

# REVIEW OF THE MENTAL HEALTH EFFECTS OF WILDFIRE SMOKE, SOLASTALGIA, AND NON-TRADITIONAL FIREFIGHTERS

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# A. INTRODUCTION

In 2019, the National Academy of Sciences, Engineering, and Medicine held a workshop on “Public Health Implications of the California Wildfires for Health, Communities, and Preparedness”, sponsored by the Roundtable on the Promotion of Health Equity, the Roundtable on Environmental Health Sciences, Research, and Medicine, and the Forum on Medical and Public Health Preparedness. Workshop participants expressed the concern that mental health effects of wildfires are under-appreciated and under-researched. In response, the National Academies selected three mental health issues for further exploration: wildfire smoke, solastalgia, and non-traditional firefighters. This narrative review was conducted to identify possible National Academy of Sciences, Engineering, and Medicine activities for the future.

# B. BACKGROUND



Climate change is leading to increased frequency, duration and severity of wildfires, with longer fire seasons too. The smoke can extend for weeks and months over populations distant from the site of the fires. The 2019-2020 fire season in Australia and 2020 season in California produced wildfire smoke for several months. The population mental health effects of urban fine particulate air pollution (PM2.5 and PM10) from industrial and motor vehicle emissions is documented and wildfires may have similar or different toxicities (van den Bosch, 20019; Wegesser, 2009; Hanigan, 2008). Understanding the mental health effects of wildfire smoke is crucial as the world enters a time in which wildfire smoke events are prolonged events.

Another under-explored topic is solastalgia. Albrecht coined the term ‘solastalgia’ describing the place-based distress people feel when environments and landscapes are transformed (but not necessarily lost) due to such occurrences as environmental degradations and droughts (Albrecht, 2005). The concept has since been extended to wildfires and other land transformations. It is a breakdown of the normal relationships individuals have with their identity and home, the loss of solace they experience, while instilling a sense of powerlessness. Albrecht

postulated this lived experience of pain from lack of solace due to transformation of the environment can escalate from generalized distress to serious health and problems including physical and mental illness and drug abuse.

After a wildfire, residents who return home to a devastated landscape face, in addition to the financial, health and social stresses of rebuilding homes and community, face an ever-present reminder through sight of their trauma. Fires leave visual reminders of a drastically altered landscape in an area chosen by its residents for the benefits of living surrounded by natural beauty. The daily reminder of that loss occurs leads to solastalgia, a form of mental or existential distress caused by environmental change, increasingly referenced in light of global climate change. What are the mental health effects associated with solastalgia after wildfires?

Our final, under-explored topic is the mental health of non-traditional firefighters, of which we identified two types. The first group is residents who do not evacuate during a fire and instead stay to protect their homes and maybe other homes in the community during a wildfire. This is sometimes called "stay and defend".

McCaffrey reported that 11.3% of 759 persons who had experienced a wildland fire in the past three years had stayed behind to protect their property and fight the fire (McCaffrey, 2018). Jensen's study of the Woolsey Fire 2018 notes that Malibu residents reported generations of residents staying and defending including local fire services training residents until the 1980s (Jensen, 2020). Federal fire frameworks in 2009 endorsed homeowners should have an option to stay and defend their homes though this was abandoned after the 2009 Australia Black Saturday Bushfires, with 173 fire-related deaths led to discouraging "stay and defend" practices. Still, Jensen's team estimated that at least 60 residents stayed behind in the Malibu-Woolsey fire in 2018.

Another group of non-traditional firefighters is prison inmates who work on wildfires as temporary, adjunct fire-fighters. Inmates work and train as wildland firefighters in nine states (Purdum, 2020). The state of California has used inmate firefighters for more than 80 years and the current program, called Conservation Camp program, is operated by the California Department of Corrections and Rehabilitation, Cal Fire and the Los Angeles County Fire Department. Together they operate 43 fire camps across 27 counties. Prisoners earn a two-day sentence reduction for every day worked fighting fires (known as "2-for-1 credits"). Currently, approximately 1,800 incarcerated persons work at fire camps in California and there have been documented injuries and deaths.

These two groups of non-traditional firefighters--residents who stay and defend and prison inmate firefighters-- are not professionally trained in coping with the lingering effects of trauma, and are not systematically supported by mental health services after a fire. Given that studies of wildland firefighters find 10-20% report post-traumatic stress symptoms, this is a gap (Fullerton, 2004).

### **Focus of the Report:**

**Given the increased incidence and severity of wildfires in the US and elsewhere, exploring the mental health and equity dimensions is timely. In order to identify topics for the National Academies of Science, Engineering and Medicine to address in the future, we reviewed the literature on three mental health issues: wildfire smoke, solastalgia, and non-traditional firefighters.**



# C. METHODS

This narrative review was complemented by a systematic search. Librarians at the National Academies of Science, Engineering, and Medicine conducted a literature search using Google, Scopus, PubMed, Medline, Embase and ProQuest Research Library from 1990-2020 to identify scientific papers, journal articles, book chapters, and reports related to three topics under mental health and wildfire:

1

Mental health impacts of wildfire smoke

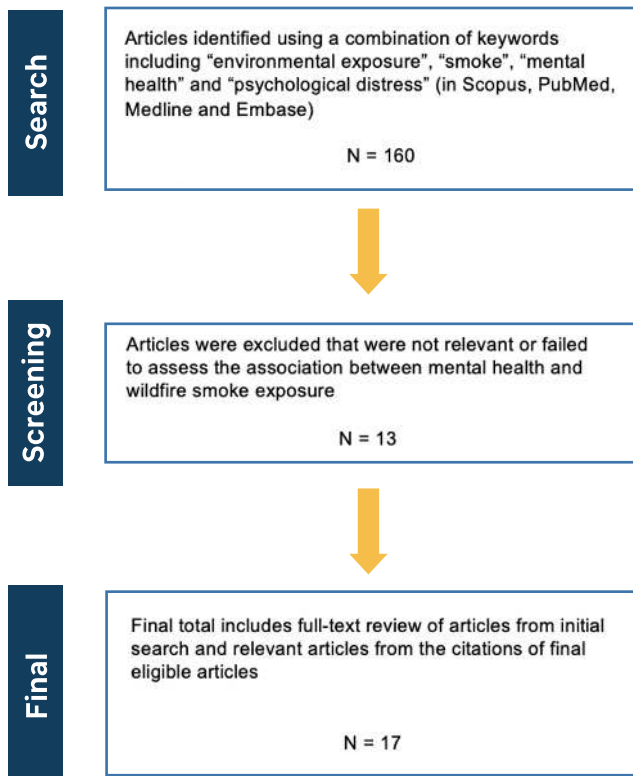
2

Mental health impacts upon returning to a burned-out landscape and solastalgia

3

Mental health impacts of wildfire on inmate and civilian firefighters.

