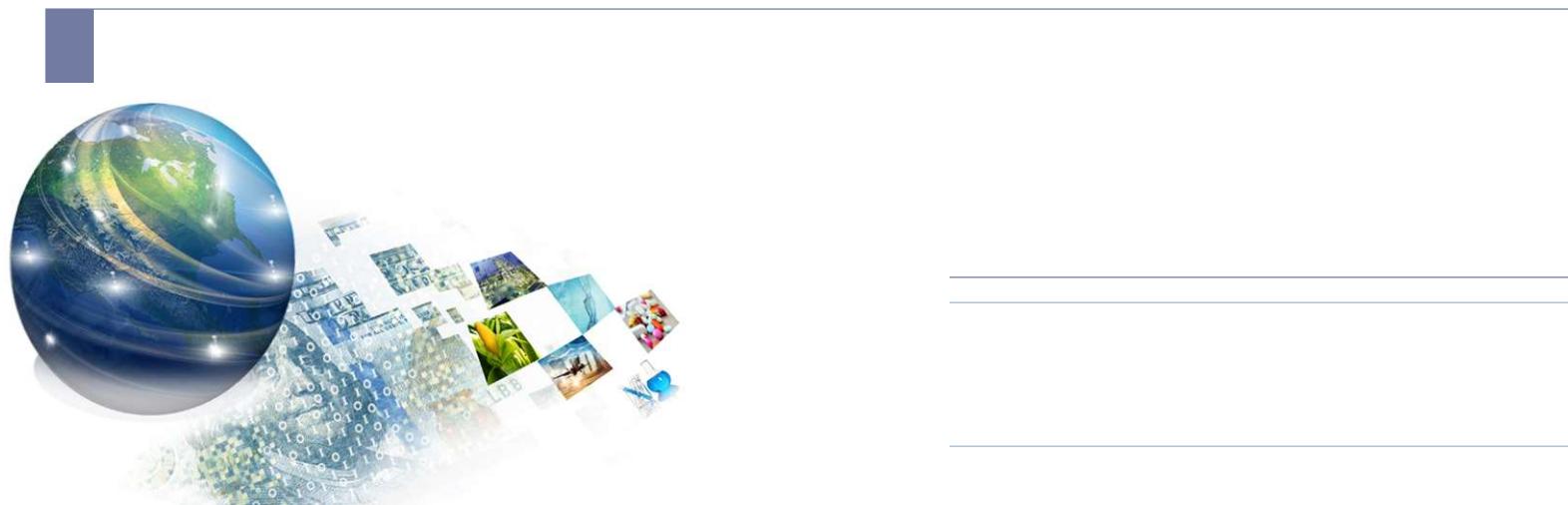


# Improving Understanding to Reduce Health Effects Toxicological Perspectives

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

## Focus

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- ▶ 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?

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- ▶ 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.



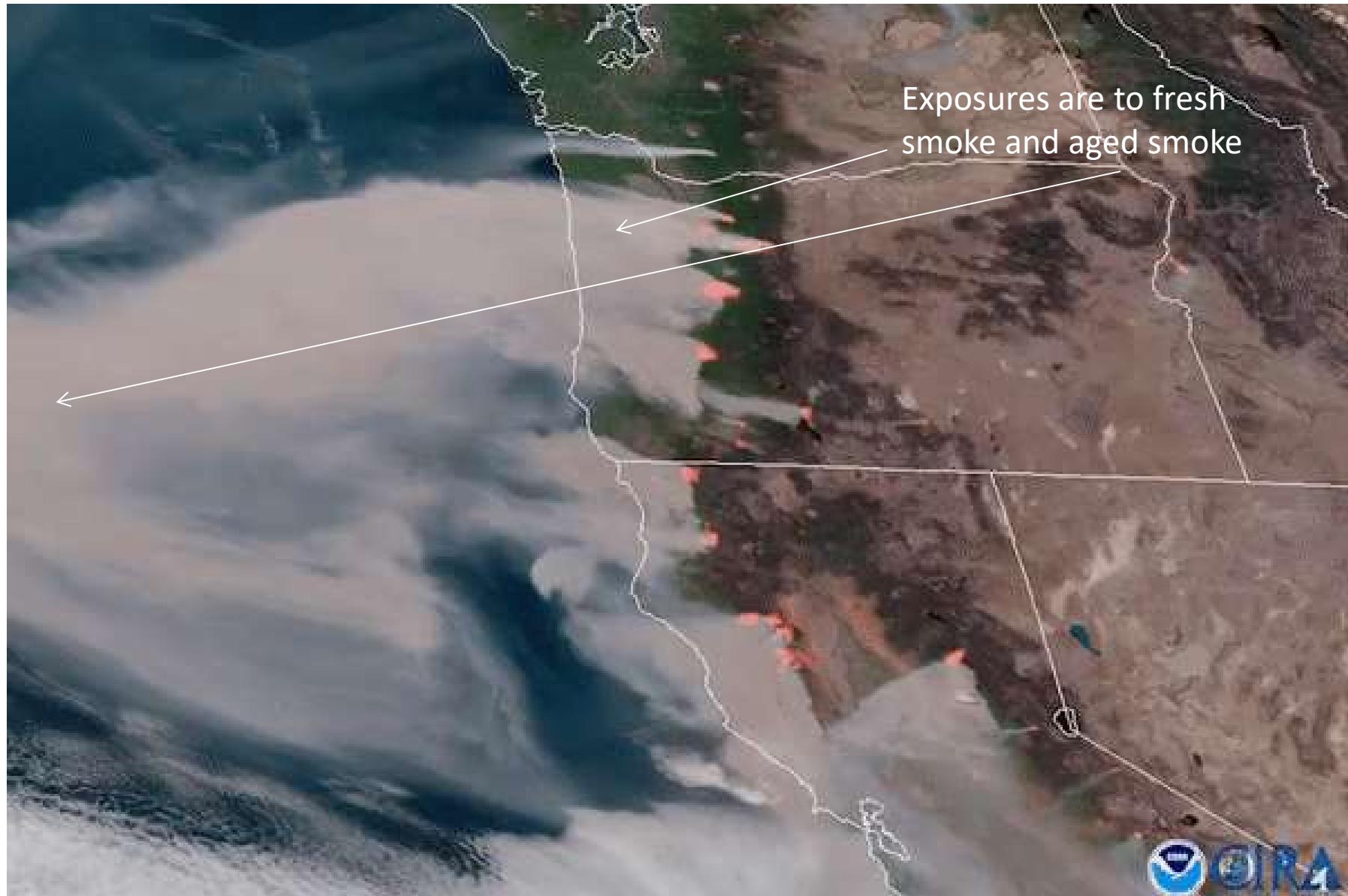
# What is known about the role of multiple stressors?

