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# Hazardous air pollutant emissions estimates from wildfires in the wildland urban interface

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## Abstract

Fires that occur in the wildland urban interface (WUI) often burn structures, vehicles, and their contents in addition to biomass in the natural landscape. Because these fires burn near population centers, their emissions may have a sizeable impact on public health, necessitating a better understanding of criteria and hazardous air pollutants emitted from these fires and how they differ from wildland fires. Previous studies on the toxicity of emissions from the combustion of building materials and vehicles have shown that urban fires may emit numerous toxic species such as hydrogen cyanide, hydrogen fluoride, hydrogen chloride, isocyanates, polycyclic aromatic hydrocarbons (PAHs), dioxins and furans, and a range of toxic organic compounds (e.g. benzene toluene, xylenes, styrene, and formaldehyde) and metals (e.g. lead, chromium, cadmium, and arsenic). We surveyed the literature to create a compendium of emission factors for species emitted from the combustion of building and vehicle materials and compared them with those from wildland fires. Emission factors for some toxic species like PAH and some organic compounds were several orders of magnitude greater than those from wildfires. We used this emission factor compendium to calculate a bounding estimate of the emissions from several notable WUI fires in the western United States to show that urban fuels may contribute a sizeable portion of the toxic emissions into the atmosphere. However, large gaps remain in our understanding of the fuel composition, fuel consumption, and combustion conditions in WUI fires that constrain our ability to estimate the impact of WUI fires.

**Keywords:** smoke, structure fires, toxic emissions, particulate matter

## Significance Statement

Wildfires in the wildland urban interface (WUI) burn homes and vehicles leading to potentially greater emissions of hazardous air pollutants than from wildfires burning only natural vegetation. The greater proximity of these wildfires to population centers and the potentially more toxic emissions make fires in the WUI a unique threat to public health. We estimate the emissions from several recent WUI fires in California and find greater emissions of some hazardous air pollutants attributable to urban fuels when compared with natural biomass and other anthropogenic sources in the airshed. Our results demonstrate that WUI fires are a potential major source of hazardous air pollutants and a better understanding of what and how much is emitted from them is needed.

## Introduction

The wildland urban interface (WUI) is the area where residential and commercial buildings are intermixed in wildlands or high population densities are adjacent to wildlands. In recent decades, the WUI has been growing in area, people, and homes (1). This mingling of the urban environment with the natural has led to increasingly destructive wildfires (2). Wildfires have also been increasing in intensity with a warming climate and overgrowth of fuels, with some fires experiencing explosive growth, rapidly consuming thousands of acres and destroying entire neighborhoods within a day or several days (3). WUI fires occur across the world, with some areas like the Mediterranean, Australia, and California

repeatedly experiencing highly destructive fires. Although infrequent, catastrophic fires like Northern California's Camp Fire in 2018 and Australia's 2019/2020 fires destroyed over 10,000 structures to become two of the most destructive fires in modern times. Smaller WUI fires, where several hundred to over a thousand structures destroyed, are much more frequent and are widespread (4). These small WUI fires occur across North America but are concentrated in areas that are prone to wildfire. Recent examples include the 2021 Marshall Fire in Colorado (1,091 structures), the 2016 Ft McMurray Fire in Alberta (3,244 structures destroyed), the 2016 Gatlinburg Fires in Tennessee (2,460 structures), the 2015 Bastrop County Complex in Texas (1,500

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structures), and so on (5). The upward trend of destructive wildfires has accelerated in recent years in California (6) and in other parts of the United States as fire danger and at-risk population continues to grow (7).

Wildland fires are one of the largest sources of pollutants to the atmosphere and, in some parts of the United States, can contribute as much as 50% of the fine particulate matter ( $PM_{2.5}$ ) during active fire years (8) and cause poor air quality in large parts of the United States for weeks at a time (9). The smoke from wildfires is composed of a diverse mixture of chemical species, including many hazardous air pollutants, like formaldehyde and polycyclic aromatic hydrocarbons (PAHs), which are known to cause cancer (10). This smoke has been linked to adverse health outcomes such as increased all-cause mortality and increased respiratory illnesses (11). Children, the elderly, and those with underlying conditions are particularly susceptible to the adverse effects associated with smoke exposure (11).

When fires occur in the WUI, a common question is if the smoke is any different from a “normal” wildfire burning only natural vegetation (i.e. biomass), and if more or different actions are needed to reduce exposure and protect vulnerable populations. The burning of structures and vehicles has differing and potentially more toxic emissions from those fires burning biomass, typical of wildfires on wildlands. Studies of occupational exposure of municipal firefighters have identified a range of acutely toxic and carcinogenic species such as isocyanates, volatile organic compounds (VOCs), and heavy metals from structure and vehicle fires (12–15). As such, firefighters use personal protective equipment and carry out decontamination procedures on their equipment to reduce exposure to these species (16). Because WUI fires will also emit these hazardous air pollutants, they may pose a unique threat to human health apart from normal wildfire smoke. Toxic metals have been observed at sites downwind of WUI fires, and increasing concentrations coincide with increasing numbers of structures destroyed in the fire (17). However, there remains minimal information about WUI fire emissions and their potential impact on first responders and public health (18).

The combination of more intense wildfires, longer fire seasons, and larger population in the WUI lead to an increased risk of catastrophic WUI fires. Because these fires occur near where people live, the emissions from burning of structures and vehicles may have an outsized impact on public health compared with wildfires that occur in more remote and less populated areas. The objective of this study was to develop an estimate of WUI fire emissions to identify the potential types and amounts of chemical species that may be emitted from these fires. We draw upon emissions data developed for structural fire environmental impact assessments and fire toxicity testing to provide an initial estimate of what may be emitted from WUI fires. We compare WUI fire emissions with other air pollution sources to provide some context for the importance of WUI fire emissions on public health. This information is a critical first step to guide future measurement efforts, to develop emissions inventories, and inform on the potential public health risks to WUI fires.

## Results

### Demographics of the WUI emission factor compilation

Of the 92 references identified that discussed emissions from structural, vehicular, furnishings, plastics, chemical, wiring, or other standard household materials, 28 references reported

emission factors (also referred to as yields) for a total of 346 test conditions covering a range of chemical species that were included in the urban fuel emission factor compilation (Table S1). Many of these observations were derived from studies done by the SP Swedish National Testing and Research Institute, now the Research Institutes of Sweden (RISE), to develop inputs for their Fire Life Cycle Analysis (LCA) tool (19). These studies ranged in scale and comprehensiveness of the materials investigated and the chemical species measured. The studies included in the compilation were carried out from 1993 (20) through 2020 (21) with the median study year of 2005. The average home age in 2022 is ~44 years (22). Additionally, the major structural components of a house may not change over its lifetime (23); therefore, older studies' burning structural components may still provide representative data for current homes. However, older furnishings burned in studies done in previous decades may not be representative of newer furnishings that may contain differing amounts of compounds like flame retardants. Additionally, consumer electronic products and vehicles have changed substantially over the past three decades and older studies with these materials may not be representative of what exists in a modern home (18). Finally, homes in the WUI may differ from the US-wide averages. For example, WUI homes may be newer, reflecting the growth of WUI areas in the past few decades, and may consist of more fire-resistant materials, reflecting building codes intended to reduce wildfire risk.

Given the limited amount of data to draw from, simplified fuel categories (Table S1) were developed to provide some insight into the different types of emissions from different materials in the urban environment. Most observations were from tests with structural or other household materials (house category: 242 observations, 70%), followed by vehicles or their components (vehicle category: 48 observations, 14%), bulk chemicals or plastics (chemical category: 29 observations, 8%), and electronic waste or cables (electronic category: 27 observations, 8%). Most of the house category consisted of furnishings or textiles found in the home (253 observations) with few studies investigating wood products (36 observations), which are estimated to contribute the bulk of the combustibles in the home (18). The vehicle category consisted mostly of car components—such as dashboards and seats (32 observations)—and tires (10 observations). These categories do not have distinct boundaries as many materials may be easily assigned to multiple categories, such as polyurethane foam, which can be found in seat cushions in vehicles or in mattresses in the home. Nonetheless, these categories are illustrative of the combustible materials that may exist in certain compartments of the urban environment.

We also categorized emissions by their scale: full scale being multicomponent mixtures combusted at their full size (e.g. full room or vehicle), large scale being multicomponent mixtures burned at less than their full size (e.g. portions of carpet and padding) or single component mixtures (e.g. tire pile), and small scale being small pieces of materials burned in controlled benchtop experiments (e.g. tube furnace or small cone calorimeter).

We identified only six observations of full-scale fires with furnishings in the home (24, 25) and nine full-scale vehicle fires (21, 26–28). The coverage of different species reported from these full-scale tests was variable. For example, Willestrand et al. (21) only reported inorganic gas phase emissions such as carbon dioxide ( $CO_2$ ), carbon monoxide (CO), hydrogen cyanide (HCN), hydrogen fluoride (HF), hydrogen chloride (HCl), total hydrocarbons (THC), and various size fractions of PM from burning electric vehicles, while Fiani (27) and Lonnermark and Blomqvist (26) reported a

wide range of inorganic gases, PM, metals, VOCs, PAHs, and dioxins from burning vehicles.

There were several large-scale experiments (20, 25, 27–36) resulting in 94 observations for a range of materials (electronics, appliances, furniture, and chemicals). Many of the observations (nearly 70%) were from small-scale experiments carried out in a tube furnace or cone calorimeter (26, 31, 37–48). Some of these small-scale experiments were done with a controlled atmosphere (i.e. controlled air composition) to represent different combustion phases that occur in enclosure fires where oxygen can become deficient as it is consumed in the fire.

