

# Reducing Exposure to Wildfire Smoke

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# Overview

## ➤ **Background**

- Factors that affect indoor air quality
- Filtration Basics
  - Central air filters and portable air cleaners
- Recent research on air filtration. Ideal and real world examples

## ➤ **Camp Fire Case Study**

- Effects of upgrading filtration in Sacramento CalEPA building
- Utility of low-cost sensors

## ➤ **Conclusion**

- Strategies to reduce exposure
- Cleaner air shelters/spaces and data gaps

# Factors Affecting Indoor Air Quality

## ➤ Modern Construction

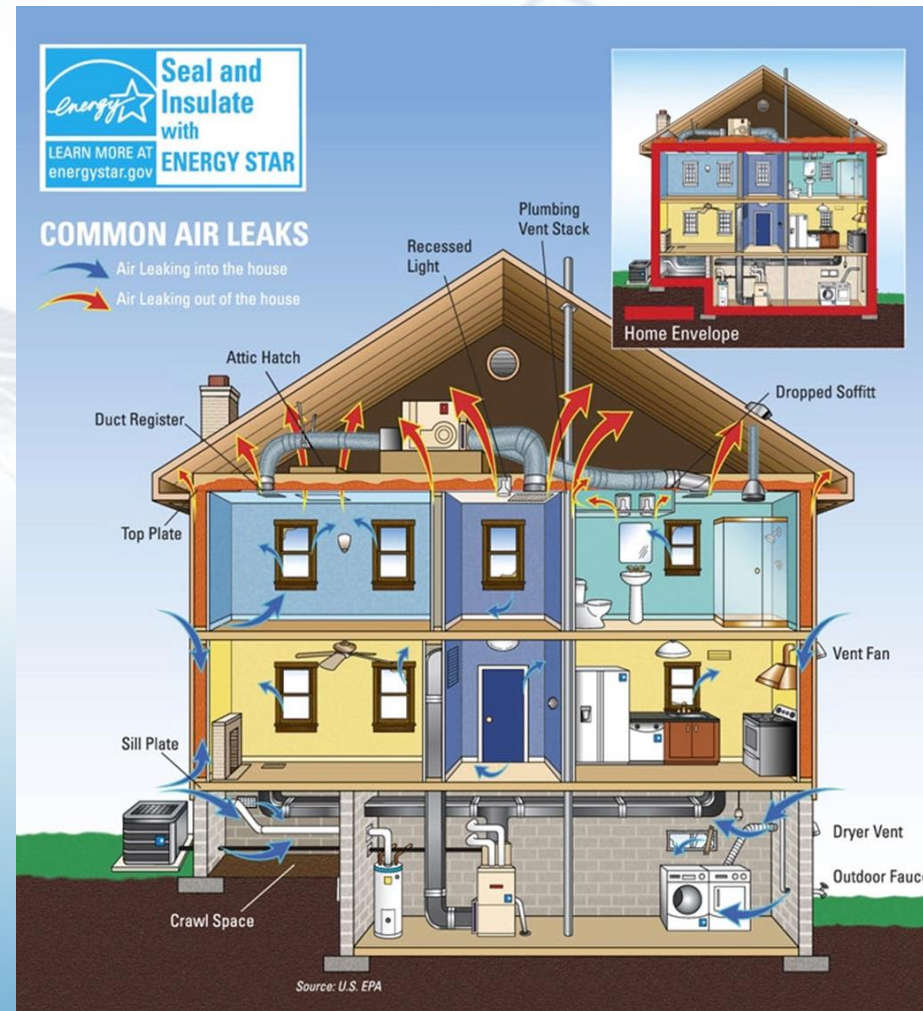
- Tight building envelope
- Low air exchange

## ➤ Sources

- Indoor - Cooking, smoking, consumer products, building materials
- Infiltration of outdoor pollutants

## ➤ Ventilation/Filtration

- Outdoor air needed
- Potential health benefits from high efficiency filtration



# Central Air System Filtration (HVAC)

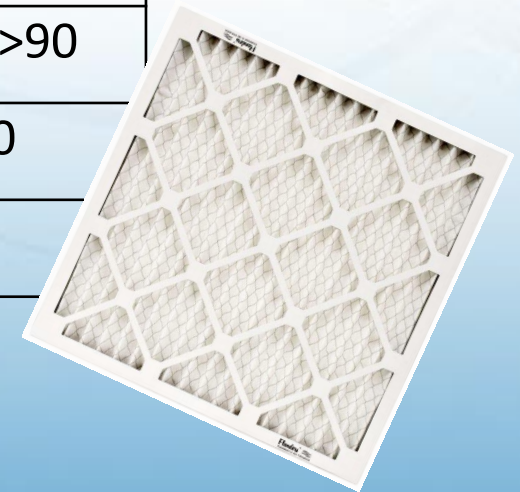
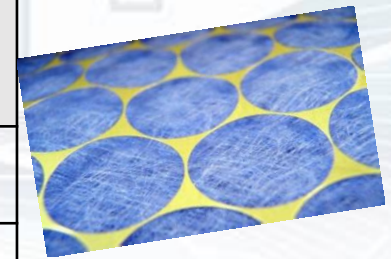
- Fibrous filters (MERV)
  - Mount at return or base of air handling unit
  - Only provides filtration while heating or cooling is needed
- Electronic In-duct devices
  - Integrated into the ducting
  - Electrostatic precipitators
  - Germicidal UV, Photocatalytic Oxidation\*



