EXPOSED AND UNPROTECTED

THE THREAT POSED BY CLIMATE CHANGE TO U.S. AGRICULTURAL WORKERS

This paper provides an overview of literature focused on the impacts of climate change and severe climate events on outdoor workers in the United States. As reflected in the literature itself, this paper emphasizes the impact of increased heat on agricultural workers, and the ways in which these workers' exclusion from crucial federal labor protections creates layered implications of exposure. To build this understanding, the paper also provides a brief history of agricultural workers in the United States, and an overview of policy changes that could help improve workers' undue exposure to climate derived injury, illess, and death.

Oxfam Discussion Papers

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EXECUTIVE SUMMARY

This Discussion Paper seeks to identify the array of potential policy avenues for tackling some of the risks posed by climate change to outdoor workers in the US. The work is based on a literature review and therefore reflects the focus areas of that literature, specifically the vulnerability of agricultural workers and the risks posed by extreme heat as well as climate change's interactions with wildfire smoke and pesticide exposure.

The literature on outdoor workers' vulnerability to climate change describes risks to several outdoor occupations (agriculture, construction, resource extraction, emergency responders, and grounds staff, among others) from a multitude of extreme weather conditions: heat, hurricanes, floods, etc. The overwhelming focus of the literature, however, is the impact of extreme heat on agricultural workers. This focus stems from the fact that extreme heat is the leading cause of weather-related injuries and deaths in the US and because agricultural workers remain essentially without protection from this stressor: there is no federal heat standard in place, limited protections from Occupational Health and Safety Administration's (OSHA) general clause, and weak enforcement of any protections that do exist. The vulnerability of agricultural workers to climate-related injury and death is compounded by their historically marginalized position. With roots in indentureship, chattel slavery, and forced labor, agricultural workers today remain excluded from protections afforded to other workers, such as provisions for minimum wages, overtime protections, certain child labor protections, and the right to bargain collectively. Furthermore, the industry holds a seeming preference for immigrant labor that has stifled the capacity of the agricultural labor force to advocate for their own protections and improved working conditions. Finally, agricultural workers are further exposed to extreme temperatures due to the physical nature of the work and need, under certain circumstances, to wear personal protective equipment (PPE), both of which increase core body temperature.

Temperatures have already increased by about 1.8°C (3.19°F) across the US, on average. Such increases are linked to increasingly severe and intense heat waves. Such conditions increase the number of days on which it is not safe to work outside. In this way, heat affects both individual worker safety and threatens economic prosperity, with knock-on implications for worker well-being. Currently in the US, around three million outdoor workers experience the equivalent of seven or more unsafe workdays per year due to extreme heat. By mid-century, this number is expected to be 14 million workers with slow action on climate change, and 18.4 million workers with no action. If only some action on climate change is taken, and if workers are not paid for days when it is too hot to work, extreme heat would result in an estimated $39.3 billion in lost annual earnings, with the average worker losing around $1,200 per year. Such averages overlook areas of acute increases in exposure, with impacts anticipated to be worst in the Southeast, Texas, and some of the Southwest.

For agricultural workers, the impacts of extreme heat will compound with forecasted increases in wildfire smoke and pesticide use—the latter possibly increasing as heat renders crops more vulnerable to infection. The primary solutions to addressing wildfire smoke and pesticide use involve the wearing of PPE, which worsens the effects of heat exposure. Notably, there is no federal standard for wildfire smoke (or outdoor air quality)—though some states have implemented standards—and protections from pesticide exposure are widely noted as inadequate at the local and national level.

Possible avenues and focus areas for policy change that were identified in the literature include: 1) creating a federal heat standard; 2) expanding OSHA protections to all agricultural workers—specifically eliminating the exclusion of small farms from any OSHA protections; 3) ensuring enforcement of existing (and to be developed) regulations; and 4) tackling the wider structural causes of vulnerability that extend beyond heat, notably lack of access to healthcare and poor-quality housing. A federal heat standard should account for humidity and include provisions mandating: breaks; access to water; access to shade; shifted work hours;

acclimatization periods; and medical screenings. Regarding enforcement, the focus is on funding, staffing, surveillance, publication of incidents, and an assessment of whether current (and proposed) provisions are working.

Due to the interactions of pesticides and wildfire smoke with heat, and the specific exposure of agricultural workers to both, these are further areas of potential policy advocacy. For pesticides, the focus is on: updating Environmental Protection Agency (EPA) assessments; putting in place regulations to protect against pesticide drift; improving labelling and warning communications; improving training; and monitoring of exposure. For wildfire smoke, the literature is extremely nascent; thus further research is needed. Essential to that research is the increased deployment of air quality monitoring stations.

Overall, a common theme in the literature was the fact that the scope for adaptation to extreme heat among outdoor workers is limited. To this end, while all the above policy avenues should be a priority, there is an urgent need to address greenhouse gas emissions to arrest, and then reverse, global heating.

INTRODUCTION

This Discussion Paper seeks to understand the risks posed by climate change to outdoor workers in the United States, with a specific focus on the impacts of heat on agricultural workers, which was the overwhelming focus of the published literature on the topic. By their very nature, outdoor workers are particularly exposed to changes in average weather conditions and, in particular, to changes in the frequency and intensity of extreme weather events. From the physiological impacts of increased heat, to the increased work caused by extreme events (for example among first responders), to lost work-days caused by weather interruptions (for example drought among agricultural workers or extreme conditions among construction workers), the potential impacts of climate change on outdoor workers are multiple.

To illustrate the scale of these risks, in the US the risk of death among outdoor workers, specifically from heat exposure, is 35 times higher than for all other workers, according to the literature (Dahl and Licker 2021). The risks experienced by outdoor workers are also not equally borne by all segments of the society, with outdoor workers being notably male (83 percent) and over-representative of Black (20 percent) and Hispanic/Latinx (29 percent) individuals, who make up around 49 percent of the outdoor workforce, despite being around only 32 percent of the overall US population. The vulnerability of outdoor workers is also significant. While outdoor workers tend, on average, to earn above the median income, a number of outdoor occupations (e.g., building and grounds cleaning and maintenance) earn substantially less (43 percent below the median for a subset of workers) (Dahl and Licker 2021).

The literature, and subsequently this review, overwhelmingly focused on heat impacts for agricultural workers. Among outdoor workers, agricultural workers experience even more acute risks owing to their extremely high levels of exposure, particularly to heat (working outdoors, during the hottest times of the year, frequently in heavy protective clothing and performing physically demanding tasks), and marginalized position in society. They tend to be excluded from many of the federal protections afforded to other workers, subject to the precarity of the US immigration system, and generally lacking in core protections such as access to health insurance or stable housing (DoL n.d.; Goldman et al. 2021).

