

PUBLIC PERCEPTION OF WILDFIRE SMOKE HAZARD

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August 2008

Abstract

On June 21, 2008, a series of dry thunderstorms sparked wildfires in several areas in northern California. This research examines residents' perception of the resultant wildfire smoke and their response to this hazard in Redding, California, after the area had experienced unhealthy air quality for several days. Interviews were conducted door to door in residential neighborhoods chosen to provide a sample diverse in demographic and socioeconomic attributes and dwelling unit age. Most respondents considered the wildfire smoke to be a health hazard and the majority of residents took simple measures such as staying indoors to reduce exposure. Television was the most frequently used source of information on the wildfire smoke, and was viewed as more useful than all other media, with the exception of the Internet. However, the latter was used by only a small proportion of respondents. Demographic, socioeconomic, and dwelling unit characteristics showed limited association with perception of the hazard, preventative measures taken, or information sources used by respondents. However, concern for more vulnerable members of the household, including children and the elderly, did affect perception of the hazard and the measures taken to reduce exposure.

Introduction and Research Objectives

Several studies have established the health hazard posed to local residents by wildfire smoke (Shusterman, Kaplan, and Canabarro 1993; Sorensen et al. 1999; Ammann et al. 2001; Bowman and Johnston 2005; Sapkota et al. 2005). Several state and federal government bodies have also issued fact sheets and guidelines delineating the risk posed by the wildfire smoke hazard and action plans to protect human health during smoke events (Oregon Department of Environmental Quality 1999; Schwela et al. 1999; Center for Disease Control 2003; U.S. Environmental Protection Agency 2004). However, the emphasis in hazards research has been on the perception of fire danger warnings, property and personal safety (injury or death), vulnerability associated with wildfires, and fire mitigation and management practices—with little or no mention of the health hazard posed by wildfire smoke (Cortner, Gardner, and Taylor 1990; Benight, Grunfest, and Sparks 2004; Kneeshaw, Vaske, and Bright 2004; McCaffrey 2004; McKee et al. 2004; Collins 2005). Previous related research on urban air pollution has found that people's perception of pollution severity and the associated health effects is not only a valid measure, but an important adjunct to scientific measures (MacGregor and Fleming 1996; Forsberg, Stjernberg, and Wal 1997; Oglesby et al. 2000; Hunter et al. 2003).

The purpose of this study is to examine residents' perception of the health risk posed by wildfire smoke and their response to the hazard. The perceived risk and response will be evaluated for any association with utility of information sources; demographic characteristics of the household, including presence of more vulnerable individuals (those with respiratory or heart problems that may be exacerbated by the smoke, young children and elderly individuals); and socioeconomic attributes of the household that may impact access to information and/or ability to take mitigating measures.

Research Design

Study Area

The study site of Redding, California, is a community of approximately 34,500 households (U.S. Census Bureau 2000a). It is located on the Sacramento River in Shasta County, approximately 160 miles north of Sacramento. This community was chosen for study as it met several criteria, including exposure to unhealthy levels of wildfire smoke for several days and sufficient size to enable a broad sampling of socioeconomic and demographic characteristics to be obtained. The urban area is designated as wholly within the wildland-urban interface (WUI) and is situated in a valley with mountains on three sides, restricting airflow and enhancing the area's susceptibility to trapped smoke (Figure 1). Following the outbreak of lightning-started fires in the mountainous terrain mainly west of the urban area starting on June 21, 2008, residents experienced several days of unhealthy air quality resulting from the wildfire smoke in the area.