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- ▶ **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.

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# Wildfire Smoke and Cardiovascular Disease Outcomes

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- 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.



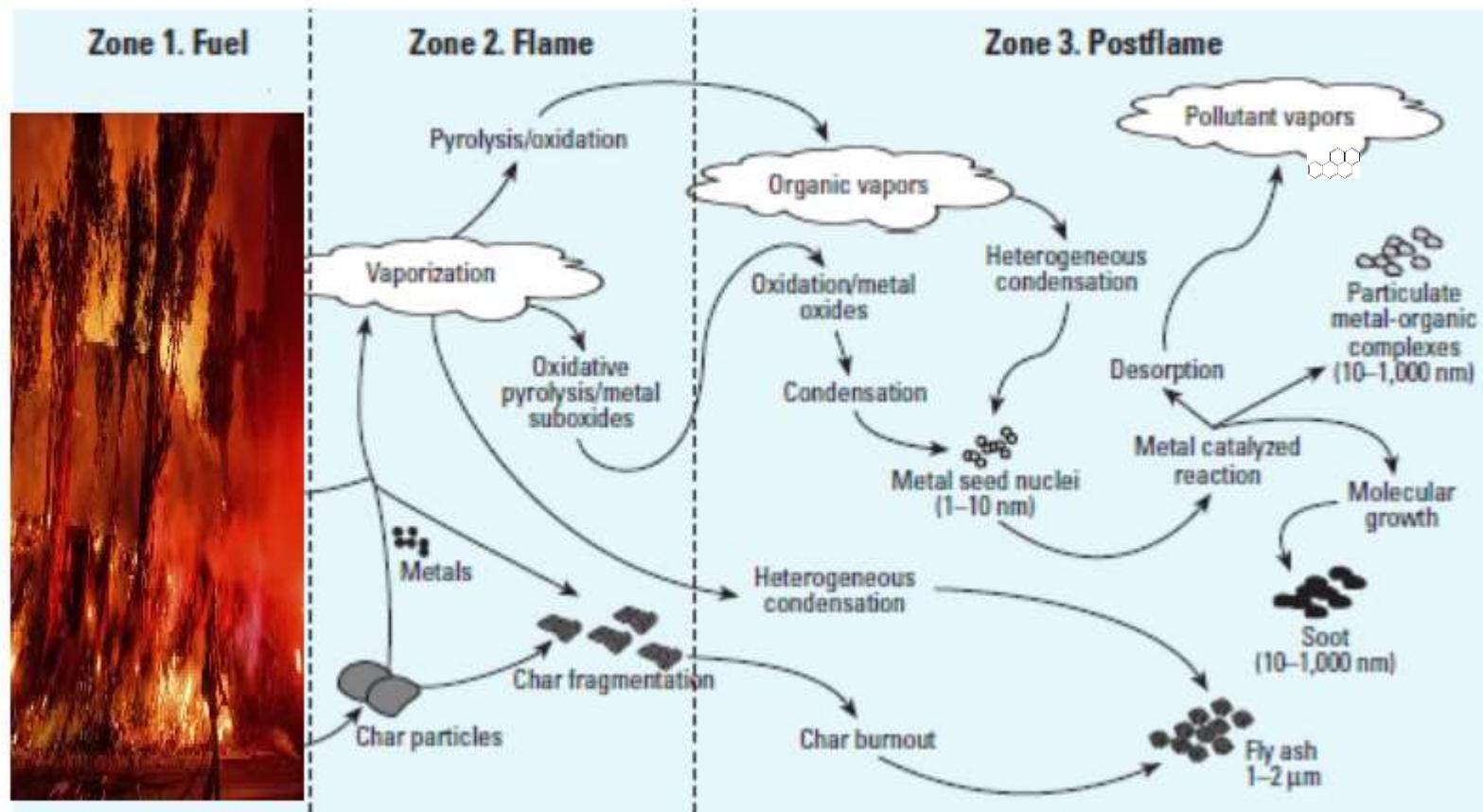
# ***Chemical Composition of Wood Smoke PM and Cardiovascular Effects***