The report proceeds as follows. First we provide a brief account of the method and limitations of the research along with a topline account describing the state of the literature. Following this section, we offer an overview of how climate change is anticipated to affect the US and the pathways by which these changes will likely affect occupational safety. Reflecting the focus of the literature reviewed, the work then explores the impact of extreme heat in particular, describing its physiological impacts, the scale of the challenge posed by heat, its economic impacts, and how it is anticipated to interact with other stressors. With an account of the biophysical nature of climate change largely covered, the report moves on to discuss the particular vulnerability of agricultural workers, describing the historic forces of marginalization and how these manifest in vulnerability and deprivation today. The report then specifically explores the possible institutions affording protection to agricultural workers and their inadequacies, before outlining the recommendations for addressing gaps in protection as articulated in the literature.

METHOD AND LIMITATIONS

This work was informed by a basic literature review, relying principally on the Google Scholar and DeepDyve databases to find early work, which we then mined for citations to build our larger reading list. Search terms included various formulations of: "united states," "agricultural worker(s)," "construction worker(s)," "outdoor," "outdoor worker(s)," "climate change," "heat," "climate disaster," and "working conditions." Various combinations and quotations were invoked to limit the search. Our search was limited by English language sources, an emphasis on impact within the United States, and a goal of work published within the last five to 10 years. Similarly, searches took place trying to identify livelihood security of agricultural workers—see Limitations section, below, for more detail. Further efforts were made to consult experts on this latter topic. The literature identified in the searches was then sourced to whatever extent was possible given issues of paywalled access, Oxfam's limited access to subscriptions, and what could be attained through requests to the original authors. The literature was then divided up between the two authors of this report. We read and developed notes, conferring when we thought we had reached saturation—the point at which new papers seemed to be repeating the content and arguments articulated in other papers. Such consultations between the authors also served to identify particularly salient references in literature we were reading (e.g., frequently cited references, references containing contradictory findings, etc.). We collected these references, reading them when access issues allowed.

The result is what we believe to be a comprehensive, though not systematic, literature review. In conjunction with the peer review process, we believe the findings contained in this work reflect a comprehensive account of the risks posed by climate change to outdoor workers in general and agricultural workers in particular, as well as an account of the forces that shape the vulnerability of these groups today. We further believe that the work provides a comprehensive account of the policy options available to advance increased protections for these workers—specifically agricultural workers—should Oxfam choose to prioritize work in this area in the future. In addition to the limitations resulting from this work not being a systematic review (see Methods), issues of potential incompleteness also pertain to tracking the specific status of policies, especially at the state level. In this regard, it was not possible to ensure that we knew the current status of all the policies in every state. Rather we relied on the literature consulted as part of this review to appraise this status. We further took on board the comments of reviewers who, on occasion, pointed out that a new law or step in the policy process had been achieved in a particular context. Despite this limitation, we believe the report provides a comprehensive (if not absolutely complete) overview of the state of protections afforded agricultural workers in a context of climate change.

In addition to issues of completeness, from the above section, the reader may note that we explicitly sought out literature pertaining to construction workers when searching the literature. This choice reflected a focus of the original terms of reference where we had intended to compare the risks experienced by construction workers with the risks to agricultural workers. Upon reading the literature, it became clear, however, that construction workers were simply treated as one among many categories of outdoor workers (emergency responders, utility maintenance crews, grounds staff, etc.) while agricultural workers received special attention in the literature—with "agricultural workers" referring to those nonfarm-owning individuals who worked on farms in the process of food production (with a major focus on crops rather than animal husbandry). For this reason, we reframed the paper to overview the risks posed by climate change to outdoor workers in general, before focusing on the specific risks to agricultural workers. This refocus reflects a minor change from the original terms of reference for this work, but one that we think makes sense given the state of the published literature.

Further to shifting our explicit focus on construction workers, it should be noted that in the original conception of this work we had intended to deliberately seek out literature considering the impacts of climate change on the livelihoods of agricultural workers, beyond a focus on their occupational well-being. We were interested, for example, in how an agricultural worker losing their job as a result of damaging drought, or experiencing a work-preventing injury as a result of a heat event, might impact the security of their livelihood and that of any dependents in their household. What, for example, were the impacts on children's ability to attend school? What happened to care responsibilities? How were social capital and financial capital redeployed to address foregone income? The idea behind this line of inquiry was to look at a possibly expanded scope for adaptation policies. For example, might public support for education or collectivized care aid in mitigating some of the damaging impacts of climate change on agricultural workers' livelihoods?

These efforts were unfruitful. We were extremely surprised to find no literature describing the impact of climate change and climate disasters on the livelihoods of agricultural workers in the US, beyond the formal bounds of their occupations. Thinking this lack of literature might be explained by the degree to which the livelihoods framework is the domain of development theory, we sought out literature describing livelihoods of migrant workers, or households outside of the US containing migrant workers. Again, we could find no literature. Finally, we reached out to a number of academics working in this field. While many of them came back describing literature on the relationship between environmental stress and mobility, none could refer us to a body of work outlining how climate change (or even any analogous environmental stress) might shape the livelihood security of agricultural workers in the US—migrant or otherwise.

This gap seems a startling one. It represents a potential glaring lack of understanding of the core dynamics shaping the well-being of a highly marginalized and at the same time essential population. As mentioned above, such a lack of knowledge also constrains the scope for identifying novel adaptation pathways. The salience of this latter point is increased by the fact that the scope for adaptation among outdoor workers in the face of climate change is currently thought to be constrained by the simple lack of options for reducing exposure—see Adaptation options section below for details. Oxfam should note this gap as a possible area for work going forward, potentially advocating with university partners in efforts to address it.

Another limitation in the literature is a missing gender analysis on how climate change will impact outdoor workers. There is a literature on the building of masculinity among migrant farmworkers, and how there was a strong framework of paternalism to encourage men specifically to leave their homes and earn stronger incomes in the mainland US for their wives/children/families (Cohen 2011; Suárez Findlay 2014). However, these analyses of how migrant agricultural workers were recruited through narratives of masculinity do not take into consideration questions of climate change or weather events. Later in this paper there will be mention, as is reflected in the literature, of how heat-related injuries have a different physiological impact on women's bodies than men's, and a discussion of the demographic breakdown of farmworkers—who are overwhelmingly male. However, the discussion of this workforce and its efforts to navigate the changing climate reality in the US does not engage questions of how these efforts reflect on frameworks of masculinities or paternalistic power dynamics within families. A family-level or household-level analysis of how climate change impacts farmworkers is also largely absent from the literature reviewed in this report.

