



# **Wildfire impacts and adaptation strategies among Highlands Fire District residents: Results of a 2022 household survey**

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**Cover photo:** 2022 Pipeline Fire; picture credit: Coconino National Forest

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## 1. Overview

Recent wildfire events in the Flagstaff, AZ, area such as the 2021 Rafael Fire have underscored the importance of wildfire risk reduction and the establishment of fire adapted communities. Progress towards better living with fire requires residents and professionals to address multiple aspects of wildfire simultaneously; this includes evacuation, property-level mitigation, and actions to address health impacts associated with smoke from wildfires and forest management activities. Given increasing wildfire risk to wildland urban interface communities like Kachina Village, Mountaineer, and Forest Highlands, there is a growing need to understand how respondents currently are taking action, and to identify resources and outreach opportunities that can expand and accelerate these efforts.

This study sought to understand:

1. Property-level home ignition zone mitigation efforts;
2. Household evacuation planning and preferences; and
3. Adaptation strategies households are using to mitigate health risks associated with smoke.

Households within Arizona's Highlands Fire District (HFD) boundaries are well-suited for investigating these foci, primarily because of their close proximity to active public land management and the diverse population living in that area based on social-economic considerations like household income, age, education, and pre-existing health conditions. Research presented here is part of a broader effort to understand community adaptation to wildfire smoke in Coconino County.

## 2. Approach

Surveys are a useful approach for rapidly establishing a basic understanding of attitudes and opinions across a population. The survey instrument used in this study was developed to align with and expand existing research around wildfire and forest management smoke. Survey questions asked about: (1) actions taken in each home ignition zone on the respondent's Highlands Fire District property, (2) level of understanding related to the *Ready, Set, Go!* evacuation messaging system, (3) intended behaviors during a wildfire, (4) preferences for smoke management, (5) information access and use regarding smoke and low air quality, and (6) basic socio-demographic information.

The survey was administered to the property owner or renter for 2,738 addresses within the Highlands Fire District boundaries from October to November 2022. Materials were mailed to the tax address on file for each property, ensuring that second home owners received a copy at their primary address. Survey materials were delivered via two phases: (1) A survey packet, including introduction letter, a paper copy of the survey booklet, and a pre-paid business reply envelope, and (2) A reminder postcard, sent two weeks after the survey packet, with an online link to complete the survey if original materials had been misplaced. The Highlands Fire District also shared reminders via their social media pages on multiple occasions.

At the time of writing, a total of **558 completed survey responses were received for a 20.4% response rate**. This is in line with response rates for several other local survey efforts on public perspectives regarding wildfire in the Flagstaff area.

### 3. Survey findings

#### 3.1 Who responded to the survey?

Survey respondents identified as 54.3% male, 45.1% female, and 0.6% other, with an average age of 62 years old. The majority of respondents identify as white/Caucasian (90.6%), with 9.4% of respondents identifying as other ethnicities or races. Approximately 78.5% of respondents had earned a four-year degree or completed a higher level of education (e.g., a Masters or Doctorate degree). The majority of respondents (80.1%) reported a total annual household income of \$60,000 or more before taxes (the average Coconino County income level in the most recent U.S. Census was \$61,888). Almost all respondents (97.4%) owned their surveyed property; as a result, the perspectives of renters are likely underrepresented in our data. The average respondent purchased their current HFD property in 2005, although tenure ranged from as recent as 2022 when the survey was conducted all the way back to 1960. Approximately 59.7% of respondents were full time residents, with 40.3% reporting that they stayed for short periods of time or less than six months of the year.

Pre-existing health conditions may cause some residents to be more vulnerable to wildfire and its associated risks. More than half (50.2%) of survey respondents reported one or more members with a pre-existing health condition that is affected by low air quality lives in their household. The most common health conditions were asthma (23.4%), diabetes (10.9%), and heart disease (10.5%), followed by chronic obstructive pulmonary disease or COPD (5.4%) and bronchitis (4.9%). Approximately 12.1% of respondents reported that someone in their household has a disability. Most (94.9%) respondents reported that all members of their household had health insurance.