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- 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.



# How toxic compounds and nanoparticles form during the combustion process



Adapted from

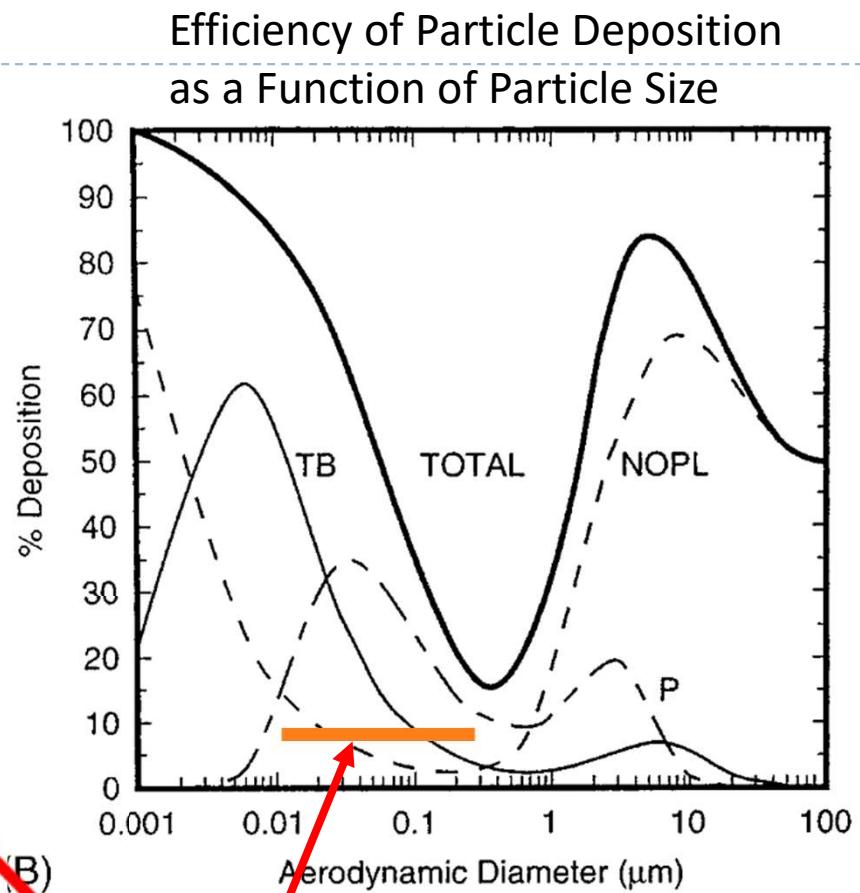
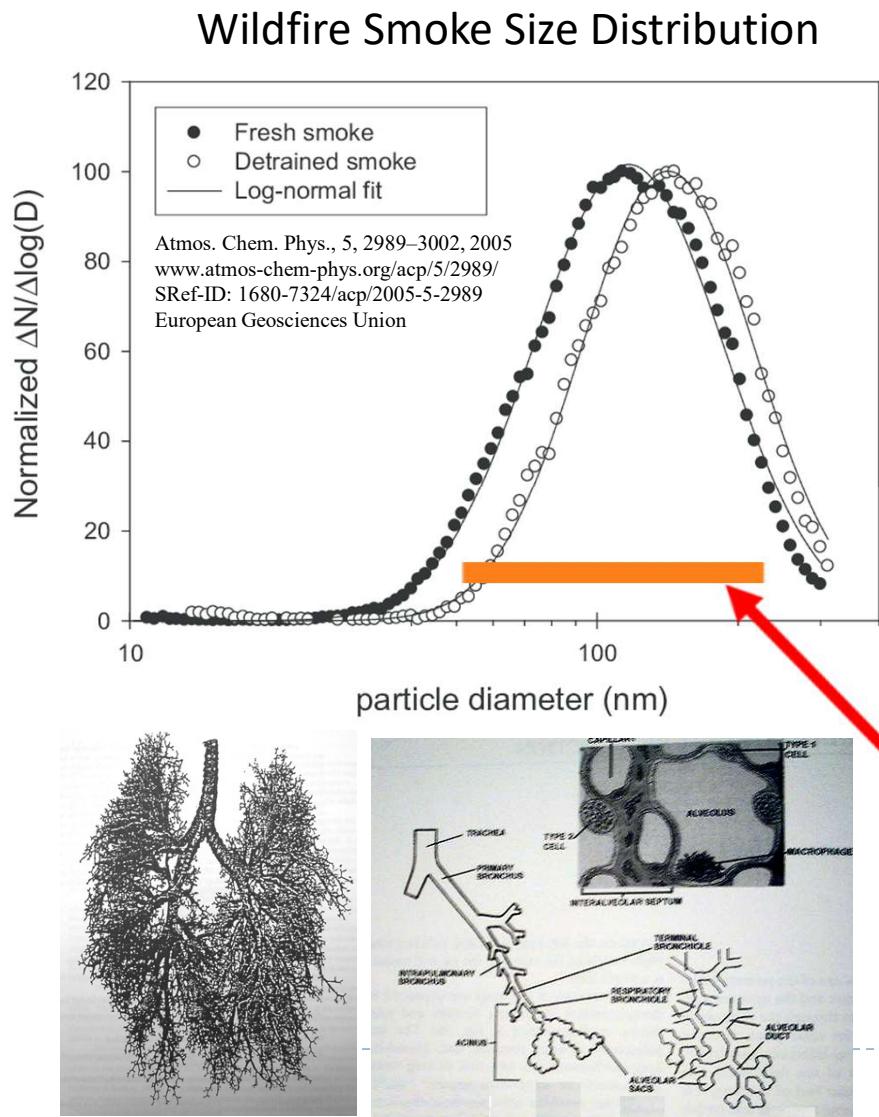
Origin and Health Impacts of Emissions of Toxic By-Products and Fine Particles from Combustion and Thermal Treatment of Hazardous Wastes and Materials

