# New Approaches to Reducing Wildfire Smoke in Frequently Impacted Communities

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# Acknowledgements

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# Motivation

What could  be done to reduce wildfire smoke in communities beyond current practices?

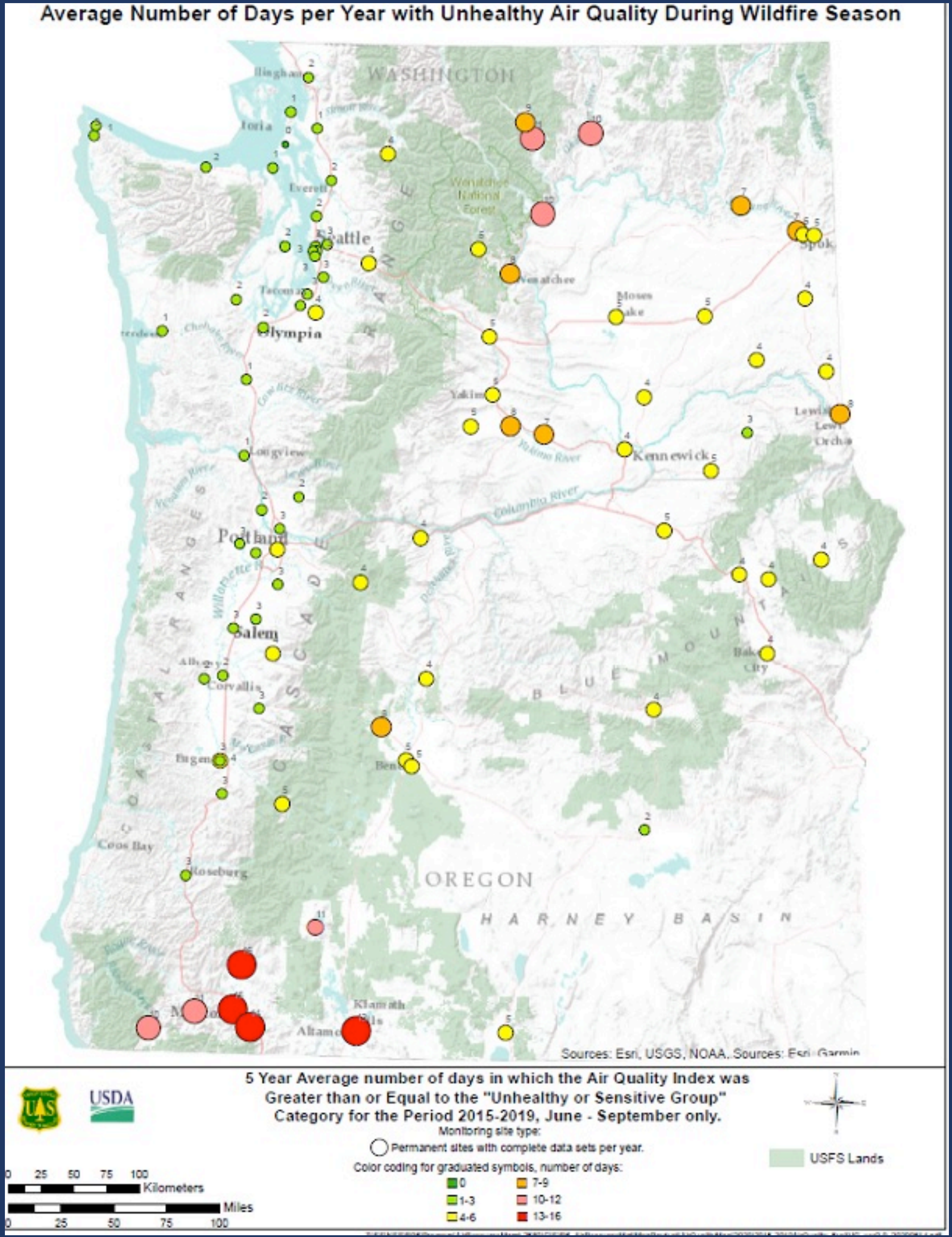
Photo credit: iStock/Daniiielc