Furthermore, while there is a more robust literature on climate change's disproportionate impact on women as it relates to their care responsibilities, there is little-to-no engagement on how these overlap with issues of labor or workforce in the United States. Some work has been conducted on how climate change impacts women agricultural workers in low- and middle-income countries, but in the context of the United States this research is largely absent (UN Secretary General 2022). Because farmworkers are historically excluded from worker protection policies , and farms as sites of employment continue to fall outside the bounds of enforcement principles due to their small numbers of employees (see Modern farmworkers and the impact of

generational exclusions section below), the application of worker protection policies to farm laborers is lax at best. This is especially important as it relates to women in the workplace and their access to state or federal worker protections, whether for pregnancy accommodations, breastfeeding protections, protection from sexual harassment, or even equal pay. Looking at how climate and gender interplay and the gaps in worker protections within the realm of labor policies as it relates to outdoor workers is an opportunity for future study.

TOPLINE RESULTS

Topline results reveal that the literature on outdoor workers and climate change is dominated by concerns regarding agricultural workers (engaged in crop cultivation, though specific crop types were not emphasized) and heat exposure. While there is also concern regarding other occupations (e.g., construction workers, first responders, resource extraction workers), and other climatic, and climate-related, impacts (e.g., hurricanes, floods, wildfire smoke, etc.), these take up far less space. The literature can generally be broken down into the following clusters: mapping the connections between climate hazards and occupational health; detailing the physiological impacts of extreme weather (including studies examining impacts at the individual level); and estimating the overall scale and cost of the potential future impacts—using monetary measures of foregone welfare. The specific literature considering agricultural workers in the US focuses on describing the structural vulnerabilities of these workers, the lack of protections they experience (even compared to other workers), and their exposure to climatic hazards (particularly heat). A large portion of this literature is concerned with identifying potential policy changes that could serve to reduce the vulnerability and/or exposure of these workers.

Within the literature there are a few notable gaps. First, as pointed out above, there is little work considering the livelihood security of agricultural workers, with concern generally reified down to considering occupational health only. Such a gap not only limits insights into the gender-disaggregated impact of occupational hazards, it also limits scope for identifying solutions to secure livelihoods outside of the workplace. This is a particularly notable limitation given the trend of ongoing emissions and lack of meaningful in-situ adaptation options identified in the literature. A further gap pertains to the handling of gender, which is only considered rather passingly. This gap can be partly explained by the fact that outdoor work is generally male-dominated (though the recent trend suggests this is changing for agricultural work). However, there is significant writing on the different ways masculinity is constructed among agricultural workers in the US, but little has been done to identify how such constructions shape risk in the context of climate change. Based on this overview, we now proceed to describe in detail the different elements of the literature review described above.

CLIMATE CHANGE AND OCCUPATIONAL HEALTH

- Climate change impacts are already being realized. Even if trend identification is hard for certain weather phenomena, models predict even more extreme changes from the long-term average.
- The primary concerns for occupational health are (in no particular order): i) heat; ii) nonheat extreme weather and weather-related events (e.g., cyclones, landslides, drought); iii) increased exposure to air pollution; and iv) increased exposure to UV radiation.
- Outdoor workers are considered the most exposed, while those engaging in physical labor and marginalized from social protections are considered the most vulnerable.

Elements of climate change are already upon us in the US, with current conditions distinct from the historical average for a number of climate- and weather-related phenomena, including hotter temperatures, more frequent fires, and changes in precipitation. For shorter-term, more geographically restricted phenomena, such as hurricanes,[1] extra-tropical storms, and convective systems (including tornadoes), variable historical data make it impossible to determine whether current incidences and intensities are distinct from the long-term average. Notably, this lack of data does not mean that there is no change; rather, it makes it impossible to state with confidence whether such a change has occurred. Data on extreme drought also show no clear trend, in part due to the complexities of the hydrological system, which is influenced simultaneously by, among other things, increased drying, changes in precipitation, and increased spring run-off, all of which are impacted by climate change. Nonetheless, climate modeling suggests that the future holds even more extreme changes from the long-term average for weather conditions that already show differences. Models likewise indicate storms of increasing intensity, and, in the case of hurricanes, possibly longer exposure. This is the case even if models indicate uncertainty about whether the total number of storms and their exact tracks will change. See Appendix 1 for more on historical trends and anticipated changes for a number of climate- and weather-related phenomena in the US.

Text Box 1: Conceptual framework and definitions

Some of the language used in this report, for example terms such as "hazard," "vulnerability," "risk," and "marginalization," have multiple meanings in different disciplines. For reasons of clarity, we define them here in line with the language used in climate change and disaster risk contexts, as this is the literature informing this Discussion Paper. We draw largely on the linguistic and conceptual framework laid out by Wisner et al. (2004) in their seminal book "At Risk."

Risk is understood as the likelihood of experiencing losses, damages, harm, or some other some other negative outcome. Risk is produced by the intersection of a hazard and vulnerability. All hazards have some probability of occurrence and are characterized in terms of their type (drought, hurricane, fire etc.), duration, intensity, and extent. Vulnerability refers to the potential for some sort of "ill-being" in response to an event—in this case the specific hazard. We understand vulnerability to be socially constructed—that is, produced by structural and individual forces in society. In the most general terms, we adopt a view that links vulnerability with power, which we view as the capacity to achieve desired ends. We link these concepts together via Sen's capabilities framework (Sen 2001), viewing power as the dynamic by which individual capabilities shape access to resources and the social structures that allow such resources to be converted into capabilities. There has been growing critique in Oxfam, and among

[1] Generally referred to as tropical cyclones in the climate literature.

civil society and practitioners, of the term "vulnerable people" on the grounds that it suggests their vulnerability is inherent to them (Oxfam 2023). With this in mind, we refrain from referring to "vulnerable people," instead using vulnerability to describe the potential for "ill-being" in the face of a hazard (Wisner et al. 2004). This approach fully appreciates both that experiences of vulnerability are contextual and transient, and that vulnerability is product of marginalizing forces in society—with an understanding of marginalization as processes that limit access to power. Further, while acknowledging that vulnerability is socially produced, we in no way suggest that people experiencing vulnerability are passive victims.

Regarding questions of agency and issues of the liminal state of vulnerability, we also refer, in this work, to the notion of adaptation. We take adaptation to describe actions and processes that stand to reduce risk. This can include individual actions as well as structural changes in society, and can pertain to changing the character of the hazard as well as the determinants of vulnerability. Other notions, such as resilience, were not referenced in the literature consulted and thus are not discussed here.