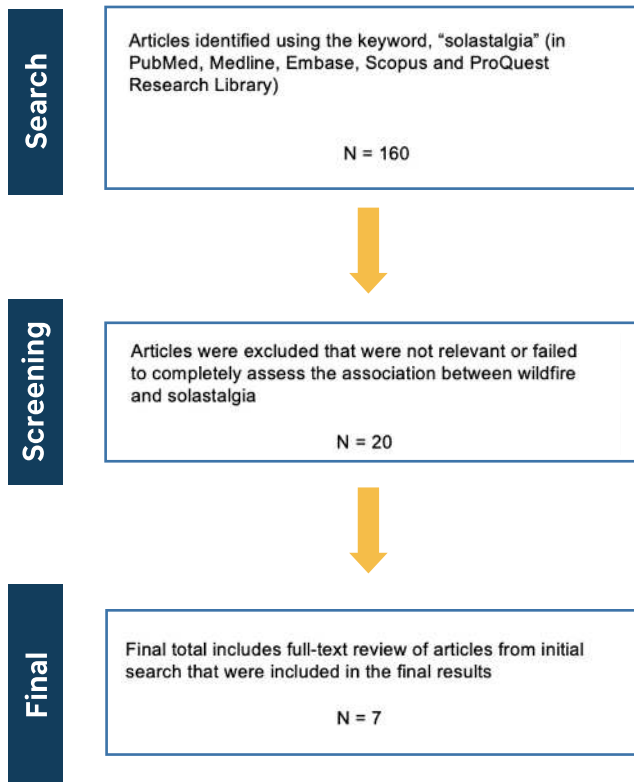
## Mental Health Impacts of Wildfire Smoke



The search was limited to studies in English language. Articles were screened for relevance to the topics. We removed articles that did not address the association between mental health and one of the three topics of the review. In all cases, we searched the citations of final eligible articles to ensure the inclusion of all the relevant articles. Lastly, we contacted experts to locate unpublished reports from the gray literature. All evaluation of results from these studies is based on authors' interpretation of the reported findings in each paper.

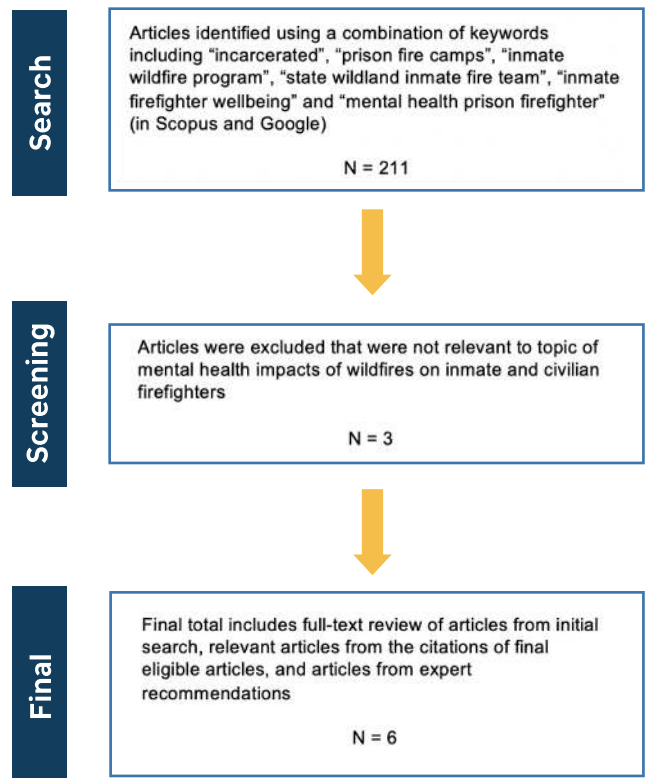
On the topic of mental health impacts of wildfire smoke, the search was conducted using a combination of multiple keywords including "environmental exposure", "smoke", "mental health", "depression", "anxiety", "psychological symptoms", and "psychological distress". This literature search yielded a total of 160 articles. We identified 13 studies for a full-text review and added 4 more studies from the bibliographies of the reviewed articles for a total of 17.

## Mental Health Impacts upon returning to a burned-out landscape (solastalgia)



On the topic of mental health impacts upon returning to a burned-out landscape, the search was conducted using the keyword, "solastalgia". This literature search yielded a total of 160 articles and we reviewed 20 studies and included 7 in the final results.

## Mental Health Impacts of Wildfires on Inmate and Civilian Firefighters



On the topic of mental health impacts of wildfires on inmate and civilian firefighters, the search was conducted using a combination of multiple keywords including "civilian", "non-traditional", "incarcerated", "prison fire camps", "inmate wildfire program", "state wildland inmate fire team", "inmate firefighter wellbeing" and "mental health prison firefighter". This literature search yielded a total of 211 articles. We reviewed 3 studies and their bibliographies and spoke with an expert on the topic thereby identifying and reviewing 3 more for a total of 6.

# D. RESULTS

## 1. Mental Health Impacts of Wildfire Smoke

We reviewed nine quantitative studies (see Table 1). Only two quantitative studies explicitly focus on associations in the short-term between smoke exposure and mental health. Moore studied the relationship between short-term increases in PM<sub>2.5</sub> and PM<sub>10</sub> due to wildfires in British Columbia and physician office visits for specific disease categories (Moore, 2006). There was an association between forest fire smoke and increased weekly rates of physician visits for respiratory complaints but no observed increased rates for cardiovascular health effects or mental illnesses.

In a study of wildland smoke exposure in six affected California counties, Duclos compared emergency room visits during the fire to two reference periods (a year before and two weeks before the fire) (Duclos, 1990). There was a statistically significant increase in visits for asthma, COPD and other respiratory conditions such as laryngitis but the increase in mental health conditions was not statistically significant ( $p=0.4$ ). Smoke exposure was not specifically addressed in the medical record abstraction and air monitoring could not be reliably quantified for the exposed counties.