\*can produce ozone and may not reduce PM

# Filter Efficiency (MERV)

MERV Rating	Average Particle Size Removal Efficiency (%)		
	Particle Size ( $\mu\text{m}$ )		
	0.3–1.0	1.0–3.0	3.0–10.0
Low (1–4)	n/a	n/a	<20
Medium (5–8)	n/a	>20 <sup>+</sup>	20 to >70
Medium (9–12)	20 to >35 <sup>++</sup>	35 to >80	75 to >90
High (13–16)	50 to >95	>85	>90
HEPA (17–20)**	$\geq 99.97$		



\*Adapted from ANSI/ASHRAE Standard 52.2

\*\*Not part of the official ASHRAE Standard 52.2 test but added for comparison purposes

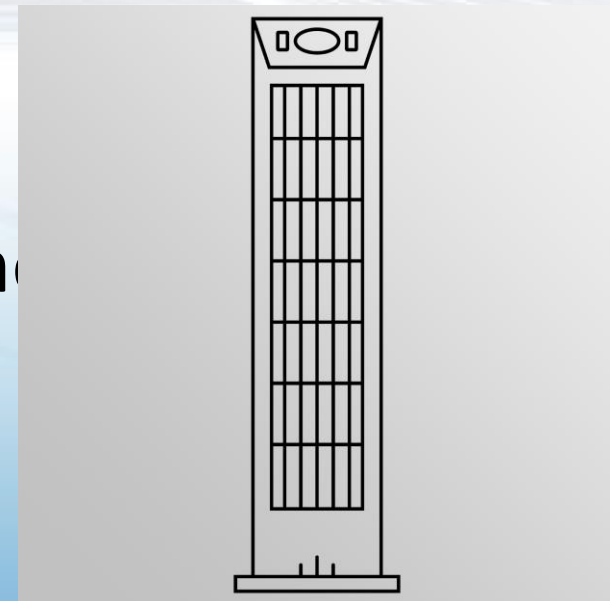
n/a: Not applicable to MERV rating (not tested)

<sup>+</sup> Not applicable for MERV 5–7

<sup>++</sup>Not applicable for MERV 9–10

# Portable Air Cleaners

- Mechanical
  - Fibrous filter - typically will be HEPA level
- Electronic
  - Electrostatic precipitator, UVGI,
  - Some can produce ozone
- Very effective for creating a clean room or space
- Can be operated continuously



# Choosing A Portable Air Cleaner

- Clean Air Delivery Rate (CADR)
- Rule of thumb: CADR for tobacco smoke 2/3 of room size.
- Not all devices rated by CADR. See CARB FAQ for additional info
- Ozone safe – CARB certified air cleaner list

➤ <https://ww3.arb.ca.gov/research/indoor/acdsumm.pdf>

➤ <https://ww2.arb.ca.gov/our-work/programs/air-cleaners-ozo-products/california-certified-air-cleaning-devices>

➤ <http://ahamverifide.org/directory-of-air-cleaners/>



California Certified Air Cleaning Devices

All portable indoor air cleaning devices sold in California must be certified by the California Air Resources Board (CARB). To be certified, air cleaners must be tested for electrical safety and ozone emissions, and meet an ozone emission concentration limit of 0.050 parts per million. For more information about the regulation, visit the air cleaner regulation.

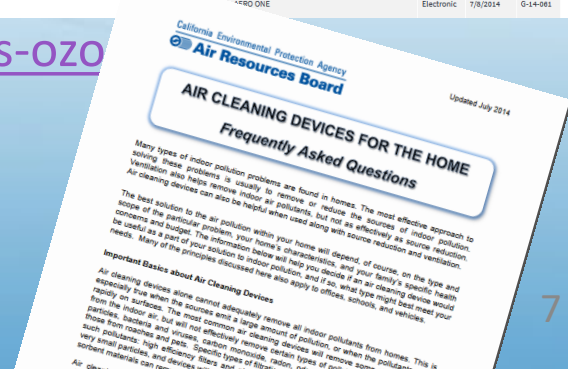
In-duct, whole-house air cleaning devices may also generate ozone, but these are not currently regulated. Check with the manufacturer of the in-duct device prior to installation.

The list below shows air cleaning devices certified for sale in California. We will update the list as devices are certified. Air cleaners that are listed as "Mechanical" are air cleaners that only use physical filtration, such as pleated or HEPA-style filters, and do not typically generate ozone. Air cleaners that are listed as "Electronic" may emit ozone, but they have been tested and found to produce an ozone emission concentration less than 0.050 parts per million. This category includes ionizers, electrostatic precipitators, FOCs, hydroxyl generators, UV light and other electronic air cleaning technologies. Devices that likely produce unsafe levels of ozone are found on our list of potentially hazardous ozone generators sold as air purifiers.