# Approach

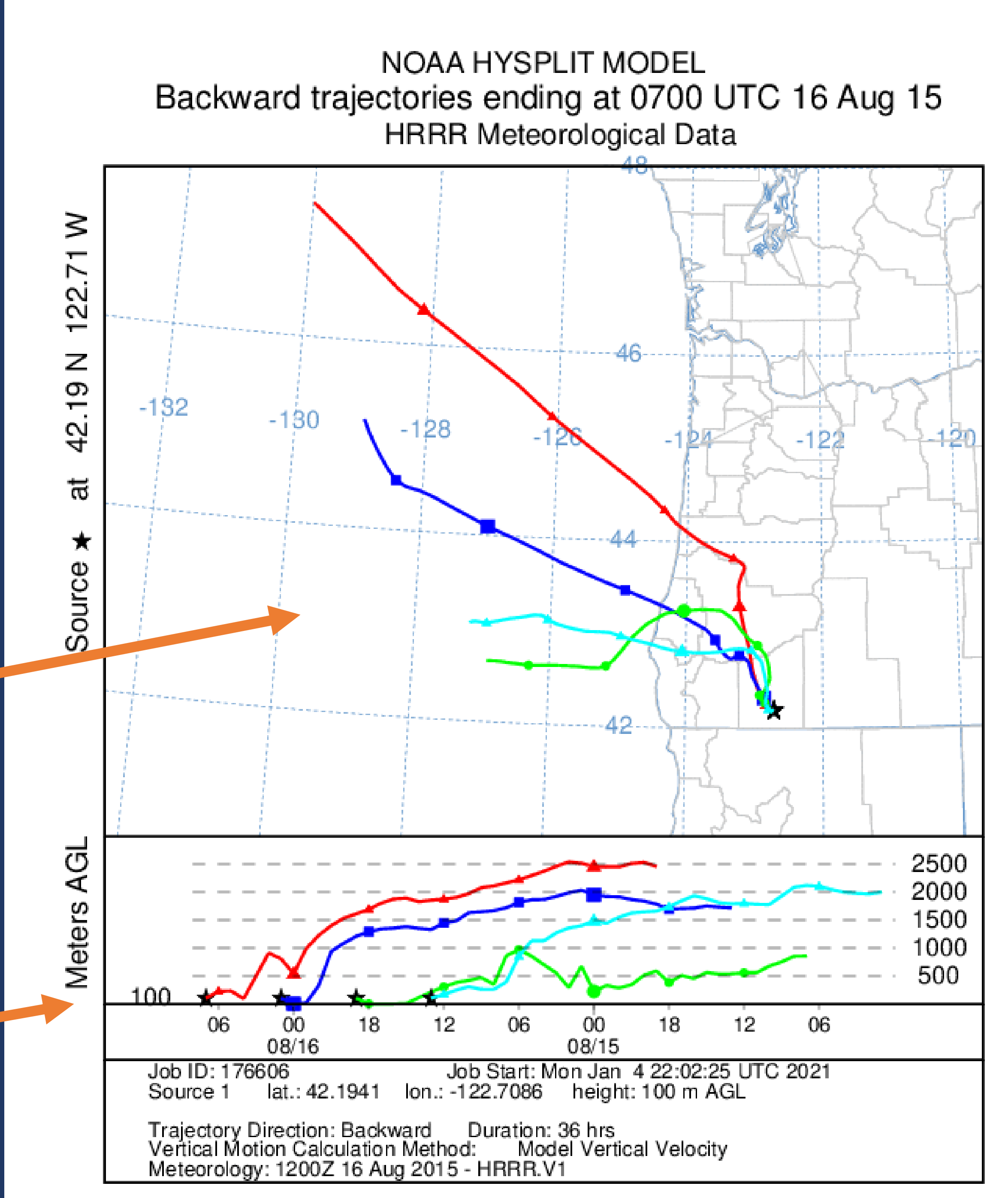
1. Identify the frequent air pathways into communities which experience frequent wildfire smoke.
2. Evaluate land management options along these pathways to identify opportunities to reduce wildfire smoke.
3. Quantify how much smoke could be reduced in affected communities
4. Use a case study to demonstrate concept