A study by Caamano-Isorna on respiratory and mental health effects due to August 2006 Galicia wildfires compared the number of fires in a region to prescriptions for drugs for obstructive airway diseases and anxiolytics-hypnotics (Caamano-Isorna, 2011). Though the study showed a significant increase in anxiolytics-hypnotics use for male non-pensioners and male pensioners from exposed municipalities it did not assess smoke exposure independently of fire exposure or other experiences.

Studies that have focused on haze caused by forest fires and burning of tropical peatland in Indonesia do report some associations as well as improve our understanding of any underlying mechanisms. De Pretto's survey in Malaysia found 70% of persons surveyed reported sadness in response to haze conditions (De Pretto, 2015).

Ho recruited 298 participants in a snowball sample who experienced short-term exposure to haze caused by forest fires in Indonesia to inquire about acute psychological symptoms of their short-term exposure (Ho, 2014). Participants were mainly students aged 18-29 years old. Ho's findings suggest that a haze crisis is associated with acute physical symptoms and mild psychological stress; The total on the Impact of Events Scale-Revised (IES-R) score was 18.47 (S.D. = 11.69) consistent with mild psychological stress (intrusion symptoms, hyper-arousal symptoms) but below the threshold of acute stress reaction syndrome at a score of 33. Physical symptoms from the haze and perceived danger of the haze's pollution were associated with greater levels of hyper-arousal (irritability, insomnia, poor concentration) and intrusion symptoms (recurrent thinking, dreams).

Tan concluded that haze may cause mild cerebral vasodilation that contributes to psychosomatic symptoms experienced by symptomatic residents (Tan, 2019). Study participants exposed to haze, and who had greater measures of cerebral vasodilation in response reported more "psychosomatic symptoms" (sore throat, nausea, anxiety, insomnia, poor appetite, headache, neck stiffness, cough, sputum, breathlessness, runny nose, joint pain, rash, lethargy, itching and watery eyes).

Two studies employing a trauma mental health framework include smoke exposure as a predictor variable. McDermott conducted a study on posttraumatic stress disorder and general psychopathology in children and adolescents following a wildfire disaster (McDermott, 2005). Children and Adolescents who saw smoke scored significantly higher on components of the Strengths and Difficulties Questionnaire, which the authors say shows that proximity and the perceived threat of fire were factors that affect stress and emotional well-being.



Similarly, in a survey of evacuees of a 2003 Southern California wildland fire, difficulty breathing due to smoke or ashes along with house or property damage and physical injury to self or loved one were predictors of a probable PTSD or major depression diagnosis (Marshall, 2007). After adjusting for demographic characteristics, difficulty breathing due to smoke exposure was no longer a predictor of probable mental health diagnosis.

Reid and colleagues published a review in 2016 of studies of studies of wildfire smoke exposure on mortality and on respiratory, cardiovascular, mental, and perinatal health (Reid, 2016). Studies that were reviewed were assessed for risk of bias based on considerations of sample size, study exposure assessment methods, controlling for potential confounding factors, and use of objective outcome measures. They found six studies that investigated the association between wildfire smoke exposure and objective mental health impacts. Two were included in their review; the Moore study that found no increase in physician visits for mental illness during the 2003 wildfire season in British Columbia (Moore, 2006) and the Duclos study that found no increase in mental health emergency room visits during the 1987 California fires (Duclos, 1990). Four were deemed to have higher potential for bias (Ho, 2014; McDermott, 2005; Marshall, 2007; Caamano-Isorna, 2011).



**Table 1. Quantitative Studies of the Mental Health Effects of Wildfire Smoke**

Source	Study Design	Summary of Result
<b>Moore, 2006</b>	Analysis of Canadian physician billing data comparing weekly visits before and after forest fires according to daily three-day averages of particulate matter	No association found for increases in visits for mental illnesses.
<b>Duclos, 1990</b>	California emergency room data reviewed for 2 <sup>1</sup> / <sub>2</sub> week period from the first day of forest fires compared to reference periods	Non-significant increase in mental health diagnoses.
<b>Caamano-Isorna, 2011</b>	Analysis of Galicia, Spain pharmacy database	More anxiolytic prescriptions associated with medium number of wildfires.
<b>De Pretto, 2015</b>	Cross-sectional survey of Malaysian citizens	70% reported sadness in response to haze conditions.
<b>Ho, 2014</b>	Survey of Singapore citizens	Short-term exposure to haze associated with mild psychological disturbances.
<b>Tan, 2019</b>	Experimental study of blood flow in cerebral arteries in the presence and absence of 30 mins of haze, Singapore	Participants who developed new psychosomatic symptoms during haze exposure showed mild cerebral vasodilation and asymptomatic participants did not.
<b>McDermott, 2005</b>	Students screened for psychological symptoms post-fire, Australia	Higher psychological symptom scores for children who saw smoke, thought self might die, family might die, home damage and lived elsewhere.
<b>Marshall, 2007</b>	Survey, 3 months post-fire	Difficulty breathing due to smoke exposure associated with probable PTSD or depression in bivariate but not multivariate analyses.
<b>Reid, 2016</b>	Literature review of studies of wildfire smoke exposure on mortality, respiratory, cardiovascular, mental and perinatal morbidities.	Six studies investigated association between wildfire smoke exposure and mental health. Four deemed to have potential for bias (Caamano-Isorna, Marshall, Ho, McDermott) and two found no increase in physician visit and hospitalizations for mental health illnesses (Duclos, Moore).

**Table 2. Qualitative Studies of the Mental Health Effects of Wildfire Smoke**

Source	Study Design	Summary of Result
<b>Mottershead, 2020</b>	Semi-structured interviews with First Nations community, Canada	Feelings of frustration, isolation, stress and depression.
<b>Dodd, 2018</b>	Semi-structured interviews with residents affected by prolonged smoke event from wildfires	Feelings of fear, stress and uncertainty. Disruption in activities and lack of physical activity from prolonged smoke. Isolation, loss of food gathering, and alteration of traditional summer activities.
<b>Hazelwood Mine Fire Inquiry, 2014</b>	Report generated after Hazelwood Coal Mine Fire, Australia	Community members report anxiety, depression, concern about smoke and ash, fear of leaving home, stress from disrupted family life, loss of enjoyment of neighborhood and concerns of increased risk in family violence and effects on young children.
<b>Berger, 2018</b>	Semi-structured interviews with staff at school for youth affected by Hazelwood Mine Fire	Heightened anxiety among students due to relocation as well as increase in frustration, stress and violence in their homes.
<b>Christianson, 2019</b>	Semi-structured interviews with evacuation affected members of Whitefish Lake First Nation	Recurring negative thoughts seeing and smelling smoke.
<b>Engebretson, 2016</b>	Mail-in surveys to residents in areas where wildfires occur near national forests or forecasted increase in wildfire activity	People who had experienced personal health effects from smoke in the past reported themselves as less tolerant of smoke.
<b>Vincent, 2018</b>	Literature review for studies of firefighters' sleep quantity and quality and effect on safety, mental and physical health, physical task performance, physical activity and cognitive performance.	Sleep is impaired during deployment for several reasons, including smoke, which can impair cognitive performance.
<b>Camilleri, 2010</b>	Mail-in surveys and subsequent interviews with adults at Bushfire Recovery Centre following Canberra Bushfires	Feeling at-risk or on-guard when seeing or smelling smoke.