Stephanie A. Cormier,<sup>1</sup> Slawo Lomnicki,<sup>2</sup> Wayne Backes,<sup>3</sup> and Barry Dellinger<sup>2</sup>

<sup>1</sup>Department of Biological Science, and <sup>2</sup>Department of Chemistry, Louisiana State University, Baton Rouge, Louisiana, USA;

<sup>3</sup>Department of Pharmacology, Louisiana State University Health Sciences Center, Baton Rouge, Louisiana, USA

# Inhaled Nanoparticles from Combustion Will Deposit in the Respiratory Tract

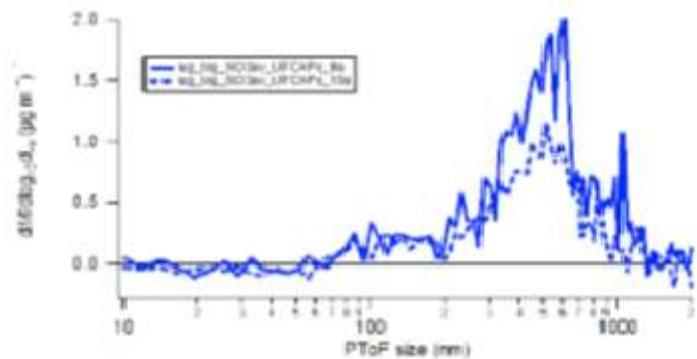


Ideal size for deep lung penetration

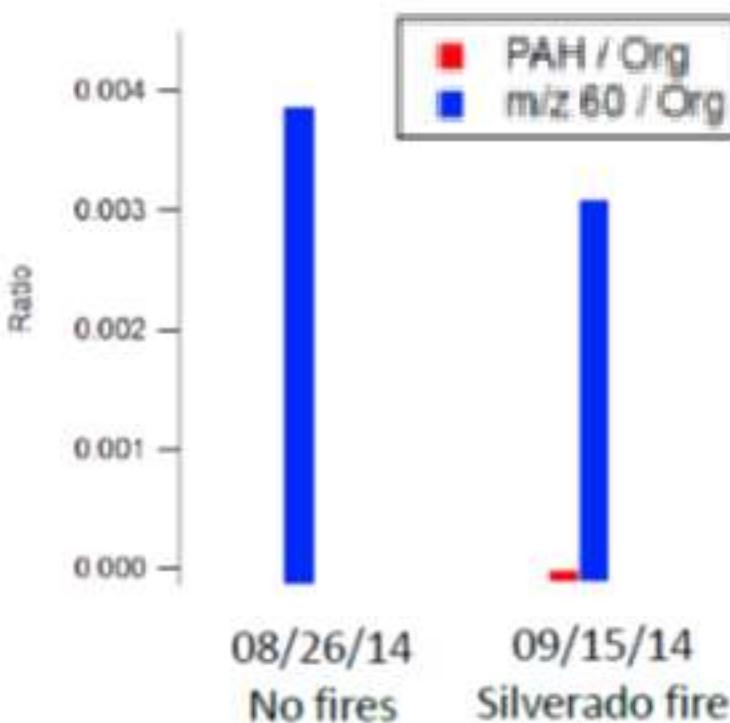
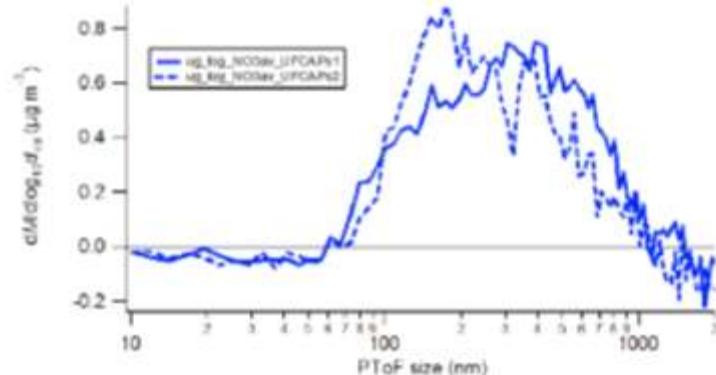
# Wildfires Increase Concentrations of Nano-sized PAHs and Nitrates in Ambient Air

## Nitrate

08/26/14 – before fire



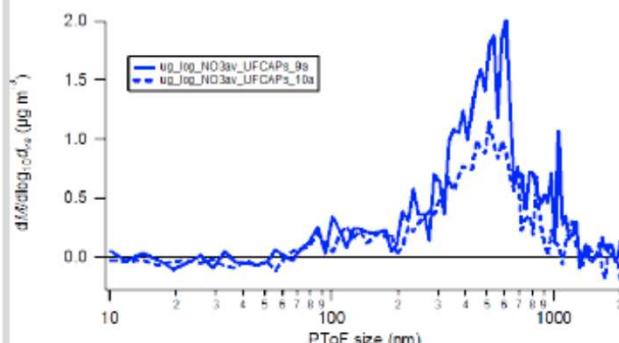
09/16/14 – during fire



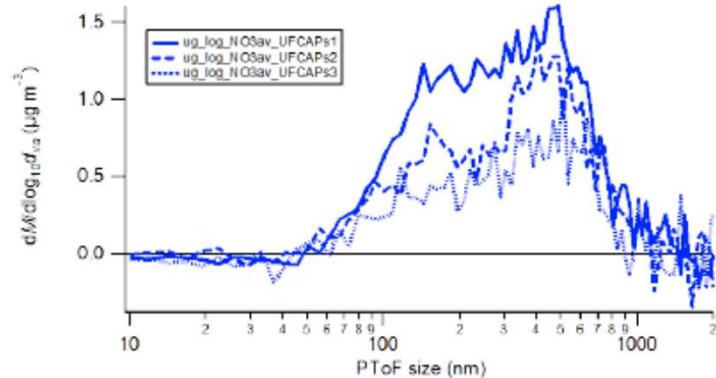
# Additional Silverado Forest Fire Influence