#### 3.2 Experiences with wildfire

Several survey questions explored respondents’ experience with wildfires. We found that:

- 87.1% of respondents are concerned about wildfire risk in the greater Flagstaff area
- 29.7% of respondents have evacuated from their home due to a **wildfire**
- 22.6% of respondents have evacuated from their home due to **low air quality caused by smoke**

#### 3.3 Property-level mitigation

Respondents were asked about the amount of work they had conducted in the three Home Ignition Zones around their property. First, we asked respondents to share the distance between their home and the nearest adjacent property line to determine how much space the respondent had to conduct work in. We received responses from 547 respondents:

**Table 1.** Distance between respondent's home and nearest property line.

Distance to nearest property line	Number of respondents	Percentage of respondents
Less than 30 feet (HIZ 1)	328	60.0%
30 to 100 feet (HIZ 2)	190	34.7%
101 to 200 feet (HIZ 3)	17	3.1%
More than 200 feet	12	2.2%

Participants were provided a diagram of the home ignition zones and asked to confirm whether they had conducted various activities in each area; overviews are provided in Table 2-4 below. The majority of respondents only had the capacity to conduct work in HIZ 1 and 2 given small lot sizes or close proximity of property lines to their residential structure. Tree removal appears to be the largest challenge for HFD respondents; many comments at the end of the survey booklet reported cost of removal as their largest barrier.

**Table 2: Home Ignition Zone 1: under 30 ft from structure; 547 respondents reported having space to do work in this Zone.**

<b>Action</b>	<b>Number of respondents</b>	<b>Percentage of respondents</b>
Removed trees less than 10 feet from your home	210	38.7%
Removed branches of trees lower than 10 feet from the ground	419	77.0%
Cleared or maintained a 30ft “green space” around your home	292	54.0%
Spaced trees or shrubs at least 10 feet apart	222	41.2%

**Table 3: Home Ignition Zone 2: 30 – 100 ft from structure; 219 respondents reported having space to do work in this Zone.**

<b>Action</b>	<b>Number of respondents</b>	<b>Percentage of respondents</b>
Removed/thinned trees and shrubs to reduce density of vegetation	151	68.9%
Removed branches of trees lower than 10 feet from the ground	169	77.2%
Maintained thinning of trees and shrubs performed more than 10 years ago	144	65.8%

**Table 4: Home Ignition Zone 3: 101 - 200 ft from structure; 29 respondents reported having space to do work in this Zone.**

<b>Action</b>	<b>Number of respondents</b>	<b>Percentage of respondents</b>
Removed/thinned trees and shrubs to reduce density of vegetation	14	48.3%
Maintained thinning of trees and shrubs performed more than 10 years ago	15	51.7%

### 3.4 Evacuation behaviors

The next section of the survey collected respondent data regarding their intended plans for evacuation during a fire event that threatened their HFD property. Respondents were asked to indicate how much they agreed or disagreed with a series of statements presenting different evacuation behaviors, shown below in Table 5.

**Table 5:** *Intended behaviors during a wildfire event that threatens the respondent’s HFD property. The most common response for each statement is bolded.*

	<b>Strongly disagree</b>	<b>Moderately disagree</b>	<b>Neither agree nor disagree</b>	<b>Moderately agree</b>	<b>Strongly agree</b>
I would remain at home and help defend my home by putting out spot fires	<b>44.6%</b>	23.4%	14.1%	12.7%	5.3%
I would evacuate as soon as I hear about a fire that may impact my property	8.2%	18.2%	18.0%	27.7%	<b>27.9%</b>
I would evacuate, but return soon after the fire to defend my property from threats	21.3 %	20.2%	19.1%	<b>26.0%</b>	13.3%
I would remain at home and safely shelter in my home without putting out spot fires	<b>78.4%</b>	16.2%	3.1%	1.3%	1.1%
I would wait to see how bad the wildfire is and evacuate if I think it is too dangerous	<b>38.0%</b>	23.0%	9.8%	20.7%	8.5%
Some members of this household would evacuate and others would remain to protect the property	<b>68.5%</b>	12.2%	8.4%	6.5%	4.4%
I would evacuate when the authorities tell me to do so	1.5%	4.0%	2.6%	14.2%	<b>77.8%</b>
I would attempt to suppress wildfires on properties neighboring my own	<b>33.3%</b>	15.1%	15.7%	22.3%	13.6%
My neighbors and I would work together to evacuate promptly	4.2%	4.4%	21.8%	32.7%	<b>36.9%</b>
My neighbors and I would work together to stay and defend our properties	<b>49.7 %</b>	22.8%	17.5%	6.7%	3.3%
I would assist professional fire fighters in their efforts to protect values at risk from wildfire	<b>24.5%</b>	14.7%	20.7%	23.1%	17.0%
I would travel to my Flagstaff-area property as quickly as possible to defend it	<b>47.6%</b>	17.9%	17.8%	9.3%	7.3%
I would remain on my Flagstaff-area property regardless of authorities’ evacuation orders	<b>80.4%</b>	11.2%	4.7%	1.6%	2.0%
I would not know what to do during a	<b>56.9%</b>	24.5%	9.1%	6.2%	3.3%

wildfire

The majority of respondents plan to evacuate from their HFD home, and intend to follow direction from professionals. There is significant interest in evacuating then returning shortly after the flame front passes; this may require additional planning related to road closures.