We reviewed qualitative studies to gain a deeper understanding of the myriad ways that smoke may affect mental well-being and to map the types of outcomes beyond clinical diagnostic categories (see Table 2).

Qualitative studies of Indigenous communities in Canada provide intriguing insights into how long periods of smoke events may affect mental health. Mottershead studied the Dene Tha' First Nation evacuation of their northwestern Alberta, Canada community for 7 days in 2012 due to wildfire smoke. They reported that the experience of evacuation and being confined indoors due to wildfire smoke created emotional complications including feelings of frustration, isolation, stress and depression for residents while they awaited updates and for the fire to be contained. (Mottershead 2020).

Dodd's study examined the impact of prolonged smoke events on mental and emotional well-being due to wildfires throughout the summer of 2014 in the Canadian Northwest Territories (Dodd). His team found that the persistent smoke had an effect on mental and emotional health. The majority of those interviewed reported "a direct connection between the wildfires and smoke and a decrease in their mental and emotional health." Fear, stress, isolation, and uncertainty were frequently expressed. Being confined to home leads to isolation from community and family which leads to loneliness, stress and anxiety. Persons who depended on the forest for supplementing their food experienced food insecurity. Some residents had to leave the community altogether because of respiratory symptoms. Lack of outdoor physical activity was a mental health stressor and the physical symptoms of smoke exposure impeded such activities. The title of the paper, "Lost summer", describes succinctly the emotional toll of being separated from the land, environment, outdoor activities, food sources and livelihoods.

*It was the lost summer...the attachment to the land and place, what it does, and when you get alienated, you know, from that place...it takes a deep, emotional toll, if not a spiritual toll.*

As another respondent said:

*It was like we didn't have a summer, for me, because, usually we get outside, we do things on the water...we enjoy being in the North. We enjoy being outside. We enjoy the environment. We enjoy cooking. Everything that's outside, we enjoy, and, I feel like I lost that...that impacts you emotionally and mentally.*

The Hazelwood Mine Fire Inquiry generated a report after a 45 day long mine fire sparked by a nearby bushfire led to persistently elevated air pollution and dramatic, thick plumes of ash and smoke covering nearby towns (Hazelwood Mine Fire Inquiry, 2014). Families had to move away or endure it by wearing masks and staying indoors. Schools relocated and businesses closed down. The assessment of psychological impacts stated;

*Many community members have developed levels of anxiety and depression, which they attribute to the mine fire. Issues raised by community members at community consultations included concern about evident smoke and ash and the generally unpleasant environment during the mine fire, and also the unknown long-term impact of the mine fire to their health. A number of individuals advised that they were afraid to leave their home for the period of time that the mine fire was burning. Many residents also suffered anxiety and stress from disrupted family life, the loss of enjoyment of their home and neighbourhood, the smell in the air, and because they could not go outside.... The Board also heard evidence about the broader social effects of the Hazelwood mine fire. Concerns were expressed during community consultations about the potential for an increase in family violence in the short to medium-term as a result of stress caused by the mine fire. Professor Campbell advised the Board that the whole community, especially young children, are at risk of psychosocial impacts as a result of the emergency, including an increased risk of family violence, drug and alcohol abuse, depression and anxiety, post-traumatic stress disorders and phobias. (Part 4, page 318).*



Additionally, Berger's phenomenological analysis of school relocation due to the Hazelwood Mine Fire supports the report's findings and describes elevated anxiety among students and increases in stress and violence in the home. (Berger, 2018)

Several studies describe how persons experiencing wildfire events had recurring negative thoughts about their experiences when confronted with reminders like the smell of smoke and images of smoke (Berger, 2018; Christianson, 2019; McDermott, 2015; Camilleri, 2010).