Please note that the list below does not reflect air cleaner effectiveness, only safety. For help in selecting an effective air cleaner for your needs, you may wish to consult our guidance on selecting air cleaners.

To search for a CARB certified air cleaner in the table below, hold down the "Ctrl" key and click the "F" key on your keyboard and then release both keys at the same time. This should bring up a search box that is different than the "Search CARB" box that is located within the browser. You may then type in the brand name, model name, or model number of the device you are searching for. Even a partial name will highlight results on the webpage.

Brand	Model Name (Model Numbers)	Type	Date Notified	EQ Number*
3M	Office Air Cleaner with Fibre™ Filter (DAC150, DAC250)	Electronic	8/20/2010	G-10-086
IQ	SQ-AP-04, 9088B	Electronic	4/13/2018	G-18-035
	SQ-AP021	Electronic	9/26/2013	G-13-078
	Electrostatic Air Purifier	Electronic	9/9/2010	G-10-081
	(SQ-AP-04, SQ-AP-04A, SQ-AP-04S)			
Sims Airwolf	AW1800	Electronic	10/24/2011	G-11-108
ActivTek Environmental	AP3000	Electronic	10/18/2010	G-10-094
	(A5015A)			
AeraMax	Pro AM5 PC, Pro AM5S PC	Electronic	8/23/2018	G-18-089
	Pro AM4 PC, Pro AM4S PC	Electronic	8/23/2018	G-18-090
	Pro AM III	Electronic	1/28/2015	G-15-010
	Pro AM IV	Electronic	1/28/2015	G-15-010
	««RO ONE	Electronic	7/8/2014	G-14-061





# Reducing Indoor PM Exposure Evidence from Recent CARB Funded Studies



# Reducing In-Home Exposure to Air Pollution

P.I. Brett Singer (LBNL)

- Evaluated eight combinations of mechanical ventilation and air filtration systems
  - Unoccupied home
- Study Examined
  - Reductions of particles and black carbon
  - Energy use
- Several filter efficiencies evaluated



# Benefits of High Efficiency Filtration to Children with Asthma

P.I. Deborah H. Bennett (UC Davis)

- Purpose: investigate the effectiveness of high-efficiency filtration in reducing indoor pollutant exposures and asthma symptoms
  - Participants (6-12 yrs.) with asthma
  - 172 homes enrolled
  - 1 year with high efficiency filtration, 1 year without
- Interventions – portable air cleaners or central-air system filters (MERV 16)
- Participants from high outdoor pollution areas (Fresno and Riverside)



# Filtration Studies

## Key IAQ Findings

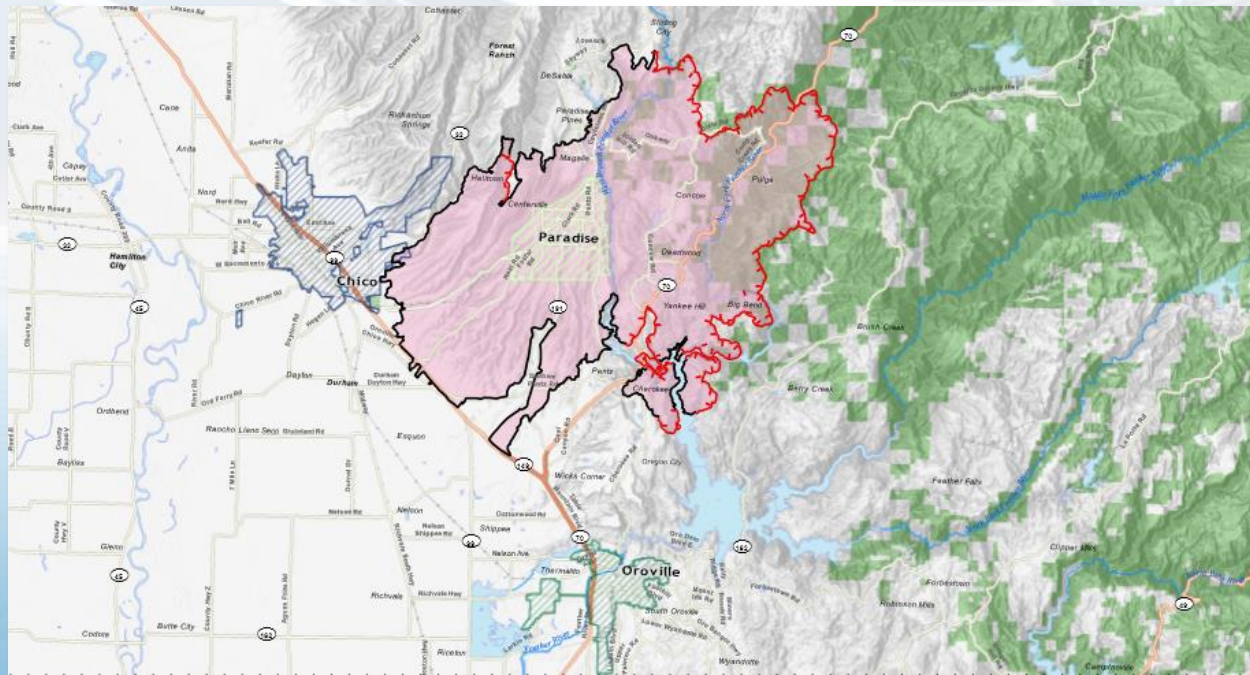
### **Singer – Test Home**

- Four systems reduced incoming PM2.5 by over 90%
- MERV 16 filters achieved the greatest reductions (~95%) for PM2.5, black carbon and UFP
- Pressure drop not significant issue for higher MERV filters

