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The efficacy of news releases, news reports, and public nuisance complaints for determining smoke impacts to air quality from wildland fire

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Abstract

Understanding air quality impacts caused by smoke from wildland fire is a major concern in the western USA. The objectives of this paper were to examine news releases, news reports, and public nuisance complaints about smoke impacts caused by forest fires to determine if these different media sources were accurate indicators of wildland fire impacts to daily air quality from 2008 to 2013. Our findings suggest that media and complaints are poorly correlated to smoke impacts to air quality and should not be used as a proxy to establish days where air quality is impacted by smoke from forest fires. With the exception of 2008, media sources failed in accurately capturing ground level smoke impacts. Media sources were found to predict a smoke impact to air quality 32% of the time, while nuisance complaints predicted 15%. Successful smoke management and wildland fire policy should include a more consistently accurate message of smoke impacts. The majority of the smoke observed in Fresno originated from northern California forest fires and on a few days from forests south of the San Joaquin Valley (SJV). Urban cities in the SJV should be concern with land management strategies outside their air basin jurisdiction.

Keywords Media · News releases · Newspapers · Complaints · Smoke impacts · Smoke management

Introduction

Wildland fire smoke impacts to air quality is increasingly becoming a global concern as more extreme wildfire events impact growing urban areas. California, with dense population adjacent to fire prone wilderness, is a model example to examine the impacts of smoke from natural areas on urban centers. Particulate matter less than 2.5 μm in size ($\text{PM}_{2.5}$) has a direct relation to smoke emissions manifesting in abrupt episodes of unusually high concentrations that make it among the best pollutants to use as an indicator to smoke impacts (Sapkota et al. 2005; Vedal and Dutton 2006; Naeher et al. 2007). $\text{PM}_{2.5}$ is a criterion pollutant regulated in the USA by the National Ambient Air Quality Standards (NAAQS) because of its adverse

human health effects including respiratory and cardiovascular illnesses and increase morbidity and mortality (U.S. EPA 2004; Boogaard et al. 2013; Li et al. 2013).

For regulatory purposes, California is divided into air basins with similar meteorology and natural features where emission can be managed to reduce exposure to airborne pollutants. Many air basins in California, which are densely populated, are in non-attainment for $\text{PM}_{2.5}$. This study focuses on the San Joaquin Valley (SJV) and Great Basin Valley (GBV) air basins. The SJV is west of the crest of the Sierra Nevada mountain range (SNM), includes major urban areas of the California Central Valley west of federally protected wilderness, and currently exceeds the state and federal air quality standards for $\text{PM}_{2.5}$. The GBV is east of the SNM, less populated, does not exceeds the standards for $\text{PM}_{2.5}$, and generally downwind of wildfires in the protected natural areas. The SNM has been and will continue to be a natural source of $\text{PM}_{2.5}$ because the ecozone formed, adapted to, and depends on fire for the health of this forest ecosystem (Schweizer et al. 2017). In the SJV and GBV air basins, the majority of $\text{PM}_{2.5}$ sources are anthropogenic (Cisneros et al. 2014). Fire contributions vary but can be significant and aggravate the already

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polluted air of the SJV especially when big suppression fire incidents occur in upwind locations (Cisneros et al. 2012; Schweizer and Cisneros 2014).

Recent studies have demonstrated that social media is valuable to assess air quality impacts from wildfires (Sachdeva et al. 2016) and can be used to monitor air quality dynamics (Jiang et al. 2015). Information on the usefulness of mass media to assess air quality is not available. Mass media plays an important role on how the public interprets and identifies environmental issues (Boykoff and Boykoff 2007; Zamith et al. 2012). It is imperative to learn more about the value of mass media in connection to air quality, since it has a wide use and plays a vital role in public health. Mass media in the form of news releases and news reports are routinely used in the SJV and GBV during wildland fire episodes to inform the public of potential smoke impacts. Understanding the accuracy of this type of mass media is of particular importance since it can impact how the public perceives the risk posed by wildland fire emissions and negatively affect fire policy in a fire prone ecosystem (Schweizer and Cisneros 2016). How media is presented affects public opinion and policy direction (Bloch-Elkon 2007), and this important and sensitive issue is no exception.