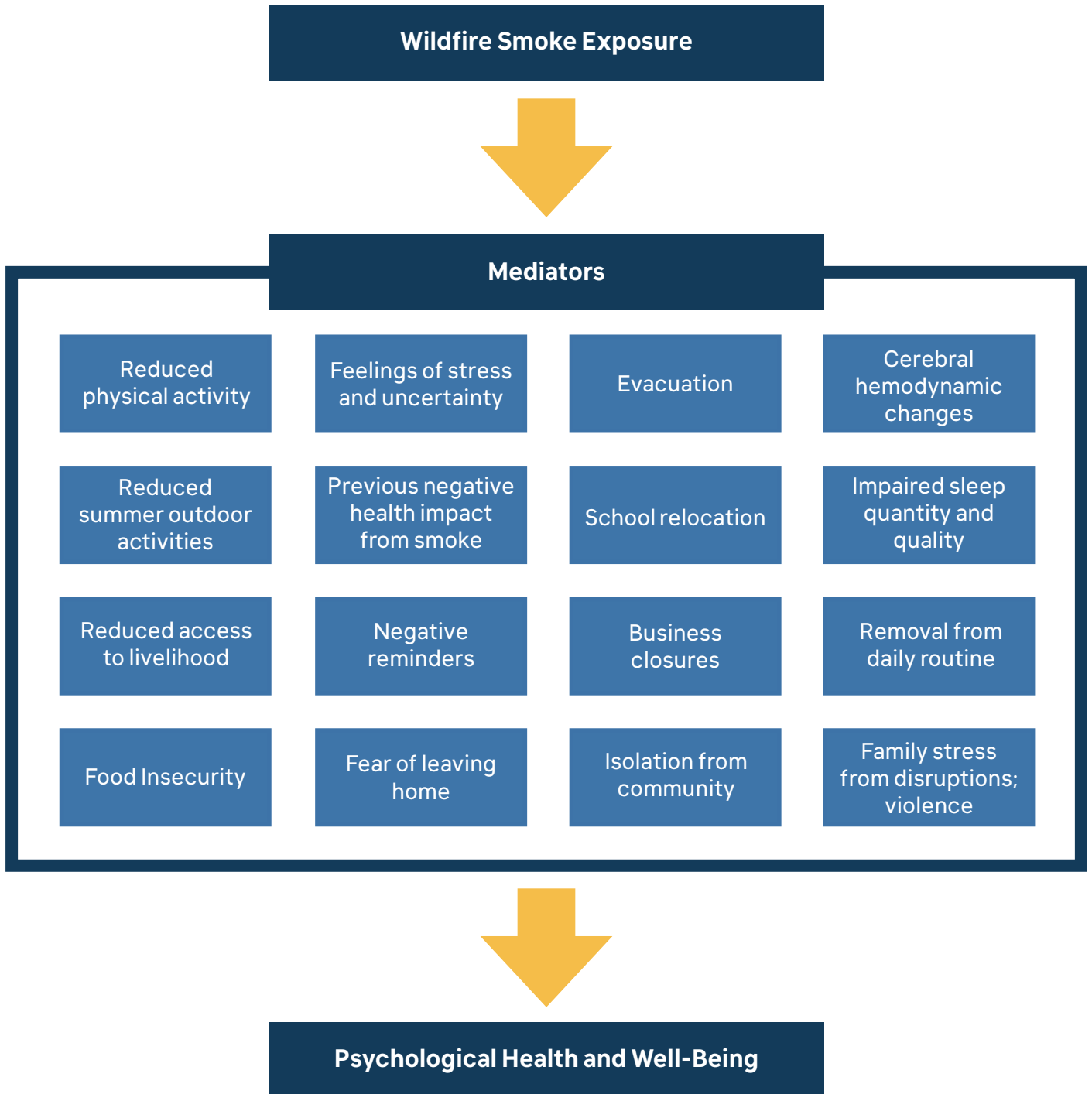
Lastly, Engrebretson's survey study asked respondents about their "tolerance" to smoke from different sources such as prescribed burns or wildfire; people who had experienced personal health effects from smoke in the recent past reported themselves as less tolerant of smoke, regardless if the source of this smoke was from a prescribed burn or wildfire (Engebretson, 2016).

Vincent suggests that wildland firefighters who are constantly exposed to smoke, noise and heat may experience impaired sleep quality and quantity which may have physiological and cognitive effects (Vincent, 2018).

We propose a model of the mechanisms that may lead to any mental health impact based on the eight qualitative studies reviewed. These mechanisms may operate at several levels including physiological, psychological, social and practical (see Figure 1).



**Figure 1. Proposed Mechanisms of Wildfire Smoke Exposure on Psychological Health and Well-Being**



## Conclusions from Reviewing Studies on the Mental Health Impacts of Wildfire Smoke

Compared to the understanding of the mental health impacts of wildland fire exposure, the understanding of the mental health impacts of wildland smoke is in its infancy. Evidence summarized by our review suggests that exposure to wildland smoke may have mental health impacts, particularly in episodes of chronic and persistent smoke events, but the literature is inconsistent.

Qualitative studies report on the association (for example, Dodd, 2018 and Mottershead, 2020) whereas quantitative studies do not support this association.

Qualitative studies gives us a rich sense of the topic. In Dodd's study conducted after a wildfire season with over 40 days of smoke, affected residents far from the fires said it was like they lost their summer. People reported isolation from others, less community participation, loss of nature, and worsened mental health.

However the quantitative studies are inadequate for addressing the question. For example, exposure determinations are often limited and short term exposures like those studied by Moore and Duclos may not have a mental health impact. Quantitative studies of comparable events such as haze do find an association (DePretto, 2015; Ho, 2014; Tan, 2019) but also have a high likelihood of bias. Overall, only a few studies address chronic exposure (Dodd, 2018; Mottershead, 2020; Hazelwood Mine Fire Inquiry, 2014; Berger, 2018) and none are quantitative. Trauma oriented studies do not provide sufficient information to assess the association (Marshall, 2017; McDermott, 2015).

Also, the quantitative studies are highly heterogeneous with respect to quality, exposure and outcomes measures, study design, sample size, and location. This limits our ability to directly compare the findings. Indeed, it is challenging to accurately assess exposure, and many studies rely on self-reported exposure or duration of time exposure. Overall, the quantitative studies are incomparable to reach a consensual conclusion and due to the low quality of these quantitative studies to detect mental health effects we conclude that the impacts have not been sufficiently studied.

**What happens when wildfires become chronic and persistent, like they did in Australia in 2019 and California in 2020? Living under the lockdowns of the COVID-19 pandemic gives some sense of what this is like; The isolation from community and the dread that leaving the house to go into the world outside is fundamentally dangerous---this might sum up the isolating and fearsome experience of the pandemic and persistent wildfire smoke events.**

My son is 1 month old, he's never breathed fresh air in his life.



 r/australia • gordogamsby • 1d ago

Given the likelihood of increasing wildfires and smoke events further study is warranted. Studies should focus on the chronic, persistent or repeated smoke events and should distinguish between the exacerbation of existing mental health states versus the impact on incidence of new symptoms. Quality of life should also be studied as an outcome. This can best be addressed in large longitudinal cohort studies that monitor the long-term impacts of susceptible populations.

Post from Reddit, "Australia Bushfires", December 2019

## 2. Mental Health Impacts of Solastalgia from Wildfires

Albrecht postulated that solastalgia, the lived experience of pain from lack of solace due to transformation of the environment, can escalate from generalized distress to serious health and problems including physical and mental illness and drug abuse (Albrecht, 2005).