Most of the emission factors reported were for the primary combustion emissions ( $\text{CO}_2$ , PM, and  $\text{NO}_x$ ) and particularly for the potent asphyxiants, CO and HCN, which are critical for estimating fire toxicity (49). Several studies (24–27, 31, 32, 34, 35) measured a wide range of hazardous pollutants including VOCs, PAHs, and polychlorinated dibenzodioxins and furans (PCDD/F). No study measured the full complement of hazardous air pollutants that may be important drivers of health risk, and lumping the studies into categories was needed to create a more complete set of emission factors as a first approximation of the emissions from WUI fires.

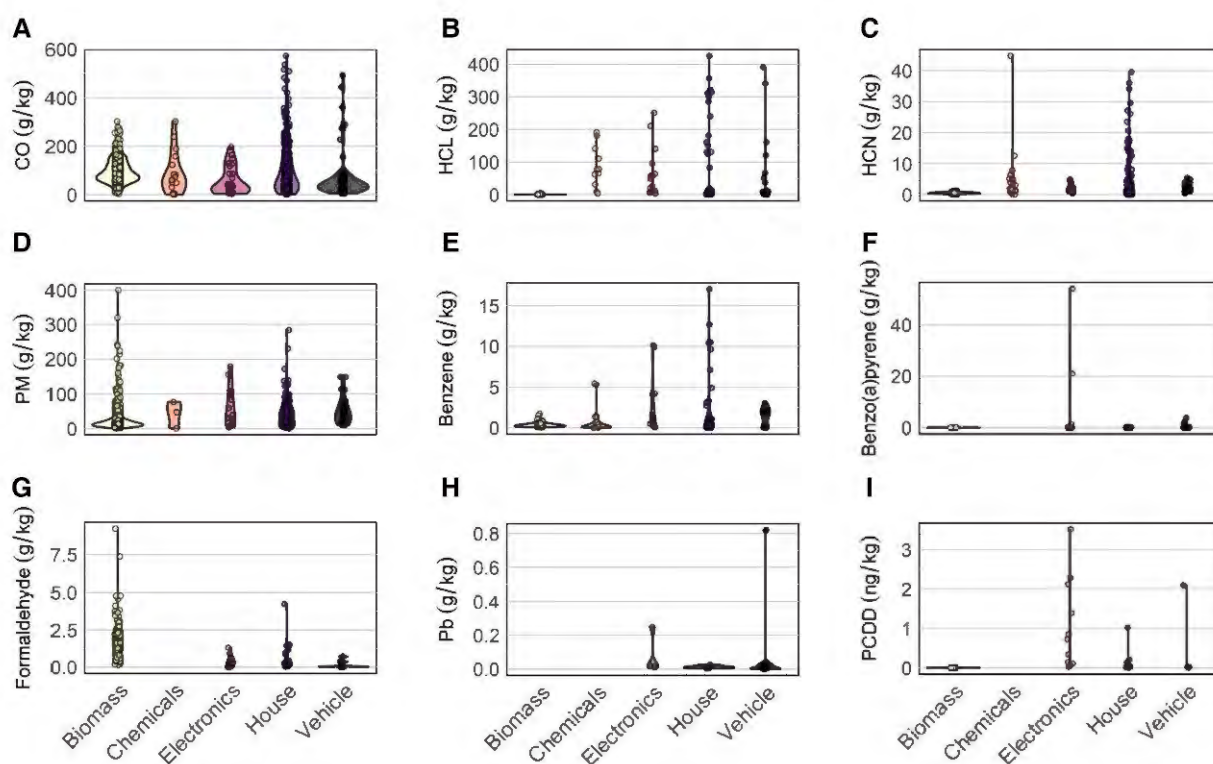
### Variation of emission factor by category

We compare emission factors across WUI categories with those used to estimate wildfire emissions (50, 51) for select species in Fig. 1. Violin plots are shown for species representing primary combustion emissions, criteria air pollutants, and hazardous metals that were selected with the greatest coverage across categories. Emission factors for all species for WUI categories are provided in Table S1.

There are some clear trends across the fuel categories by species type (Table S2). Species like  $\text{CO}_2$ , CO, and PM (including

$\text{PM}_{2.5}$  and inhalable particulate matter— $\text{PM}_{10}$ ) that are produced from all combustion systems are emitted at similar levels from all fuel categories. Some hydrocarbons and oxygenated hydrocarbons typical of biomass combustion (e.g. methane, formaldehyde, and acrolein) are emitted in greater amounts from biomass combustion compared with urban fuels. However, most species had larger emission factors for urban materials compared with biomass. Generally, the inorganic gases and VOC emission factors are one to three orders of magnitude greater from urban fuels compared with biomass. Emission factors for HCl and PAHs are three orders of magnitude and dioxins/furans are five and six orders of magnitude greater for urban fuels compared with biomass. Some of these large differences (i.e. dioxins/furans) are not only because of very large emission factors for urban fuels, but also because the emission factors are comparatively very low from biomass.

There are many gaps in the emissions data that make it difficult to compare for all species from all categories. Even for biomass burning that has been well studied in the past few decades (52), there is still minimal data on metal emissions from wildfires. Metal emissions may serve as a unique fingerprint for WUI fires (17) but are not included in the Smoke Emissions Reference Application (SERA) database from which our biomass burning emission factors were derived (51). Therefore, we estimated biomass metal emission factors by applying SPECIATE (US EPA's repository of speciation profiles) PM compositional profiles to PM emission factors to compare with median emission factors from structure and vehicle fuels (Fig. 2). These comparisons show Cu over 61,000% and Zn over 412,000% greater for vehicle emissions compared with biomass (Table S2), which correspond to the elevated Cu and Zn emissions observed from fires with greater numbers of structures involved in the analysis by Boaggio et al. (17). This provides further evidence that WUI fires may have a distinct metal signature from wildfires burning only biomass.



**Fig. 1.** Violin and strip plots of emission factors for select chemical species [A) CO; B) HCl; C) HCN; D) PM; E) benzene; F) benzo(a)pyrene; G) formaldehyde; H) Pb; and I) PCDD] for each of the major categories: biomass, chemicals, electronics, house, and vehicle.

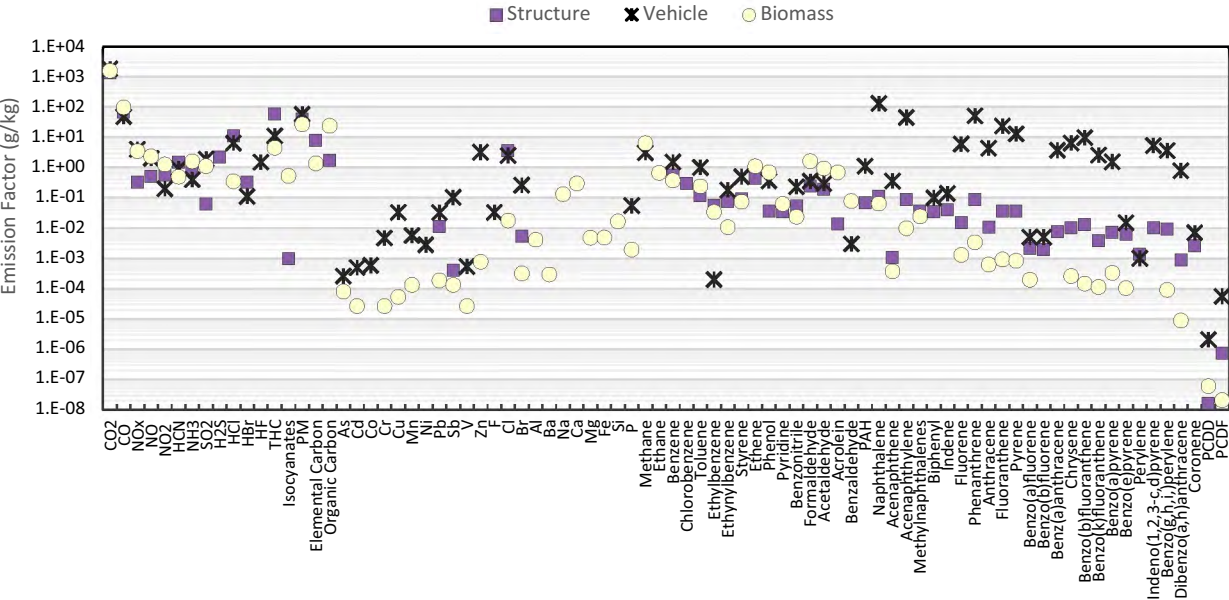


Fig. 2. Median structure and vehicle emission factors compared with mean biomass emission factors from the SERA database (data in Table S2).

Table 1. Case study destructive WUI fires in California occurring during 2020 and 2017.

