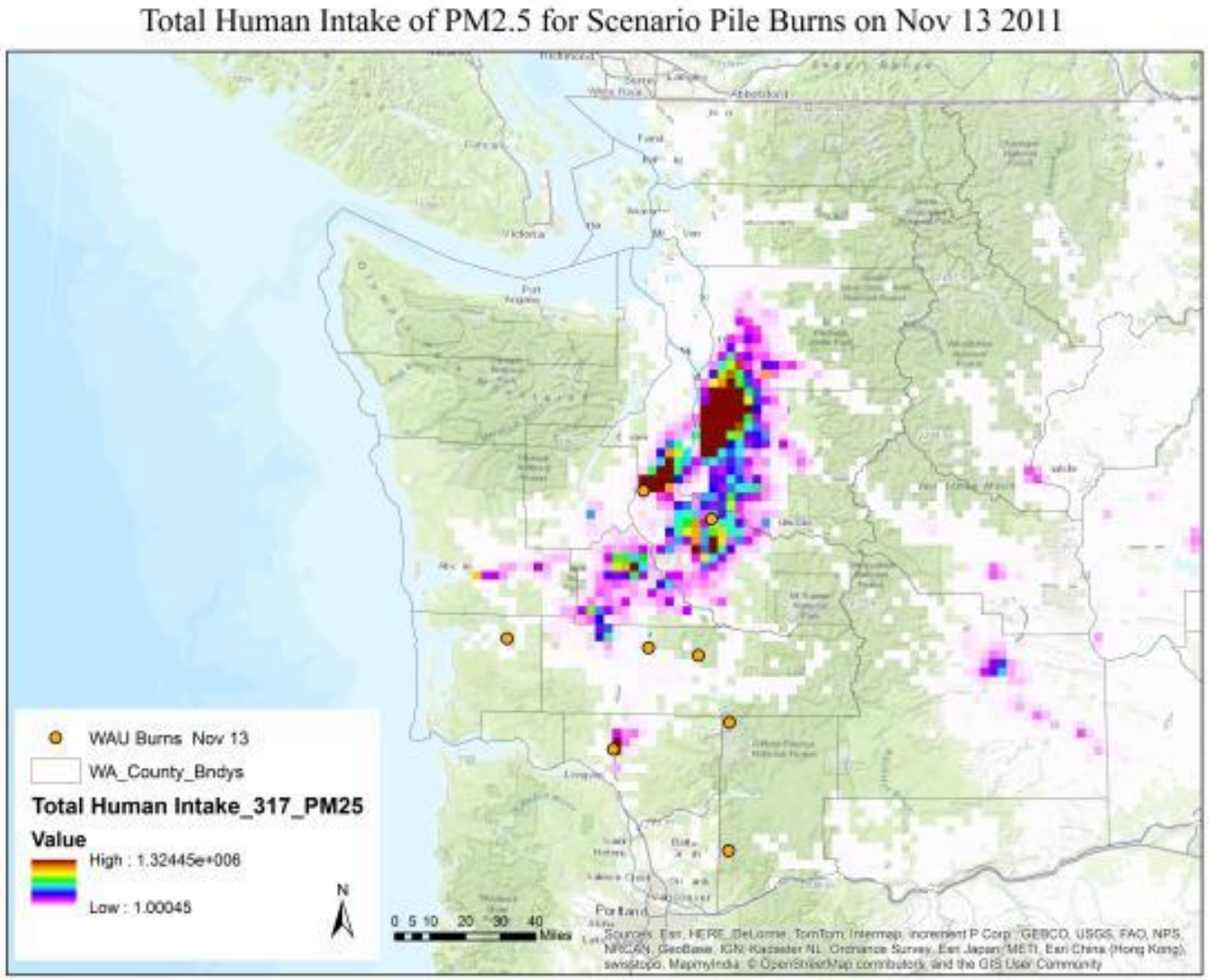
The result is the estimated $PM_{2.5}$ intake by the underlying population and spatially represent

6. Impact on population



- Population data from the 2010 census converted to raster cells
- Census block data converted to points and then the points converted to 4km x 4km raster cells, matching the same grid as the AIRPACT data