Overall, these changes have significant implications for outdoor workers who are most exposed to the changes in weather and climate. From agricultural and construction workers toiling in extreme summer heat to emergency services being placed under greater strain and operating under more extreme conditions, the array of vulnerabilities is vast. The literature describing the vulnerability of these workers identifies numerous pathways between the multiple impacts of climate change and worker well-being. These are variously described to include:

- *Increased ambient temperatures, as well as increased frequency and intensity of extreme heat events.* The impacts of heat are compounded by high levels of humidity and have been identified as driving dehydration, reduced productivity, increased fatigue, and physiological strain that progresses through heat stress, cramps, rashes, fainting, heat disorder, and death. Heat can additionally cause chronic kidney disease and increased work accidents. Finally, increased heat can interact with other occupational hazards, increasing the absorption of toxins and requiring increased application of pesticides to protect heat-stressed crops (Beyranevand and Skipper Nelson 2021; Chirico and Taino 2018; Constible et al. 2020; Pal, Patel, and Banik 2021; Dillender 2021; Applebaum et al. 2016).
- *Nonheat, extreme weather, and weather-related events (cyclones, landslides, lightning, droughts, etc.).* Such events variously result in physical injuries (exposure to toxic substances via spills, damaged containers, etc.), sicknesses (as a result of increased vector-borne diseases, through increased exposure to ticks, mosquitoes, rodents, etc., which variously stand to experience increased growing seasons, ranges, etc.), and loss of livelihoods and economic hardships (due to production losses/foregone productive opportunities, increased fatigue and illness) (Constible et al. 2020; Pedersen et al. 2021; Chirico and Taino 2018; Pal, Patel, and Banik 2021; Applebaum et al. 2016).
- *Increased exposure to air pollution, driven by increased ground-level ozone, larger and more frequent wildfires, and longer periods of pollen production.* This is thought to drive increased mortality among exposed workers (Beyranevand and Skipper Nelson 2021; Chirico and Taino 2018; Constible et al. 2020; Pal, Patel, and Banik 2021).
- *Increased exposure to ultraviolet radiation*, driven by stratospheric ozone-depleting greenhouse gasses, resulting in eye and skin damage (Chirico and Taino 2018; Pal, Patel, and Banik 2021; Applebaum et al. 2016).

Further to these direct impacts, two indirect pathways of impact are also described in the literature: i) psychological distress that results from managing the impacts mentioned above, including potentially new threats such as increased domestic violence (Pal, Patel, and Banik 2021; Pedersen et al. 2021; Constible et al. 2020); and ii) impacts to worker well-being that result from the economic changes necessitated by a transition to low-carbon economy (Chirico and Taino 2018). Together these stressors are anticipated to operate on workers through four pathways: i) reduced productivity; ii) reduced incomes; iii) potential suicide; and iv) reduced job safety (Pal, Patel, and Banik 2021; Constible et al. 2020).

The occupations that are identified as most vulnerable to these impacts include: outdoor workers in general (Constible et al. 2020; Chirico and Taino 2018), with a specific focus on those occupations that involve substantial physical labor; agricultural workers (Pal, Patel, and Banik 2021); those involved in mining (Dillender 2021); and emergency responders (Pedersen et al. 2021; Chirico and Taino 2018). Additional vulnerabilities are identified among workers who are temporarily or informally employed, with immigrant workers identified as acutely vulnerable. This is explained on the basis that such workers know their jobs less well, have less access to worker protections, and have reduced recourse to formal mechanisms for complaint for fear of recrimination (Constible et al. 2020). Occupations that fail to include health insurance, or that employ populations that tend to lack such insurance, are rendered more vulnerable to climate change hazards (Constible et al. 2020). A notable feature of the literature is the extent to which exposed occupations tend to over-represent low-wage Black and Hispanic/Latinx populations (Constible et al. 2020).

Notable in these general accounts is the message that climate change is not simply a source of hazards, but that it is creating new hazards and compounding old ones at scales previously unseen. Further changes in exposure to these hazards are argued to be increasing at a rate that outstrips current protections and strains the ability of those institutions to respond with new protections. Finally, a central argument in the literature is that while climate change threatens to make a number of occupations substantially more dangerous in the future, it is also the case that the impacts of climate change are already being felt by exposed workers. There is thus an urgent need to take significant actions to ensure worker safety, now and in the future (Constible et al. 2020).

Within this general literature on climate change and occupational safety, there is a large body of work with a specific focus on the impacts of extreme heat and on the vulnerability of agricultural workers. This review moves on to discuss this literature in detail. We discuss the general risks posed by heat and its interaction with other stresses, before turning to a discussion of the particular vulnerabilities faced by agricultural workers.

EXTREME HEAT

- Extreme heat manifests in physiological stress, which, if the thermoregulatory system is overwhelmed, can result in death. Prior to death, heat impairs cognitive and physiological functioning, reducing productivity. Vulnerability to extreme heat is modified by several individual-level characteristics.
- Heat is the leading weather-related cause of death in the US, with the Southwest, Southern Great Plains, Midwest, and Southeast most exposed.
- Extreme heat is already thought to be reducing productivity, with impacts anticipated to worsen in the future. The negative impacts of heat on productivity threaten both the larger economy and individual livelihoods.
- The negative impacts of heat will be exacerbated as they compound with other hazards (e.g., smoke and pesticides) or environmental variables (e.g., built environments, causing heat islands).

Several distinct bodies of work consider the impacts of extreme heat. These include: descriptions of the physiological mechanism by which extreme heat causes physical stress; the scale of current exposure to extreme heat, the economic impacts of extreme heat, forecasts of future heat impacts and the interaction of heat with other stressors. Each of these is discussed below.

THE PHYSIOLOGICAL IMPACTS OF HEAT

Exposure to high temperatures elevates core body temperature and increases cardiovascular stress. It increases the rate of respiration and reduces blood pressure. When the body's thermoregulatory response is overwhelmed, sustained elevated core body temperatures can lead to damage to one's internal organs. Collectively, these physiological impacts manifest on a continuum. On the one end are sunstroke, rashes, syncope (fainting), cramps, fatigue, and exhaustion. On the other end, prolonged exposure can lead to cardiovascular and respiratory failure, and eventually death unless medical treatment is provided immediately (Dillender 2021; Pal, Patel, and Banik 2021; CDC 2008; Austin et al. 2021; Constible et al. 2020). Heat exposure also operates indirectly on health, contributing to increased traumatic injury rates (Dillender 2021; Austin et al. 2021). In addition to its immediate effects, there is also evidence suggesting a connection between heat exposure and long-term health conditions, via cases of kidney disease among sugar workers of Central America (Applebaum et al. 2016). Finally, heat can complicate other exposures. For example, under higher temperatures the rate at, and degree to, which toxicants are absorbed into the human body can increase—for example through increased respiratory action or changes on the surface of the skin (Gordon and Leon 2005). As will be shown below, this can create particular complications where increased heat drives increased pesticide exposure among agricultural workers.