The local Air Quality Management District office informed the public of the air quality during this period through bulletins issued to the local news media including the local newspaper, radio, and television stations. Air quality information was also available from the local newspaper's Web site (<http://www.redding.com/weather/>), the county's site (<http://www.co.shasta.ca.us/departments/resourcemgmt/drm/aqmain.htm>), and federal Web sites (<http://airnow.gov/>), as well as several commercial Web sites. Readings were taken from the monitor in Anderson, approximately nine miles south of the center of Redding. Bulletins were issued each morning and noted the average level of particulate matter 2.5 (PM_{2.5}) and the corresponding ranking on the Air Quality Index (AQI) Chart for the prior 24 hours up to 4 a.m. The Air Quality Index is divided into six categories: good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy, and hazardous (U.S. Environmental Protection Agency 2008). In the four weeks prior to the survey being administered, the Redding area experienced one day in the "unhealthy for sensitive groups" category, eighteen days in the "unhealthy" category, and seven days in the "very unhealthy" category.

Survey Design

The four-page survey instrument elicited responses in five categories:

- First, respondents were asked to rank a series of statements relating to their perception of the risk posed by wildfire smoke in their neighborhood and inside their home on a five-point Likert scale from "strongly disagree" to "strongly agree."

- Second, the number of times the respondent had been exposed to wildfire smoke in the last five years and the preventative measures taken to minimize exposure during the current event were noted for the respondent and other household members.
- Third, health characteristics of household members, including the incidence of asthma, allergy to wood smoke, heart problems, and chest illnesses provided a measure of potential vulnerability to the wildfire smoke for the household.
- Fourth, information sources used to learn about the wildfire smoke hazard and a ranking of their perceived utility on a five-point Likert scale from “not at all useful” to “very useful” were posed.
- Last, characteristics of the dwelling (including age and air conditioning and heating methods), the respondent (including age, gender, educational level, and race/ethnicity), and the household (including number of residents, number of children, and gross household income) were noted.

Sampling Methodology

Prior to entering the field, the Redding urban area was mapped using ArcView, a geographic information systems software program, and data from the 2000 Census (U.S. Census Bureau 2000b). Residential areas that varied in dwelling age, demographic characteristics, and socioeconomic status were tentatively identified as potential locations to be surveyed. This information was supplemented and updated in interviews with local, city, and county representatives. Neighborhood areas of approximately four to six blocks varying in dwelling age, demographic characteristics, and socioeconomic status were then chosen and their status confirmed by field observation. The survey was administered by the principal investigator (PI) and a graduate research assistant going door to door to a one in four sample. Where a householder declined to be interviewed, the next house in sequence was substituted. Where there was no response, at least one callback was attempted before that household was replaced. Interviewing was conducted from Friday through Monday, including evenings, to ensure as representative a sample as possible. A total of 104 households were replaced as a result of refusals (67) or not finding the resident at home (37). A total of 76 surveys were completed in the field and one survey was returned by mail.

Findings

Sample Characteristics

The demographic and socioeconomic characteristics of the sample are set out in Table 1. The racial/ethnic composition of the sample closely reflects that reported by the Census Bureau (U.S. Census Bureau 2000a) for Redding as a whole, with a majority White population (89.6 percent for the sample versus 88.7 percent for the city) and the remainder split between African-American (2.6 percent and 2.2 percent), Asian (1.3 percent and 3.0 percent), Hispanic (2.6 percent and 5.4 percent) and American Indian (2.6 percent and 2.2 percent). The sample was biased towards older respondents (those 65 years or older, representing 32.5 percent of the sample versus 15.5 percent of the Redding population), and female respondents (62.3 percent of those sampled versus 52.1 percent of the urban population). The median category for the reported gross household income (\$35,000 to \$49,999) was also higher than the 1999 median household income of \$34,194 listed by the

Census Bureau. However, this difference may reflect a normal adjustment upwards over time. A slightly higher percentage of respondents had completed high school (90.9 percent versus 85.2 percent for the population).

In terms of the dwelling unit, 84.4 percent of respondents owned their home (Table 2). Eighty-seven percent resided in detached houses, with the remainder split between duplex/triplex housing (7.8 percent) and mobile homes (5.2 percent). A slightly higher percentage used gas (42.9 percent) versus electricity (55.8 percent) for cooking, and three-quarters of those sampled used central air conditioning. A fifth of all respondents relied on a swamp cooler—an evaporative system that draws outside air into the dwelling—as their primary cooling system. Just over half of all respondents had a fireplace (40.3 percent) or woodstove (11.7 percent), though over half of these respondents said that they never (46.2 percent) or rarely (11.5 percent) used them.

