

Improving Understanding to Reduce Health Effects Toxicological Perspectives

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The National Academies of Sciences – Engineering – Medicine
Board on Atmospheric Sciences and Climate

Focus

- ▶ What air quality information is needed to improve understanding of effects on human health?
- ▶ What is known about the role of multiple stressors?



What air quality and toxicology information is needed to improve understanding of effects on human health?

- ▶ Particle Size of the smoke as it ages and transports.
- ▶ Detailed Chemical Characterization of the Smoke Over Time.
- ▶ Data on the bioavailability of smoke toxins.
 - ▶ Wildfire
 - ▶ Wildfire + Structures
- ▶ Better toxicity assessments of wildfire smoke constituents.
- ▶ Prospective epidemiological assessments over time to assess potential chronic consequences.



What is known about the role of multiple stressors?

▶ Age

- ▶ Different effects in younger and older individuals
- ▶ Need more information on effects on developing lungs and hearts.

▶ Sex

- ▶ Women and men may respond differently especially with respect to cardiovascular outcomes.
 - ▶ Post-menopausal women may be at elevated risk

▶ Mental Health

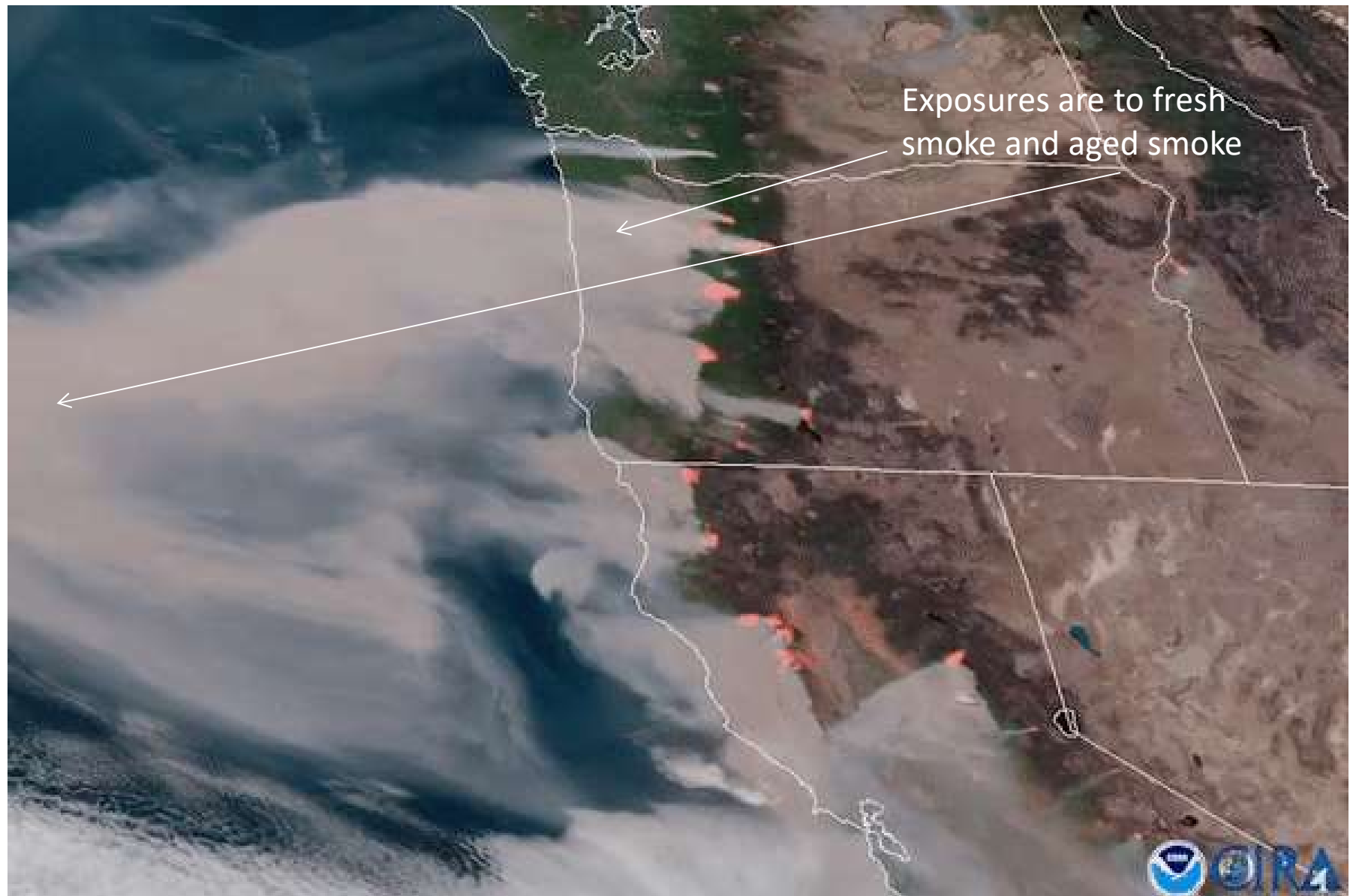
- ▶ Stress is documented to reduce immune system function but more studies are needed.