The impacts of heat are compounded by individual characteristics, such as a failure to drink enough fluids, particular medications, lack of recent exposure, age, previous experience of heat-related illness (HRI), personal levels of physical fitness, and level of exertion (Beyranevand and Skipper Nelson 2021; Runkle et al. 2019). Being overweight and being elderly are also identified as significant risk factors (Constible et al. 2020; Gubernot, Anderson, and Hunting 2014). Notably, exertional heat stroke can occur in young, otherwise healthy workers performing heavy physical labor (Austin et al. 2021). The literature suggests that biological sex does not act as a strong differentiating factor in determining vulnerability to HRI (Beyranevand and Skipper Nelson 2021; Goldman et al. 2021; Austin et al. 2021). The exception is in the case of pregnancy, for which heat exposure is associated with adverse birth outcomes (Beyranevand and Skipper Nelson 2021; Austin et al. 2021), including lower birth weight, which correlates with lower performance on numerous tests in later life.

The scope for such intergenerational impacts has caused some authors to speculate that prolonged heat stress might have decadal-long impacts on productivity (Heal and Park 2016).

While the impact of biological sex is relatively limited, gender has been identified as playing a strong role in shaping exposure and vulnerability to hazardous heat. Specifically, men tend to be over-represented in outdoor work, and thus more exposed to temperature extremes (Goldman et al. 2021), with evidence that they dominate documented cases of HRI as well as resulting hospitalization (Choudhary 2014). The clarity of such findings is muddied, however, by evidence that men are more likely to seek hospitalization for HRI (Choudhary 2014). Further, women are documented as being given more dangerous jobs—including in agriculture, where they show a disproportionate incidence of facial injuries and trauma (Goldman et al. 2021). Observational studies of differentiated HRI by sex and gender therefore need to be read with care. Beyond heat stress, it is worth noting the degree to which the literature points to women's exposure to sexual harassment and gender-based violence in agricultural workplaces (Goldman et al. 2021; Guild and Figueroa 2018).

Finally, educational attainment is classically thought to reduce heat risk, in part because levels of education tend to reduce exposure to heat as a hazard (through greater access to indoor, air-conditioned jobs) and because knowledge of heat as a hazard reduces risk (Runkle et al. 2019). However, one study, examining the impact of heat stress on grounds staff at public universities, found that education levels correlated with an increase in heat stress events. The explanation for this finding was thought to lie in acclimatization, as it was thought that educated staff were in management roles and therefore mainly based in air-conditioned offices. This led to a lack of acclimatization, which triggered heat stress events whenever staff went outside into the heat (Runkle et al. 2019).

Environmental factors can likewise exacerbate heat impacts. Factors include humidity, direct sun exposure, abundance of radiant heat sources, limitations on air movement, and types of personal protective equipment (PPE) and clothing (Beyranevand and Skipper Nelson 2021). As a result, certain professions are both more exposed and more vulnerable to heat effects. These professions include outdoor workers, indoor workers operating in environments without air conditioning, workers who require PPE, workers engaged in physically strenuous tasks, and workers operating in environments with other sources of ambient heat (e.g., fires) or thermally conductive environments (e.g., black roofs) (Gubernot, Anderson, and Hunting 2014; Chirico and Taino 2018; Applebaum et al. 2016; CDC 2008). Specifically, vulnerable occupations include: agricultural workers, construction workers, firefighters, first responders, military personnel, and teachers (due to a lack of air conditioning coverage in many schools) (Gubernot, Anderson, and Hunting 2014; Applebaum et al. 2016; Chirico and Taino 2018). Due to the way that toxicants can interact with heat (mentioned above), workers exposed to toxic chemicals are thought to be doubly exposed: having to wear PPE, inducing further heat stress, and being more vulnerable to failure/limitations of that equipment. Such occupations compound the risks faced, for example, by agricultural workers exposed to pesticides or nicotine (in the specific case of tobacco farming), first responders dealing with chemical spills, and construction workers exposed to hazardous material, e.g., asbestos (Applebaum et al. 2016; Gubernot, Anderson, and Hunting 2014; Chirico and Taino 2018; Arcury and Quandt 2011).

Notably in the context of this report, agricultural workers are not just vulnerable to high temperatures while working outdoors. Among agricultural workers who rely on their employer for housing, substandard living conditions, sometimes with no air conditioning, increase the risk of HRI when workers are unable to cool their bodies at night (Ferguson, Dahl, and DeLonge 2019; Chirico and Taino 2018). Likewise, stresses regarding poor nutrition and food insecurity often lead to chronic underlying conditions that increase vulnerability to HRI when exposed to extreme temperatures (Gubernot, Anderson, and Hunting 2014; Guild and Figueroa 2018; Chirico and Taino 2018).

The exact point at which heat stress becomes a problem is uncertain. The Centers for Disease Control (CDC) uses 100°F (Licker, Dahl, and Abatzoglou 2022), OSHA uses a threshold of > 91°F (Austin et al. 2021) while other thresholds include > 85°F (Austin et al. 2021). Notably, evidence from the literature suggests such thresholds might need to be much lower, especially if they are to account for the impacts of humidity and the potential need to wear heavy clothing as part of safety protocols (Austin et al. 2021). Some scholars argue that once humidity-inclusive temperatures exceed 95°F/35°C, extended work outdoors becomes unmanageable, as heat dissipation is simply not possible (Heal and Park 2016). Observational work has identified that cases of heat-related illness in the United States begin to rise when the heat index reaches 80°F (Licker, Dahl, and Abatzoglou 2022) while other work suggests temperatures above just 70°F can start to generate an increase in injury rates (Dillender 2021). Elsewhere, work shows that the relationship between temperature and heat stress events is nonlinear, with the rates of heat stress going up more quickly once temperatures exceed 85°F (Runkle et al. 2019). Notably, reducing the threshold for heat exposure has significant implications for considering rates at which exposure is expected to increase under climate change, as lower thresholds mean much larger exposures under increasing temperature (Austin et al. 2021). Quantifying the exact nature of the relationship between heat and injuries is challenging due to problems of under-reporting. One novel study using injury claim data suggested that a day with temperatures above 86°F–88°F saw increases in three-day claim rates by 2.1–2.8 percent (compared to days with temperatures between 59°F–61°F). Days with temperatures over 100°F saw increased same-day claim rates by 7.6–8.2 percent and three-day claim rates by 3.5–3.7 percent (Dillender 2021).