### **Bennett – Occupied Homes**

- For all homes, indoor PM concentration (all size ranges) reductions ranged from 34% to 52%.
- Portable air cleaners reduced mean PM2.5 concentrations by 51%
- Central system filters reduced mean PM2.5 concentrations by 37%

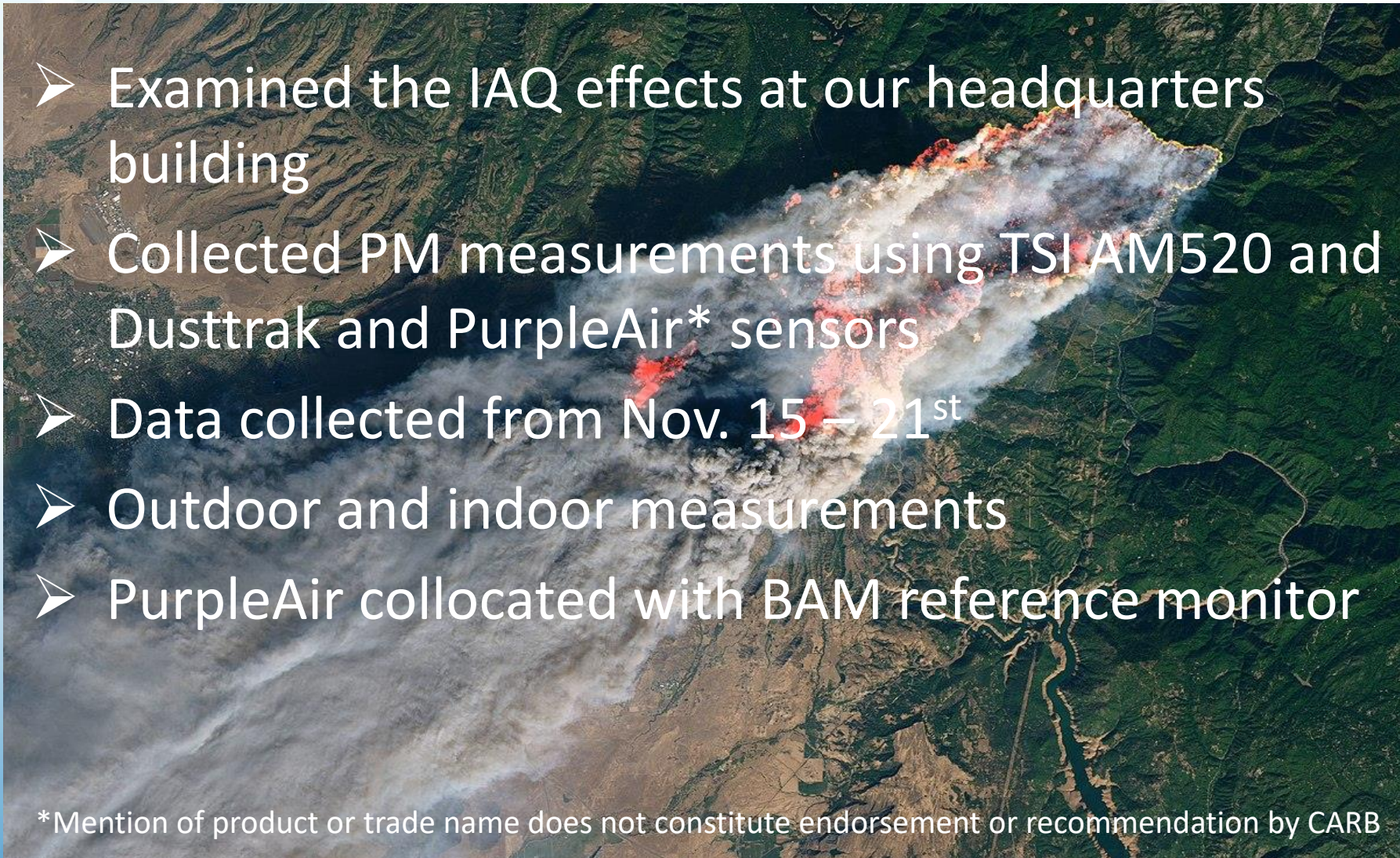
# Camp Fire 2018



# Camp Fire Case Study

- 
- Camp fire deadliest and most destructive fire in CA history (85 fatalities)
  - Fire started Nov. 8<sup>th</sup> 2018
  - Burned 153,336 acres and destroyed almost 19,000 structures
  - 100% containment on Nov. 25<sup>th</sup> 2018
  - Fire only about 80 miles (128km) from Sacramento
  - In Chico area, PM above 1,000  $\mu\text{g}/\text{m}^3$  on 4 days