Typically, studies that determine smoke impacts on $PM_{2.5}$ from wildland fire depend on statistical analysis of plume modeling, remote sensing and satellite analysis, ground level monitoring, or some combination to determine exposure. Other studies rely on epidemiological data to determine when smoke causes the most impacts to human health. In this study, we use news releases, news reports, and documented public nuisance complaints to provide us with the days that were “impacted” or “unhealthy air quality” caused by wildland fire from 2008 to 2013 in the SJV and GBV air basins.

To the best of our knowledge, this is the first study that uses this type of information when determining wildland fire smoke impacts. There are two objectives in this paper. One is to examine air quality advisories in news releases and news reports to understand their effectiveness in determining smoke impacts caused by forest fires. The second is to examine smoke nuisance complaints documented by air regulators of the SJV and GBV and find the level of association with smoke impacts. Our hypothesis is that the information produced by the different sources (news releases, news reports, and complaints) can be used to determine days where air quality was impacted by a wildland fire smoke.

Methods

Study location and air quality data

Our study took place in the SJV and GBV air basins of California (Fig. 1). Our analysis used all days where there

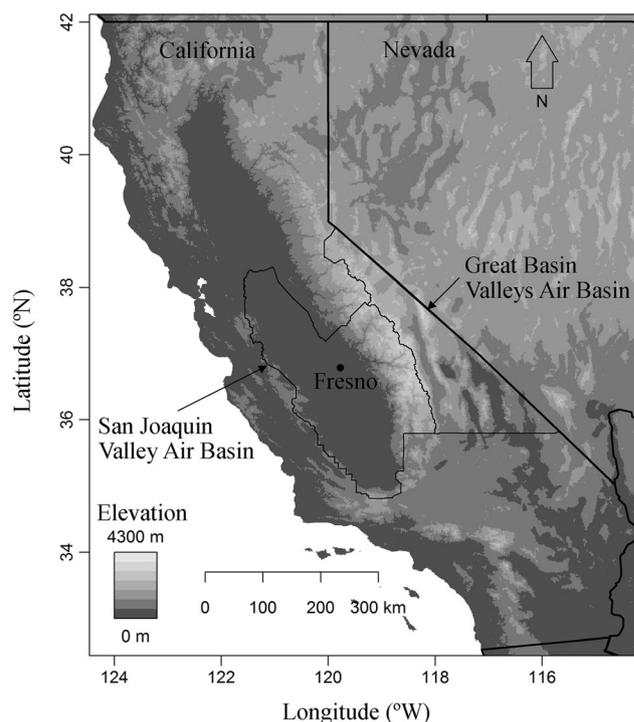


Fig. 1 Location map of air basins

was a claim (media or complaint) of wildland fire impact in any location of these air basins that occurred from 2008 to 2013. $PM_{2.5}$ ground level monitors were used as indicator for air quality impacts caused by smoke from forest fires. Data was collected from $PM_{2.5}$ compliance networks (California Air Resources Board Air Quality and Meteorological Information System (AQMIS2) website at <http://www.arb.ca.gov/aqmis2/aqmis2.php>). Representative monitoring sites, typically the closest available, were selected for individual claims.

Media and complaints

An original dataset was created of news releases and other mass media products (newspapers, public television station or media link, and Internet-based news) and are referred in the text as media sources. Media sources were selected when they mentioned forest fires (including prescribed fires), wildland fire smoke, and air quality impacts occurring in counties of the SJV and GBV for the years 2008–2013. Media sources were collected from the San Joaquin Air Pollution Control District (SJVAPCD) press release and news archive (SJVAPCD 2016).