SCALE OF HEAT RISKS

In general, heat is identified as the leading weather-related cause of death in the US, exceeding deaths from lightning, hurricanes, tornadoes, and floods combined (Gubernot, Anderson, and Hunting 2014; Farhang Dehghan et al. 2020). Each year there are thousands of occupational heat-related illnesses. The last decade saw more than 300 civilian workers die on the job due to environmental heat exposure. Notably, this number is an underestimate as it overlooks a variety of severe or fatal injuries/illnesses—such as falls or heart attacks for which heat was a contributory cause (Gubernot, Anderson, and Hunting 2014).

As mentioned above, outdoor workers are both particularly exposed and uniquely vulnerable to heat stress. Estimating the risk to outdoor workers based on the risks experienced by the general population is difficult due to the fact that workers may have far less control over their environment than do the general population. For example, outdoor workers cannot access air conditioning and might have limited access to shade (Gubernot, Anderson, and Hunting 2014). Further, due to the way workplace injuries and illnesses are reported, formal reporting is thought to underestimate real prevalence (Jacklitsch et al. 2016) by as much as 300 percent (Guild and Figueroa 2018; Ferguson, Dahl, and DeLonge 2019). With these caveats in mind, OSHA estimates that, for the US in 2016, outdoor workers comprised 52.3 percent of workers affected by heat impacts and accounted for 79.2 percent of heat-related deaths (Dong et al. 2019). These numbers corroborate other estimates, which place outdoor workers' risk of death from heat exposure 35 times higher than for all other workers—a statistic with startling implications for the 32 million outdoor workers in the United States (Dahl and Licker 2021). Estimates of workers whose heat exposure led to a fatality range widely, from 400 to nearly 800 workers in a 24-year period (1992–2016), but even these numbers are low given that often statistics exclude foreign workers, such as those on H-2A visas (Chirico and Taino 2018; Constible et al. 2020; Austin et al. 2021). Considering the exclusion of foreign workers, these numbers could be as high as 1,200 to 2,400 workers experiencing heat-related fatalities.

In terms of geographic exposure, within the US, the Southwest, Southern Great Plains, Midwest, and Southeast are thought to be the most exposed. In numerous counties in these regions, workers are already

exposed to more than seven days per year when heat renders the conditions "unsafe." Within these regions, urban areas have historically been the most exposed to extreme heat, with the highest number of person-days[2] per year of extreme heat exposure. Large cities in the southernmost states are most exposed, such that the counties containing Miami (Miami-Dade County, Florida), Phoenix (Maricopa County, Arizona), and Houston (Harris County, Texas) are the only ones to experience, on average, 10 million or more person-days per year with a heat index above 100°F (37.8°C). (Dahl and Licker 2021). The number of counties with similar levels of exposure is expected to increase under climate change (see below).

Again, in the US, the implications of greater exposure to extreme heat in southern regions and large cities are complicated for outdoor workers. The overall number of outdoor workers is highest in urban areas. However, in cities, such workers also represent a smaller proportion of the total workforce compared to rural areas. Overall, this means that the majority of counties do not see a huge exposure of outdoor workers to extreme heat. Specifically, out of 1,972 counties (of a total of 3,108) in which outdoor workers constitute more than 25 percent of the workforce, only 132 experienced 30 or more days with a heat index greater than 100°F (which is when work reductions would have been recommended according to the existing protections in the US—see above) (Dahl and Licker 2021).

THE ECONOMIC IMPACTS OF INCREASED TEMPERATURES

Increased heat threatens workers' physical well-being, and thereby threatens their income streams and livelihoods. In terms of the economic impacts of these changes on workers and the economy, it has been estimated that higher temperatures will reduce global gross domestic product (GDP) by $2.4 trillion by 2030 (Dong et al. 2019), putting pressure on the individual livelihoods of outdoor workers (particularly in the case of hourly and piecework (Constible et al. 2020)) and threatening the larger tax base that supports social and other services (Licker, Dahl, and Abatzoglou 2022). In addition to threatening worker well-being, however, higher temperatures also affect worker productivity, resulting in further impacts for worker livelihoods and the overall economy. In this respect it is notable that the World Health Organization (WHO) has stated that any decline in a worker's performance of daily activities due to heat, cold, or extreme weather should be considered a 'health effect' of climate conditions (Runkle et al. 2019).

Pathways for reduced productivity derive from reduced cognitive function and reduced labor supply. Estimating the relationship between productivity and temperature is, however, difficult. Laboratory studies need to be viewed with caution because, in the real world, workers will respond to temperatures in a variety of contextually specific ways: shifting their work hours, seeking time in the shade, taking more breaks, wearing different clothing, etc. Since the array of measures is huge and highly contextual, laboratory studies cannot account for all of them, thereby limiting their relevance to real-world scenarios. Such limitations raise the importance of observational studies for understanding historic relationships. The limitation here, however, is that relationships under future temperature increases might behave differently from the past. For example, capacity to work under very high temperatures might suddenly decline (for example if there are real limits to adaption (Dillender 2021)). As a result, there are also limits to what can be extrapolated from historical data (Heal and Park 2016).

[2] The notion of person-days derives from the study design, which intended to work out the areas with the greatest exposure to hot days. In order to account for the fact that we care more about an increase in hot days in heavily populated places, the study multiplied the number of days of exposure, by the number of people exposed, giving the notion of "person-days".

Such difficulties notwithstanding, evidence of the scale of the potential impacts of temperature on productivity suggests they are nontrivial. Looking at plant-level productivity, research from US automotive manufacturing has demonstrated that six or more days with temperatures exceeding 90°F reduces weekly production by about 8 percent, although the study's capacity to control for the use of air conditioning was limited (Heal and Park 2016). Such findings are echoed in other research, which also highlights that such reduced productivity likely derives from reduced job-task productivity, rather than increased absenteeism (Heal and Park 2016). However, evidence also suggests a significant role for reduced time allocated to labor. Research among highly exposed industries shows that temperatures above 85°F result in reduced time allocated to labor by as much as 1 hour/day (14 percent). Most of this reduction happens at the end of the day when fatigue from prolonged heat exposure sets in (Heal and Park 2016).