# Spatial patterns of smoke impacts to communities

Average number of days/wildfire season with unhealthy air quality



# Where does the smoke come from?




Bird's eye view

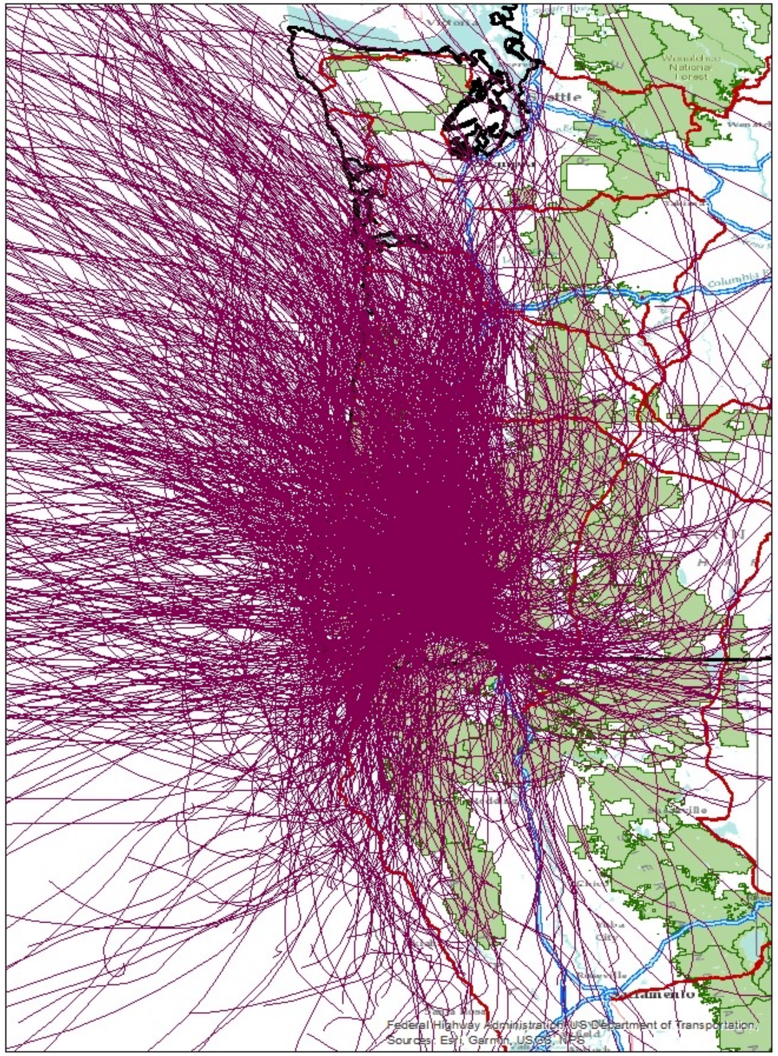
Worm's eye view

Model Input:

- Origin at community
- Run model backwards
- Meteorological data: HRRR v1, 3 km horizontal resolution.
- 36-hour back trajectory
- 100 meter starting height
- 4 trajectories/day
- One trajectory every six hours
- (midnight, 6 am, noon, and 6 pm)

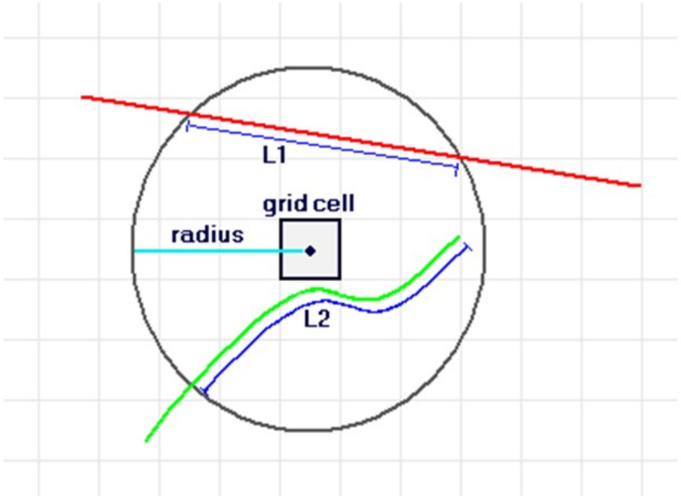
# Medford, OR all back-trajectories 2015-2019