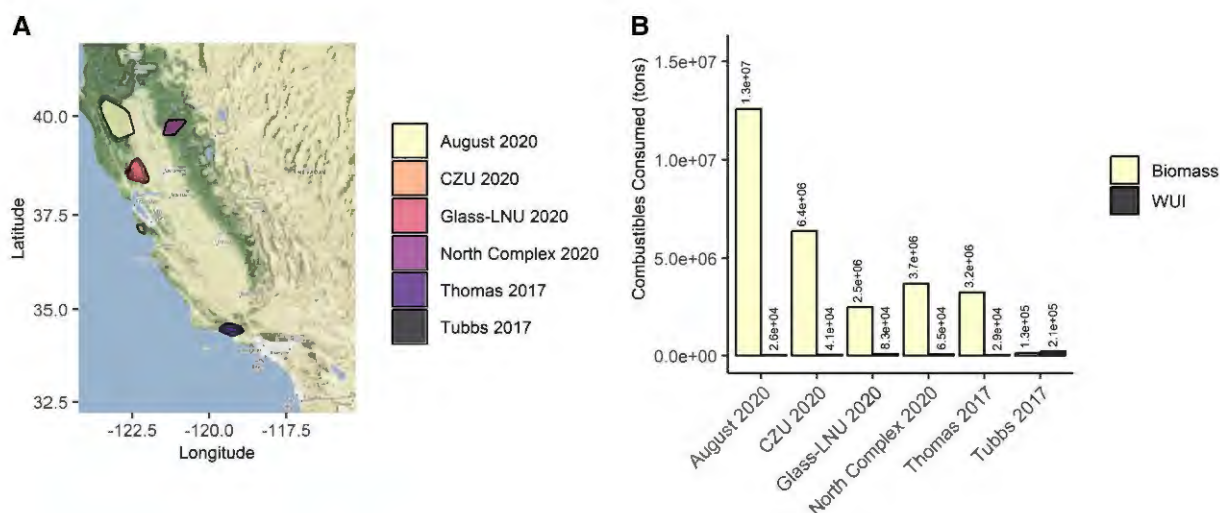
| Fire name                   | Air basin           | Cause           | Duration                          | Burned area (acres) | Structures destroyed | Vehicles destroyed <sup>a</sup> | Structures destroyed/area burned (building/mile <sup>2</sup> ) |
|-----------------------------|---------------------|-----------------|-----------------------------------|---------------------|----------------------|---------------------------------|----------------------------------------------------------------|
| Tubbs <sup>b</sup>          | SF Bay Area         | Power line      | 2017 October 8–2017 October 31    | 142,813             | 7,774                | 7,070 <sup>c</sup>              | 98.0                                                           |
| Thomas                      | South Central Coast | Power line      | 2017 December 4–2018 January 12   | 281,893             | 1,063                | 1,526                           | 2.4                                                            |
| North Complex               | Mountain            | Lightning       | 2020 August 17–2020 December 5    | 318,935             | 2,352                | 3,377                           | 4.7                                                            |
| Glass/LNU Lightning Complex | SF Bay Area         | Lightning/arson | 2020 September 27–2020 October 20 | 363,220             | 3,011                | 4,323                           | 2.6                                                            |
| CZU Lightning Complex       | North Central Coast | Lightning       | 2020 August 17–2020 October 2     | 86,509              | 1,490                | 2,139                           | 11.0                                                           |
| August Complex              | North Coast         | Lightning       | 2020 August 16–2020 November 12   | 1,032,648           | 935                  | 1,343                           | 0.6                                                            |

<sup>a</sup>Estimated from the vehicle to structure ratio destroyed in the 2018 Camp Fire, which was 1.44 as described in the Methods section.  
<sup>b</sup>Includes Nuns, Patrick, and Atlas Fires which occurred in the same air basin during the same time.  
<sup>c</sup>The Camp Fire vehicle to structure ratio was used for the Nuns, Patrick, and Atlas Fires and summed with that reported for the Tubbs. The California DMV estimated 4,000 vehicles destroyed in the Tubbs Fire in a 2018 blog post: <https://www.dmv.ca.gov/portal/news-and-media/dmv-identifies-thousands-of-vehicles-destroyed-in-northern-california-wildfires/>.

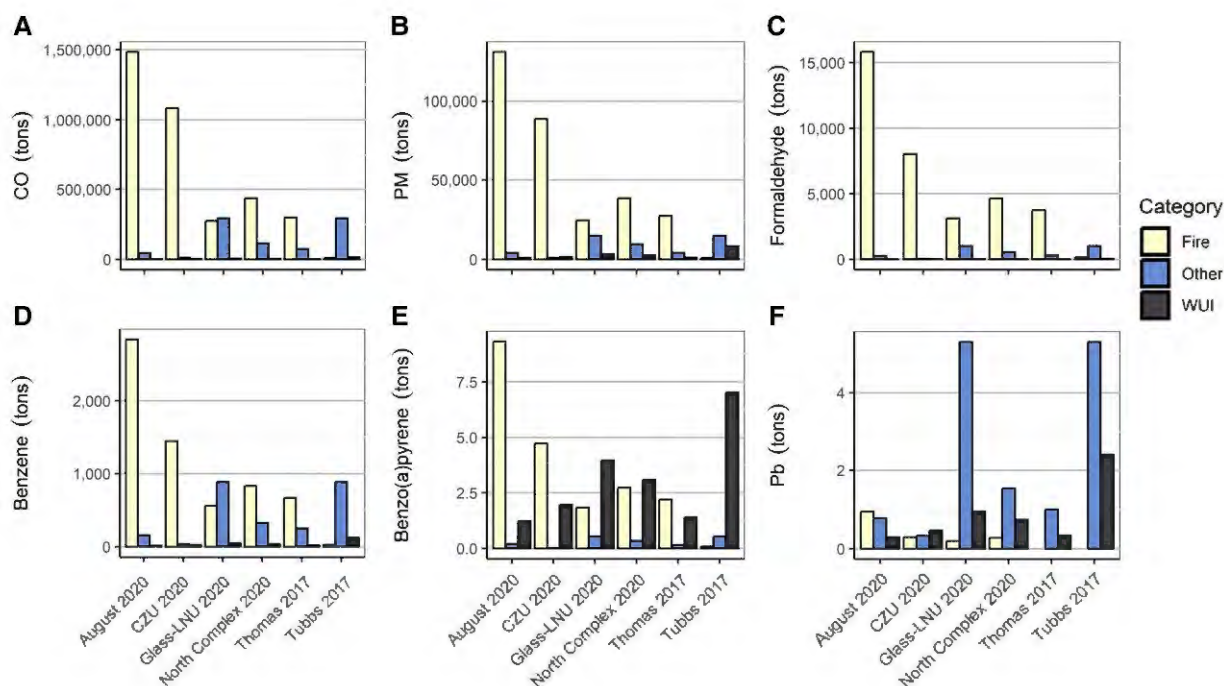
Estimated air pollutants emitted from WUI fires

We used several wildfires that burned in California in 2017 and 2020 to demonstrate a variety of WUI fires (Table 1). These wildfires span from those with very large burn area consuming primarily biomass fuels (August 2020 Fire) to relatively small wildfires with a small burn area, but large numbers of structures and vehicles destroyed (Tubbs 2017 Fire). The locations and the extent of the wildfires are shown on the map in Fig. 3. We compared the emissions from each wildfire with other air pollution sources in the same air basin to provide a frame of reference for the quantity of emissions that population is routinely exposed to. These emissions were derived from the most recent release of the National Emissions Inventory (NEI), 2017 (53), and include

the annual emissions for all nonfire sources for counties in the air basin. Emissions were categorized as “Fire” for emissions from burning wildland biomass in each wildfire (derived from NEI estimates), “WUI” for emissions from burning vehicles and structures (calculations described in the Methods section), and “Other” for emissions from all other sources in the air basin (derived from NEI estimates). Other sources included point sources like industrial facilities, area sources like oil and gas operation, and mobile sources from on-road and off-road operations and represent their emissions over the entire year. For some air basins, the Other category is sizeable due to densely populated areas and many anthropogenic activities. The wildfires analyzed here impacted a range of air basins, with the



**Fig. 3.** Location and combustibles consumed for destructive WUI fires in California during 2017 and 2020 used in this analysis. A) Final spatial extent for each wildfire. B) Consumed combustibles for each fuel type, for each fire, as described in Table S3.



**Fig. 4.** Emissions estimates in tons for criteria pollutants and select hazardous air pollutants (A) CO; B) PM; C) formaldehyde; D) benzene; E) benzo(a)pyrene; and F) Pb for Fire, Other, and WUI categories for each case study fire.

most densely populated being the San Francisco air basin, which was impacted by the Tubbs 2017 and Glass-LNU 2020 Fires. Conversely, the CZU Complex Fire impacted the mostly rural/agricultural areas in North Coastal air basin that has much lower Other emissions compared with the other air basins in California. Another key point is the difference in temporal distribution of these emissions, where Other emissions are for the entire year, the Fire emissions are spread out over the several weeks of the wildfire, and the WUI emissions are occurring over just a few days. By not distinguishing across these time frames, our comparison may obscure the importance of differing acute exposures for emissions distributed over days, weeks, or a year.

### Primary combustion emissions

Figure 4 compares the total emissions by category for select species for each wildfire (all species are listed in Table S3). The WUI emissions are minimal compared with the Fire and Other sources for most criteria air pollutants (i.e. PM, CO, NO<sub>x</sub>, and SO<sub>x</sub>) and primary combustion species (i.e. CO<sub>2</sub>, CH<sub>4</sub>, and other hydrocarbons). These results suggest that the regulatory air pollution monitoring network would not be able to detect any difference in emissions from a WUI fire when compared with other sources or wildfires. Not surprisingly, the Fire emissions are generally larger than Other emissions for these primary combustion pollutants for all

wildfires, except for the two that impacted the San Francisco Bay Area air basin, where there are substantial emissions over the year from anthropogenic activity.