Complaints were compiled from the SJVAPCD and Great Basin Air Pollution Control District (GBAPCD). These are formal private resident complaints regarding smoke created by wildland fire and air quality. Complaint information was not available for 2008. This data is publicly available and

includes no personally identifiable information. Thus, an Institutional Review Board was not required.

Remote sensing data

The Hazard Mapping System (HMS) fire and smoke analysis is produced daily by the National Oceanic Atmospheric Administration (NOAA) National Environmental Satellite, Data and Information Service—Office of Satellite and Product Operations. Satellite images are used to identify smoke. HMS data is reliant on visible wavelength and satellite analysts to estimate spatial distribution and smoke concentration (light, medium, and heavy density). HMS data (NOAA 2016) was used to provide spatial extent estimate and presence of smoke as an estimate of wildland fire smoke impacts on PM_{2.5} at ground level (Preisler et al. 2015). Smoke plumes detected by satellite imagery were used to capture the presence or absence of smoke from large wildfires for the years 2008–2013.

Analysis and accuracy testing for media sources and personal complaints

The analysis was conducted at the county level. The steps used to decide if there was an air quality impact from wildland fire smoke are as follows:

- Step 1. Use HMS to discern if smoke was present in the area of interest. If no smoke was observed, then the claim was false.
- Step 2. If smoke was present in step 1, then ground monitoring data was used to determine ground impacts. Compare observed PM_{2.5} concentrations with ground level measurements, as well as to published historic PM_{2.5} monthly averages for the area (Cisneros et al. 2014).
- Step 3. Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) was used to produce back-trajectories and to confirm the source of the air quality impact (Stein et al. 2015). This step was used when ground-based measurements and HMS data (steps 1 and 2) were inconclusive to determining wildland fire impacts for a given area (< 10% of the days).

Statistical model

Given the availability of data, Fresno is the only county further explored using a statistical model. The statistical model was used for the sole purpose of estimating the probability of impact to PM_{2.5} from wildland fire episodes in Fresno for the

days with media claims. A detailed description can be found in Preisler et al. (2015).

Results

Sources of media

A total of 270 media sources were found. From these, only 90 mentioned “unhealthy air quality” or risk to human health to residents of a county or counties which pertained to forest fire smoke (Table 1). These media sources also included those with a prediction or warning of an air quality impact from wildland fire smoke. Often, several media sources were collected for the same day from different sources. This was especially true for the years 2008 (33 media sources available for 14 days) and 2013 (37 media sources for 21 days).

Eighteen news releases were collected for the duration of the study (Table 1). The majority (67%) of sources of media came from newspapers (60 articles). Eleven (12%) of the media sources were from public television stations or link media. One (1%) came from an internet based news source. Most of the newspaper articles were published in 2008 and 2013, whereas most of television news/link media were produced during 2013 and none were found in 2008. The majority (78%) of all media sources for the duration of the study were released during 2008 and 2013, which coincided with high fire activity in Northern California that led to visible smoke in the area (Cisneros et al. 2014; Navarro et al. 2016).

Media and complaint time distribution

Table 2 shows the number and distribution of occurrence for media sources and complaints. Media reports are distributed from May to October, with the majority occurring from June to September. There were a total of 27 complaints, collected from two air pollution control districts, related to air quality smoke from biomass burning impacts that were used for this study.

The majority (55%) of complaints were from the GBAPCD. Most (67%) of the complaints were made in 2011 and 2012. For the period of this study, there was at least one complaint in every month, except during January, April, and May. Most of the complaints occurred during the month of July. In 2009, the complaints were made from October through December. In 2010, there were only two complaints which were made in July. During 2011, a single complaint was received during six different months in addition to five complaints received for the month of July. Only 5 months in 2011 did not have a complaint while other years would have 8 or 9 months without getting a smoke related air quality complaint.