Total human intake of PM 2.5



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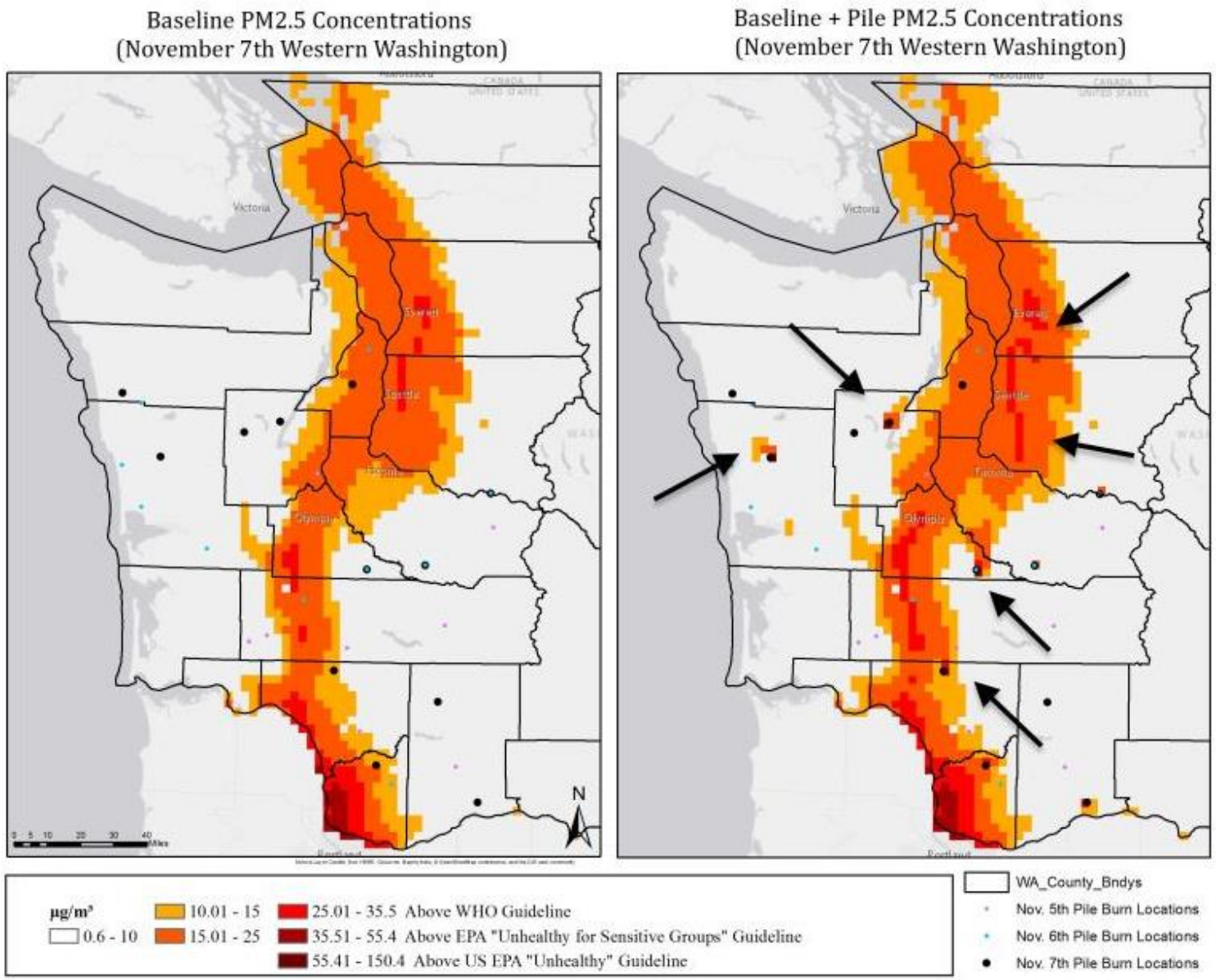
The result is the estimated $PM_{2.5}$ intake by the underlying population and spatially represented