▶ Multiple chemical exposures

- ▶ We should develop an AQI that considers more than one pollutant.
- ▶ Interactive effects?



Wildfires are More Frequent and More Intense



Focus of this Presentation

- Inhaled Particles and Respiratory Disease
 - Strong epidemiological evidence of acute effects
 - Asthma
 - COPD
- Inhaled Particles and Cardiovascular Disease
 - Weaker evidence of acute effects from epidemiology and ecological studies (Effects are often not statistically significant)
 - Heart disease is causally associated with exposures to ambient particulate matter (USEPA)
 - Inhaled particles and gases associated with wildfires are composed of chemicals associated with heart disease and cancer.



Wildfire Smoke and Cardiovascular Disease Outcomes

- There is wide agreement that exposure to the mixture of components that we characterize as wildfire smoke is associated with illnesses and deaths.
 - Exposures worsen the frequency and severity of lung disease episodes (including respiratory tract infections, chronic diseases such as bronchitis or emphysema and inflammatory diseases such as asthma) and can directly or indirectly affect people's hearts.
 - Epidemiological studies have been major contributors to our understanding of the relationship between ambient particulate matter (PM) and cardiac morbidity and mortality with both short- and long-term exposure.
 - Wildfire smoke contains, in addition to conventional ambient PM, PM from biomass combustion.
 - The composition of wildfire smoke includes several chemicals that initiate lung inflammatory responses, are known carcinogens and exacerbate atherosclerosis and cardiovascular diseases.
 - Exposure may represent a significant risk factor for adverse cardiovascular health effects.