Higginbotham developed and validated the 81 item Environmental Distress Scale (EDS) to measure six environmental distress components including the concept of solastalgia. (Higginbotham, 2006). He viewed environmental distress as a complex, four-stage process as shown

*First, individuals perceive environmental change events (e.g., power station emissions, loss of forest or pasture) in terms of frequency and/or intensity. Second, perceived change is appraised as either benign (and not considered further) or seen as potentially threatening to the well-being of oneself or others. Third, individuals experience the impact of the environmental change across a host of interrelated dimensions, including physical symptoms and emotional reactions (fear, anger), social and economic disturbance, and, potentially, the psychological response of "solastalgia" (feelings of distress at the degradation of ones valued environment). Fourth, the appraisal of threat and its impact leads to some form of action to resolve, control, or adapt to the changes. Actions range from simply trying to gather more information to initiating a protest and modifying one's residence to mitigate intrusion of, for example, dust and noise.*

Finding that EDS scores were significantly higher, as predicted, in the high disturbance communities compared with the low disturbance community residents across all six subscales, including solastalgia, Higginbotham concluded

*We might further consider whether or not the experience of solastalgia is essentially the primary process underlying the EDS measurement as a whole. In other words, solastalgia may well account for most of what we have measured under the rubric of environmental distress. Further empirical and conceptual work clarifying this distinction should be performed.*

We found only one study that quantitatively assessed the relationship of solastalgia to mental health. Three years after the Wallow Fire, in Arizona, Eisenman and McCaffrey initiated a study of mental health in the five communities surrounding the burn (Eisenman, 2015). During their trips to the study site residents told the study team that they were "grieving for the loss of the landscape." The team subsequently conducted a household survey mailed to all 1,387 households in the five communities surrounding that fire. Solastalgia was measured using a scale adapted from Higginbotham and supplemented with questions based on themes heard during formative research. Persons who scored higher on the solastalgia score were significantly more likely to report psychological distress and this association remained in the multivariate regression controlling for adverse financial impact ( $p < 0.001$ ). In the multivariate analysis, higher solastalgia score and an adverse financial impact of the fire were associated with clinically significant psychological distress.

Our scan result updates those of Galway who reviewed 29 papers from 2004-2018 published on solastalgia (Galway, 2019). Only Eisenman studied wildfires and mental health according to that review (Eisenman, 2015).

Three studies qualitatively connect solastalgia to wildfires. Dodd's study broadens our understanding by connecting wildfire smoke (Dodd, 2018) to solastalgia among the interviewees who reported feeling dislocated from the land and environment and its effect of emotional wellbeing. Participants connected the persistent smoke and their inability to experience the environment and land, their dislocation, as an experience of environmental change that will continue into the future, especially with climate change.



Waks, Kocher, and Huntsinger interviewed 27 nonindustrial forest landowners whose properties burned in a wildfire in California's central Sierra Nevada in 2014 (Waks, 2019). The authors report that many experienced solastalgia at the loss of forest. Interestingly, community members living near burned public lands felt that the opportunity to participate in land restoration and replanting helped them reconnect to the forest and their "special places."

Finally, Ryan & Hamin explored solastalgia in people living in Los Alamos who had experienced a major wildfire event (Ryan, 2008). Individuals reported having grieved at the condition of the forest post-wildfire event. As noted from one participant, "There's so many people here who just grieve at the condition of the forest. And I don't like it either."

### **Conclusions from Reviewing Studies on the Mental Health Impacts of Solastalgia from Wildfires**

We did not review aligned concepts such as landscape identity and place attachment. Wildfire studies on these similar topics may exist and this is a limitation of our review. Solastalgia overlaps with broader topics of environmentally induced distress, eco-anxiety, eco-grief, and the emotional and mental health toll that climate change poses to the world. Galway has already noted the need for study of the "cumulative nature of health impacts that emerge as a consequence of the transformation of the cherished landscapes." Further quantitative research is needed that addresses the burden, impacts, and distribution of solastalgia after wildfires and other climate change events.

## **3. Mental Health Impacts of Wildfires on Civilian and Inmate Firefighters**

In the Woolsey Fire Report issued by the Los Angeles Emergency Preparedness Foundation, 60 semi-structured interviews of individuals directly impacted by the Woolsey Fire were conducted, including 52 with persons who stayed and defended (Woolsey Fire Report, 2019). The report states that those who chose to remain and suppress fires instead of evacuating "have done so over multiple fires." The report estimates "several hundred structures were saved by their endeavors."

The report states "psychological trauma related issues were apparent among community members" which, according to the first author, refers mostly to community members who had stayed to fight the fire and were interviewed for the report [personal communication]. These impacts include mental health concerns (PTSD, depression, substance abuse, anger, distress, disbelief) expressed by residents. However the report does not include any data to support this statement, such as a methods or findings section that shows the percentage of participants who noted mental health impacts. Importantly, the Woolsey Fire Report calls for the development of "certified volunteer firefighters" (p.50).

In Eisenman's study conducted one year after the Wallow Fire, in Arizona, the researchers conducted a household survey mailed to all 1,387 households in the five communities surrounding the fire (Eisenman, 2015). The survey contained one question that asked about actively defending during the fire: "During the Wallow Fire, did you do anything to actively defend your home from fire or smoke damage, such as activate an external sprinkler system, extinguish burning embers on or near your home, or hose down your roof?" In the bivariate analyses, factors associated with a K10 score > 15 were active defense of one's home from fire (OR 2.15, 95%CI 1.35-3.42). Authors note that actively defending one's home was associated with distress may indicate that more direct experience with fire contributes to greater psychological health impact. However, these findings should be qualified since they did not specifically ask how direct the threat was to

the individual. It is possible that individuals took action to protect their house, such as turning on a sprinkler system, even when flames were not in the immediate area.

There are no quantitative studies on inmate firefighters. The qualitative literature that we reviewed focused on how participation contributed to positive changes in inmate lives.

Goodman's article states that while only paid a dollar an hour fighting fires, inmate firefighting is seen commonly as a "win-win-win" with the state saving money from prison labor, California Department of Corrections and Rehabilitation improving its public image and inmates learning work ethic and undergoing rehabilitation (Goodman, 2012). From field observations as well as semi-structured interviews with inmates, this study reported that many inmates view the work as "simultaneously heroic, dignified work and a form of labor exploitation". Described as "uncommon heroes" in the news during wildfire seasons, inmates note that the recognition and appreciation is fleeting while they perform less desirable work than non-inmate firefighters and regularly will be treated with discrimination and overt hostility. Regardless, many inmates agreed that the work is important and are proud of the work they have done to save properties and lives. Many view it as giving back to society and even as a sort of penance for harms they might have caused in life prior to incarceration. In addition to feeling wanted by society, many noted being able to learn good work ethic as their primary motivator whilst also helping them feel physically stronger.



Melligan evaluated the lived experiences of eleven former female California inmate firefighters and noted participants reported the program to have a positive effect on their family relationships and self-esteem, prepared them to be mentally and physically stronger, provided them with better communication tools, and a sense of determination (Melligan, 2017). A limitation in Melligan's study was she screened out potential participants who reported current treatment for any significant mental health issues.