4 trajectories/day x 77 days/year x 5 years = 1540 trajectories

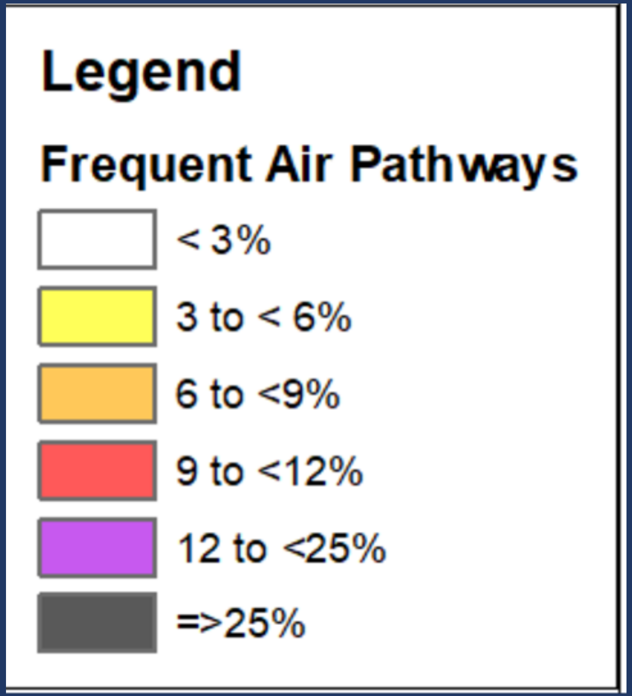


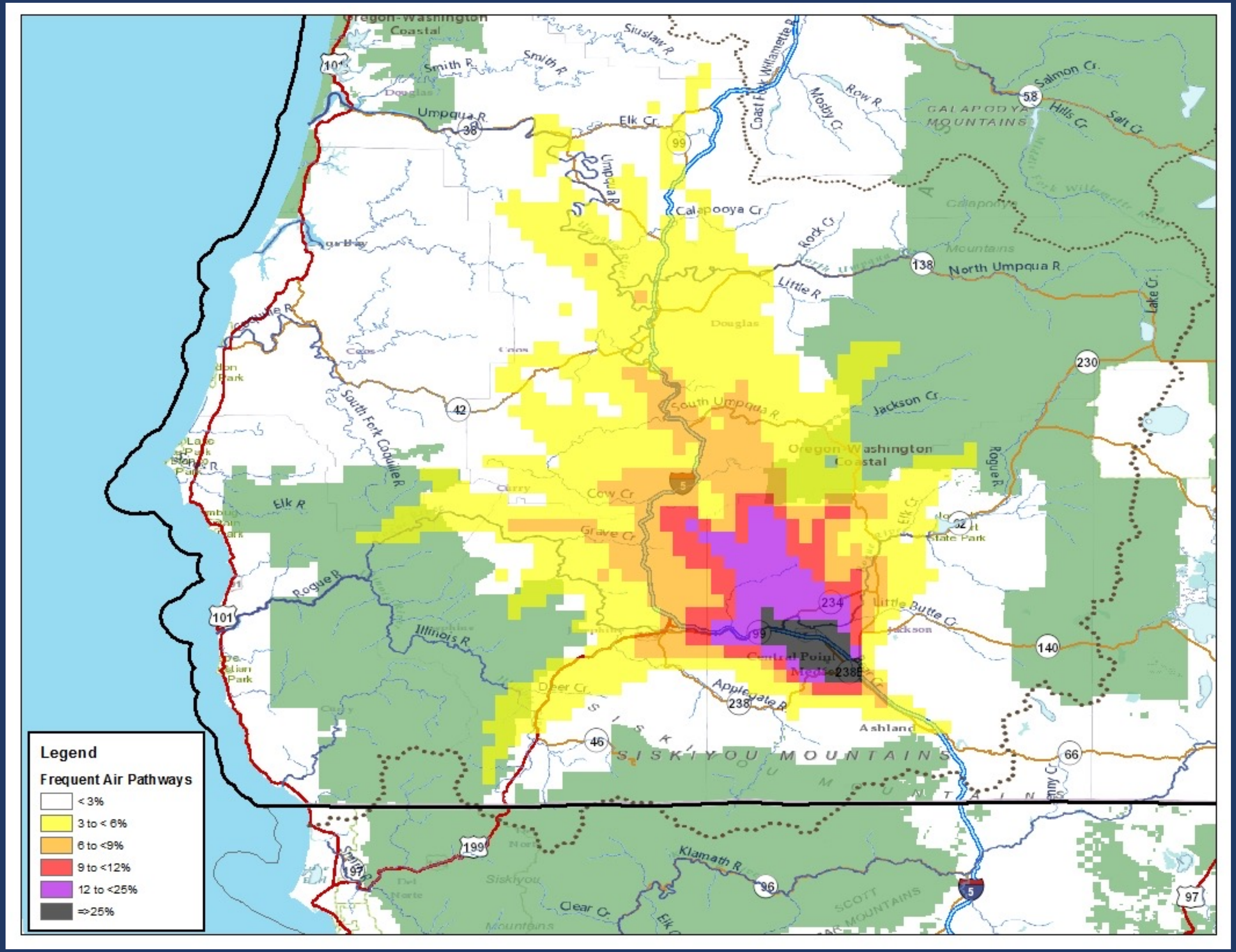
# Line density function in ArcGIS

- A grid is overlaid on the map
- Grid cell size = meteorological grid cell size (3 km)
- A circular neighborhood is used to determine the length for the line density (creates smoothing)
- Density = (L1 + L2)/Area of Circle
- Raster image is created using a bin classification scheme