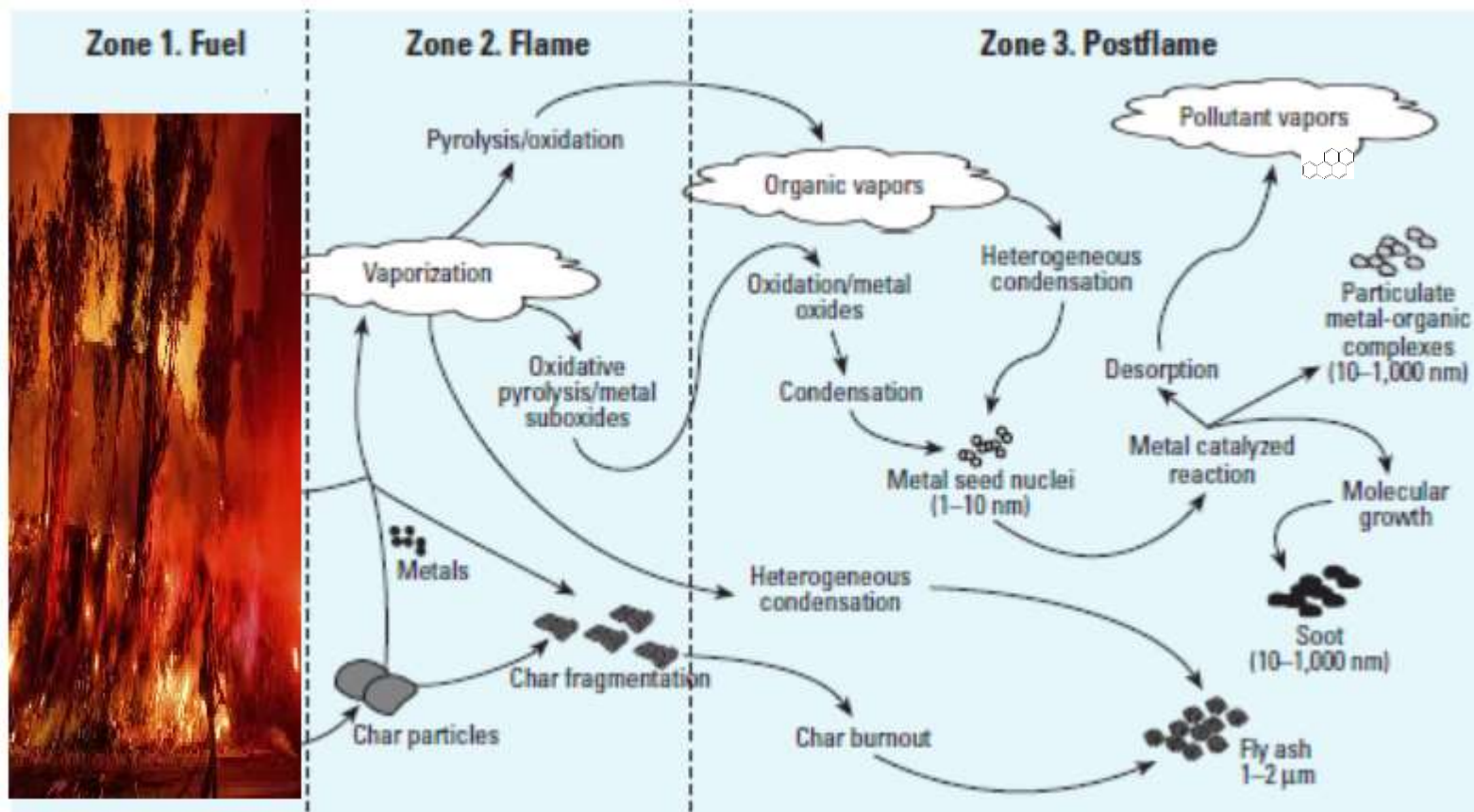


Chemical Composition of Wood Smoke PM and Cardiovascular Effects

- The composition of wood fire smoke emissions vary depending on multiple parameters such as the physical features of the vegetation of the ecosystem, and environmental parameters such as humidity, temperature, wind speed, and the type of ignition.
 - During wood combustion, polymers break apart, which produce a variety of smaller toxic molecules such as polycyclic aromatic hydrocarbons, aldehydes, free radicals and others that are carcinogenic.
 - The mode of toxicity of inorganic gases was through an irritant response and that of free radicals and particulate matter was through a stress reaction.
 - However, several other mechanisms have been suggested.
 - inflammatory response in the airways,
 - Alteration of cardiovascular risk by increasing acute-phase proteins .
 - A population-based study of emergency department visits and daily concentrations of fine particulate matter during a wildfire in North Carolina determined an excess relative risk of 42% for congestive heart failure.
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How toxic compounds and nanoparticles form during the combustion process



Adapted from

Origin and Health Impacts of Emissions of Toxic By-Products and Fine Particles from Combustion and Thermal Treatment of Hazardous Wastes and Materials

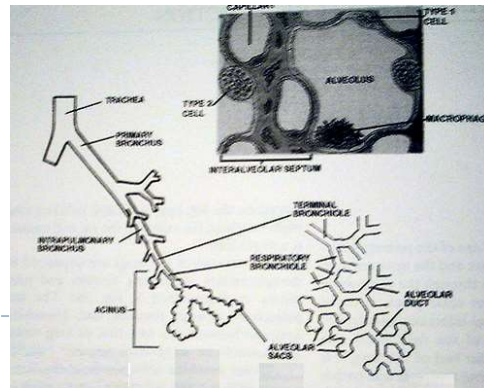
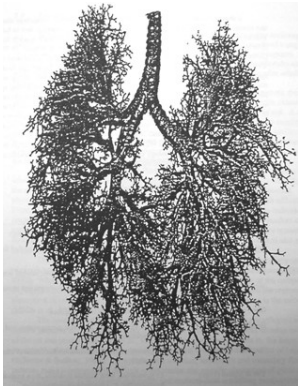
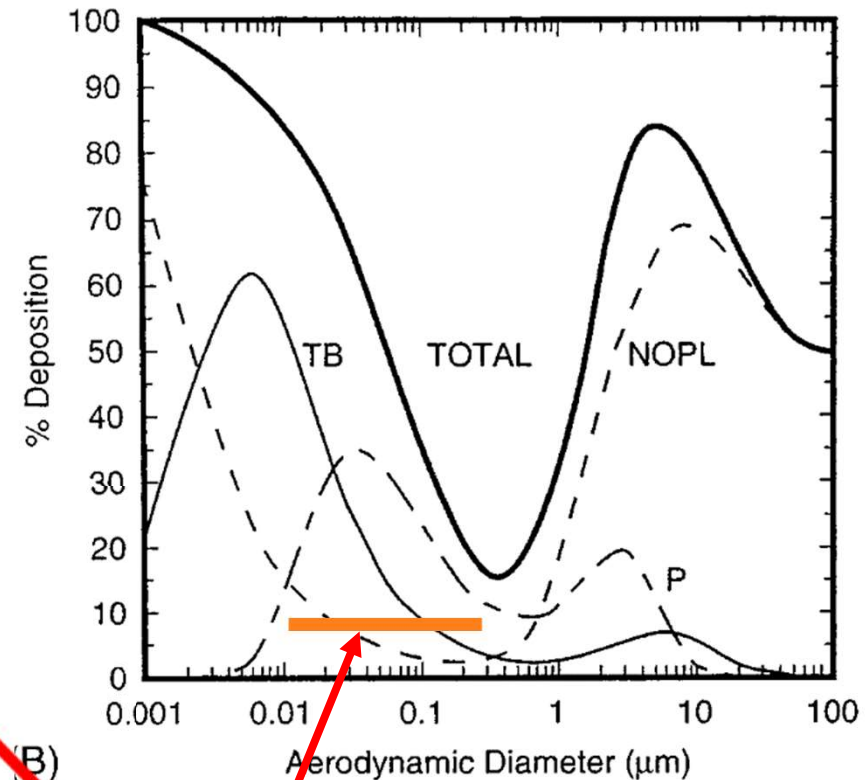
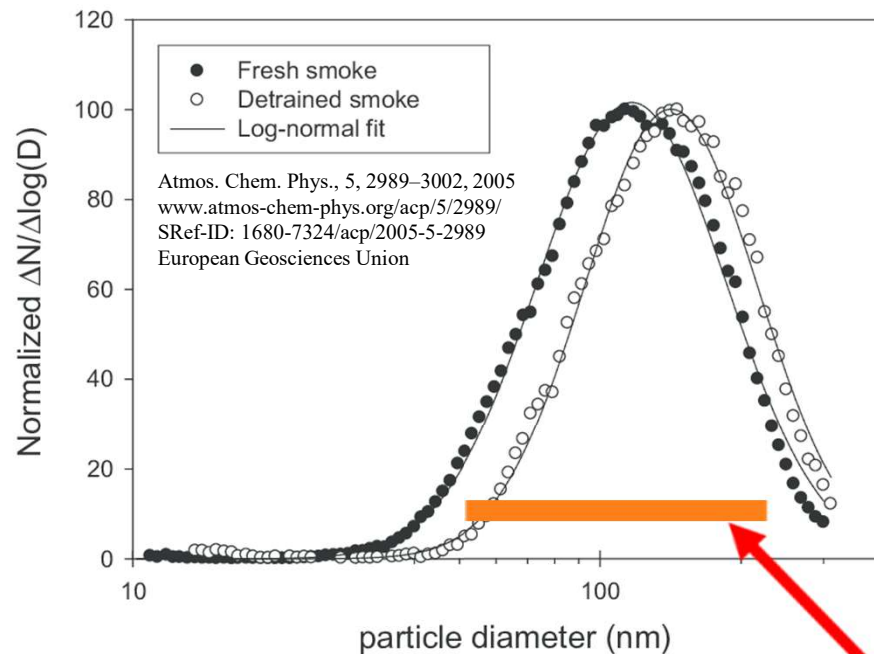
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Inhaled Nanoparticles from Combustion Will Deposit in the Respiratory Tract