Finally, Feldman conducted 15 months of in-depth ethnographic research with these crews but her paper focused on public perception of inmate firefighters. She found inmate firefighters experienced the work as transformative (Feldman, 2020). Lack of any identifying clothing positively shifted participant's perspectives of themselves. She did not report on the mental health impacts of participating in the program.

### **Conclusions from Reviewing Studies on the Mental Health Impacts of Wildfires on Civilian and Inmate Firefighters**

No study provides quantitative information that directly addresses the mental health impact of community-member firefighters. Given that cross-sectional surveys and cohort studies of wildland firefighters find post-traumatic symptoms among 10–20% of responders, this is a major gap. McCaffrey's study and the Woolsey Fire Report indicate this practice is higher than commonly recognized. But more needs to be known to understand the nature of the behavior and its health risks. Such studies would also address associated risk and protective factors, comparisons to population and to people who did not stay and fight, and the longitudinal course of symptoms. They would consider functional limitations as well. It is noted too that respiratory, musculoskeletal and physical injuries have not been studied.

The same can be said of inmate firefighters. There are similarly no studies of the health or mental health impacts to this group. All the studies we identified adopt a particular framing that, as pointed out by J. Carlee Purdum, fails to situate the knowledge building within the larger topics of incarcerated persons working in disasters (currently the case in 30 states), mass incarceration and prison labor, social vulnerability to disasters, and environmental racism.



# E. IMPLICATIONS OF THIS REVIEW

Exploring mental health is timely as the incidence, duration and severity of wildfires increases in the US and elsewhere attributable in part to climate change. In turn, this will bring prolonged fire seasons bringing more smoke, landscape destruction and exposure to firefighters. It is important to better characterize the mental health impacts of wildland firefighting to better protect the health of these workers, the mental health effects of smoke to better protect communities, and the contribution of place-attachment and solastalgia to mental health. The data and key findings of this report highlight gaps in the literature and suggest areas for theoretical, methodological, and practical advances for wildfire research.

The learning from qualitative research is valuable and gets to the social well-being, emotional well-being and spiritual impacts. Qualitative research provides outcomes of importance beyond diagnostic codes and categories which are inherently limited in information and meaning, and likely less prevalent. Understanding wildfires, particularly smoke but any of the issues examined here, as lived experiences invites greater discourse. Quality of life should also be studied as an outcome. By avoiding the pathologizing framework of mental health diagnoses it also allows more stakeholders to engage, for instance first responders and community members who may not want to be pathologized as traumatized.

Our review provides a path forward for further research by the National Academies of Science, Engineering and Medicine on the mental health effects of wildfires. Our model of the potential pathways between smoke exposure and mental health effects is an unique contribution and unexpected result of this scan. It advances our understanding of the factors mediating any relationship between smoke exposure--especially prolonged smoke exposure--and mental health and well-being.

The National Academies of Science, Engineering and Medicine can begin with a workshop to develop and prioritize a research agenda based on this report. That agenda might include: research on the effects of smoke especially prolonged events and repeated events (including broad considerations of mental health beyond clinical diagnostic categories to include all aspects of well-being); research on the effects of various responder groups; and, research on post event mental health issues including solastalgia (and the potential for forest recovery to facilitate healing). Potential partners include the Centers for Disease Control and Prevention, National Fire Protection Association, NIEHS, NIST, and the United States Forest Service.



# REFERENCES AND REVIEWED PAPERS

## Background:

Fullerton, C. S., Ursano, R. J. and Wang, L. "Acute Stress Disorder, Posttraumatic Stress Disorder, and Depression in Disaster or Rescue Workers", 2014.

Hanigan IC, Johnston FH, Morgan GG. 2008. Vegetation fire smoke, indigenous status and cardio-respiratory hospital admissions in Darwin, Australia, 1996-2005: a time-series study. *Environ Health* 7:42, PMID: 18680605, 10.1186/1476-069X-7-42.

Jensen SJ, Feldman-Jensen S, Woodworth BH. "Resilience under fire: attitudes and behaviors of those who chose to stay and defend in the November 2018 Woolsey Fire". Quick Response Report: Natural Hazards Center. <https://hazards.colorado.edu/quick-response-report/resilience-under-fire>. Accessed March 16, 2021.

McCaffrey S, Wilson R, Konar A. 2018. Should I Stay or Should I Go Now? Or Should I Wait and See? Influences on Wildfire Evacuation Decisions. *Risk Anal* 38(7):1390-1404, PMID: 29168989, 10.1111/risa.12944.

Purdum, JC, Meyer, MA. 2020. Prisoner labor throughout the life cycle of disasters. *Risk, Hazards & Crisis in Public Policy*. doi:10.1002/rhc3.12191

Van den Bosch, M., Meyer-Lindenberg, A. "Environmental Exposures and Depression: Biological Mechanisms and Epidemiological Evidence" *Annual Review of Public Health* 2019 40:1, 239-259

Wegesser TC, Pinkerton KE, Last JA. 2009. California wildfires of 2008: coarse and fine particulate matter toxicity. *Environ Health Perspect* 117(6):893-897, PMID: 19590679, 10.1289/ehp.0800166.

Woolsey Fire Report. Los Angeles Emergency Preparedness Foundation, 2019. <https://laepf.org/woolsey-fire> [accessed 16 November 2020].

## Wildfire Smoke Exposure:

Berger E, Carroll M, Maybery D, Harrison D. 2018. Disaster Impacts on Students and Staff from a Specialist, Trauma-Informed Australian School. *J Child Adolesc Trauma* 11(4):521-530, PMID: 32318173, 10.1007/s40653-018-0228-6.

Caamano-Isorna F, Figueiras A, Sastre I, Montes-Martínez A, Taracido M, Piñeiro-Lamas M. 2011. Respiratory and mental health effects of wildfires: an ecological study in Galician municipalities (north-west Spain). *Environ Health* 10:48, PMID: 21600035, 10.1186/1476-069X-10-48

Camilleri P, Healy C, Macdonald E, Nicholls S, Sykes J, Winkworth G, et al. 2010. Recovery from bushfires: The experience of the 2003 Canberra bushfires three years after. *Australasian Journal of Paramedicine* 8:1-15, 10.33151/ajp.8.1.112.