# Camp Fire... continued

- 
- An aerial photograph of the Camp Fire, showing a large, intense fire with a thick plume of white and grey smoke rising from the center. The fire is surrounded by green hills and a river valley. The smoke plume extends towards the left side of the image.
- Examined the IAQ effects at our headquarters building
  - Collected PM measurements using TSI AM520 and Dusttrak and PurpleAir\* sensors
  - Data collected from Nov. 15 – 21<sup>st</sup>
  - Outdoor and indoor measurements
  - PurpleAir collocated with BAM reference monitor

# Joe Serna Jr. CalEPA Building (2000)

- 25 story tower - Sacramento.
- First building in nation to be certified LEED Platinum
- The HVAC system allows for on-demand fresh air, flushing internal air and cooling with outside air
- HVAC energy efficiency measures save electricity. \$1.15 per sq ft.
- Energy costs lower than typical buildings of the same size
- Building filtration upgraded MERV 13 to 16. Upgrade started Nov 16 and completed Nov 18<sup>th</sup>.



**13 CBS Sacramento** NEWS WEATHER SPORTS BEST OF VIDEO MORE **CBS13 ON AIR** 85°

## Smoke From Camp Fire Has Created Unhealthy Conditions In Sacramento Area

November 10, 2018 at 7:50 pm Filed Under: air quality, Arden Arcade, Camp Fire, Folsom, Roseville News, Sloughhouse

Smoky skies of downtown Sacramento Saturday afternoon.