Efficiency of Particle Deposition as a Function of Particle Size

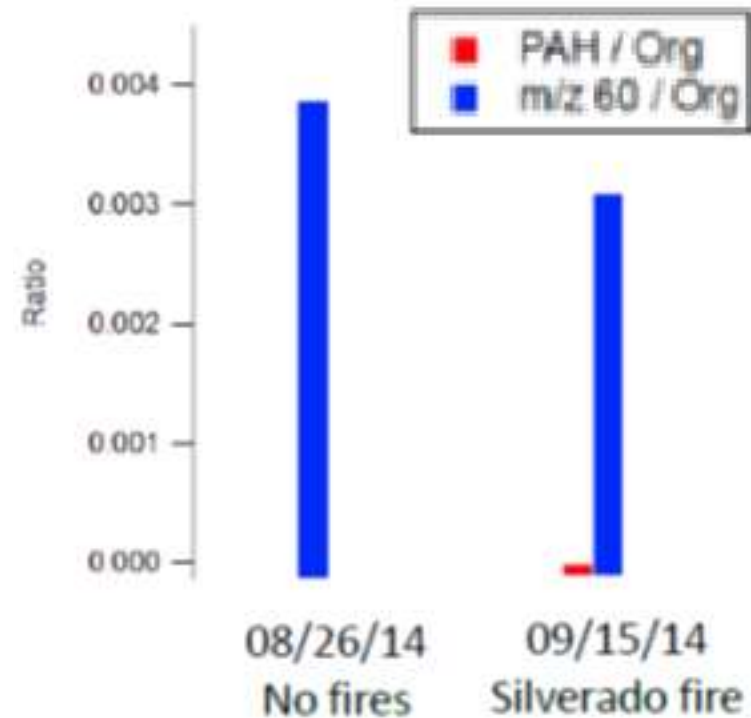
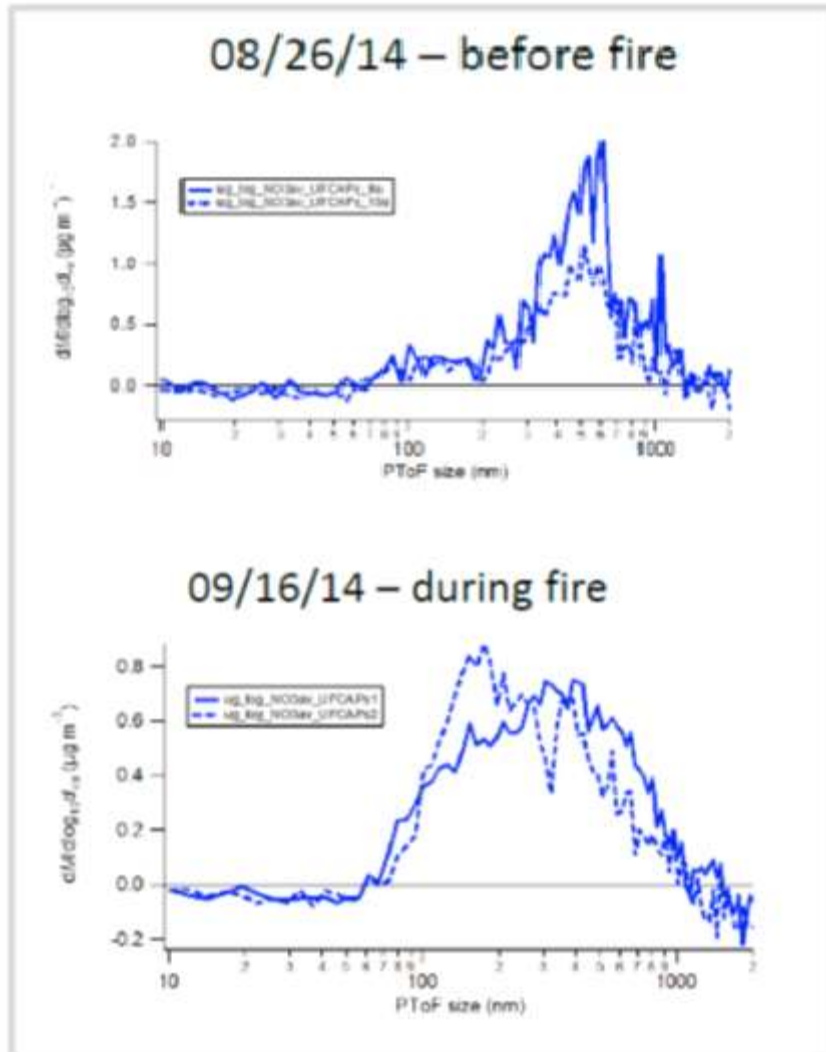
Wildfire Smoke Size Distribution