Perception of the Wildfire Smoke Risk and Preventative Measures Taken

The majority of respondents (80.4 percent) stated that air quality in their neighborhood was generally good (Table 3). When asked if smoke from wildfires was a health concern in their neighborhood, the majority agreed (24.7 percent) or strongly agreed (54.5 percent), while only a small proportion (26 percent) stated that the smoke didn't bother them. However, while just over one-third (34.7 percent) considered it more dangerous than air pollution from other sources, nearly half of the respondents (44.0 percent) considered wildfire smoke less dangerous. Several residents commented that the wildfire smoke was "natural" and therefore less dangerous.

Most respondents felt that the air quality in their home was generally good (84.4 percent) (Table 4). In ranking how airtight their dwelling was on a five point scale from "very leaky" to "very airtight", just over half considered it to be airtight (23.4 percent) or very airtight (31.2 percent). The two measures were positively associated with each other (Spearman's rank order correlation .30, N=76, $p < .01$) suggesting that perceived infiltration of outside air was an important component of respondents' perception of indoor air quality. Income level was positively associated with how airtight the respondent felt their home to be (Spearman's rank order correlation .28, N=66, $p < .05$), while dwelling age was negatively associated with this measure (Spearman's rank order correlation $-.37$, N=71, $p < .001$). Neither income nor dwelling age was associated with respondent's evaluation of the general air quality in their home. This finding reinforces the view that exterior sources of pollution, in this case from wildfire smoke, may be more salient in formulating respondents' concern over the level of indoor air quality than potential indoor pollution sources such as use of the fireplace.

Though two-thirds were concerned about the health effects of wildfire smoke in their home, respondents expressed more concern for the health consequences of wildfire smoke on children in the household, particularly as many noted that they had to keep them indoors more, and for elderly members of the household. The health concern over wildfire smoke was moderately associated with the consequences for children (Spearman's rank order correlation .57, N=30, $p < .01$) and elderly members of the household (Spearman's rank

order correlation .54, $N=33$, $p < .01$) suggesting that the perceived threat to these more vulnerable individuals generates greater concern over smoke levels.

Nearly 90 percent of respondents reported taking some form of preventative measures to reduce exposure to the wildfire smoke. For those taking any precautions, the most common measure taken was to stay indoors (88.2 percent), followed by closing windows (86.8 percent) and limiting physical activities (70.6 percent) (Table 5). Only about one-third of households with a swamp cooler took the advice given in public announcements to turn them off. Few used in-home air filters or purifiers (36.8 percent) or masks (11.8 percent), though the former measure was more widely used by other members of the household (41.8 percent). Those households where asthma, wood smoke allergy, and heart or chest illnesses were present were not more likely to adopt the most common measures noted above. With only one exception, the presence of these health conditions did not significantly alter measures taken to reduce smoke exposure, this exception being where a member's physical health impairment was perceived to be an allergy to wood smoke (14 respondents or 18.2 percent of the sample). These households were more likely to report limiting their physical activities (Spearman's rank order correlation .33, $N=68$, $p < .01$). On the practical side, in prolonged events such as the one under study here, programs to open and publicize the availability for use of air-conditioned facilities, such as school gyms, may be beneficial.

A higher proportion of respondents with no asthma sufferers in the household reported using an air filter or purifier (44.7 versus 35.3 percent), though the difference was not statistically significant. Preventative measures taken were not associated with how many times the respondent had previously been exposed to wildfire smoke. The extent and prolonged nature of exposure in the current event may have served to level the field in terms of residents feeling the need to take some action. When asked if there were any additional comments they wished to make about the current wildfire smoke, 21 percent of respondents commented that the present wildfire smoke event was the worst in their experience.