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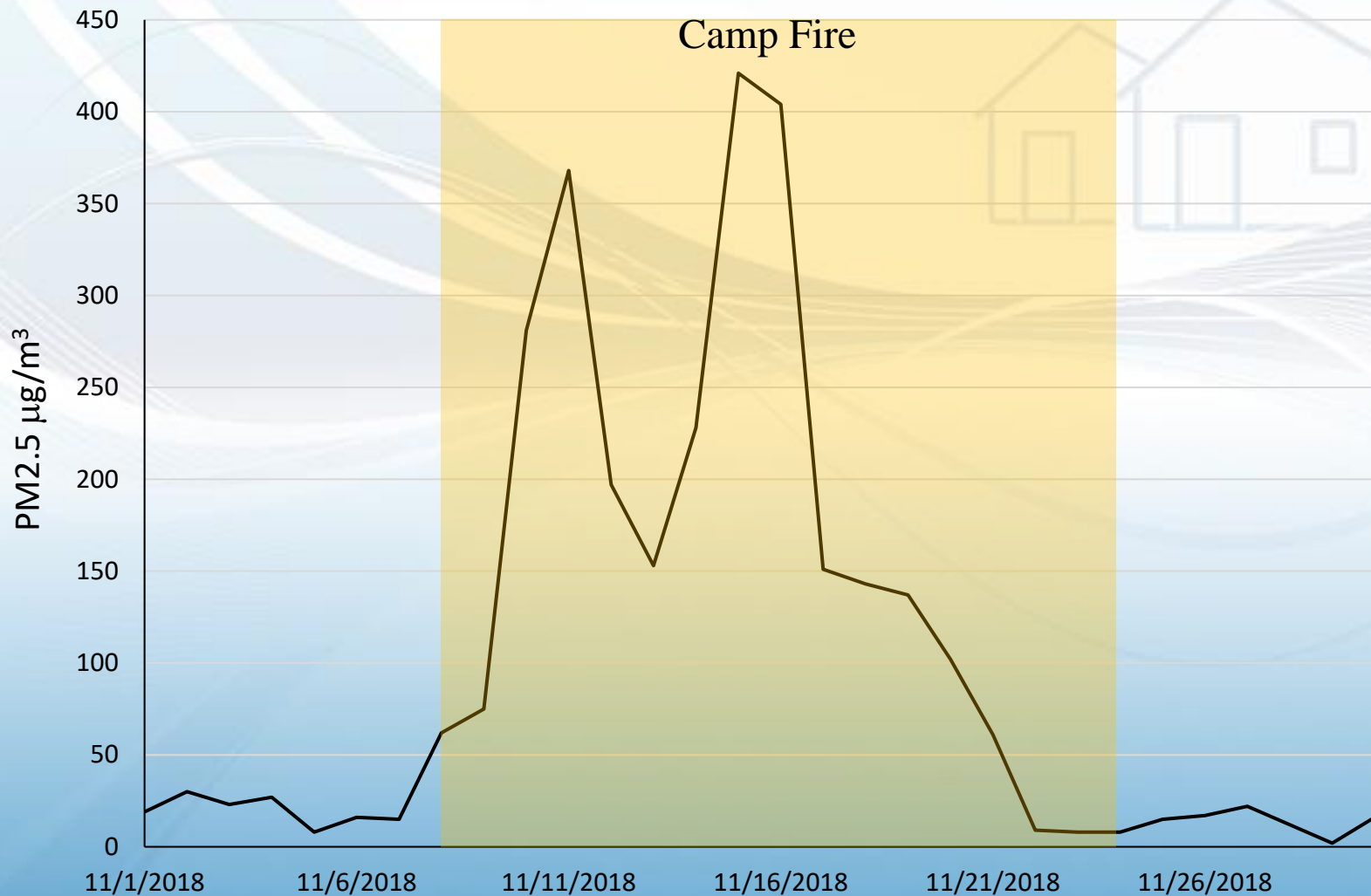
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- Bear That Wandered Onto UC Davis Campus Tranquilized, Released Back Into Wild
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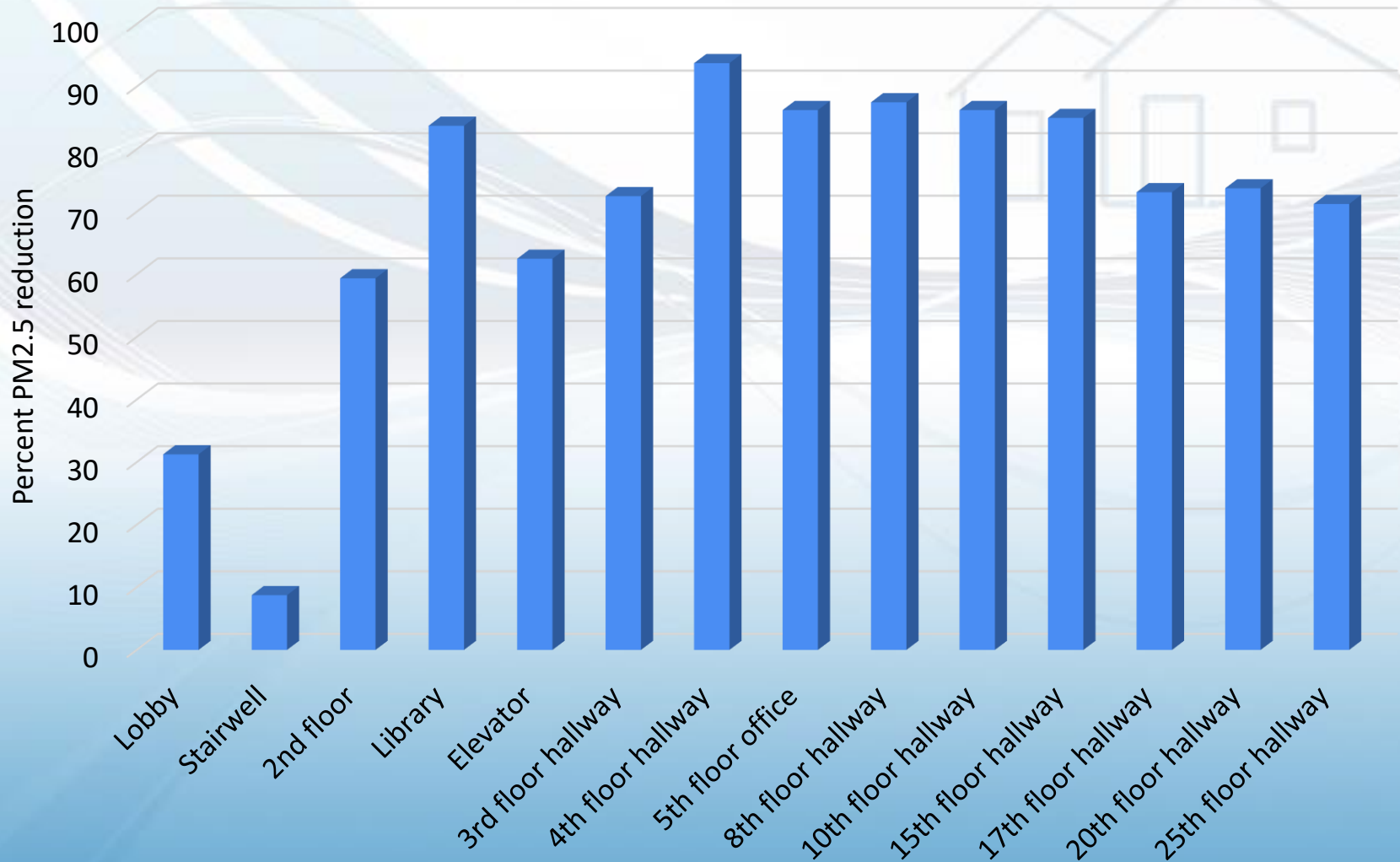
SACRAMENTO (CBS13) — Air quality in Arden Arcade, Folsom, Roseville, and Sloughhouse is now hazardous due to smoke from the Camp Fire.