## Nitrate

08/26/14 – before fire

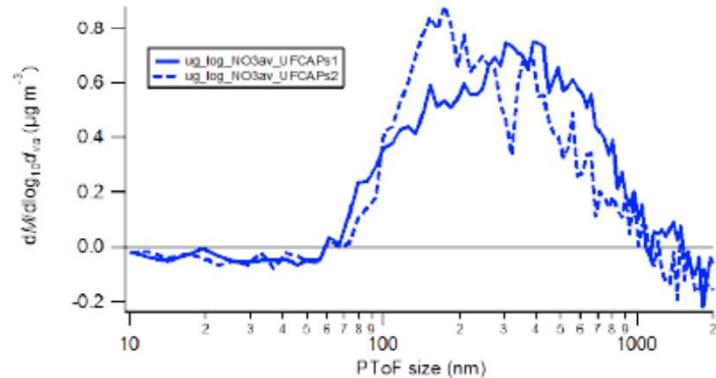


09/15/14 – during fire

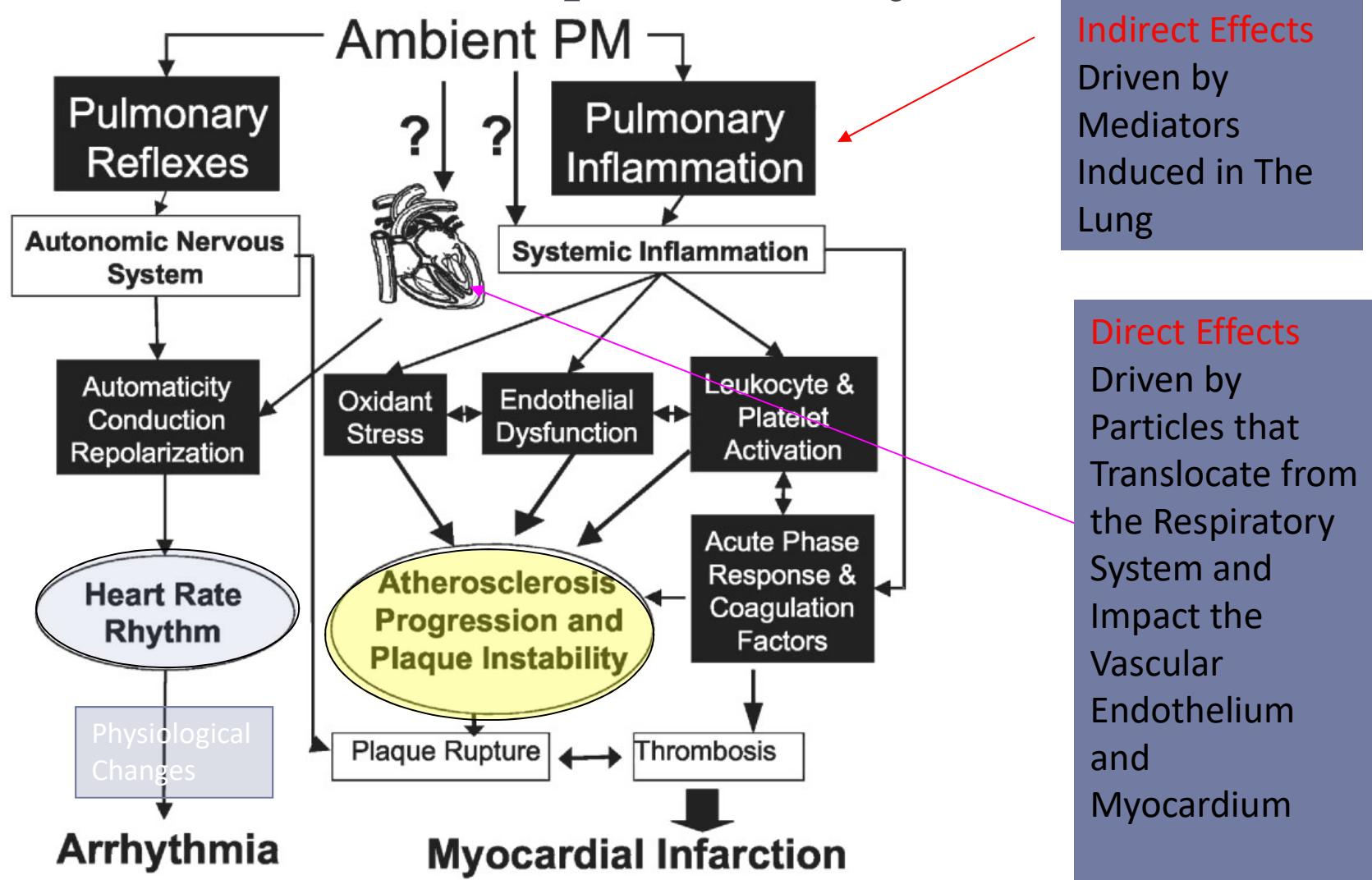


- More nitrate in smaller diameters during Silverado forest fire.
- Particulate nitrate increases during biomass burning periods, e.g. Behera and Balasubramanian (2014), Bi et al. (2011), and Qin and Prather (2006).

09/16/14 – during fire



# Inhaled Pollutants can Induced Effects Through Multiple Pathways



Adapted from: Pope, 2006, Ischemic heart disease events triggered by short-term exposure to fine particulate air pollution., Circulation :114, 2443 -8