Air Quality Standards Assessment



Air Quality Standards

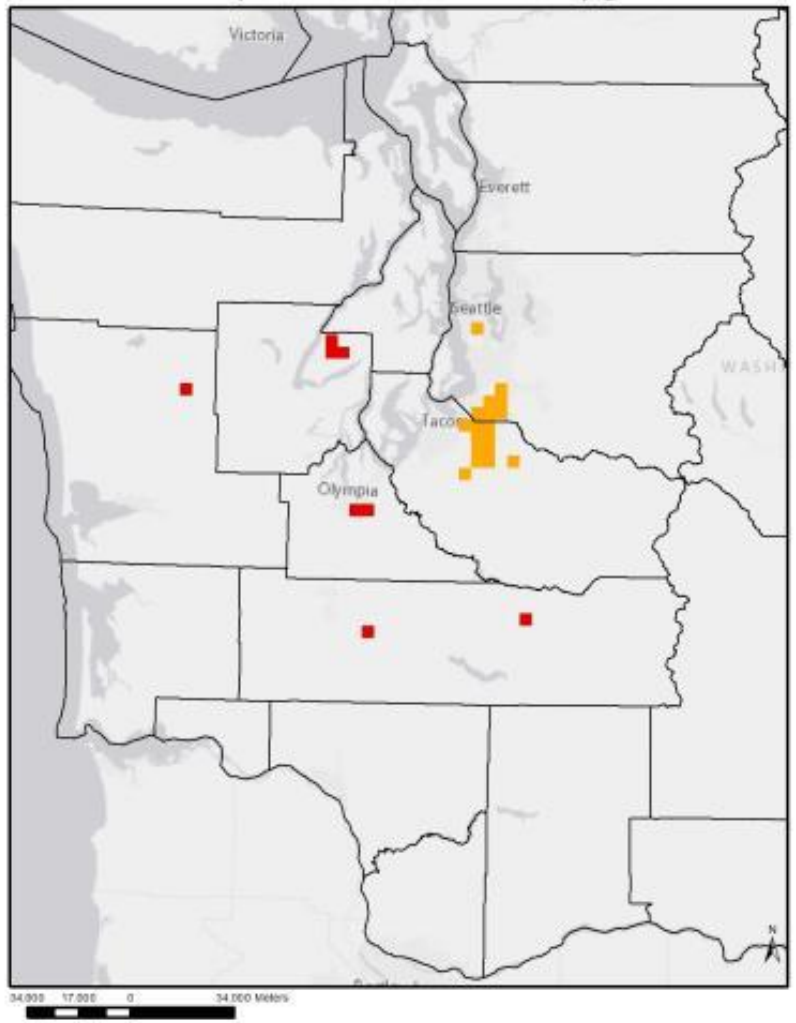
- 25 microgram/cubic meter (WHO guideline)
-
- 35.5 microgram/cubic meter (US EPA guideline “Unhealthy for Sensitive Groups”)
-
- 55.5 microgram/cubic meter (US EPA guideline “Unhealthy”)
-
- 150.5 microgram/cubic meter (US EPA guideline “Very Unhealthy”)
-
- 250.5 microgram/cubic meter (US EPA guideline - Hazardous)

Affected Populations- PM2.5 >25 µg/m³

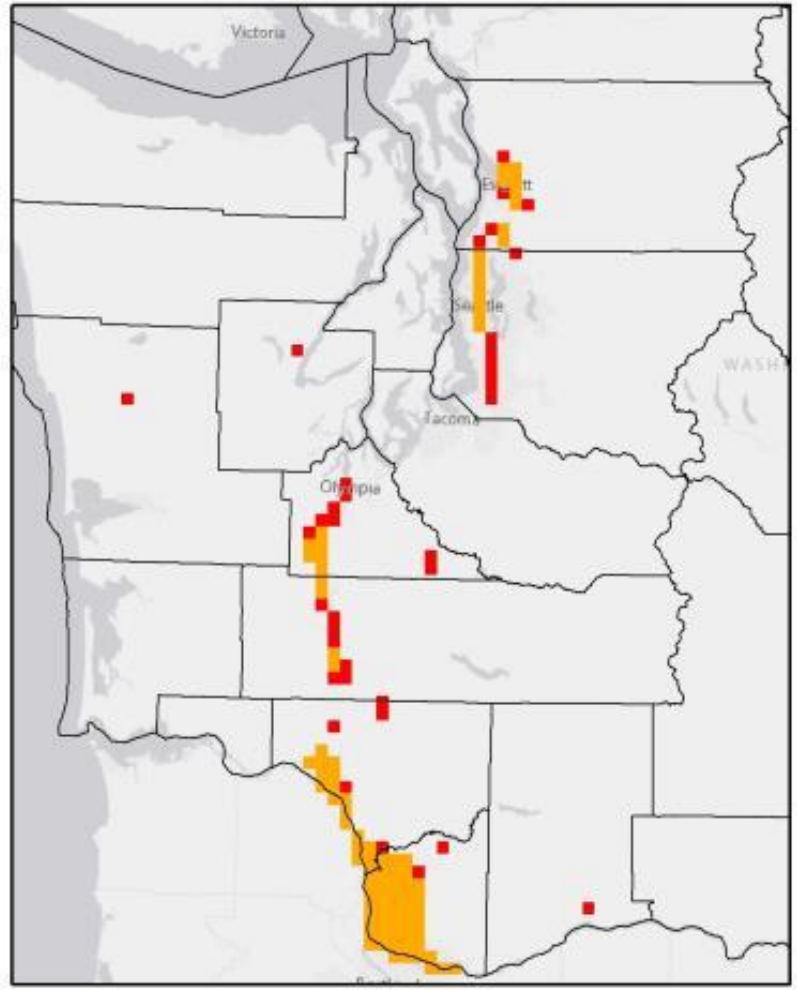
Population affected by baseline (no burn) PM2.5 >25 µg/m³