Coconino County uses the three-level *Ready, Set, Go!* (RSG) evacuation notification system during wildfire. Survey participants were provided with a description of the system and its levels, then asked a series of questions about its application during emergencies. Table 6 presents data collected about respondents’ understandings of the RSG system.

**Table 6:** *Intended behaviors during a wildfire event that threatens the respondent’s HFD property. The most common response for each statement is bolded.*

	<b>Strongly disagree</b>	<b>Moderately disagree</b>	<b>Neither agree nor disagree</b>	<b>Moderately agree</b>	<b>Strongly agree</b>
People expect to be notified by professionals about when to evacuate	1.4%	0.7%	1.3%	14.1%	<b>82.5%</b>
The RSG warning system for evacuation is clear	2.0%	3.1%	2.2%	23.3%	<b>69.4%</b>
The RSG warning system is the best way to ensure the safety of residents in my community	1.6%	2.2%	12.3%	30.9%	<b>53.0%</b>
The RSG warning system will not affect my plans during a wildfire	<b>58.1%</b>	20.3%	9.2%	5.7%	6.8%
Residents only need to evacuate if they are contacted as part of the RSG warning system	<b>30.2%</b>	<b>30.2%</b>	14.3%	13.9%	11.5%
All three levels of the RSG warning system will occur during wildfires	<b>28.0%</b>	16.9%	21.1%	12.5%	21.5%
I know how I would be contacted about evacuation using the RSG system	8.0%	15.2%	12.1%	27.1%	<b>37.6%</b>

It is likely that many respondents had first-hand experience with the RSG system a year prior to this survey in 2021 during the Rafael Fire. The vast majority of respondents expect to be told by professionals to evacuate, and a subset of respondents only plan to evacuate if contacted using the RSG system. A substantial number of respondents believe that all three stages of the RSG system will occur during evacuation, and a small number do not know how they would be contacted; this suggests there may be a need for additional education about how the RSG



system is put into practice, rather than a more traditional evacuation education focus on explaining what the three stages mean.

Respondents were also asked about different cues that might trigger their evacuation process outside of the RSG system (Table 7). Health impacts, followed by visual cues such as seeing the fire and reductions in air quality are most influential on self-evacuation.

**Table 7:** Role of different cues in decision making about whether to evacuate from the HFD area. Most common responses are indicated in bold.

I would consider evacuating once...	Strongly disagree	Moderately disagree	Neither agree nor disagree	Moderately agree	Strongly agree
I learn about a wildfire in my area	12.9%	18.7%	19.9%	<b>28.6%</b>	19.9%
Embers or ash start falling in my area	5.8%	15.2%	10.5%	26.9%	<b>41.7%</b>
I can see flames from my house	1.5%	4.8%	6.4%	17.8%	<b>69.6%</b>
Air quality inside my house has visibly decreased	2.2%	6.4%	11.6%	27.2%	<b>52.6%</b>
Visibility has noticeably declined in my area	5.1%	12.5%	15.6%	<b>34.9%</b>	32.0%
I or others in my household begin to feel unwell	1.5%	2.2%	3.8%	21.4%	<b>71.1%</b>
Road closures are introduced in my area due to low visibility	2.4%	4.2%	10.7%	27.2%	<b>55.5%</b>

### 3.5 Smoke impacts to households

A series of questions asked about experiences with smoke specifically. Smoke was a concern for many respondents who participated in this survey. Awareness of smoke in the area was moderate, but when it was present respondents felt they were well informed about its source.