A notable feature of the economic literature is that it suggests that impacts on productivity begin to occur at much lower levels than threats to physical health. For example, in both India and the US, declines in productivity have been documented starting around 22°C (71°F), declining by 1.8 percent/°C in India and 2.8 percent/°C in the US (Heal and Park 2016). Reviews of the economic literature suggest marked effects on productivity beginning when temperatures exceed 78°F (25°C), which includes evidence corroborating claims that task productivity can begin to fall at temperatures as low as 72°F, and indicating similar rates of decline (2 percent/°C for cognitive tasks), though noting the relationship becomes nonlinear (i.e., productivity declines more quickly at higher temperatures) as one moves further from the optimal temperature of around 68°F (20°C) (Heal and Park 2016).

There is also evidence that hotter countries experience lower levels of productivity. However, this work should be viewed with extreme caution. Numerous factors shape productivity, and cross-country comparative work isolating the role of temperature runs the risk of environmental determinism. From a more nuanced perspective, there is mixed evidence as to whether increasing temperatures will be more tolerable in already hot places or in currently cool places, with competing theses as to whether scope for adaptation is larger in cooler areas or whether acclimatization matters more. Heal and Park (2016) argue there is evidence that hot areas tend to see lower declines in productivity in the context of hotter weather, suggesting scope for adaptation in cooler areas, though they note there could well be limits for outdoor workers. To this end, Dillender (2021) finds that hot days in cooler climates have fewer impacts on worker well-being than is the case in hot areas, as workers in cooler areas are able to shift work hours, which is simply not possible in places that experience frequent hot weather.

Regardless of the debate on the possibilities for adaptation, there is believed to be significant evidence to suggest that limited access to capital and greater exposure to heat stress among low-income countries likely means that the impacts of heat on productivity will be felt most acutely in those countries. Likewise, within nations, low-income groups doing more exposed manual labor are anticipated to suffer worse productivity declines (Heal and Park 2016).

While worker productivity affects economic activity, it should be further noted that heat can change agricultural productivity. Increased rates of transpiration and reduced moisture content can reduce harvest size. Further, increased exposure to fire smoke can affect crops, most notably wine grapes (Austin et al. 2021). Such impacts stand to compound challenges for worker livelihoods as the sector shrinks, and place further pressure on the economic and tax base of certain regions.

Finally, it should be noted that it is not only hot temperatures that are associated with increased injury. Cold temperatures also have physiological effects (causing arteries to narrow, blood to become more viscous, and the body to lose heat, thereby depleting energy). Cold weather is also associated with muscle sprains, strains, and injury, and in the worst cases can drive hypothermia. Freezing conditions also introduce specific hazards such as ice. Like high temperatures, cold exposure can result in reduced productivity (Dillender

2021). Quantifying this relationship is similarly difficult. However, one empirical piece of work finds that days with temperatures between 35°F–40°F are associated with an increase in three-day claim rates of 3.4 percent–5.8 percent (Dillender 2021).

FORECASTS OF FUTURE HEAT IMPACTS

As mentioned above, climate change has already driven significant changes in temperature, with average temperatures increasing by as much as 1.8°F, on average, across the US. Such averages, of course, belie greater increases in certain parts of the country, like the Southeast, Texas, and parts of the Southwest (more below). Further, there is evidence of more frequent and intense heat waves in recent decades (Constible et al. 2020). Climate change is anticipated to increase heat exposure, increasing the number of days when outdoor work is unsafe (Dahl and Licker 2021), preventing work, and disrupting commutes (Constible et al. 2020). Climate change also stands to increase the duration of periods during which working conditions are unsafe (Runkle et al. 2019). It is also likely to drive the onset of extreme temperatures earlier in the year, which is anticipated to increase stress on well-being, as the time for acclimatization is diminished (Gubernot, Anderson, and Hunting 2014).

The productivity of outdoor manual labor is already thought to have declined based on climate change by 5.3 percent between 2000 and 2016, with significant declines of more than 2 percent between 2015–2016. Effects being most notable among some of the most vulnerable countries in the world (Watts et al. 2018). Currently in the US, around three million outdoor workers experience the equivalent of seven or more unsafe workdays per year due to extreme heat. By mid-century, this number is expected to be 14 million workers with slow action on climate change, and 18.4 million workers with no action (Licker, Dahl, and Abatzoglou 2022). Assuming moderate greenhouse gas emissions reductions (Representative Concentration Pathway (RCP) 4.5–see Text Box 2 below), outdoor worker exposure to extreme heat would triple the late-20th-century baseline by mid-century. Assuming workers are not paid for time missed when it is too hot to work, whether based on an hourly or piecemeal rate, an estimated $39.3 billion in annual earnings (3.7 percent of outdoor workers' earnings) would be placed at risk. By late century, this number increases to $49.2 billion (4.7 percent of earnings) (Licker, Dahl, and Abatzoglou 2022). Under the worst case scenario (RCP 8.5), mid-century losses reach $55.4 billion (Licker, Dahl, and Abatzoglou 2022). Returning to the moderate scenario (RCP 4.5), the average outdoor worker in the United States risks losing approximately $1,200 in earnings per year, while under the worst-case climate scenario (RCP 8.5), annual earning losses climb to $1,700. This translates to more than 7.1 million US workers seeing 10 percent of their earnings placed at risk. Slow action on climate change reduces the number of workers exposed to 250,000 (Licker, Dahl, and Abatzoglou 2022).

Text Box 2: Representative concentration pathways (RCPs)

Efforts to model future climate impacts vary depending on the model inputs. Some of these inputs vary based on available data, and some depend on unknown data. The most important unknown for such models is the rate at which emissions declines will take place and therefore the concentration of carbon dioxide that will be reached in the atmosphere. To account for this, the Intergovernmental Panel on Climate Change (IPCC) developed a set of scenarios termed the "Representative Concentration Pathways" (RCPs) that reflect the amount of CO2 in the atmosphere. Climate modelling then uses these different scenarios as inputs to the models when determining the impact on the climate and the resultant impact on society. The RCPs were first developed for use in the Fifth IPCC report released in 2014. Prior to that, emissions scenarios were developed as part of the Special Report on Emissions Scenarios (SRES). The difference between the RCPs and SRES is that the latter start with the

socioeconomic context and look at what emissions they would produce, while the RCPs start with the atmospheric concentrations of carbon and determine what socioeconomic actions would be needed to achieve these concentrations .