For most of the wildfires evaluated here, the WUI emissions for oxygenated hydrocarbon species are much lower than the Fire emissions of those species. This is not surprising, since oxygenated hydrocarbons such as formaldehyde, acetaldehyde, and acrolein are emitted from biomass burning in large amounts. The one exception to this trend is for the Tubbs wildfire, which has comparatively low acreage burned (<150,000 acres), but many structures destroyed (>7,700). For the Tubbs wildfire, the WUI emissions are either greater or similar to the Fire emissions, but typically less than Other emissions in the densely populated San Francisco Bay Area air basin.

## Hazardous air pollutant emissions

The hazardous air pollutants like PAH, toxic metals, and chlorinated hydrocarbons exhibit different trends from the criteria pollutants and hydrocarbon pollutants. Fire and WUI categories both have high PAH emissions of similar magnitude. Only the August Fire and CZU Fires, with their low destroyed structure to area burned ratios (Table 1), routinely had larger Fire PAH emissions compared with WUI PAH emissions. Again, the Tubbs Fire is notable in this comparison with 78 times higher benzo(a)pyrene emissions compared with Fire emissions and 13 times Other emissions in the San Francisco Bay Area air basin (estimated for 2017). Lead (Pb) (Fig. 4F) was the only metal for which data were available from all three categories, but not from all wildfires. Pb emissions were two to three times Other and Fire emissions for all wildfires. There were limited data for all other hazardous air pollutants,

prohibiting comparison across the three main categories (Fire, Other, and WUI).

A more comprehensive view across many species can be made with a heat map of the ratio of WUI to Fire categories (Fig. 5A) and WUI to Other categories (Fig. 5B). Different species are shown in each figure since not all categories have all species. The heat map presentation also makes it readily apparent that the Tubbs Fire is the only wildfire in our case study where the WUI emissions dominate the Fire emissions for all species but the oxygenated hydrocarbons and primary combustion emissions. One interesting feature is the high ratios for phenanthrene differing from the other PAH. This is likely due to the vehicle emission factors, which were much higher than the other fuel categories. These emission factors were for full-scale burns where combustion involved the entire vehicle and may be more representative of emissions in a WUI fire. However, there are too few emission factor observations for the other categories for this difference to be conclusive.

The ratio of the WUI to the Other heat map also shows some distinctive patterns, with all the PAH ratios well above 1. Chlorobenzene, Cl, Sb, and HCl also have ratios much larger than 1. This is the first evidence that WUI fires may be the largest emission source for some of these species into an air basin. Some of these air pollutants may be important drivers of health risk and in current emissions inventories they are not estimated.

## Discussion

Emissions inventories play an important role in identifying the major sources of air pollution and the drivers of health risk. This information can be used to guide policy decisions made to reduce

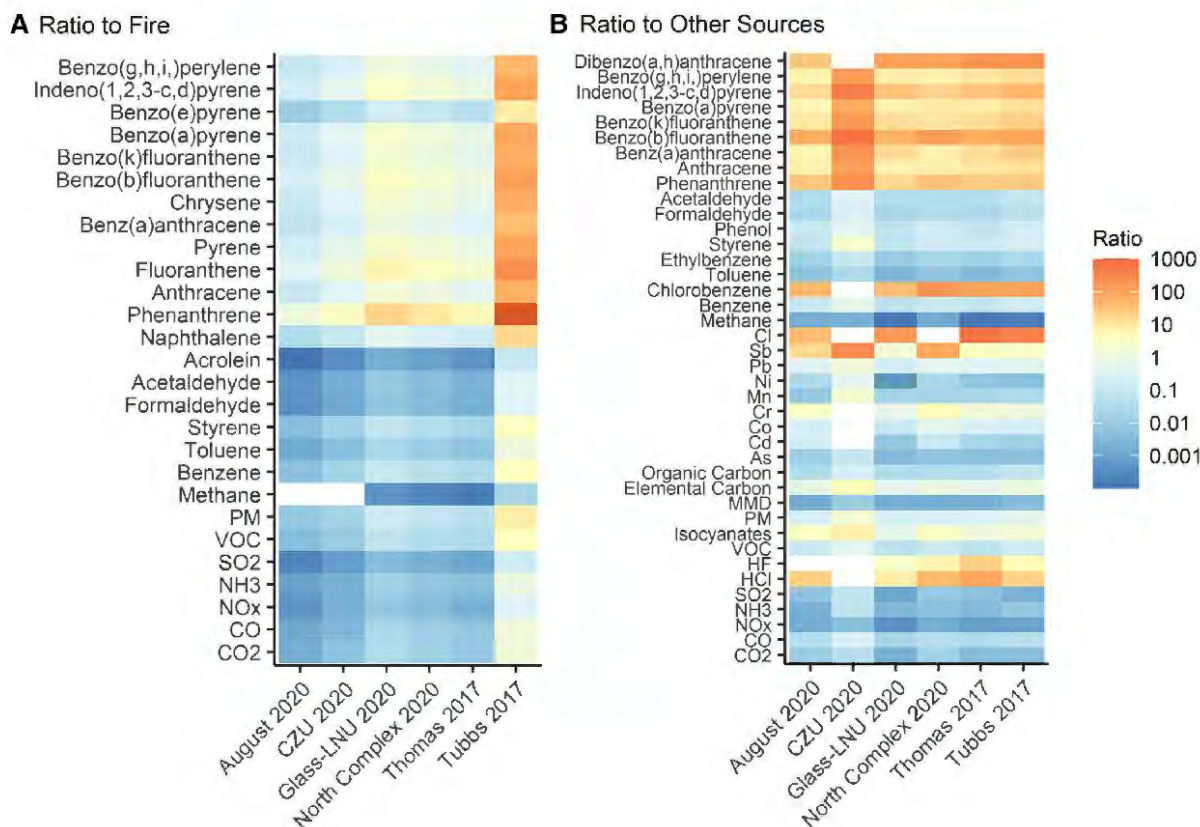


Fig. 5. Heat map of the ratio of emissions between categories. A) WUI emissions to Fire emissions. B) WUI emissions to Other emissions for each wildfire.

the public health risk to hazardous air pollution, including decisions on future research efforts, air quality monitoring infrastructure, public health outreach, and mitigation measures. Until now, structural fire emissions have not been inventoried in the United States and thus were not included in assessments of the impacts of air pollution on human health. We demonstrate that WUI fires may be a sizeable source of certain hazardous air pollutants, but not necessarily contribute to increased criteria air pollutants or greenhouse gases that are routinely monitored. Moreover, in some locations and some years, WUI fires may constitute the single largest source of these pollutants and may be an important driver of risk.

Although there is likely very large uncertainty in the inventory developed here, there is no unambiguous method to validate a WUI fire emissions inventory. Such an evaluation would require measurements of before and after fire fuel loadings, assessment of combustion conditions during the fire, in addition to near-fire emissions measurements. This type of data set does not currently exist. Furthermore, ambient monitoring data are not suitable for comparison because dispersion, atmospheric chemistry, and the impact of other sources need to be factored in, all of which introduce large uncertainties. We ensure our inventory has the highest data quality by following recognized good practices for developing a bottom-up inventory that is transparent, complete, and accurate given the available information (54, 55). Although we have attempted to generate an inventory with the best available information to achieve the greatest accuracy, there are many data gaps that result in large uncertainty of the estimates presented here. Our study improved upon existing methodologies by applying assumptions appropriate for WUI fires, but the data sources for calculating the inventory need further improvement to better estimate average emissions and uncertainty estimates.

We examined each input into the inventory to identify where improvements are needed. A large source of uncertainty in the WUI fire emissions inventory is the amount, composition, and condition of the fuel. Similar to wildfire emissions inventories, the data inputs on the fuel can be the largest source of uncertainty in the emissions estimate (56). Statistics on new home construction (57) and home energy usage (58, 59) can provide some information and the major materials that are used in structures (e.g. roofing and siding), but not information on insulation or indoor surface finishes, plumbing fixtures, or wiring. Moreover, these sources do not provide detailed information on the chemical composition of the materials in the structure. There is no standardized source of information on commercial buildings, which may also be consumed in a WUI fire. Information on the contents in the home are derived from fuel loading surveys, the majority of which focus on fire risk and only quantify the combustibles inside the structure, while it is clear from the metal emission factor data that noncombustible materials are being transformed in the combustion process and emitted into the air. Much more detailed information on the composition of all the materials in the structure and contents are needed to estimate emissions for environmental health risk.

Even with detailed knowledge of the amount and chemical composition of the structure, vehicle, and their contents, there are many unknowns related to the combustion conditions, potential chemical interactions, and resulting emissions. One critical unknown is the amount of WUI fuel that is consumed in the fire. Current fire statistics only report if a structure is destroyed or damaged, but there is no linkage to how much of the original structure remains in each of these categories. We assumed 80% of the combustibles are consumed when a structure is destroyed

and did not include damaged structures. This may be a conservative estimate since many postfire images show complete destruction, but these images may show a biased subset of homes. More information is needed on how much of the destroyed or damaged structure or vehicle remains after the fire to provide a better estimate of fuel consumption and how that may vary between fire scenarios.