Table 1 Media year of occurrence

| Sources of media | 2008 <i>n</i> | 2009 <i>n</i> | 2010 <i>n</i> | 2011 <i>n</i> | 2012 <i>n</i> | 2013 <i>n</i> | Total <i>n</i> |
|------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| News releases SJVAPCD | 2 | 0 | 4 | 3 | 1 | 8 | 18 |
| Newspapers | 31 | 2 | 4 | 1 | 0 | 22 | 60 |
| Public TV station/link media | 0 | 0 | 3 | 1 | 0 | 7 | 11 |
| Internet based news sources | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| All media | 33 | 2 | 12 | 5 | 1 | 37 | 90 |
| Complaints | NA | 4 | 2 | 11 | 7 | 3 | 27 |

Media and complaints accuracy

Table 3 describes the comparison of the claim (health advisory or air quality impact) of smoke impact and the observed PM_{2.5} concentrations. Media sources were found to predict an increase or smoke impact to air quality, as determined by an exceedance of expected PM_{2.5}, 32% of the time. Media reports showed 73% accuracy during 2008 and 13% in 2013. None of the media claims were able to predict an air quality impact for the years 2009 through 2012.

Looking at specific sources of media, news releases were able to predict a PM_{2.5} air quality impact 11% of the time for all years, with a 25% success in 2013 but were unable to predict the other years. Newspaper reports predicted air quality impacts caused by wildland fire smoke 45% of the time during the studied years and with 77 and 14% success during and 2008 and 2013 respectively but were not found to be successful in other years. Public television/link media and Internet news failed to predict for all years of the study.

Table 2 Number and distribution of occurrence for media sources (M) and complaints (C). Note that complaint information was not available for 2008, and there are days that have several different media sources

| | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | Total | |
|---------|------|---|------|---|------|---|------|----|------|----|------|---|-------|----|
| | M | C | M | C | M | C | M | C | M | C | M | C | M | C |
| Jan. | | | | | | | | | | | | | | |
| Feb. | | | | | | | 1 | | | | | | | 1 |
| Mar. | | | | | | | 1 | | | | | 1 | | 2 |
| Apr. | | | | | | | | | | | | | | |
| May. | | | | | | | | | | | 4 | | | 4 |
| Jun. 11 | | | | | | | 1 | | | | 7 | | 18 | 1 |
| Jul. 15 | | | | 3 | 2 | 4 | 5 | | | | 8 | 2 | 30 | 9 |
| Aug. | | | 2 | | | | 1 | 1 | 2 | 16 | | | 19 | 3 |
| Sep. 6 | | | | | 9 | 1 | 1 | | 3 | 2 | | | 18 | 4 |
| Oct. 1 | | | | 1 | | | 1 | | | | | | 1 | 2 |
| Nov. | | | | 2 | | | | | | | | | | 2 |
| Dec. | | | | 1 | | | | | 2 | | | | | 3 |
| Total | 33 | | 2 | 4 | 12 | 2 | 5 | 11 | 1 | 7 | 37 | 3 | 90 | 27 |

Nuisance complaints predicted smoke impact from wildland fire 15% of time for the duration of the study. The only 2 years that the complaints were able to predict were 2010 and 2011, with 100 and 18% respectively found to effectively relate to a PM_{2.5} impact. Nuisance complaints for smoke typically had a political or personal component. A complaint would often include a justification for the complaint that was based on a personal health ailment and/or dislike of fire management. Large full suppression fires such as the rim fire did not receive complaints while prescribed fires or those considered by the complainant to be allowed to burn did. Not only were all fires that the complaint perceived as allowed to burn, but certain complaints also appeared to have bias against a single agency management of a fire.