- 33.2% of respondents reported that they often see smoke in the Flagstaff area. Full-time respondents are more than three times as likely to report seeing smoke in the Flagstaff area compared to part-time respondents
- 54.8% of respondents disagreed that “residents have a say in decisions related to smoke in this area”
- 33.3% of respondents stated that they want to be more involved in local decision-making about smoke

In order to understand how households respond to smoke, baseline data on impacts from smoke events to date were collected. Approximately 24.6% of respondents reported that their health had previously been affected by low air quality. The most common source of health-impacting smoke was wildfire (16.5% of respondents), followed by prescribed fire (9.8%) and managed fire (6.9%). Slash pile burning (6.3%) and other sources of low air quality (8.2%) such as urban smog were also reported as caused of previous health issues.

Respondents were invited to report whether they had experienced a broad range of impacts associated with low air quality from smoke that have affected their day-to-day activities. Responses were not limited to experiences documented while living in the HFD area – it could also include impacts experienced at a prior residence or job. Only 33.6% of respondents reported impacts from previous smoke experiences; the most common were disruption to daily routines (32.6%), with all others rarely reported. Those included financial loss because of smoke (1.6%) and missing work or losing income because of smoke (2.7%). Full time residents were typically at least twice as likely to have reported all of these smoke impacts.

### *3.6 Access to smoke-related information*

Access to information about potential smoke events like prescribed fire or slash pile burning, reporting on smoke sources, and smoke forecasting (e.g., duration and changes in air quality) are critical for households looking to take action to mitigate low air quality from smoke. Survey respondents generally felt that they were well informed about the source of smoke, with 74.1% of respondents agreeing that they know why there is smoke in the Flagstaff area when it is present. Additionally, 52.1% of respondents agreed with the statement “It is easy to find information about air quality in the area.”

Respondents were asked to indicate where they access information about smoke in HFD and the surrounding area, and the extent to which they found that source trustworthy or untrustworthy. Responses are summarized in Table 8. Local Fire Departments, Coconino County, and the US Forest Service were identified as the most trustworthy sources. Notably, fewer respondents used Environmental Protection Agency and Arizona Department of Environmental Quality as information sources, which would include AirNow and other related national and state-level air quality reporting tools.

Respondents were also asked about their interest in a range of resources that could improve access to information about air quality related to smoke. Findings are summarized in Table 9. The most sought-after resource was an email or text messaging alert system that rapidly communicated a predicted decline in air quality, followed closely by a website or app that could communicate whether air quality is unhealthy. Data gathered from this question highlight a low awareness of existing resources; for example, numerous apps and websites already exist that document air quality in real time, but only 24.4% of respondents state that they already had access to that resource.

**Table 8:** Respondent identification of trustworthy and untrustworthy information sources on air quality. Most frequent responses are indicated in bold.

Information source	Very untrustworthy	Somewhat untrustworthy	Neither trustworthy or untrustworthy	Somewhat trustworthy	Very trustworthy	I do not use this source
Local Fire department	2.1%	2.1%	4.7%	11.5%	<b>71.8%</b>	7.8%
Coconino County	2.9%	2.5%	7.0%	19.8%	<b>62.1%</b>	5.7%
U.S. Forest Service	2.9%	2.7%	6.6%	16.8%	<b>61.5%</b>	9.6%
Arizona Department of Environmental Quality	3.4%	3.4%	9.2%	19.5%	<b>48.6%</b>	15.9%
Arizona Department of Forestry and Fire Management	3.1%	2.5%	9.8%	17.5%	<b>50.1%</b>	17.0%
U.S Environmental Protection Agency	5.5%	7.6%	15.8%	14.5%	<b>36.1%</b>	20.4%
My healthcare provider	4.4%	4.0%	25.9%	11.7%	<b>28.5%</b>	25.5%
My health insurance company	9.8%	11.9%	<b>29.6%</b>	9.8%	10.0%	28.8%
My neighbors, friends, or family	3.4%	6.7%	<b>28.4%</b>	27.2%	23.0%	11.3%