Use and Perceived Usefulness of Information Sources

The most frequently used source for information on the wildfire smoke was the television (89.6 percent) followed by the local newspaper (83.6 percent) and friends (59.7 percent) (Table 6). More than half of respondents also reported using the radio (53.2 percent), particularly while driving. They particularly remembered the message to switch the car air conditioning to recycle mode. Internet sources were used by less than one-fifth of all respondents, though they were perceived to be more useful than any other source by those using them. Other sources volunteered by respondents included family members living elsewhere (11.7 percent) and classes (7.8 percent). Only two socioeconomic/demographic attributes were associated with use of particular sources. Use of the local newspaper was positively associated with education (Spearman's rank order correlation .32, $N=77$, $p < .01$) and income (Spearman's rank order correlation .27, $N=67$, $p < .05$). Higher income individuals were also more likely to use nongovernment Internet sources (Spearman's rank order correlation .28, $N=65$, $p < .05$).

When those interviewed were asked to rate the usefulness of the sources they used, television received the most positive ranking from the majority of respondents, though Internet sources were ranked slightly higher by those who used them (Table 6). While still positive, friends and the local newspaper ranked lowest in usefulness. Television was the only source where perceived usefulness had an association with the respondents' socioeconomic/demographic attributes. This source was ranked higher by older individuals (Spearman's rank order correlation .33, N=77, $p < .01$) and female respondents (Spearman's rank order correlation .28, N=77, $p < .05$). Respondents in households where asthma was triggered more frequently by wood smoke were also more likely to rank television as a useful information source (Spearman's rank order correlation .63, N=20, $p < .01$).

Respondents were asked if they had seen or heard of the Air Quality Index (AQI) chart, which is a primary tool for communicating the unhealthiness of the air. Sixty respondents (77.9 percent) reported seeing the chart while another seven (9.1 percent) had heard of it. Those who had seen the chart ranked it as more useful than those who had only heard of it (Chi-square 10.24, N=67, $p < .05$). Knowledge and ranking of the usefulness of the chart did not vary by demographic or socioeconomic characteristics. Those who used television as an information source ranked the chart as more useful (Spearman's rank order correlation .26, N=65, $p < .05$). However, those using federal Web sites ranked the Chart's usefulness lower (Spearman's rank order correlation -.25, N=65, $p < .05$).

Conclusions

Each year the threat of wildfires continues to grow as human occupancy of the wildland-urban interface expands. This season has been one of the worst experienced in California, and may prove to be the worst season on record. Smoke from wildfires created unhealthy air quality in many areas of northern California. This research adds to the limited work done on residents' perception of the health hazard posed by wildfire smoke and their response to this hazard.

In practical terms, several findings may prove useful. The majority of respondents perceived the wildfire smoke to be a health hazard. However, less than half of all respondents perceived wildfire smoke to be more dangerous than air pollution from other sources. The view that wildfire smoke was less dangerous was generally accompanied by the statement that it was "natural". Education on the potentially dangerous components of wildfire smoke is warranted. The extent of the perceived usefulness of television as a source of information on wildfire smoke suggests that this medium may be advantageous for public education on the hazards of wildfire smoke. The visual and relatively widespread availability of this medium may be key in its communication effectiveness, as evidenced by the greater usefulness attributed to the AQI chart by those who saw it on the television. Immediacy and specificity of information provision, such as the message to turn the automobile air conditioning to recycle heard on the car radio, also appears vital. Many who perceived the information they received to be less useful commented on the dated nature of the information, even though it may have only been from the day before. While the ephemeral nature of this hazard makes provision of real-time information difficult, several respondents felt that more should be done to provide such information directly to the public.

Though commonly found to be a factor in previous hazards research, past experience did not influence perception of the hazard or measures taken to mitigate it in the current circumstances. A possible explanation for this lack of effect may be due to the more serious and prolonged nature of the event under study here. Similarly, while socioeconomic status was not associated with choice of information source or preventative measures taken, it was clear that households in the lower socioeconomic categories may be at a disadvantage. For example, several mentioned that turning off the swamp cooler, the only source of air conditioning for many lower income households, was not an option in the June/July heat. Low-income households, as well as those in older dwelling units, were also more concerned that their home was not airtight, thus allowing smoke to pollute their indoor environment. Therefore, those charged with healthcare planning and information provision for the growing threat of wildfire smoke need to address the concerns of those without alternate cooling methods in the home. They may also find it useful to consider a program to facilitate the adoption of simple measures, such as caulking and weather stripping, which are linked to smoke exclusion as well as energy conservation. Such programs would have greatest utility when planned specifically with low-income households and those in older housing in mind.