The sizeable literature on fire safety engineering and fire toxicity has highlighted the importance of the chemical composition of the fuel, the oxygen available for combustion, and the temperature in controlling the amount and composition of emissions (49). Standardized methods have been developed to study the emissions of materials combusted in a range of conditions that are typical for enclosure fires occurring within a structure (49). However, there is currently no information on the combustion conditions in WUI fires and what fraction of the fuel may burn at high temperature under- or overventilated or in low-temperature smoldering processes. This uncertainty also exists in the wildfire emissions inventory where common practice is to assume that a fraction of the fuel burns in flaming conditions versus smoldering conditions (60, 61). The flaming-smoldering fraction is modeled depending upon the fuel characteristics and environment conditions (62).

Drawing upon our understanding of pollutant formation in waste incineration and open waste burning, we know that fuel chemistry, temperature, and residence time all interact and greatly impact emission rates of some species (63–65). Much of the emissions data relied on for this inventory are derived from the combustion of individual materials and often in the absence of the inorganic support structures or surfaces that may exist in homes. Additionally, the few studies carried out at full scale likely have combustion conditions that differ than those in WUI fires that often occur during extreme winds (66).

The emissions estimates compiled here are a reasonable first approximation despite the large number of unknowns. These results suggest that some hazardous air pollutants, but not criteria air pollutants, may be emitted from WUI fires in much larger amounts than wildfires in wildlands or other anthropogenic sources. However, this estimate may greatly differ than what is truly emitted, and additional research is needed to develop and refine data inputs to the emissions model and this needs to be verified with measurements of concentrations near WUI fires to constrain and improve this emissions estimation method. Current monitoring networks focus on criteria pollutants and have measurements of detailed chemical composition with minimal spatial and temporal resolution (18). Supplemental measures of detailed chemical composition of ambient concentrations near WUI fires, in addition to information on urban fuels and combustion conditions, are greatly needed to improve the emissions estimates developed in this study.

## Methods

### Emission factor compilation

We compiled emission factors from a comprehensive literature search of simulations of fires of structures, vehicles, and their components (Table S1). Web of Science and Google Scholar were used to identify peer-reviewed and other data sources reporting emissions from the burning of urban materials. Key words included combinations of “fire,” “smoke,” “toxicity,” “municipal,” “structure,” “vehicle,” “car,” “furnishings,” and a variety of individual materials (e.g. “wood,” “plastic,” “fabric,” and “textile”). Each

**Table 2.** Comparison of assumptions for emissions estimates from structure fires across estimation methods.

|                                          | CARB 1999                                      | SP 2009                                                                    | BC 2000                                                                         | WUI Fire 2022                      |
|------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------|
| Reference                                | California Air Resources Board, Lozo 1999 (67) | SP Technical Research institute of Sweden, Blomqvist and McNamee 2009 (68) | British Columbia Ministry of Water, Land, and Air Protection, Wakelin 2000 (69) | This study                         |
| Combustible structure                    | 1,649 ft <sup>2</sup><br>11 tons               |                                                                            |                                                                                 | 2,150 ft <sup>2</sup><br>33.4 tons |
| Combustible content                      | 7.9 lb/ft <sup>2</sup>                         | 3.69 lb/ft <sup>2</sup>                                                    |                                                                                 | 5.87 lb/ft <sup>2</sup>            |
| Fraction consumed                        | 7%                                             | 5% room of origin<br>35% several rooms<br>80% multiple structures          |                                                                                 | 80%                                |
| Loading factor—mass burned per structure | 1.23 tons/fire                                 |                                                                            | 1.04 tons/fire <sup>a</sup>                                                     | 39.72 tons/fire                    |

<sup>a</sup>Total combustible fuel consumed per fire incident, assumed one incident equivalent to one structure.

source was reviewed for relevance to a WUI fire; specifically, we determined if the fuel was representative of a human-made (e.g. vehicle) or human-processed natural material (e.g. wood decking) and if the combustion conditions were a suitable simulation of open burning. Lab-scale studies focusing on waste incineration or those using devices such as a fluidized bed reactor, which may have high temperatures and/or pressures, well-mixed fuel and oxidizer, or mechanically processed fuel (e.g. pulverized), were deemed to be not representative of open burning conditions that may occur in a WUI fire and were excluded from the data set. The list of relevant sources was further expanded by reviewing sources citing the initial list of sources. Sources providing only concentration data were excluded from the data set since they could not be used to generate emission factors. Sources reporting duplicate information were identified and the source with the most comprehensive data reported was included in the data set. Only full-scale data were retained for experiments using the identical fuels at multiple scales (e.g. the TOXFIRE experiment (33)).

Emission factor or yield data from each study were consolidated in an Excel spreadsheet and categorized by the scale of the experiment: full scale (involving multiple items at full size) or other (e.g. lab scale, bench scale, and microscale); type of material: house or vehicle; material subtype: furnishing, component, or tire; and combustion conditions: flaming, overventilated or smoldering, underventilated. Emissions were reported as factors (e.g. g emitted species/kg load) or yields (e.g. g emitted species/kg combustible load) from combustion of structural or vehicular components. In the absence of information on combustibles per fuel charge, it was assumed that the entire fuel charge was made of combustible material. Units were converted for all species to grams per kilogram. An initial review of the compilation was made for each species by category. Outliers were investigated and sources with consistently higher emission factors were removed. Removal of these sources reduced the number of species reported, but they were limited to small-scale experiments.

A summary emission factor data set was developed for use in emissions inventory development by taking the median of all observations for any house materials, regardless of scale or combustion conditions. For the vehicle category, the median of the full-scale experiments was used since there were more comprehensive emissions available for those experiments. In the case that emissions data from full-scale vehicle experiments were not available, the median emission factor from the entire data set for any vehicle material was used. Species where this gap-filling approach was used are highlighted in red text in Table S2.

Biomass burning emission factors for comparison with the WUI emission factors were derived from the online SERA database (51). The complete SERA database for all vegetation types and experimental approaches was filtered to remove emission factors associated with slash fires and outliers and downloaded on 2022 December 1.

## Emissions inventory methodology

Several methods for estimating emissions from structures and vehicles have been published in the context of municipal fires (67–70). All methods use the same basic emissions inventory development approach of:

$$E_x = A \times B \times F \times EF_x \quad (1)$$

where  $E_x$  is the mass of emissions of species  $x$ ,  $A$  is the activity (e.g. number of houses or vehicles consumed by fire),  $B$  is the combustible mass of fuel,  $F$  is the fraction of the fuel consumed, and  $EF_x$  is the emission factor for species  $x$ . Major differences among methods exist in the assumptions used to estimate the combustible fuel loading for the structure (or vehicle), the fraction of fuel consumed in the fire, the emission factor, and the chemical species. We have translated these methods for the WUI fire context by modifying key assumptions of fuel load and consumption (Table 2) and updating and expanding emission factors.

Emissions estimates from municipal fires assume a small percentage (e.g. ~7% in CARB 1999 (67)) of the structure is consumed and that most of the fuels are from the room of origin. Images of neighborhoods after a wildfire has passed through show many houses are reduced to only the noncombustible components, such as masonry. Therefore, we assumed a greater percentage of the combustible loading would be consumed in a WUI fire. We used 80% as an initial estimate following a survey of fire investigators in Sweden estimating ~80% loss when the fire spreads to multiple structures (68). This may be an underestimate for a WUI fire in the United States where most of the homes are wood construction (18), which is relatively uncommon in Sweden (68). Since most of the combustibles are consumed in WUI fires, we also inventoried the entire home as opposed to just the rooms where most municipal fires begin (kitchen and bedroom) to include in the combustible load.

The structural combustible load is estimated from data for a typical North American house built in 1998 compiled by the National Academies (18) and detailed in Table S4. The house contents are estimated from the median of fire load density measurements in North American residences of 600 MJ/m<sup>2</sup> reported in Xie

et al. (71). Fire load density is converted to combustible mass using the material distribution from SP 2009 method (68) and the material energy content from Elhami-Khorasani et al. (72) (detailed in Table S5A and B). The vehicle composition was similarly calculated for a typical sedan model year of 2017 (detailed in Table S6) of 93 lb of tires and 810 lb of combustible material (18, 73).

The CARB 1999 and BC 2000 emissions estimates are based on a set of default emission factors that are applied per ton of combustible mass burned. The SP 2009 emissions estimate breaks down the combustibles by type (e.g. wood, paper, textiles, rubber, and plastics) and uses material-specific emission factors (68). There is a paucity of emissions data available for each combustible type and only a few have complete data for a wide range of hazardous pollutants. There was insufficient data to adequately capture the impact of the variation within a type (e.g. textiles may be cotton, wool, or acrylic), so emission factors were lumped into the two general categories for house and vehicles as described above. These emissions measurements spanned all combustion conditions: pyrolysis, smoldering, and flaming; in the absence of information on typical structural/vehicle combustion conditions in a wildfire, the median was taken for all observations.

## WUI fire case studies

We identified WUI fires within California with corresponding EPA NEI data to obtain estimates of burned area and emissions from each wildfire and comparison data from other source sectors (e.g. industrial emissions). The NEI calculates fire emissions using the BlueSky Framework, which models the fuel loading, fraction consumed, and applies vegetation-specific emission factors for each fire (74). The NEI is produced every 3 years with 2020 the most recent release (74). While other wildfire emissions inventories exist with greater temporal coverage, they do not include emissions from other emissions sources and may not include emissions for a wide range of hazardous air pollutants. Eight of the current Top 20 Most Destructive California Wildfires (compiled by Cal Fire as of 2022) occurred during 2020 and 2017 (75). These fires provide a range burned acreage and structures destroyed and were used in this analysis to illustrate the scale of WUI fire emissions in comparison with other emissions sources. The ratio of structure destroyed to burned area ranges from 0.6 to 98 (building/mile<sup>2</sup>) and encompasses that observed in the Camp Fire (78.5 building/mile<sup>2</sup>), which is the most destructive fire in California, but could not be included in the analysis because of the lack of an NEI emissions estimate for the wildland biomass fuels.