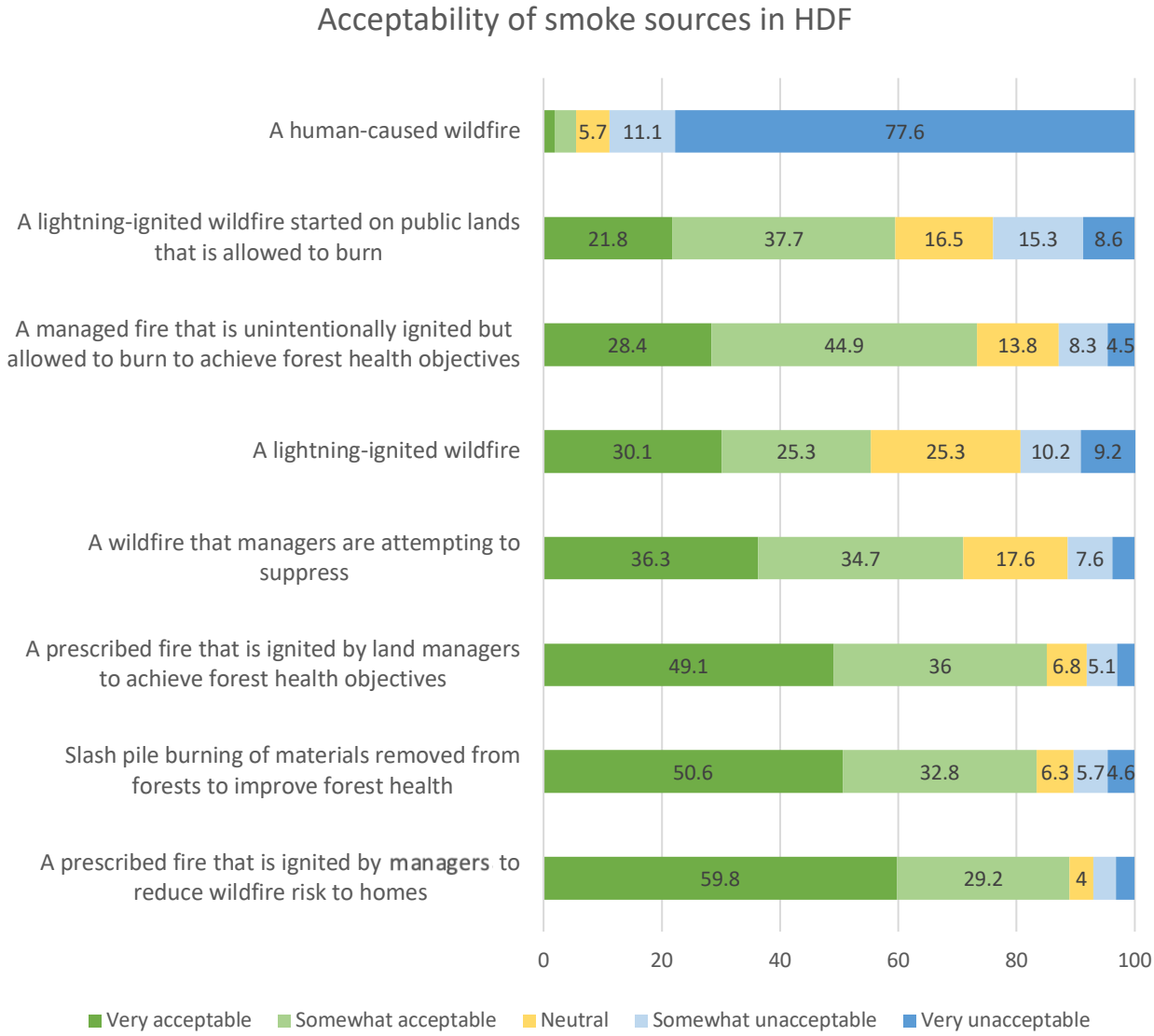
**Table 9:** Respondent interest in different resources providing information on local air quality

Resource	I would be interested	I would not be interested	I already have access to this resource
A website or app that indicates when air quality is unhealthy	66.8%	8.8%	24.4%
Educational materials about air quality	40.2%	34.4%	25.4%
A household assessment conducted by an expert with recommendations for improving air quality	27.0%	66.9%	6.1%
Open house or listening sessions with local fire professionals about smoke	41.8%	53.8%	4.4%
Opportunities to ask questions about forest and fire management to land managers	48.7%	42.6%	8.7%
An email or text messaging alert system to let me know when air quality is about to decline	83.1%	9.1%	7.8%

### 3.7 Influence of smoke source

Respondents were asked several questions related to different sources of smoke in their area. The survey instrument included definitions for four terms: wildfire, prescribed fire, managed fire, and slash pile burning. This ensured that all participants were familiar with the language used in the survey before responding to questions that included these terms.

Respondents were asked to indicate how acceptable or unacceptable they found smoke originating from different fire ignition sources (Figure 1). Prescribed fires were consistently reported to be the most acceptable source of smoke in and around the HDF, followed by slash pile burning. Human-caused wildfires were the least accepted by a significant margin; more than 88% of respondents found this source of smoke unacceptable.