# Outdoor PM 2.5 Concentrations (Nov. 2018, Sacramento)

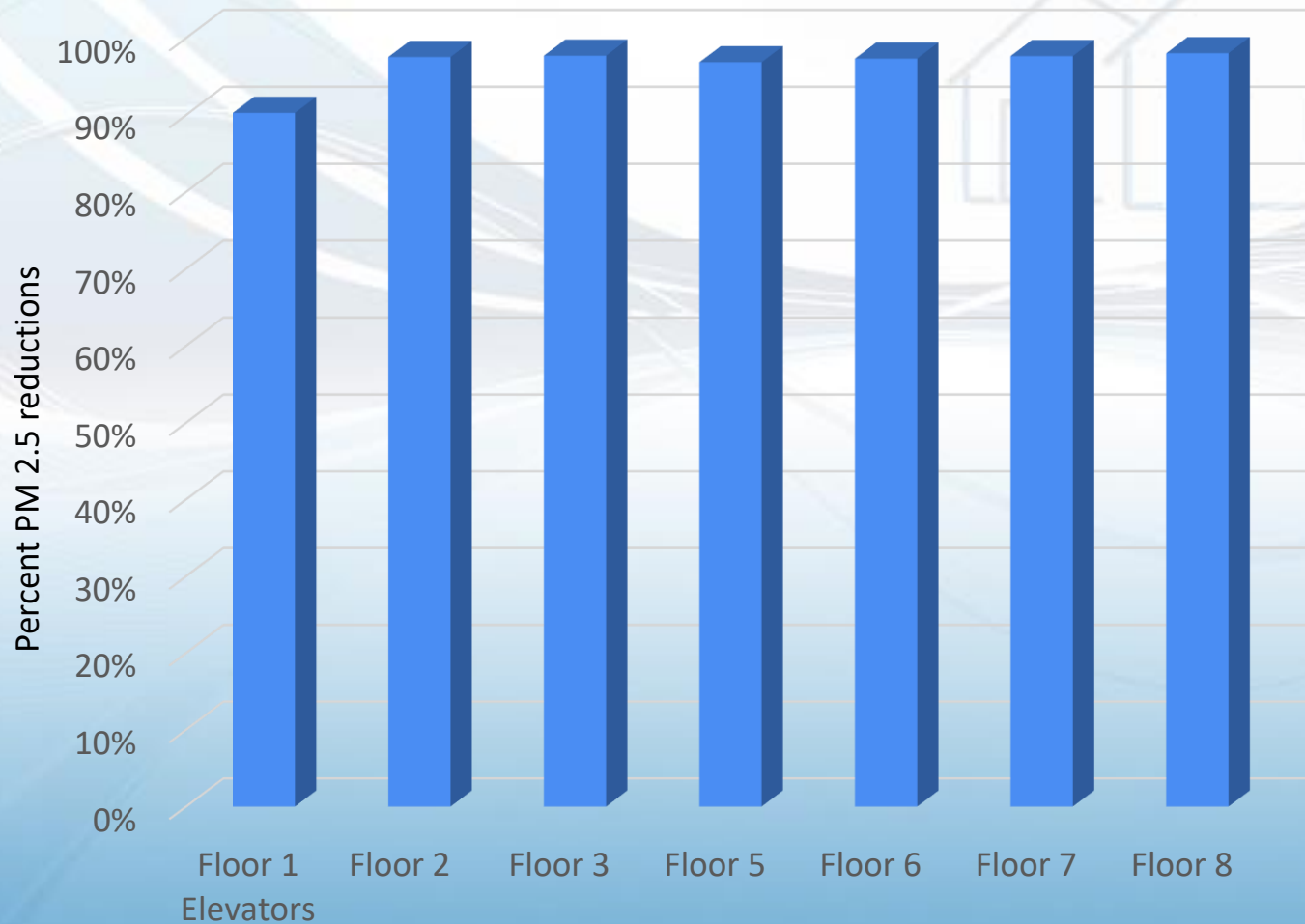




# Percent Reduction of Indoor PM 2.5, CalEPA Bldg. Nov. 15<sup>th</sup> (Outdoor avg. = 421 $\mu\text{g}/\text{m}^3$ )



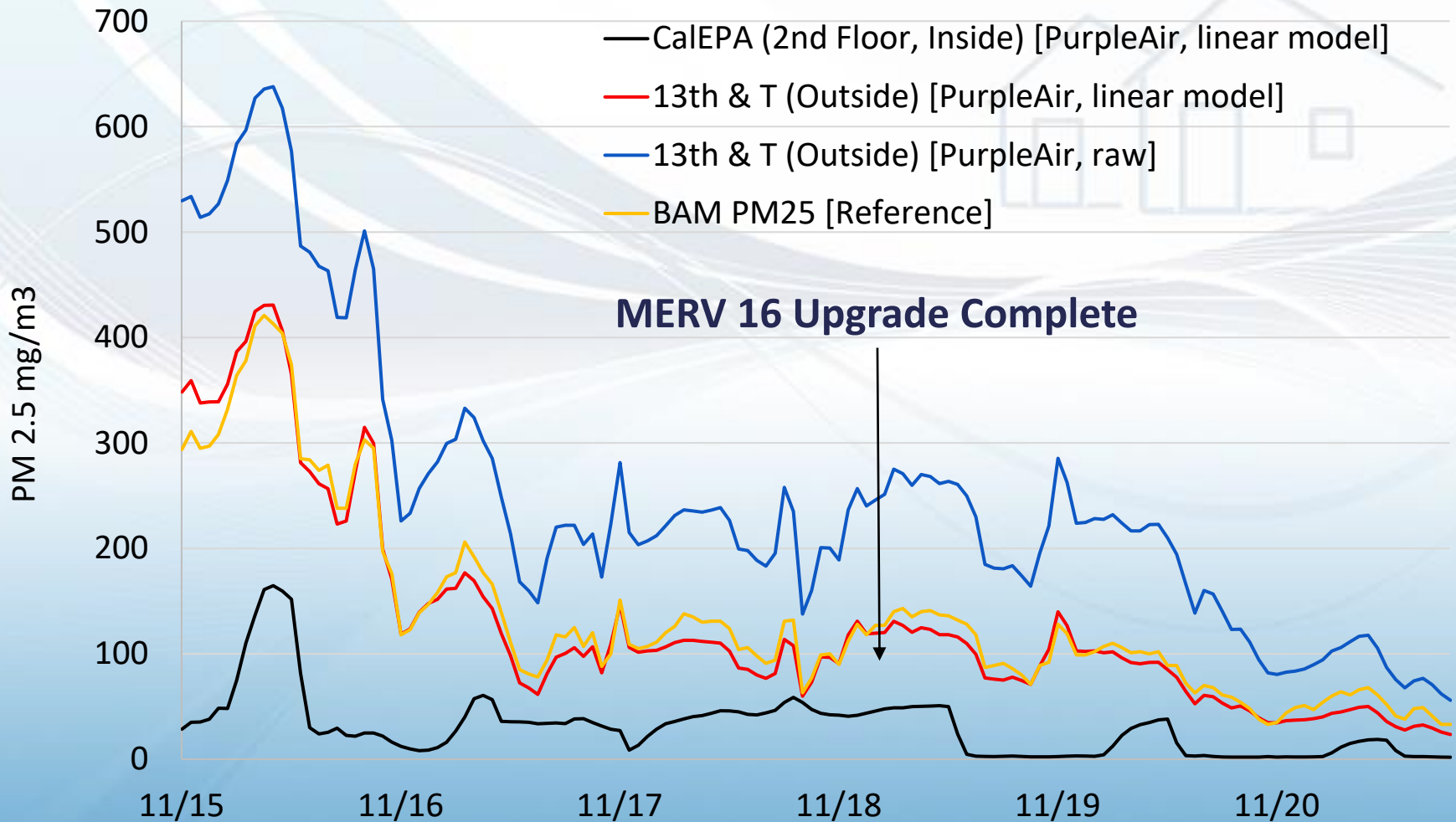
# Percent Reduction of Indoor PM 2.5 CalEPA Bldg. Nov. 19<sup>th</sup> (Outdoor avg. = 432 $\mu\text{g}/\text{m}^3$ )



# Low Cost Monitors

- Low cost monitor use increasing
  - >1,600 PurpleAir monitors in CA as of 2018
  - Small, quiet, low power, WiFi connectivity
  - Used for citizen science
  - Augmenting regulatory networks
  - Fairly good precision but not as accurate
- Smoke from Camp fire - opportunity for real-time comparison to regulatory monitors

# Indoor and Outdoor PM2.5 Low Cost Monitor Data



# Conclusion



# Strategies to Reduce Smoke Exposure

- Stay Indoors
  - Minimize indoor sources
  - Keep windows doors closed. Reduce fresh air uptake into home/offices
- Use high-efficiency filtration ( $\geq$ MERV 13) in central system
  - check that system can handle higher MERV filters
- Use portable air cleaners (get before fire season)
- Reduce activity: esp. vulnerable populations
  - Children and elderly
  - People with pre-existing respiratory or cardiovascular disease

# Cleaner Air Space or Shelter

- Definitions: Cleaner air space or shelter
- Guidance from Appendix of updated EPA wildfire guide
  - Newer facilities with tight sealing windows/doors
  - Facilities should have central A/C with high efficiency filtration ( $\geq$  MERV 13)
  - Properly maintain filters and ventilation. High MERV filters on fresh air intakes