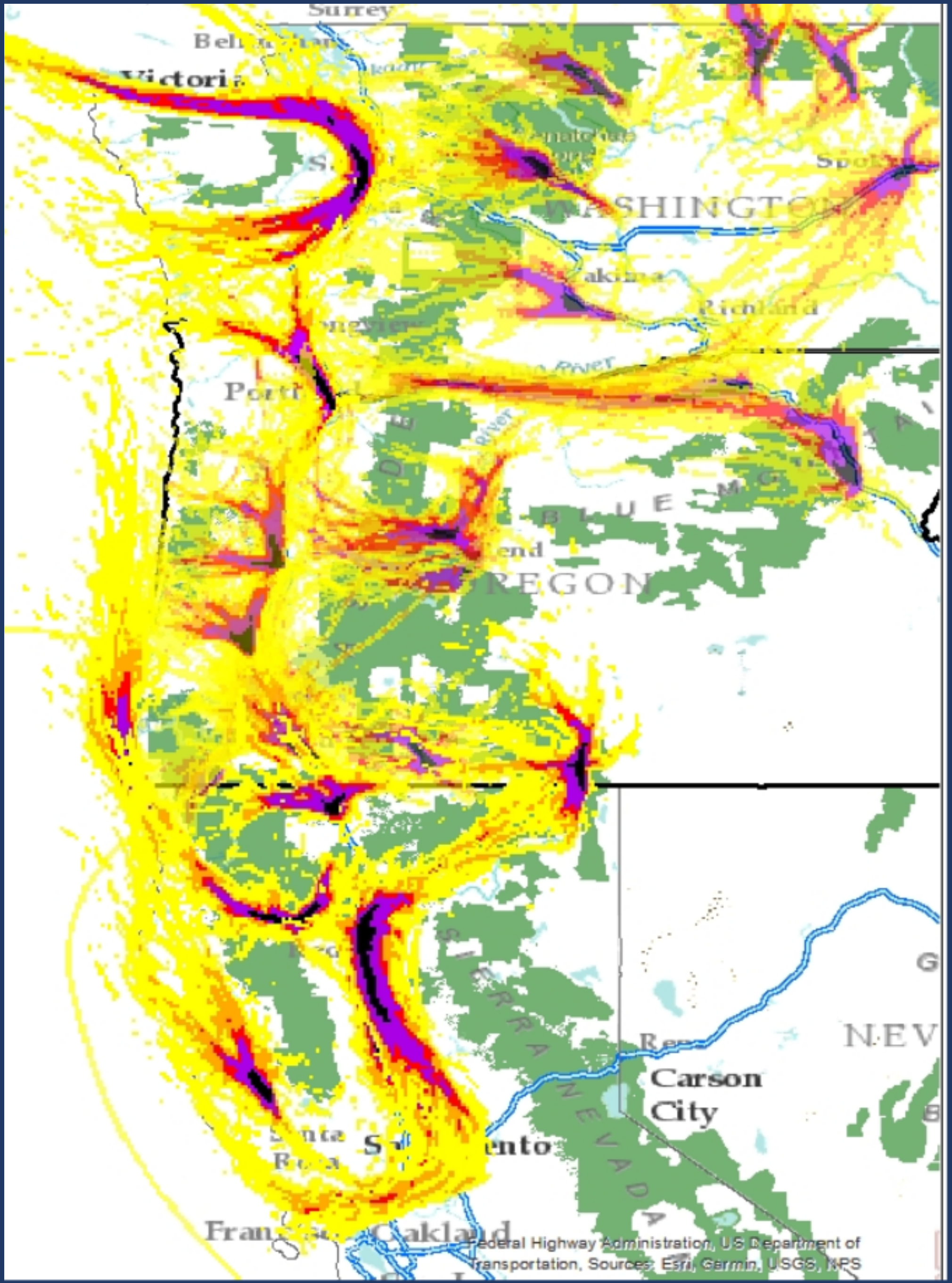


# Back trajectory frequencies into Medford, OR



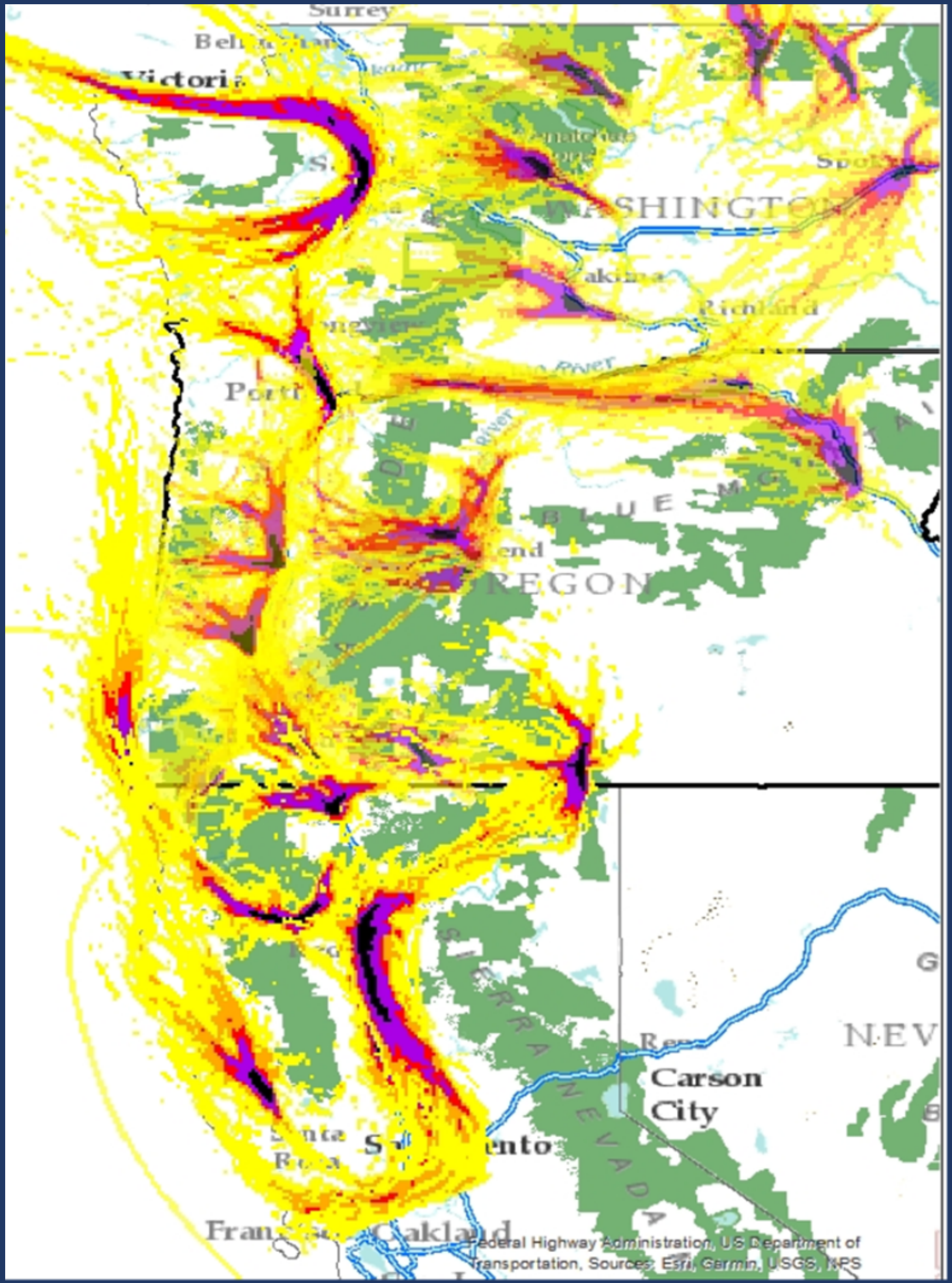
# Frequent Air Pathways into Communities of the Pacific Northwest During Summer August & September