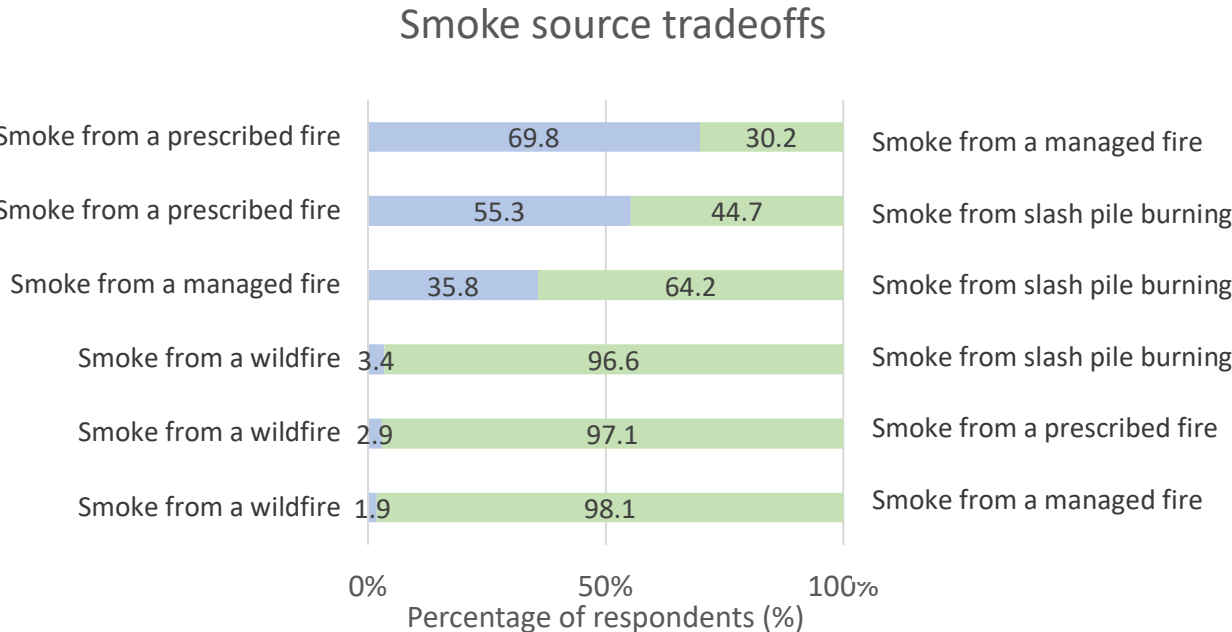
**Figure 1:** Acceptability of smoke caused by different sources of fire ignition.

Survey respondents were also asked to estimate how many days of unhealthy air quality they could tolerate from different smoke sources before it became an issue for themselves or other members of their household. The average response in days is shown in Table 10. There was little variation in tolerance from different sources, although wildfires were reported as most tolerable, and slash pile burning as least.

**Table 10:** Average number of days survey respondents could tolerate unhealthy levels of smoke from different fire sources.

I could tolerate unhealthy levels of smoke from...	Mean # days	Standard deviation
A wildfire for	5.6 days	7.4
A prescribed fire for	5.3 days	7.8
A managed fire for	5.1 days	6.2
Slash pile burning for	4.9 days	6.9

Finally, respondents were asked to make decisions about management tradeoffs between different smoke sources (Figure 2). Prescribed fire was most consistently indicated as a preferable source of smoke, while smoke from a wildfire was consistently identified as least desirable.