  - Ensure space can handle higher cooling load and occupancy
  - Proper safety equipment (CO and Smoke Detectors, etc.)
  - Ensure adequate services like restroom facilities

# Data Gaps/Future Research

- Better understand what constitutes a good cleaner air space or shelter
  - More info about filtration efficacy for cleaner air spaces (e.g. libraries, theaters, malls, schools)
  - Monitoring of indoor PM (real-world)
  - Database of buildings and IAQ
- Efficacy and safety of box fan/filter combo
  - More affordable option or if portables not available.
  - Not recommended at this time
- Collaboration with City of Sacramento to study cleaner air shelters before and after retrofit





# Additional Resources

## ➤ Guides, Fact Sheets, Air Cleaners and Filtration

- [https://www3.epa.gov/airnow/wildfire\\_may2016.pdf](https://www3.epa.gov/airnow/wildfire_may2016.pdf) (update coming soon)
- [https://airnow.gov/index.cfm?action=topics.smoke\\_wildfires](https://airnow.gov/index.cfm?action=topics.smoke_wildfires)
- <https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home>

## ➤ Research

- BC Centre for Disease Control. Evidence review for clean air shelters

[http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Health-environment/WFSG\\_EvidenceReview\\_CleanAirShelters\\_FINAL\\_v3\\_edstrs.pdf](http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Health-environment/WFSG_EvidenceReview_CleanAirShelters_FINAL_v3_edstrs.pdf)



Thank You!

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# PurpleAir Comparison