**Legend**

**Frequent Air Pathways**

- < 3%
- 3 to < 6%
- 6 to <9%
- 9 to <12%
- 12 to <25%
- =>25%




# APPLICATION

1. If a wildfire starts within a frequent air pathway to a community => increased chance of long-term smoke impacts
   a. Community Messaging and Response
   b. Influence Allocation of Fire Suppression Resources

2. Land management planning:
   a. Location of fuel treatments

# Next steps

Define how much air quality could be reduced if fuel treatments occurred in high frequency air pathway areas?

Methodology

Select a case study

Compare emissions and downwind impacts from two scenarios:

(1) Untreated Fuels

(2) Treated Fuels

# Calculating Change in Air Quality

$$\frac{E1}{C1} = \frac{E2}{C2}$$

E1 = Total emissions of PM2.5 from fire with untreated fuels (modeled)

C1 = Concentration of PM2.5 from fire with untreated fuels (observed)

E2 = Total emissions of PM2.5 from fires with treated fuels (modeled)

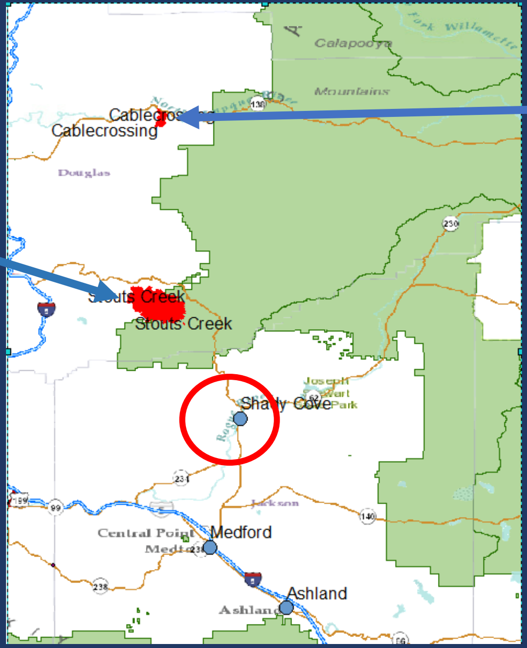
C2 = Concentration of PM2.5 from fires with treated fuels (calculated)

*Assumptions: plume rise, meteorology, & atmos. chemistry are the same b/w scenarios*

# Case Study: Shady Cove, OR
# August 2, 2015
# 295 ug/$m^3$ PM2.5 (24-hr avg.)

**Stouts Creek Fire**

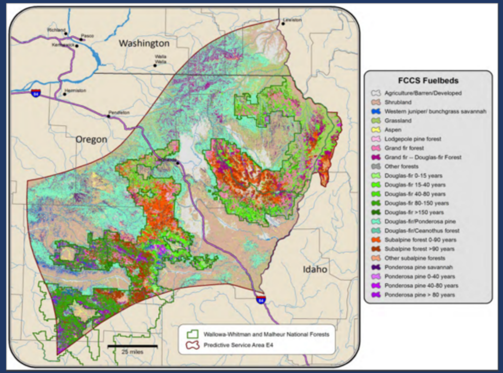
- Started July 30, 2015
- 32 km NNW of Shady Cove
- By Aug 2: 10,700 acres
- 90% Contribution