Additional population affected by pile burns PM2.5 >25 µg/m³

Affected Populations- PM2.5 >25 µg/m³ Nov. 1



Affected Populations- PM2.5 >25 µg/m³ Nov. 7



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Results
Impacted population

3 of the days during the burn period contributed ~80% of the population impact

People affected by PM2.5 greater than 25 micrograms/cubic meter (µg/m³)				
Burn Date	Burn Day	Baseline w/out burns affected people	Baseline with burns affected people	Additional people affected from the added piles burns PM2.5 >25 µg/m³
Nov. 1	305	245,028	259,650	14,622
Nov. 2	306	0	14	14
Nov. 3	307	0	21	21
Nov. 4	308	371,046	375,026	3,980
Nov. 5	309	0	5	5
Nov. 6	310	885,655	904,431	18,776
Nov. 7	311	815,933	1,093,547	277,614
Nov. 8	312	3,600	5,049	1,449
Nov. 9	313	0	10,487	10,487
Nov. 10	314	0	14,590	14,590
Nov. 11	315	283,039	284,041	1,002
Nov. 12	316	0	172	172
Nov. 13	317	0	1,646	1,646
Nov. 14	318	0	6,813	6,813
Nov. 15	319	2,588	4,308	1,720
Nov. 16	320	0	64	64
Nov. 17	321	0	0	0
Nov. 18	322	0	1,070	1,070
Nov. 19	323	28,525	40,577	12,052
Nov. 20	324	698,644	699,926	1,282
Nov. 21	325	0	2	2
Nov. 22	326	0	97	97
Nov. 23	327	0	0	0
Nov. 24	328	0	51	51
Nov. 25	329	0	0	0
Nov. 26	330	0	280	280
Nov. 27	331	0	386	386
Nov. 28	332	421,535	461,346	39,811
Nov. 29	333	1,430,332	1,460,917	30,585
29 Day total number of additional affected people from pile burns=				438,591

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Concentration Results and Air Quality Standards

Days when the total (baseline + prescribed burn) ambient 24 hours pm2.5 average is greater than:

25 microgram/cubic meter (WHO guideline)
Exceeded 28 out of 29 days

35.5 microgram/cubic meter (US EPA guideline "Unhealthy for Sensitive Groups")
Exceeded 23 out of 29 days

55.5 microgram/cubic meter (US EPA guideline "Unhealthy")
Exceeded 13 out of 29 days

150.5 microgram/cubic meter (US EPA guideline "Very Unhealthy")
Exceeded 2 out of 29 days

250.5 microgram/cubic meter (US EPA guideline - Hazardous)
Exceeded 1 out of 29 days

* A maximum daily average value is the highest pixel value occurring anywhere in the state during that day

Discussions

- Results show an increase in poor air quality in the direct vicinity of the pile burns mainly caused by $PM_{2.5}$
- Depending on the amount of slash burned and the weather, particulate matter also travels great distances away from the pile burns, reaching densely populated areas such as Seattle and Tacoma, in addition to impacting smaller communities.
- Particulate matter concentrations with the added pile burns exceed several air quality standards over the burn period, some concentrations reaching EPA “very unhealthy” air quality status.
- Additionally, results also show that 3 days of the 29-day pile burning scenario account for 80% of the daily total impacted population affected by pile burn $PM_{2.5}$ concentrations that exceeded the WHO guideline of 25µg/m³.

Discussions

- Results suggest that emissions from slash pile burns are critical at the local level.
- Policies aimed at promoting alternative uses of biomass could dramatically reduce the impact on human health.
- In areas where slash pile burning cannot be avoided, this study can help policy makers identifying best practices in fire management based on site specific factors, e.g. meteorological conditions, air chemistry, biomass supply, number of piles, size and shape, population density and site morphology.
- Since these factors are site specific, the application of this method to other regions would be beneficial to know how pile burning affects populations in other parts of the country.

Next steps

- **We have compiled the complete dataset of all prescribed burns in PNW for a single year**
  - 2011
  - Complete species list

- Develop human health assessments based on emission profiles
  - Spatially nuanced respiratory impact
  - Spatially nuanced carcinogenic and non-carcinogenic (airborne)

Acknowledgement

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Thank you for your attention