Ideal size for deep lung penetration

Wildfires Increase Concentrations of Nano-sized PAHs and Nitrates in Ambient Air

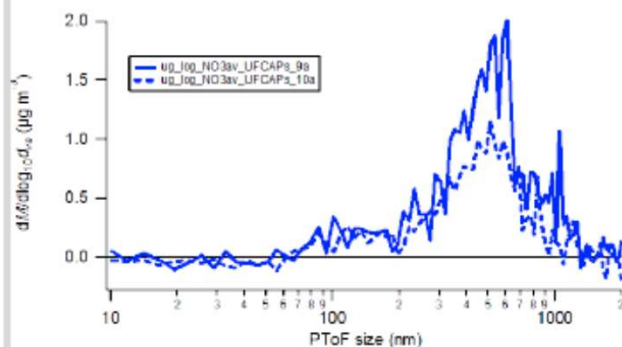
Nitrate



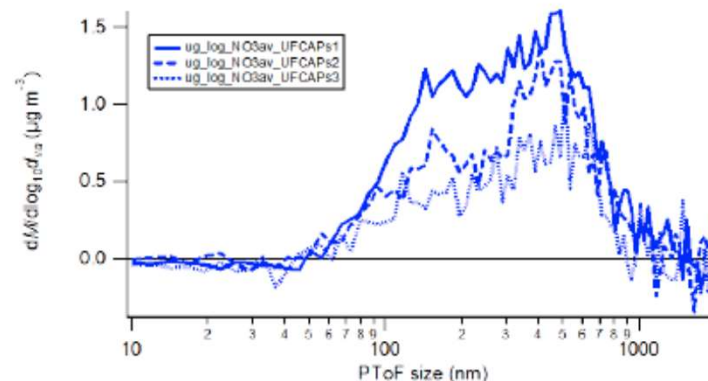
Additional Silverado Forest Fire Influence