Estimate of impact caused by wildland fire

Figure 2 describes the probability of exceeding the expected PM_{2.5} levels in Fresno for days with media claims. The probability of exceedance for all days with media was 23% (95% CI 9–38%). However, it is driven by year 2008. The probability of exceedance for media claims in 2008 was 49% (95% CI 24–73%). The probability when not including media for the year 2008 was not significant. Air quality impacts are very noticeable in 2008 where PM_{2.5} reached a maximum hourly concentration of 137 µg m⁻³ with a mean average of 20 µg m⁻³ (Fig. 3). Lesser impacts were observed in Fresno during 2013 with a maximum hourly PM_{2.5} concentration of 99 µg m⁻³ and mean of 11 µg m⁻³, the second lowest mean concentration during the study (Fig. 3).

There were of total of 37 days in Fresno, where media-claimed air quality was impacted by forest fire smoke. Only 6 days were found to be impacted by smoke. There were a total of 14 days where air quality was impacted that were not captured by media. Smoke for 16 of the impacted days noted here came from northern California forest fires. On three occasions, smoke originated from forest south of the SJV and only on one occasion the smoke originated from the SNM.

Table 3 Number of media found to predict an air quality impact to PM_{2.5} attributed to smoke

| Sources of Media | 2008 <i>n</i> | 2009 <i>n</i> | 2010 <i>n</i> | 2011 <i>n</i> | 2012 <i>n</i> | 2013 <i>n</i> | Total <i>n</i> |
|------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|-------------------|
| News releases SJVACPD | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| Newspapers | 24 | 0 | 0 | 0 | 0 | 3 | 27 |
| Public TV station/link media | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Internet based news sources | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| All media (% accurate) | 24 (73%) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 5 (13%) | 29 (32%) |
| Complaints (% accurate) | NA | 0 (0) | 2 (100%) | 2 (18%) | 0 (0) | 0 (0) | 4 (15%) |

Discussion

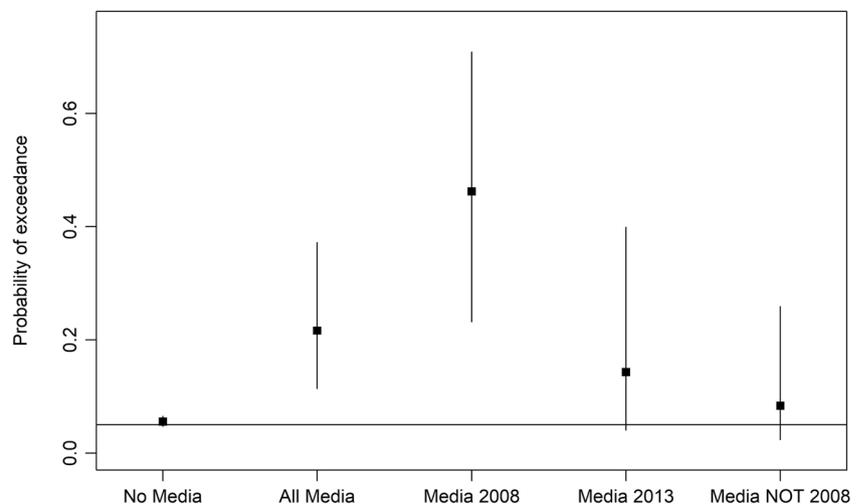
The main hypothesis of this paper was that the media and complaints could be used as a proxy to distinguish the days that were affected by smoke from forest fires. Our findings indicate that media and complaints cannot be used as a proxy to distinguish the days that were affected by smoke from forest fires. With the exception of 2008, when smoke was widespread across most of California, media sources failed in predicting smoke impacts. The media were correct about smoke impacts 32% of the time during the study. The complaints were 15% accurate when the smoke impacts were investigated and often corresponded to a localized impact from a prescribed fire.