Christianson AC, McGee TK, Whitefish Lake First Nation 459. 2019. Wildfire evacuation experiences of band members of Whitefish Lake First Nation 459, Alberta, Canada. *Nat Hazards* 98(1):9-29, 10.1007/s11069-018-3556-9.

De Pretto L, Acreman S, Ashfold MJ, Mohankumar SK, Campos-Arceiz A. 2015. The Link between Knowledge, Attitudes and Practices in Relation to Atmospheric Haze Pollution in Peninsular Malaysia. *PLoS One* 10(12):e0143655, PMID: 26646896, 10.1371/journal.pone.0143655

Dodd W, Scott P, Howard C, Scott C, Rose C, Cunsolo A, et al. 2018. Lived experience of a record wildfire season in the Northwest Territories, Canada. *Can J Public Health* 109(3):327–337, PMID: 29981098, 10.17269/s41997-018-0070-5.

Duclos P, Sanderson LM, Lipsett M. 1990. The 1987 forest fire disaster in California: assessment of emergency room visits. *Arch Environ Health* 45(1):53–58, PMID: 2180383, 10.1080/00039896.1990.9935925.

Engebretson JM, Hall TE, Blades JJ, Olsen CS, Toman E, Frederick SS. 2016. Characterizing Public Tolerance of Smoke from Wildland Fires in Communities across the United States. *Journal of Forestry* 114(6):601–609, 10.5849/jof.14-142.

Hazelwood Mine Fire Inquiry. <http://report.hazelwoodinquiry.vic.gov.au/index.html> [accessed 11 February 2021].

Ho RC, Zhang MW, Ho CS, Pan F, Lu Y, Sharma VK. 2014. Impact of 2013 south Asian haze crisis: study of physical and psychological symptoms and perceived dangerousness of pollution level. *BMC Psychiatry* 14:81, PMID: 24642046, 10.1186/1471-244X-14-81.

Howard C, Rose C, Dodd W, Scott P, Cunsulo-Willox A, Orbinski J. 2017. P062: SOS: Summer of Smoke--a mixed-methods, community-based study investigating the health effects of a prolonged, severe wildfire season on a subarctic population. *Canadian Journal of Emergency Medicine* 19(S1):S99–S99, 10.1017/cem.2017.264.

Marshall GN, Schell TL, Elliott MN, Rayburn NR, Jaycox LH. 2007. Psychiatric disorders among adults seeking emergency disaster assistance after a wildland-urban interface fire. *Psychiatr Serv* 58(4):509–514, PMID: 17412853, 10.1176/ps.2007.58.4.509.

McDermott BM, Lee EM, Judd M, Gibbon P. 2005. Posttraumatic stress disorder and general psychopathology in children and adolescents following a wildfire disaster. *Can J Psychiatry* 50(3):137–143, PMID: 15830823, 10.1177/070674370505000302.

Moore D, Copes R, Fisk R, Joy R, Chan K, Brauer M. 2006. Population health effects of air quality changes due to forest fires in British Columbia in 2003: estimates from physician-visit billing data. *Can J Public Health* 97(2): 105–108, PMID: 16619995, 10.1007/BF03405325

Mottershead KD, McGee TK, Christianson A. 2020. Evacuating a First Nation Due to Wildfire Smoke: The Case of Dene Tha' First Nation. *Int J Disaster Risk Sci* 11(3):274–286, 10.1007/s13753-020-00281-y.

Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. 2016. Critical Review of Health Impacts of Wildfire Smoke Exposure. *Environ Health Perspect* 124(9):1334–1343, PMID: 27082891, 10.1289/ehp.1409277.

Tan BY, Leong AZ, Leow AS, Ngiam NJ, Ng BS, Sharma M, et al. 2019. Psychosomatic symptoms during South East Asian haze crisis are related to changes in cerebral hemodynamics. *PLoS One* 14(1):e0208724, PMID: 30615620, 10.1371/journal.pone.0208724.

Vincent GE, Aisbett B, Wolkow A, Jay SM, Ridgers ND, Ferguson SA. 2018. Sleep in wildland firefighters: what do we know and why does it matter? *Int J Wildland Fire* 27(2):73–84, 10.1071/WF17109.

## **Solastalgia:**

Albrecht G. 2005. "Solastalgia". A New Concept in Health and Identity. PAN: Philosophy Activism Nature.  
Canu WH, Jameson JP, Steele EH, Denslow M. 2017. Mountaintop Removal Coal Mining and Emergent Cases of Psychological Disorder in Kentucky. *Community Ment Health J* 53(7):802–810, PMID: 28213767, 10.1007/s10597-017-0122-y.

Eisenman D, McCaffrey S, Donatello I, Marshal G. 2015. An Ecosystems and Vulnerable Populations Perspective on Solastalgia and Psychological Distress After a Wildfire. *Ecohealth* 12(4):602–610, PMID: 26302957, 10.1007/s10393-015-1052-1.

Galway LP, Beery T, Jones-Casey K, Tasala K. 2019. Mapping the Solastalgia Literature: A Scoping Review Study. *Int J Environ Res Public Health* 16(15):2662, PMID: 31349659, 10.3390/ijerph16152662.

Higginbotham N, Connor L, Albrecht G, Freeman S, Agho K. 2006. Validation of an Environmental Distress Scale. *EcoHealth* 3(4):245–254, 10.1007/s10393-006-0069-x.

## **Civilian & Inmate Firefighters:**

Eisenman D, McCaffrey S, Donatello I, Marshal G. 2015. An Ecosystems and Vulnerable Populations Perspective on Solastalgia and Psychological Distress After a Wildfire. *Ecohealth* 12(4):602–610, PMID: 26302957, 10.1007/s10393-015-1052-1.

Feldman LR 2020. Anti-heroes, wildfire, and the complex visibility of prison labor. *Crime, Media, Culture* 16(2):221–238, 10.1177/1741659019865309.

Goodman P 2012. Hero and Inmate: Work, Prisons, and Punishment in California's Fire Camps. *WorkingUSA* 15(3):353–376, 10.1111/j.1743-4580.2012.00398.x.

Melligan KM 2017. *On the Fire Line: The Lived Experiences of California Female Inmate Firefighters* [Doctoral dissertation, Capella University]. <https://www.academia.edu/37977286>

Woolsey Fire Report. Los Angeles Emergency Preparedness Foundation, 2019. <https://laepf.org/woolsey-fire> [accessed 16 November 2020].