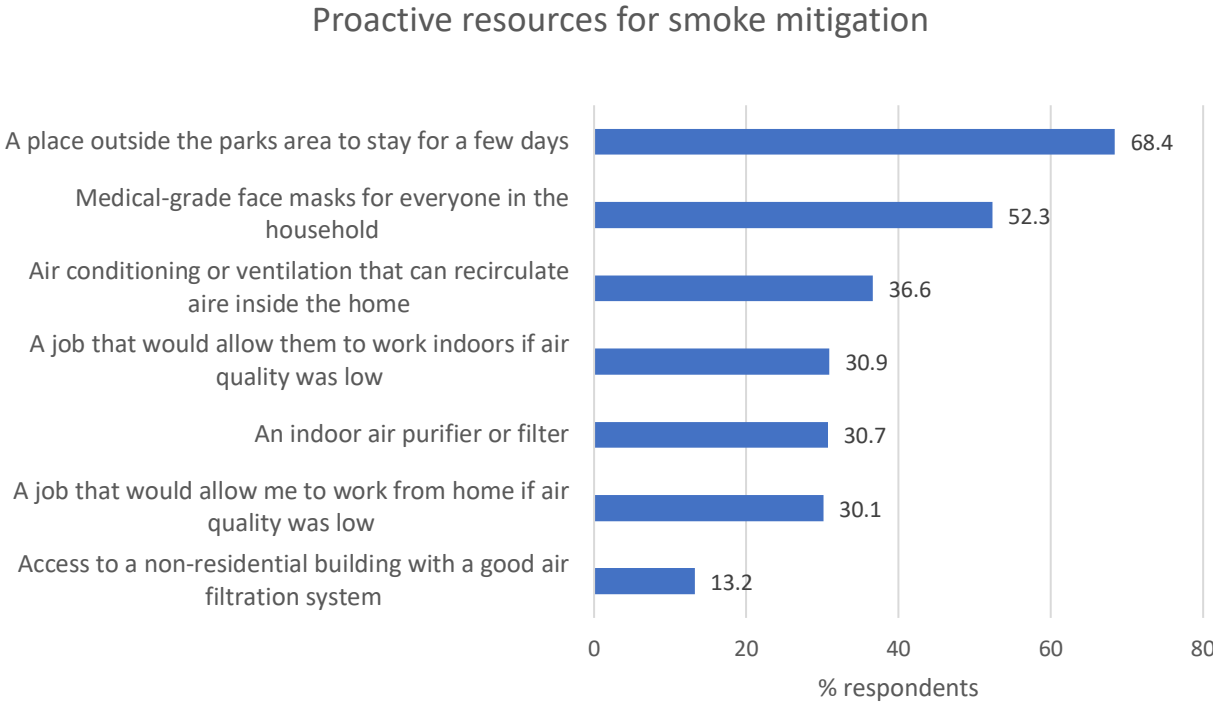


**Figure 2:** Smoke source tradeoffs presented to survey respondents. Percentages indicate how many respondents preferred each option within a given tradeoff pairing.

Survey respondents were also asked about desirability of tradeoffs that compared prescribed fire against management techniques that did not produce smoke, including mastication, hand thinning, grazing, and commercial timber sales. In each of these tradeoffs, prescribed fire was the preferred management strategy for no more than 29% of respondents. This indicates that although there is some level of tolerance for smoke in the HFD area, survey respondents consistently support non-smoke producing alternatives wherever possible.

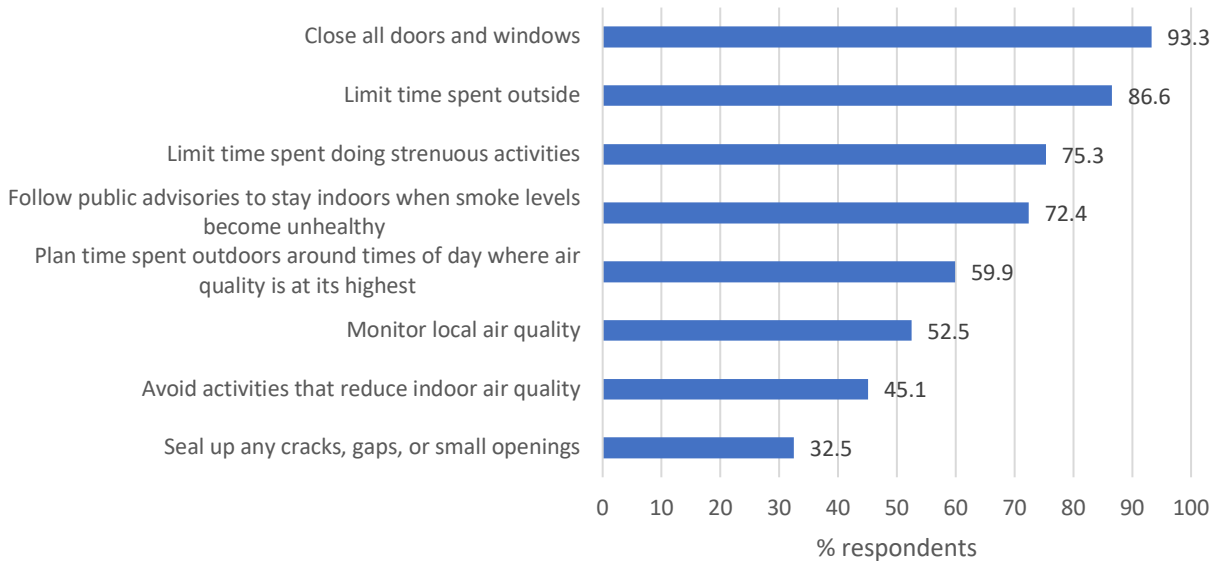
**3.8 Current smoke adaptation efforts**