HMS and HYSPLIT together with ground level air quality monitoring data were used in this study to determine the accuracy of the media and complaints. While these are excellent tools and have been used extensively in many air quality studies, there are several limitations. The complex terrain of the Sierra Nevada reduces the effectiveness of transport models. HYSPLIT is limited by both the temporal and terrain resolution of the meteorological model but can give useful indicators of smoke transport (Schweizer and Cisneros 2014). The relationship between HMS smoke detects and absolute ground level impacts to PM_{2.5} concentrations is weak. HMS can be

used to determine if smoke was observed above a specific location on a given day and to calculate the probability of PM_{2.5} exceedance from the expected but is not a good indicator of how large the impact is to ground level PM_{2.5} concentrations (Preisler et al., 2015). However, when combined with ground level data, it allows for an empirical decision matrix for smoke impacts on the area of interest. Ground level monitors of PM_{2.5} are not equally distributed. Monitors are not widely available in the foothills often nearer to a wildland fire and where impacts can be higher and vary in agreement with federal reference methods and equivalents (Schweizer et al. 2016). These limitations are a challenge and need to be considered when relating smoke exposure to public response.

The accuracy of media was strongest for 2008, when smoke from hundreds of northern California wildland fires transported into the SJV and impacted ground level air quality in the area (Table 3). The Northern California forest fires affected all sites in the area during June and July 2008 (Cisneros et al. 2014). These fire season effects are obvious in Fresno, with PM_{2.5} monthly averages doubling during June and July (Fig. 4). In 2013, the media was less accurate (13%). These impacts came from forest fires in northern California and upwind of the SJV and not from forest fires in the SNM (Navarro et al. 2016). There is a tendency to believe that if a fire is in the vicinity and smoke is visible, then air quality is or will be

Fig. 2 Probability of PM_{2.5} concentrations exceeding the expected with 95% confidence bar for days with media claims in Fresno



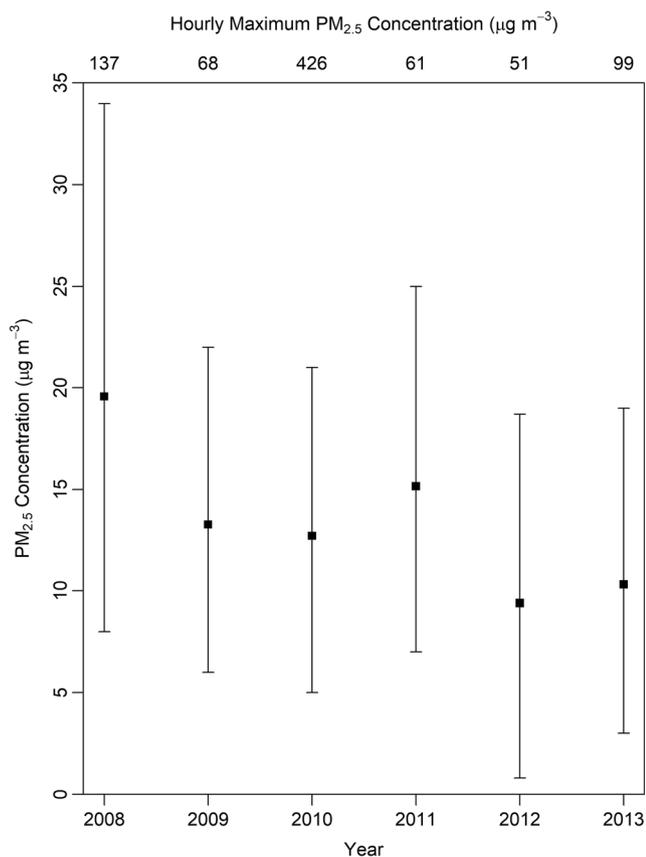


Fig. 3 Annual mean PM_{2.5} concentrations in Fresno for May through October. The square dot is the mean and the lower and upper whiskers representing the 10th and 90th percentile

impacted. The reality is that forest fire smoke is driven by meteorology and will follow predominant wind patterns that