Nitrate

08/26/14 – before fire

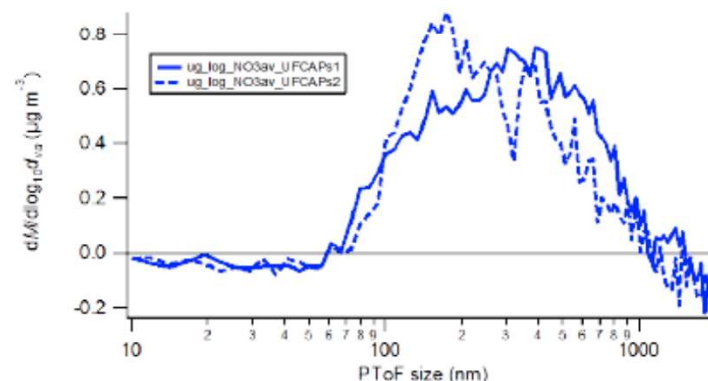


09/15/14 – during fire

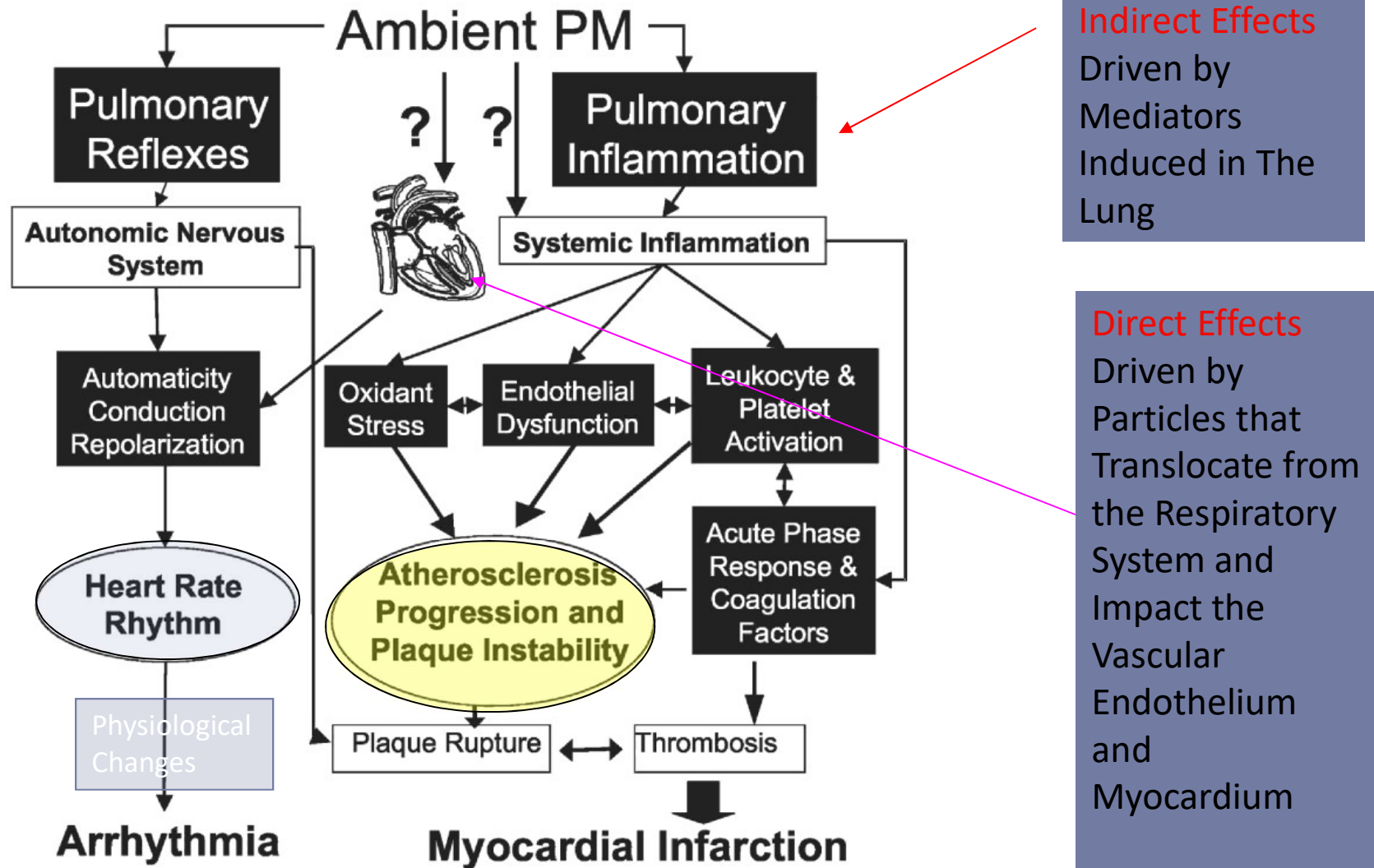


- More nitrate in smaller diameters during Silverado forest fire.
- Particulate nitrate increases during biomass burning periods, e.g. Behera and Balasubramanian (2014), Bi et al. (2011), and Qin and Prather (2006).

09/16/14 – during fire



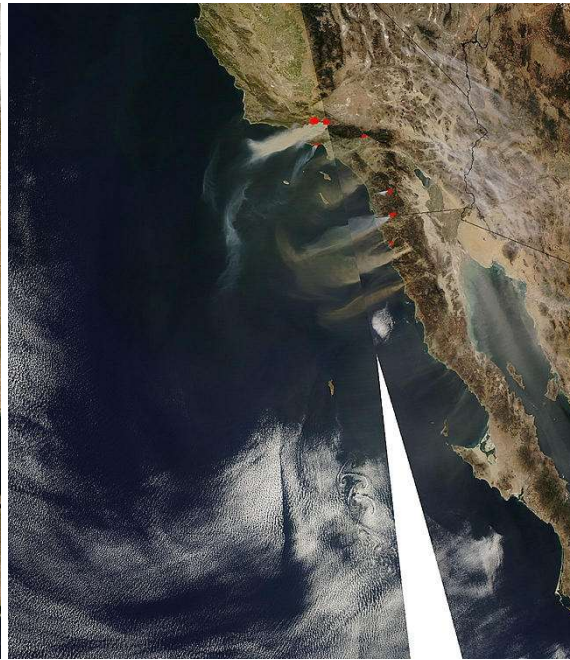
Inhaled Pollutants can Induced Effects Through Multiple Pathways