**Cable Crossing Fire**

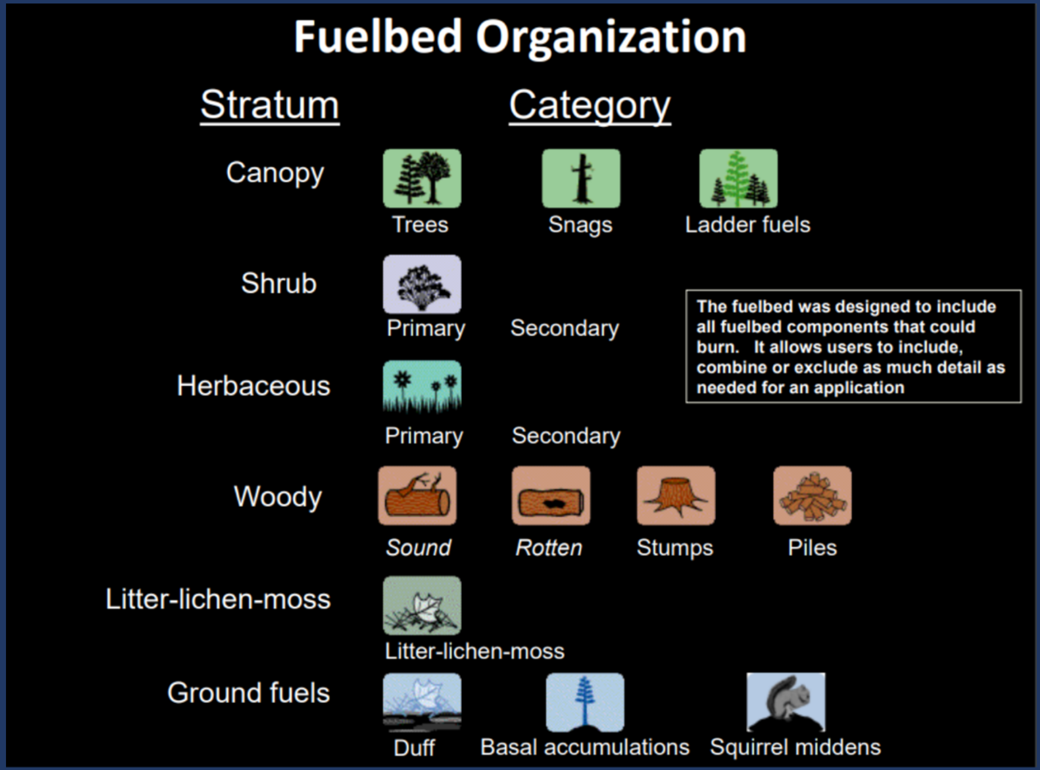
- Started July 28, 2015
- 77 km NNW of Shady Cove
- By Aug 2: 1574 acres
- 10% Contribution


# Emissions




$$Emissions = \sum_1^n (Fuel\ Bed)_n \sum_1^k (Vegetative\ Stratum)_k (\text{Fire Environment})$$