Supporting research on vulnerability, the response relating to vulnerable subgroups, proved informative. The presence of these subgroups alone was not the defining factor. In both practical and theoretical terms, attitudinal measures were found to trump strictly physical measures—that is, concern for the health consequences on children versus simply knowing children are present in a household provides more predictive power in judging potential actions that a household may take. For example, greater concern for the affect of wildfire smoke on the health of children and elderly subgroups was associated with a higher overall health concern generated by wildfire smoke, and the adoption of preventative measures such as limiting physical activities. Therefore, this research suggests that identifying the residents' level of concern for health consequences for potentially vulnerable members of their household is the key to formulating appropriate policies and programs. Defining and responding to these concerns will be crucial in assisting residents in mitigating the negative effects of the wildfire smoke hazard.

Acknowledgements

This research was funded by a grant from the University of Colorado Natural Hazards Center through its Quick Response Research Program, which is funded by the National Science Foundation grant No. CMM10734304. The author would also like to acknowledge the financial support provided by the Department of Geography, Texas State University-San Marcos.

The author gratefully acknowledges the residents of Redding, California, who took the time to respond to the survey and share their experiences. The author also thanks Diane Menard (City of Redding Development Services Department Planning Division), Cathy Scott (Shasta County Assessor's Office), Ross Bell (Shasta County Department of Resource Management Air Quality Management District), Stephanie Nelson (Greater Redding Chamber of Commerce), and Dr. Greg Reed, a local geographer who assisted by providing a wealth of local knowledge on the Redding area. Special thanks go to Suzi

Wiseman, who assisted in the survey work. Finally, the author appreciates the support of the staff at the University of Colorado Natural Hazards Center.