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10/21



10/22



10/23



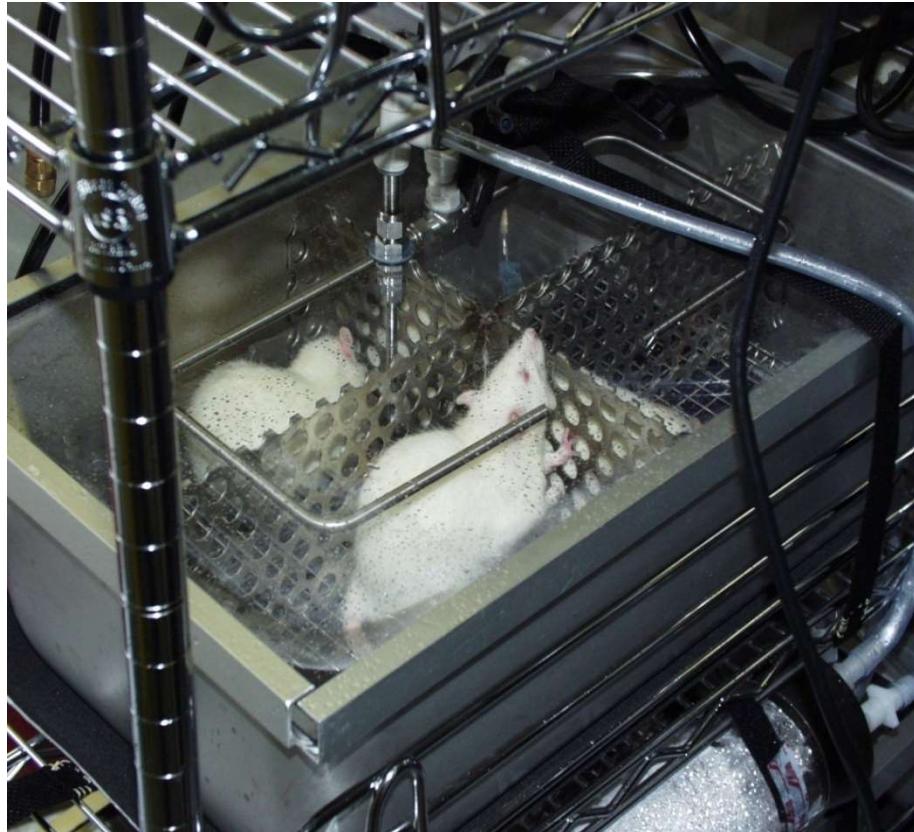
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Rats or Mice Can Be Exposed to Purified Air or CAPs in Sealed Chambers