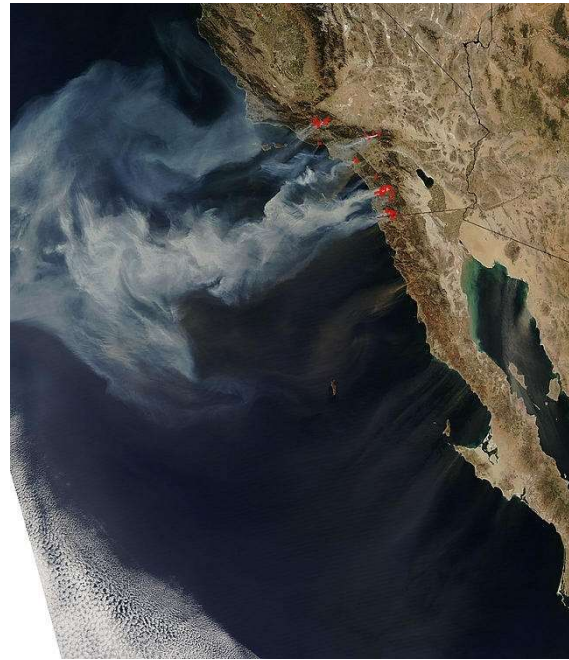
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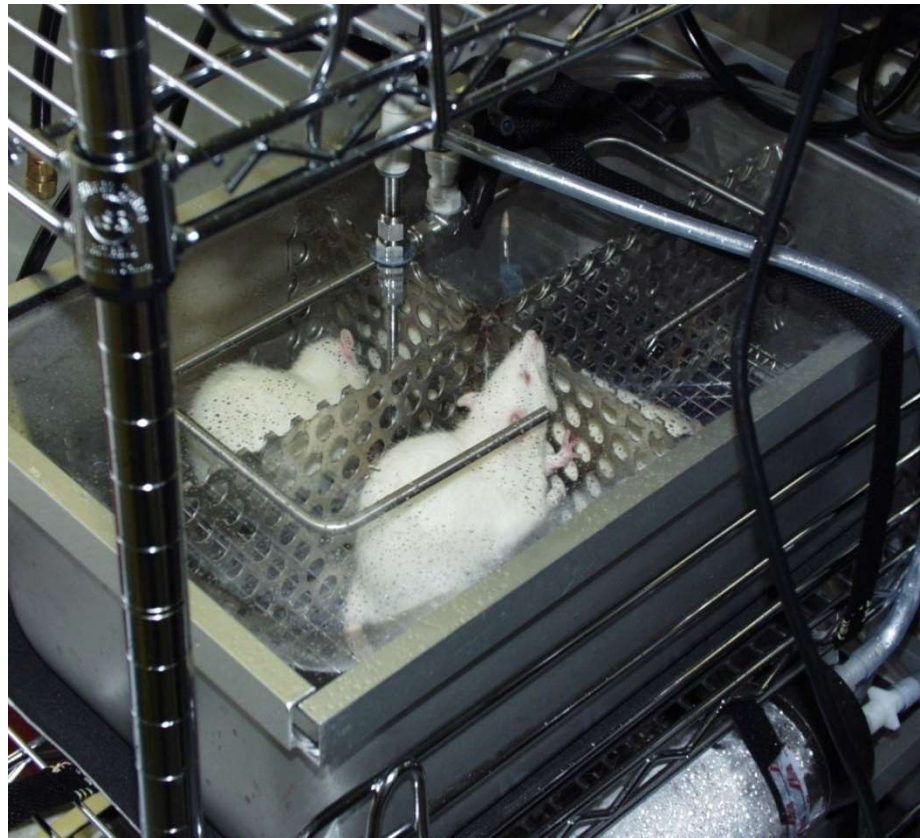
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Rats or Mice Can Be
Exposed to Purified
Air or CAPs in Sealed
Chambers