California provides records of the number of structures destroyed but does not report the number of vehicles destroyed in each fire. The California Department of Resources Recycling and Recovery estimated 27,000 destroyed vehicles were recovered from the cleanup operation after the Camp Fire, which results in an estimated 1.44 vehicles per structure destroyed in the fire. This ratio is applied to all other fires to provide an estimate of the vehicles consumed in each of the wildfires. However, the actual number of vehicles destroyed may vary widely between fires depending upon the time allowed for evacuation, since vehicles may be moved from the area threatened by the fire.

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## Supplementary material

Supplementary material is available at PNAS Nexus online.

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## Author contributions

A.L.H. conceived the study. A.L.H., A.A., J.M.V., and V.R. collected the data. A.L.H. and A.A. analyzed the data. A.L.H. wrote the draft manuscript. All authors contributed to the final manuscript.

## Data availability

All data used to generate the figures and tables in this manuscript may be found in the [supplementary material](#).

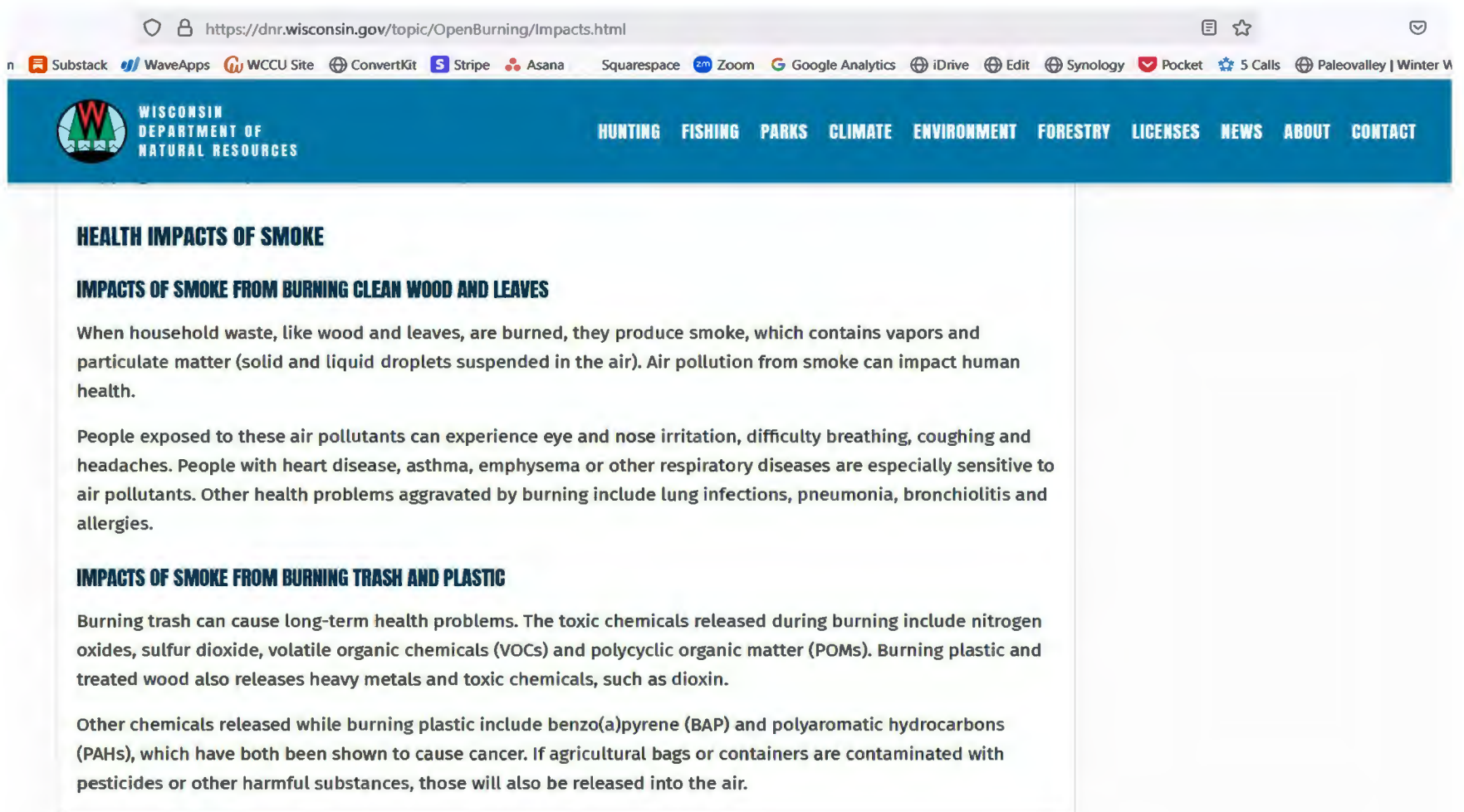
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Resource 3: <https://dnr.wisconsin.gov/topic/OpenBurning/Impacts.html>



The screenshot shows a web browser displaying the URL <https://dnr.wisconsin.gov/topic/OpenBurning/Impacts.html>. The browser's address bar and tabs are visible at the top. The website's header features the Wisconsin Department of Natural Resources logo on the left and a navigation menu with links: HUNTING, FISHING, PARKS, CLIMATE, ENVIRONMENT, FORESTRY, LICENSES, NEWS, ABOUT, and CONTACT. The main content area is titled "HEALTH IMPACTS OF SMOKE" and includes two sub-sections: "IMPACTS OF SMOKE FROM BURNING CLEAN WOOD AND LEAVES" and "IMPACTS OF SMOKE FROM BURNING TRASH AND PLASTIC".

## HEALTH IMPACTS OF SMOKE

### IMPACTS OF SMOKE FROM BURNING CLEAN WOOD AND LEAVES

When household waste, like wood and leaves, are burned, they produce smoke, which contains vapors and particulate matter (solid and liquid droplets suspended in the air). Air pollution from smoke can impact human health.

People exposed to these air pollutants can experience eye and nose irritation, difficulty breathing, coughing and headaches. People with heart disease, asthma, emphysema or other respiratory diseases are especially sensitive to air pollutants. Other health problems aggravated by burning include lung infections, pneumonia, bronchiolitis and allergies.

### IMPACTS OF SMOKE FROM BURNING TRASH AND PLASTIC

Burning trash can cause long-term health problems. The toxic chemicals released during burning include nitrogen oxides, sulfur dioxide, volatile organic chemicals (VOCs) and polycyclic organic matter (POMs). Burning plastic and treated wood also releases heavy metals and toxic chemicals, such as dioxin.

Other chemicals released while burning plastic include benzo(a)pyrene (BAP) and polyaromatic hydrocarbons (PAHs), which have both been shown to cause cancer. If agricultural bags or containers are contaminated with pesticides or other harmful substances, those will also be released into the air.





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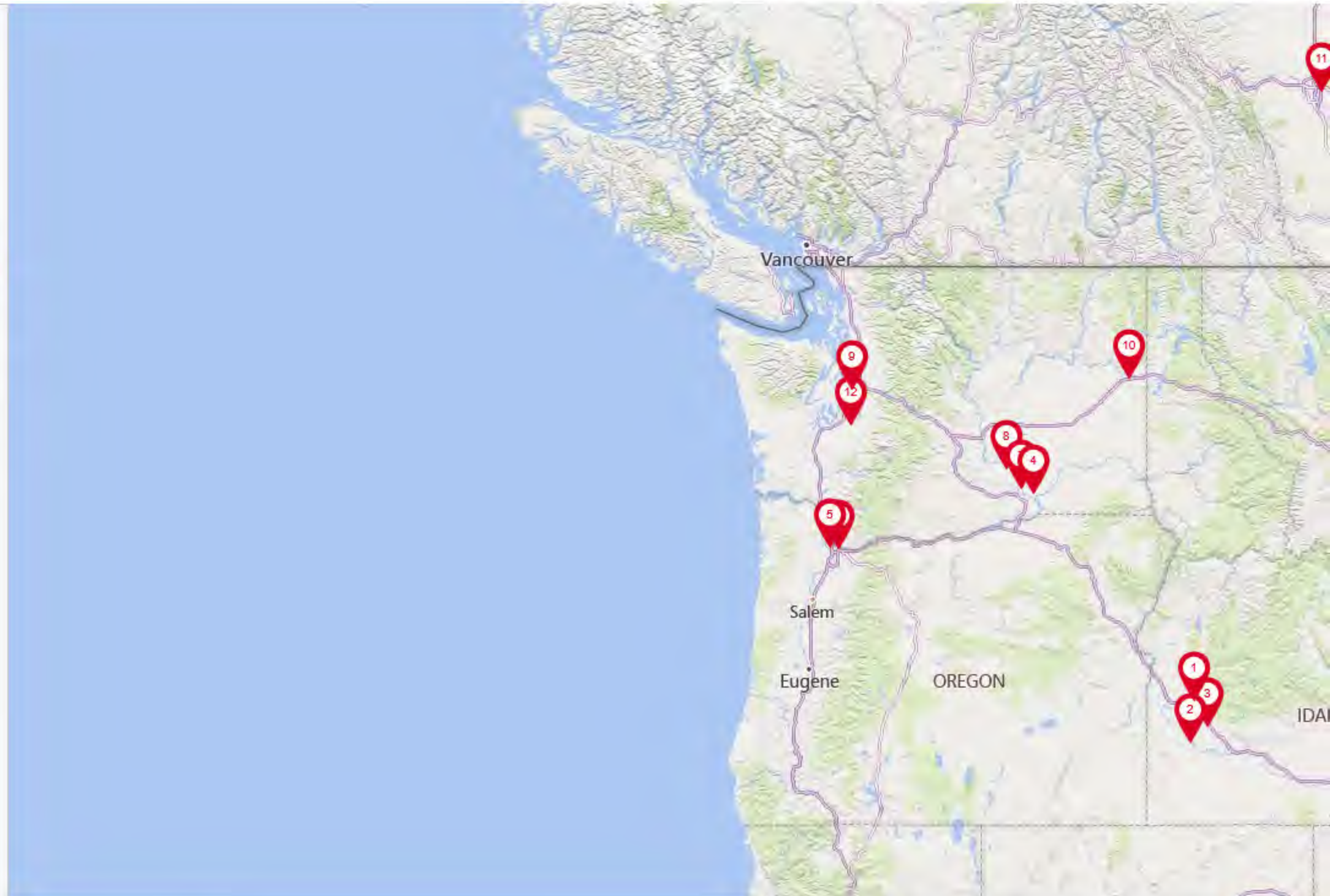
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## Fact Sheet