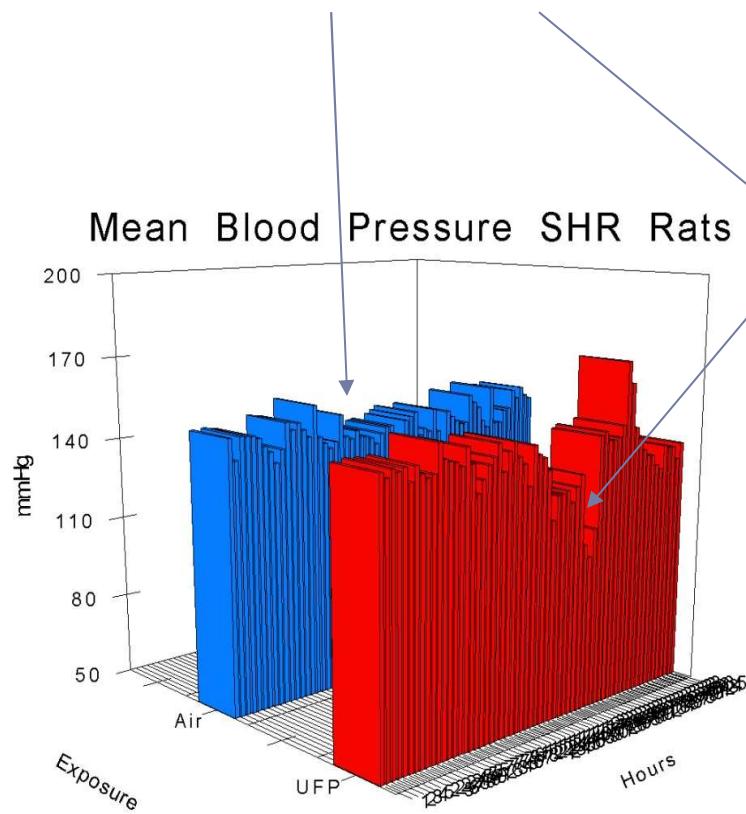


The Sealed Chambers Can Be Placed Onto Racks to Facilitate Transport

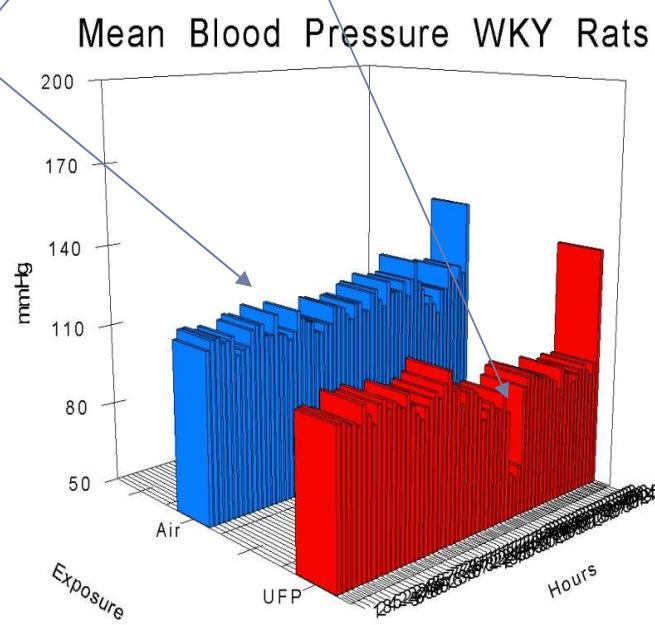


# Blood Pressure

Blood Pressure Stable in Air-Exposed Rats

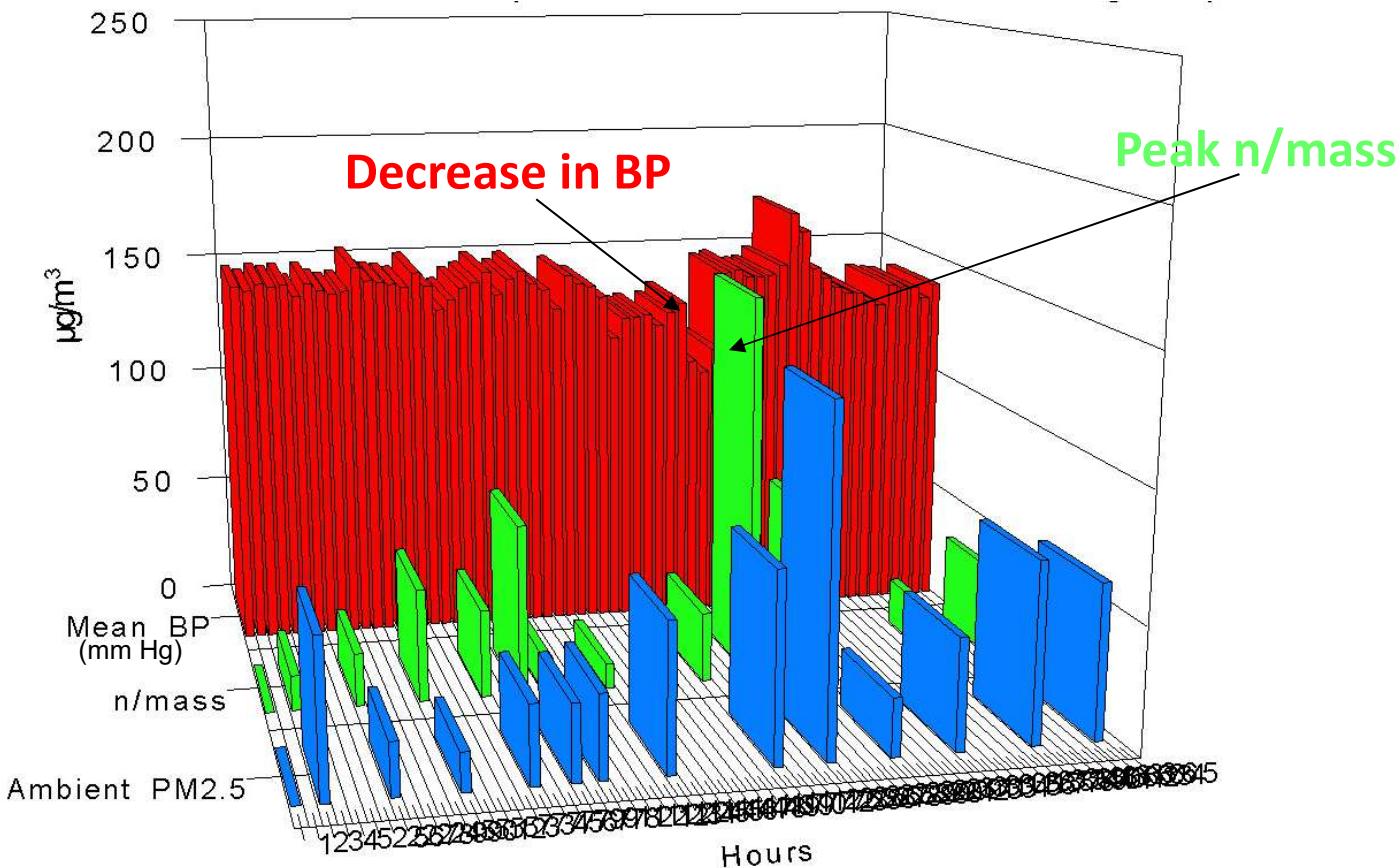


Significant Drop in Blood Pressure in UFP-exposed Rats During Fire



# Results... (cont.)

## Ambient PM<sub>2.5</sub> 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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