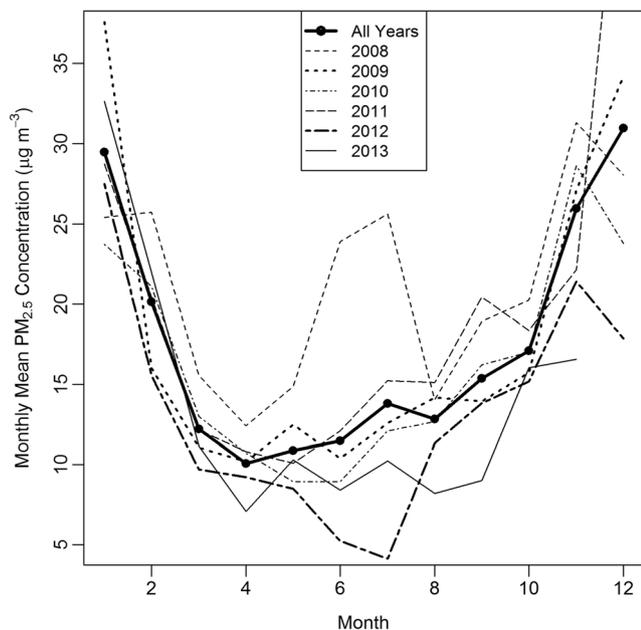


Fig. 4 Monthly PM_{2.5} concentrations in Fresno

do not appear to be reflected in the media sources. Based on previous studies, the predominant patterns of historic (2002–2013) fire smoke in the SNM area have been for the most part away from the SJV leading to smoke impacts in mountain communities closer to the fire and downwind (north and east of the Sierra Nevada) of the fire and in some cases have reached Nevada (Cisneros et al. 2012; Schweizer and Cisneros 2014; Burley et al. 2016; Navarro et al. 2016). The majority of the smoke observed in Fresno originated from northern California forest fires and on a few days smoke drifted from forests south of the SJV. The findings of this study indicate that urban cities like Fresno should be concerned with land management strategies outside their air basin jurisdiction.

The mass media plays an important role in how the public perceives environmental issues (Boykoff and Boykoff 2007; Zamith et al. 2012) with the manner by which media is presented affecting public opinion and policy directions (Bloch-Elkon 2007). Additionally, the use of mass media as a risk communication tool can be problematic since messages are shaped and chosen by journalists on the basis of their own demands (Wakefield and Elliott 2003). News releases from an Air Pollution Control District (APCD) are an important piece in risk communication. However, warnings about air pollution impacts are only abided by when pollution forecasts are known, credible, and people believe they are vulnerable (Johnson 2012).

During this study, newspapers were the only mass media that were able to predict (32% of the time) impacts from forest fires in the SJV and this was only for 2008. For the SJV, out of the 18 the news releases disseminated during the study, only 2 correctly captured impacts in 2013. SJV may be reducing the value of air quality messaging by over representing the risk of smoke from wildfire to Valley residents. Residents of the SJV, when asked about the most serious community problems (out of 8), responded that forest fires were the least of their concern (Cisneros et al., 2017). The residents of SJV also responded that forest fires were a low concern (6 out of 8) as a contributor to air pollution with only construction and blowers and lawn mowers being of less concern (Cisneros et al., 2017). Thus, the residents of the SJV did not consider forest fires to be a serious community problem or perceived it to be a main contributor to air pollution. Smoke is extremely visible and can be smelled at low concentrations. Not seeing or smelling smoke may greatly contribute to Central Valley residence perception that wildfire smoke is only a minor air quality problem. News release credibility may enhance personal experience to reduce effectiveness of this messaging in a true public health emergency.

Media sources are currently over-representing ground level smoke impacts which may be bolstering smoke averse populations. Some overestimation is desirable and should be expected when attempting to protect human health and message

about smoke impacts. But, in the Central Valley, there is a large disconnect between media source and actual ground level impacts that needs to be addressed. Complaints were also inaccurate and often incorporated a dislike or mistrust of current forest fire policy and management and suggested that no amount of smoke was acceptable. Successful smoke management and wildland fire policy should include a more consistently accurate message of smoke impacts.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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