# Protect Surface Waters While Cleaning Up Your Property After a Wildfire

This fact sheet provides homeowners with guidance for protecting water quality during wildfire cleanup by using stormwater management techniques. Ash and debris generated from wildfires can be harmful to our rivers and streams. When rainwater carries sediment and debris from burned areas it also transports pollutants to our surface waters. Many of these pollutants can be toxic to humans and aquatic life.

## Cleaning up the ash

When cleaning up ash, be sure to use the appropriate safety measures. Visit the Oregon Department of Environmental Quality's [How to Safely Clean Up Ash and Debris From Burned Buildings page](#) for more information about safely cleaning up ash and debris. Never hose ash into streets or storm drains. Instead, direct wash water to vegetated areas or other areas of your yard where the lawn or plants help filter the ash out of the water as it soaks into the ground. Clean out accumulated debris in storm drains and stormwater conveyance ditches on your property to prevent flooding.

## Stabilizing your site

**Control the perimeter:** Place straw wattles, long tubes of straw often available at local hardware stores, around burned structures or vehicles to contain debris and filter runoff. Wattles can also be placed at the top of streambanks or around storm drains on your property. If you don't have access to wattles, you can use fallen branches, small berms like the photo to the right, or [check dams](#) to contain debris.

**Preserve existing vegetation:** Preserving the existing vegetation on a burned site is typically the best preventative measure for erosion and the least expensive. Vegetation prevents soil from eroding and carrying ash and debris with it. When possible, leave vegetation in place and prevent equipment from driving over it.

**Stabilize entry and exit points:** Protect areas where vehicles and heavy equipment travel into and off of the property. Use paved access points if they are available, or place gravel on entry and exit points.



Compost berm to stabilize site.

### Translation or other formats

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**Install soil stabilization measures:** For larger areas of exposed soil, apply a layer of weed-free straw. The straw will reduce the impact of raindrops on soil particles and will prevent erosion. For hillsides and slopes, erosion fabric and wattles are effective for preventing transport of sediment.

**Vegetate for long-term stabilization:** Reseed areas where it is appropriate, and plant larger shrubs and trees for additional soil stabilization from plant roots.

**Manage household hazardous waste:** Burned structures can leave behind contaminants. Visit DEQ's [How to Safely Clean Up Ash and Debris From Burned Buildings page](#) for more information about how to manage household hazardous waste in ash and fire debris.



Gravelled site entrance.

## For more information

There are partners and resources available assist homeowners after wildfire. The following partners, programs and resources may be especially relevant:

- [DEQ's basin coordinators](#) for questions on water quality impacts.
- Oregon Department of Forestry - [Help after a wildfire](#).
- [County soil and water conservation districts](#), [Oregon State University Extension Service](#) and [local watershed councils](#) can often provide technical assistance and link landowners with funding resources.
- Oregon Department of Emergency Management – [Wildfire Response and Recovery website](#).

## Non-discrimination statement

DEQ does not discriminate on the basis of race, color, national origin, disability, age, sex, religion, sexual orientation, gender identity, or marital status in the administration of its programs and activities. Visit DEQ's [Civil Rights and Environmental Justice page](#).



To: [landfillappeals@bentoncountyor.gov](mailto:landfillappeals@bentoncountyor.gov)

Subject: Oppose/Deny LU-24-027 – **Disaster Debris Impacts**

Dear Benton County Commissioners Wyse, Malone and Shepherd,

Submitted by:

Carol McClelland Fields – 37326 Soap Creek Road

PhD in Industrial/Organizational Psychology.

Co-Chair of Soap Creek Prepared (since 2022) and Soap Creek Valley Firewise (since 2023)

Author of five published books

10-year resident living less than 5 miles from Coffin Butte Landfill, which was less than 1/2 the size it is now when we moved here.

I have smelled the landfill stench INSIDE my house several times in 2025

Health challenges exacerbated by landfill toxins and PFAS

Avid observer of nature and impacts on the environment

I am writing because we strongly oppose any expansion of the Coffin Butte landfill and urge you to **uphold your Planning Commission's unanimous denial of LU-24-027**, Republic Services' application to expand the Coffin Butte Landfill. The Planning Commission carefully considered all evidence provided by the applicant, as well as considerable testimony, and concluded unanimously that the application did not meet the required Burden of Proof.

### **SHORT SUMMARY**

On March 31, 2025, 60 Minutes (CBS) aired: **California wildfires left behind 9 billion pounds of toxic ash and debris** after the devastating wildfires that ravaged cities in Los Angeles, California in January 2025. Watch here:

<https://www.youtube.com/watch?v=iYFksPCL-l8>

Here's what happens after a wildfire:

- **First Priority: Remove hazardous waste, electric car batteries, power wall chargers, or any other batteries.** These materials cannot be recycled; they must go to *hazardous material landfills*. Even after a fire is out, lithium batteries can explode or reignite because they are unstable. Teams must dismantle and neutralize hazardous materials before moving them.
  - Republic Services has stated that **Coffin Butte Landfill takes hazardous disaster debris from wildfires.**

- Republic Services' own Environmental Services Map **does NOT list Coffin Butte Landfill as an Environmental Services Facility.**
- **Second Priority: Remove all toxic ash, debris, and the top six inches of contaminated soil and transport it to dry-climate landfills.** In LA, this amounted to 9 Billion (yes, *that's a B*) pounds of toxic ash and debris were removed and taken to 17 landfills and recycling centers in various *dry-climate landfills* throughout the southwest.
  - **Given our wet climate**, adding more hazardous disaster debris into the Coffin Butte Landfill Expansion will **generate even MORE toxic, PFAS-laced leachate than the current landfill.**
  - **Given that the detrimental impacts of PFAS chemicals are cumulative**, this means human bodies, wildlife, and the environment will **carry increasing levels of PFAS in their systems.**
- **Third Question: Homes that Didn't Burn.** 10,000 homes didn't burn to the ground during the LA Wildfires, but indoor air quality within these homes remains incredibly toxic. Because home-owners haven't suffered a "physical loss," insurance co. may not cover clean-up or losses.

**If a large fire originates on Coffin Butte Landfill Expansion or is sparked by flying embers from a nearby fire:**

- **The toxic nature of a burning landfill** (smoke, ash, soot, particulate matter, gases, and chemicals), **would negatively impact the entire region – where the fire burned and downwind of the fire. (Think about how far we were from the 2020 fires that turned out skies red for weeks.)**
- **Even if your home survives the fire, the ash, chemicals, and soot** penetrating the buildings through cracks around windows and doors **make your home unlivable.** Furthermore, ***it is toxic and dangerous to continue to live in the region.*** A 2023 EPA study found that emission factors for some toxic compounds were more than 1,000 times **higher in urban wildfires than in fires that burned in woodland areas.** Ensuing health challenges range from: headaches, dizziness, and cognitive trouble to reproductive, kidney, respiratory problems, cardiovascular problems, and cancer.

The proposed use **seriously interferes with** uses on adjacent property, with the character of the area, or with the purpose of the zone [Benton County Code 53.215 (1)]

The proposed use **imposes an undue burden on** any public improvements, facilities, utilities or services available to the area [Benton County Code 53.215 (2)]

## **FULL DESCRIPTION OF FINDINGS**

I want to draw your attention to a recent segment that was broadcast on **60 Minutes** (CBS) on March 31, 2025: **California wildfires left behind 9 billion pounds of toxic ash and debris.** (Resource 1: <https://www.youtube.com/watch?v=iYFksPCL-l8> - For copyright reasons, I have no other way to share this 60 Minutes episode. I did include a screenshot of the page.)