Select these




Use default values or customize

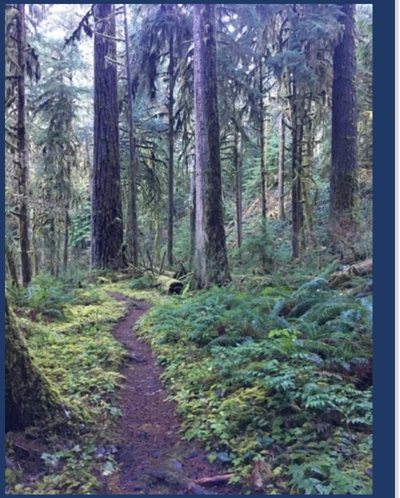
- Fuel moisture
- Wind
- Slope

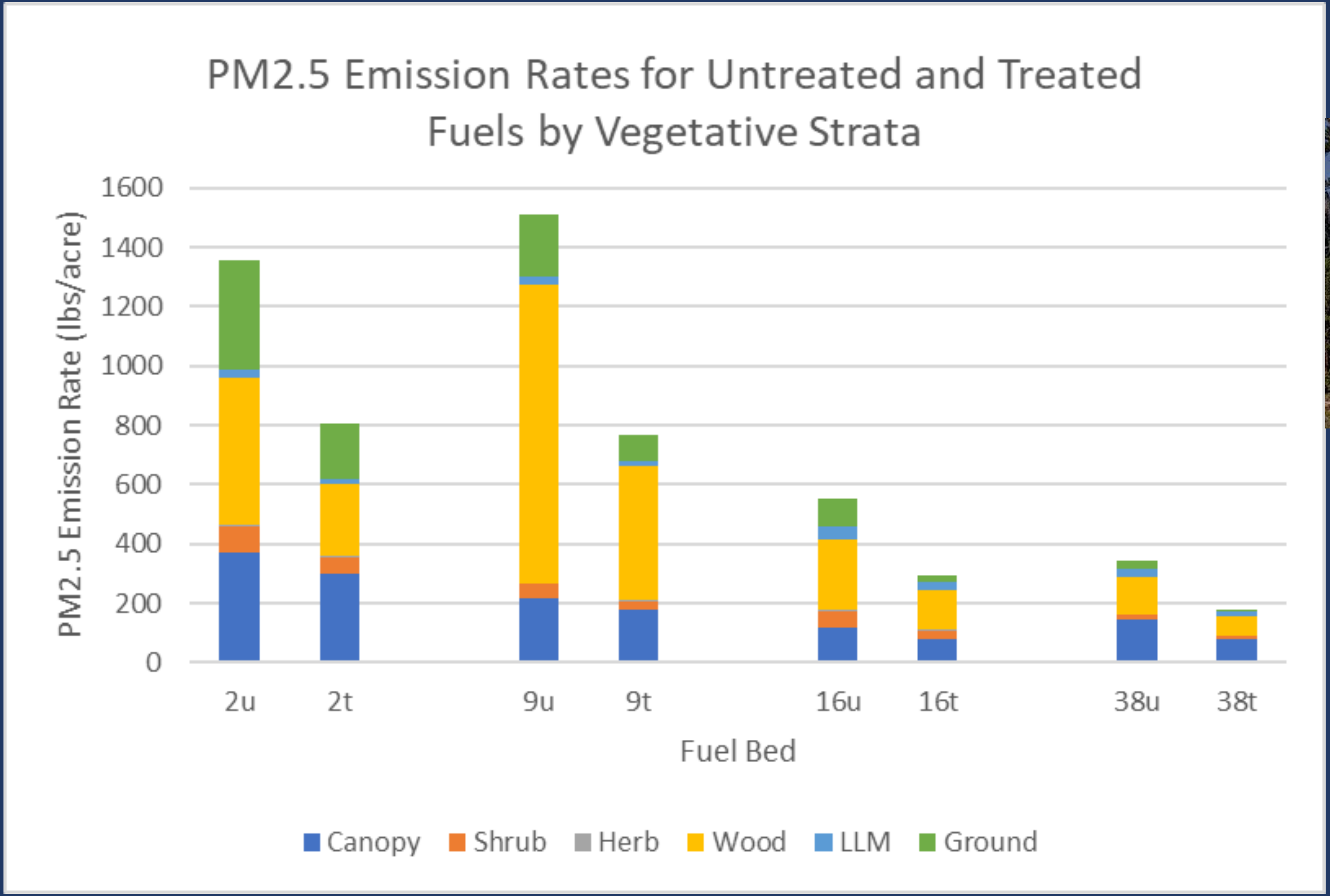
Provide these

# Fuel Treatment – Changes to Vegetative Strata

| Fuel Stratum | Subcategory | Modification |
|---|---|---|
| **Canopy** | Tree Overstory<br><br>Tree Midstory and Understory<br><br>Snags<br><br>Ladder fuels | Reduced canopy by 15%, no changes in density.<br><br>Reduce density and cover by 50%<br><br>No changes<br><br>Eliminated |
| **Sound Wood** | 1hr, 10hr, and 100hr<br><br>1000hr, 10,000hr, and >10,000hr | Reduce tons/acre by 60%<br><br>Reduce tons/acre by 50% |
| **Rotten Wood** | 1000hr, 10,000hr, and >10,000hr and stumps. | Reduce tons/acre by 60% |
| **Shrub** | Primary and secondary | Reduce cover by 50% |
| **Herbs** | | Reduce cover by 50% |
| **Litter** | | Reduce coverage by 40% |
| **Duff** | | Reduce depth by 40% |

# Smoke Emissions by Vegetative Strata






# Results from Stouts Creek Fire, only…

| 24-hour PM2.5 | Untreated Fuels | Treated Fuels | Difference |
|---|---|---|---|
| Emissions (tons) | 3,025 tons | 1,660 tons | 1,365 tons |
| Concentration (µg/m$^3$) | 295 | 162 | 133 |

# Results from two fires, but only one fire assumed to have treated fuels

$$C2 = \frac{(E2*C1)}{E1} = \frac{1660\ tons*295\frac{ug}{m^3}}{3025\ tons} = 162\ ug/m3$$ => 45% reduction (One fire only)

$$C2_{rev} = \frac{(1660\ tons*265.5\frac{ug}{m^3})}{3025\ tons} + 29.5\frac{ug}{m3} = 175.2\ ug/m^3$$ => 41% reduction (Two fires)

*41% - 45% reduction in 24-hour Avg Conc. Of PM2.5 in Shady Cove.*

# Conclusions

- Frequent Air Pathways into communities can help focus risk mitigation efforts for smoke
- Fuel beds and veg. layers matter!  Focus on those which emit the most smoke during wildfires.
- Targeted fuel treatments can substantially reduce downwind air quality impacts in communities.

# Next Steps

1. Within public land management agencies:
    a) Interdisciplinary Teams to design treatments
    b) Regional Investment Board – decide where funds will go.
    c) Work with Fire & Aviation Group to allocate resources

2. AQ Agency, Public Health Agency, Public:
    *a) Comments on programmatic or project-level NEPA*
    *b) Partner with Fire Prevention Program to prevent smoke.*


# Questions?

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