One core goal of this study was to understand what adaptive actions residents are already taking to address smoke consequences at the household level. We provided respondents with two lists of potential smoke risk mitigation actions: one list focused on proactive actions respondents may have already taken ahead of future low air quality events (Figure 3), and a second list focused on actions they might take in response to low air quality (Figure 4). The majority of respondents reporting that they had somewhere they could stay outside the Flagstaff area were part-time residents.



**Figure 3:** Number of respondents who reported having access to proactive smoke mitigation actions.

### Smoke mitigation activities during a fire



**Figure 4:** Number of respondents who reported planning to undertake reactive mitigation activities to address smoke events.

The survey also asked respondents a series of questions related to their capacity to improve air quality during smoke events for their household. Approximately 62% of respondents felt they had the information they needed to make decisions related to air quality, and 55.7% agreed that they knew how they could improve air quality in their home. Affordability of these actions was a substantial barrier; only 28.3% of respondents agreed that actions to improve air quality in their home were affordable, and 33.7% of respondents agreed that smoke was infrequent enough in the area that investment in actions to improve air quality were not necessary.

### 3.9 Smoke adaptation programs

Survey respondents were provided with descriptions of two programs that are being used elsewhere in the US to improve access to clean air during smoke events:

- **Clean air spaces**, which are designated public buildings with high-quality air filtering systems that residents can use when air quality is low.
- **Air purifier programs**, which focus on the provision of high-quality HEPA indoor air filtration devices for households to use during periods of low air quality.

Approximately 40.6% of respondents were interested in accessing a clean air space if one were available to them. All interested respondents stated that they had their own transportation to a clean air space if one were set up and were willing to travel around 25 miles on average to access that space.

A further 47.1% of respondents were interested in participating in an air purifier distribution program if one were made available. Air purifier programs can operate under several structures, ranging from permanent donations of units to cost-shares for households purchasing units. HFD respondents were most interested in access to a “library” style program where they could check filters out as needed.

#### 4. Takeaways

Below we share key findings and recommendations for organizations, land management agencies, and governments planning to manage wildfires or conduct forest management activities that involve smoke production in the HFD area:

- **Financial support for tree removal would likely make the largest difference to HIZ mitigation** in HDF; most properties are small, and affordability of tree removal was repeatedly reported as a barrier.
- **The majority of HFD residents intend to evacuate during a wildfire**; however, many respondents indicated that they would evacuate immediately upon hearing of a fire that threatened their area, but there was little evidence of this behavior during the 2021 Rafael Fire which indicates that there may be a disconnect between what residents believe they would do in theory and in practice.
- Familiarity and trust in the *Ready, Set, Go!* (RSG) evacuation system is high; however, many survey respondents indicated that they expect to be told by an official when to evacuate. Furthermore, some believe that they need only evacuate if they are contacted via the RSG system, but a portion of respondents were not clear how RSG information would be communicated to them. A substantial portion also believe all three phases of the RSG system will occur during a fire. Collectively, this suggests that **education about what each stage of the RSG system entails has been widely successful, but additional practical information regarding its implementation is missing.**
- HFD residents are interested in opportunities for face-to-face interactions with managers making forest management and fire decisions. **Open houses, public meetings, and listening sessions would likely be well attended** if they were held, based on responses to this survey.
- **Full-time residents face higher levels of smoke exposure compared to part time residents**; the latter are more likely to be able to relocate or avoid the area during a wildfire or smoke event.
- **Almost half of survey respondents expressed interest in a HEPA air purifier program**; operation of a HEPA filter loan program out of the HDF station on Old Munds Highway could help minimize impacts from smoke to the most vulnerable members of surrounding communities while building greater support for fire and forest management efforts that produce smoke.
- **Residents are interested in accessing information related to smoke and air quality, but do not have a clear idea of where to access this content.** Communication of key apps, web pages, and other materials via fliers or social media posts could help provide residents with trustworthy sources for smoke information.