You are likely aware of the devastating wildfires that ravaged neighborhoods and cities in Los Angeles, California in January 2025. Watching this short 15-minute segment raised my awareness of what happens after wildfires:

**Debris Removal Phase 1 – Removing hazardous waste, electric car batteries, power wall chargers, or any other battery.** Even after a fire, lithium batteries can explode or reignite because they are unstable. It takes six people up to two hours to remove six drums of cells from each battery, then the cells go into a saltwater bath for three days, and finally they are steamrolled to make sure they can no longer function. This material can't be recycled, it **must go to hazardous material landfills.**

**Debris Removal Phase 2 –** Removing the rest of the debris – in this case, **9 Billion (yes, that's a B) pounds of toxic ash and debris from the 2025 LA Fires** – and depositing the debris in 17 landfills and recycling center in various **dry-climate landfills** throughout the southwest. In addition, they **scraped 6 inches of contaminated soil throughout the region.** (The current "rule" is that anything deeper than 6 inches is said to be due to prior contamination.)

**Devastating Limbo for Homes that Didn't Burn** – 10,000 homes didn't burn to the ground during the LA Wildfires, which might sound like cause for celebration until you learn that these **homes are filled with soot, ash, and toxins, asbestos, exploded batteries, insulation, lead levels, arsenic, and debris. The indoor air quality within these homes is incredibly toxic.** There is a film of toxic dust throughout every home and smell the toxicity. Can these homes be cleaned to the point of being livable? Or are they total losses. Unfortunately, this is new territory and because they haven't suffered a "physical loss," the clean-up and their losses may not be covered by insurance.

**This information concerns me for two reasons.**

1. **If a large fire originates on Coffin Butte Landfill + Expansion or is sparked by flying embers from a nearby fire, the toxic nature of a burning landfill** (smoke, ash, soot, particulate matter, gases, and chemicals), **would negatively impact the**

entire region – where the fire burned and downwind of the fire.

In the aftermath of a large wildfire, **even if your home survives the fire, the ash, chemicals, and soot** penetrate the buildings through cracks around windows and doors, **making your home unlivable**. Furthermore, **it is toxic and dangerous to continue to live in the region**. Ensuing health challenges range from: headaches, dizziness, and cognitive trouble to reproductive, kidney, respiratory problems, cardiovascular problems, and cancer.

A 2023 study by researchers at the **Environmental Protection Agency (EPA)** found that emission factors for some toxic compounds were more than 1,000 times **higher in urban wildfires than in fires that burned in woodland areas**. (Resource 2: <https://academic.oup.com/pnasnexus/article/2/6/pgad186/7202258>)

**Excerpt from Abstract**

*Fires that occur in the wildland urban interface (WUI) often burn structures, vehicles, and their contents in addition to biomass in the natural landscape. Because these fires burn near population centers, **their emissions may have a sizeable impact on public health**, necessitating a better understanding of criteria and hazardous air pollutants emitted from these fires and how they differ from wildland fires.*

**Excerpt from Significance Statement**

**Wildfires in the wildland urban interface (WUI) burn homes and vehicles leading to potentially greater emissions of hazardous air pollutants than from wildfires burning only natural vegetation.** The greater proximity of these wildfires to population centers and the potentially more toxic emissions **make fires in the WUI a unique threat to public health**...Our results demonstrate that WUI fires are a potential major source of hazardous air pollutants and a better understanding of what and how much is emitted from them is needed.

**Now imagine how toxins generated from a Coffin Butte Landfill-based fire would contribute to the impact of a local WUI fire.**

*Burning trash can cause long-term health problems. The **toxic chemicals** released during burning include nitrogen oxides, sulfur dioxide, volatile organic chemicals (VOCs) and polycyclic organic matter (POMs). Burning plastic and treated wood also releases **heavy metals** and toxic chemicals, such as dioxin.*

Other chemicals released while **burning plastic** include benzo(a)pyrene (BAP) and polyaromatic hydrocarbons (PAHs), which have both been shown to cause cancer. If agricultural bags or containers are contaminated with pesticides or other harmful substances, those will also be released into the air. (Resource 3: <https://dnr.wisconsin.gov/topic/OpenBurning/Impacts.html>)

**Increasing the size of the landfill with an expansion would contribute additional toxins to any local WUI fire.**

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- The proposed use **seriously interferes with** uses on adjacent property, with the character of the area, or with the purpose of the zone [Benton County Code 53.215 (1)] – *A Toxic fire definitely interferes with use of adjacent property and beyond – nearby homes, Benton County, surrounding counties; the entire character of the area would be irrevocably changed; and Rural Residential properties and Urban would no longer be livable.*
  - The proposed use **imposes an undue burden on** any public improvements, facilities, utilities or services available to the area [Benton County Code 53.215 (2)] – *Undue burden would especially impact fire & emergency services, health services, mental health services, Republic Service employees, utility employees, and residents who pay county taxes.*
- 

**The Bottom Line: Expanding the landfill in such close proximity with residential neighborhoods, agricultural lands, and forested areas, creates greater fire risk and more likelihood that WUI fires would be catastrophic in nature.**

- 2. Given wildfire debris from structures is so hazardous** – asbestos, insulation, plastics, exploded batteries, appliances, coolant fluid, polyester curtains, cleaning products, lead, arsenic, mercury, cadmium, chromium and a variety of other dangerous PFAS chemicals – ***Why on Earth is hazardous/disaster debris coming to Coffin Butte Landfill?***

Corporate Republic Services Site lists several services under **Disaster Response**: (Resource 4: <https://www.republicservices.com/environmental-solutions/emergency-response-services/disaster-response>)

**Disaster Debris Removal and Waste Disposal**

- *Flood water management and mobile treatment*

- Construction and demolition (C&D) waste
- Asbestos containing material and PCBs
- Compressed gas cylinders and other volatile hazards
- Biological material and biohazardous waste
- Hazardous waste disaster cleanup
- Hazardous and non-hazardous waste transportation and disposal
- Hazmat disaster cleanup

### **Wildfire Hazardous Waste Response**

*Significant quantities of hazardous material and debris create unique challenges for cleanup and recovery from the widespread destruction caused by a wildfire. Our dedicated crews have supported hazardous waste disaster cleanup efforts for dozens of wildfires, including countless major disasters over recent years. During each event, our crews worked closely with regulators to provide management, assessment and removal of Household Hazardous Waste (HHW), asbestos containing material, and other hazardous debris from **thousands of sites across the Pacific Northwest and other areas of the country.***

**Republic Services' Environmental Services Map does NOT list Coffin Butte Landfill as an Environmental Services Facility.**

(Resource 5: <https://www.republicservices.com/facilities/environmental-solutions>)

In addition, **I don't see any mention of these disaster services on the Coffin Butte Landfill's site.**

### **DEQ Fact Sheet: Protect Surface Waters While Cleaning Up Your Property**

(Resource 6:

<https://www.oregon.gov/deq/wildfires/Documents/wfSWHomeownersFS.pdf>)

*After a Wildfire: **Ash and debris generated from wildfires can be harmful to our rivers and streams.** When rainwater carries sediment and debris from burned areas it also transports pollutants to our surface waters. **Many of these pollutants can be toxic to humans and aquatic life.** Water seeping through hazardous disaster debris would amplify these effects.*

Under their Corporate PFAS Solutions Services, Republic Services describes their Long-Term Secure Disposal Options are RS' landfills in Grand View, Idaho, and Beatty, Nevada, that have special design and construction **"with the added natural protection of being in arid locations with very little rain and low humidity."**

(Resource 7: <https://www.republicservices.com/environmental-solutions/treatment-disposal/pfas-solutions>)

**The pollutants from disaster debris are toxic to humans and water species.**

**The best place to put disaster debris is in an arid location.** We all know this area is not an arid location with very little rain and low humidity. **Coffin Butte Landfill + Expansion has the exact opposite description – high levels of rain and humidity.**

**Why on Earth is the Coffin Butte location / expansion taking in hazardous waste?**

**Given our wet climate, adding more dangerous disaster debris into the Coffin Butte Landfill + Expansion will generate even MORE toxic leachate than the current landfill already does.** This toxic commodity needs to be disposed of even though no local water treatment plant has the ability to remove PFAS from the leachate to create non-harmful water.

Instead, the diluted leachate gets released into the Willamette River upstream from cities that receive their drinking water from the Willamette River.

**Given that the detrimental impacts of PFAS chemicals are cumulative,** this means human bodies, wildlife, and the environment will have **increasing levels of PFAS in their systems.**

Republic Services may be “getting rid” of a noxious problem, but **at what cost to the people, wildlife, and ecosystems downstream?**

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- The proposed use **does seriously interfere with** uses on adjacent property, with the character of the area, or with the purpose of the zone [Benton County Code 53.215 (1)] – *Additional leachate that is even more toxic than the “regular landfill leachate” impact adjacent properties and beyond – local wells, water intakes along the Willamette River; if our waterways become polluted due to the extra toxic leachate and the regular toxic leachate, the character of our area and the state of Oregon would be compromised. Imagine the public relations nightmare if people along the Willamette River have health impacts from leachate chemicals in their drinking water. What kind of reputation will Corvallis and Benton County have then?*

- The proposed use **does impose an undue burden on** any public improvements, facilities, utilities or services available to the area [Benton County Code 53.215 (2)] – *Extra toxic leachate from disaster debris + additional leachate from the expansion would impose an undue burden on health services, agriculture, and residents throughout the Willamette Valley.*
- 

**The Bottom Line: Disaster Debris does not belong in a landfill in a wet climate.  
Republic Services built state-of-the-art landfills in dry climates for this very reason!**

**Please reject LU-24-027. Thank you for your consideration and for protecting the health and future of Benton County.**

Sincerely,  
Carol McClelland Fields  
Corvallis, OR 97330