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Tables and Figures

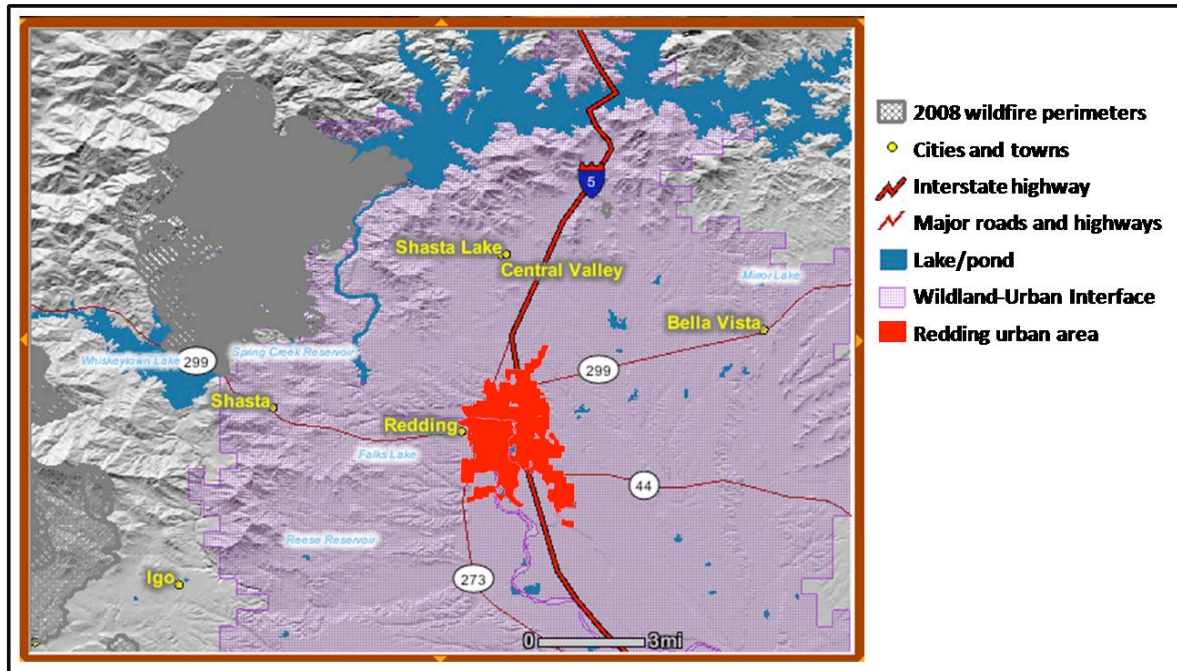


Figure 1. Redding and surrounding area with 2008 wildfire perimeters. (Source: U.S. Department of the Interior 2008. Redding urban area from U.S. Census Bureau 2000b)

Table 1. Respondent characteristics

Characteristic	Percent
Age category	
18 to 24 years	6.5
25 to 34 years	9.1
35 to 44 years	16.9
45 to 54 years	18.2
55 to 64 years	29.9
65 to 84 years	2.6
85 years and older	
Male	37.7
Race/ethnicity	
White	89.6
African American	2.6
Asian	1.3
Hispanic	2.6
American Indian	2.6
Gross household income	
under \$10,000	4.5
\$10,000-14,999	4.5
\$15,000-24,999	4.5
\$25,000-34,999	4.5
\$35,000-49,999	22.4
\$50,000-74,999	17.9
\$75,000-99,999	19.4
\$100,000-149,999	13.4
\$150,000-199,999	3.0
\$200,000 or more	6.0

Table 2. Dwelling unit characteristics

Characteristic	Percent
Owner occupied	84.4
Dwelling unit type	
Detached house	87.0
Duplex/triplex	7.8
Mobile home	5.2
Cooking fuel	
Electric	42.9
Gas	55.8
Cooling method	
Central air conditioner	75.3
Wall unit	9.1
Swamp cooler	20.8
Fireplace - wood	40.3
Fireplace - gas	20.8
Woodstove	11.7

Table 3. Perception of wildfire smoke in respondent’s neighborhood

Item*	Mean
In <i>my neighborhood</i> ,	
the air quality is generally good	4.19
smoke from wildfires doesn’t bother me	2.32
smoke from wildfires is a health concern	4.17
wildfire smoke is less dangerous than air pollution from other sources	2.84

* Measured on a 5-point scale, from “strongly disagree” to “strongly agree”

Table 4. Perception of wildfire smoke in respondent’s home

Item*	Mean
In <i>my home</i> ,	
the air quality is generally good	4.23
I/we like to use the fireplace/woodstove in winter	3.29
I am generally in good health	4.29
smoke from wildfires is a health concern	3.75
I am concerned about the health consequences of wildfire smoke on my children	4.27
I am concerned about the health consequences of wildfire smoke on elderly members of my household	3.88

* Measured on a 5-point scale, from “strongly disagree” to “strongly agree”

Table 5. Use of preventative measures against smoke exposure

	Self (N=68)	Other members (N=55)
Stay indoors	88.2	87.3
Limit physical activities	70.6	81.8
Use in-home air filter/purifier	36.8	41.8
Close the windows	86.8	87.3
Leave high exposure area	50	61.8
Wear mask / filter	11.8	10.9
Turn off swamp cooler	36.8	53.3
Evacuate	19.1	23.6

Table 6. Information source use and ranking

Source	Percent who use source	Mean usefulness ranking*
Radio	53.2	3.8
Television	89.6	4.1
Local newspaper	63.6	3.6
Friends	59.7	3.6
Books	9.1	4.0
The Internet		
– county site	14.3	4.2
– state site(s)	15.6	4.3
– federal site(s)	10.4	4.3
– other site(s)	13.3	4.1

* Measured on a 5-point scale, from "not at all" to "very useful" for those citing each source