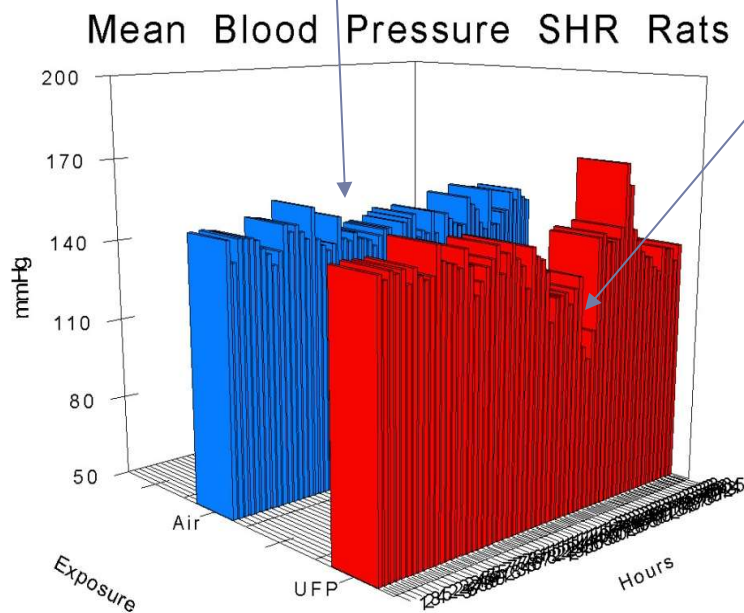


The Sealed Chambers Can
Be Placed Onto Racks to
Facilitate Transport

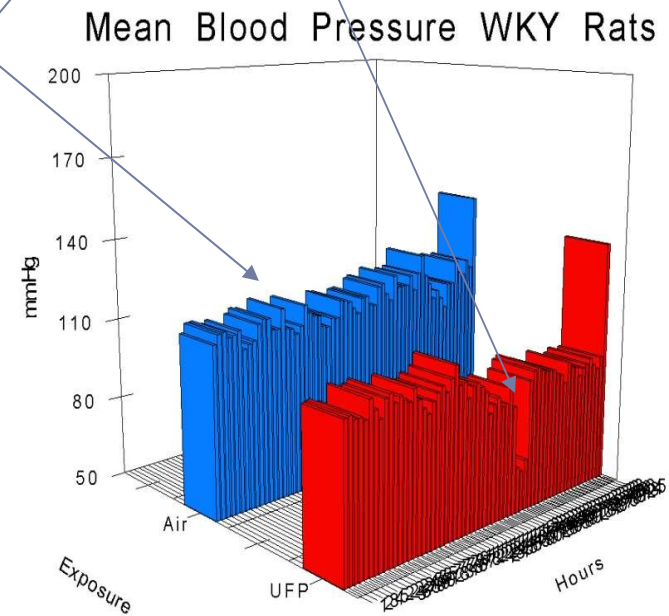


Blood Pressure

Blood Pressure Stable in
Air-Exposed Rats

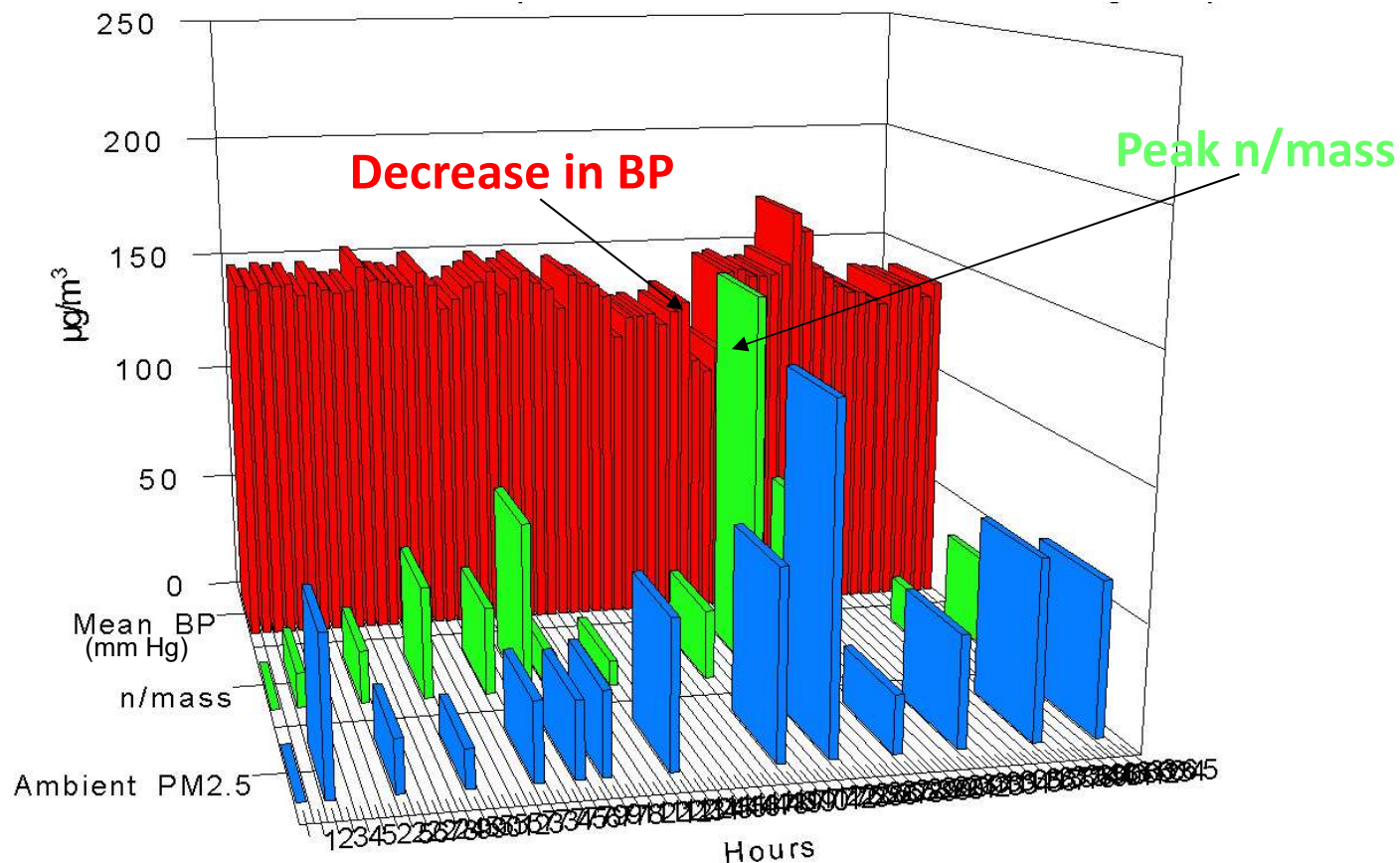


Significant Drop in
Blood Pressure in UFP-
exposed Rats During
Fire



Results... (cont.)

Ambient PM_{2.5} concentrations during exposures



**BP decreases with increase in number/mass ratio,
suggesting a larger impact of UFP during fires**

Conclusions

- ▶ Wildfire exposures can exacerbate heart disease and cancer
- ▶ Nanoparticles emitted during combustion processes contain toxic components and carcinogens
- ▶ Long term risks of exposure to smoke may include elevated risk of heart disease and possibly cancer because wildfires are no longer an occasional phenomenon.
- ▶ As wildfire frequency and intensity increases the exposures to firefighters and bystanders will also increase as will the potential adverse effects on health.



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