In the literature reviewed for this report's discussion of future climate impacts on outdoor workers, it is common for the literature to invoke some selection of these scenarios when describing impacts. For this reason, we briefly outline the eight scenarios below:

- - RCP1.9: Limits warming to below 1.5°C, the aspiration of the Paris Agreement, and is the most stringent reduction pathway.
- - RCP2.6: Also a very stringent reductions pathway. Likely limits temperature rise to 2°C. Requires that emissions start declining in 2020 and reach zero by 2100.
- - RCP3.4: Lies between the very stringent pathway of RCP2.6 and the less-stringent RCP4.5. One variant of RCP3.4 includes possibilities for scaled removal of CO2 from the atmosphere.
- - RCP4.5: Is an intermediate scenario in which emissions peak by 2040. While exaggerated toward an availability of fossil fuels, it is thought to be the plausible baseline scenario, considering the fact that fossil fuels are not renewable.
- - RCP6: Sees emissions peak around 2080 and produces average temperature increases of 3°C–4°C.
- - RCP7: Like RCP3.4, RCP7 is a gap-filling baseline scenario, representing the medium to high end of warming scenarios.
- - RCP8.5: Sees emissions continue to rise throughout the 21st century. This is believed to be unlikely but is possible given the lack of understanding of climate feedbacks. The scenario is invoked as the worst-case scenario for climate change.

These nationwide averages obscure the much larger losses in the most affected parts of the country. Under the moderate scenario (RCP 4.5), 10 counties with the highest losses see average annual lost earnings of $5,600 per person, while for the worst-case scenario (RCP 8.5) the number is $7,000. Within this, the greatest losses accrue to workers in construction and extraction occupations (Licker, Dahl, and Abatzoglou 2022). The areas most affected by lost work-days are anticipated to be the Southeast, Texas, and some of the Southwest. Specifically, Louisiana will see among the highest (34) number of unsafe workdays on average by mid-century under RCP8.5. Across the country, over 60 percent of counties are anticipated to be affected by increasing heat exposure (Licker, Dahl, and Abatzoglou 2022).

INTERACTION OF HEAT WITH OTHER STRESSORS

While heat impacts are a significant and worsening stressor, it should be noted that the impacts of heat can be compounded by other environmental stressors, which are also being exacerbated by climate change. Within the literature on outdoor workers, and especially farmworkers (as the focus of this work), both wildfires and dust, as well as pesticides, have been identified as of significant concern.

Increased wildfires, as well as increased dust exposure, are a threat to all outdoor workers (Constible et al. 2020). Wildfires and subsequent smoke exposure events are thought to be growing in terms of both prevalence and magnitude, and present a growing annual hazard (Pedersen et al. 2021). Exposure to wildfire smoke is associated with respiratory irritation as well as symptoms and exacerbations of underlying asthma and chronic obstructive pulmonary disease (inflamed lungs). Though health effects of short-term exposure to wildfire smoke tend to be self-limited, more work is needed to understand the health effects of longer-term cumulative exposure, interactions of wildfire smoke and agricultural burn and other pollutant exposures, and interactions of workplace exposures with home and community exposures (Austin et al. 2021). Most of our

current understanding of the occupational risks of smoke exposure derive from the experience of firefighters, for whom exposure has been linked with increased risk of respiratory illness and negative mental health outcomes (Austin et al. 2021; Constible et al. 2020). Notable in this respect is that fact that firefighters, in particular, are affected by the increasing fire occurrence, which is driving exhaustion due to reduced recovery times between wildfire seasons (Pedersen et al. 2021).

The only study on wildfire exposure and agricultural workers in the US, undertaken in Washington State, used air quality monitoring and temperature data to identify that fine particulate (less than 2.5 microns in length, known as "PM2.5") concentrations were highest in the summer months, during the same period that agricultural workers were at their highest levels in the state. Notably, concentrations were also highest on hot days (> 85°F) and among the Washington State counties that had the largest populations of agricultural workers (Austin et al. 2021). Fine particulates are of concern, as their small size allows them to travel deep into the respiratory tract. They have been linked with a variety of more and less severe respiratory and cardiovascular diseases (New York State Department of Health 2018). There is good reason to believe that the impacts of increased fires will compound the difficulties of increased heat exposure. This is doubly true given that one precaution for working in environments with poor air quality is mask-wearing, an act that is more uncomfortable during periods of increased heat. A notable feature of the wildfire exposure is our lack of understanding of the extent of the problem, due to inadequate air quality monitoring. Austin et al. (2021) found that within Washington State there was, on average, only one air quality monitoring station every 3,330 km,2 with some Washington counties having no dedicated air quality monitoring stations at all (Austin et al. 2021).

Two further points are worth noting. First, recent increases in the density of air quality monitoring sensors in California have transformed our understanding of the scale of the problem, indicating that it was 10 times worse than previously thought (Austin et al. 2021), with disproportionate exposure among low-income populations (Fowlie, Walker, and Wooley 2020). Second, new evidence has recently come to light on the severe and negative impacts of woodsmoke on people's health. Specifically, morbidity from pollution caused by cooking indoors on unimproved cookstoves has led to a reevaluation of the health impacts such that, in 2010, morbidity associated with lower respiratory infections was estimated to be higher than from malaria and tuberculosis in Sub-Saharan Africa (World Bank Group 2012; Africa Progress Panel 2013). Such findings raise the alarm on the potential scale of health impacts from increased wildfire smoke in the US. A lack of monitoring as to the exact scale of air pollution problems, our historic underestimation of their impacts, and the growing exposure to air pollution caused by climate change raise the importance of investing much more heavily in understanding the risks of air pollution to outdoor workers, both currently and in the future.

Dust from increased droughts has also been identified as a source of important air pollution along with increased fires (Constible et al. 2020). Dust is thought to act similarly to wildfire smoke, driving respiratory ailments. In addition to particulate pollution, in the case of rural areas, dust can also carry the increased risk of inhalation of pesticides—discussed in greater detail below—resulting in pathogens being carried into the bloodstream via the lungs (Constible et al. 2020). While this review saw limited reference to the risks posed by increased dust, one paper referred to a phenomenon known as "Valley fever," a respiratory illness caused by multiple species of Coccidioides fungi and spread by contaminated dust. Arizona and California are thought to be the worst-affected states. In the majority of cases, Valley fever manifests as flu-like symptoms such as coughing and fatigue. In rare cases, infection has been known to spread outside the lungs, resulting in meningitis and other severe conditions. For reasons that are not currently understood, African Americans and people of Filipino descent are more likely to develop serious Valley fever infections than are other racial and ethnic groups (Constible et al. 2020).

Regarding pesticides, as was mentioned above, there is emergent evidence that under higher temperatures the human body is increasingly susceptible to pesticides and other toxicants, for which both the acute and

long-term effects appear increased (Ferguson, Dahl, and DeLonge 2019; Constible et al. 2020; Goldman et al. 2021). Further complicating matters is that the increased use of pesticides increases the need for protective clothing, which compounds heat stress. Finally, under higher temperatures, crops are anticipated to be additionally stressed and vulnerable, thereby necessitating the greater use of pesticides under a changed climate (Goldman et al. 2021). This vicious cycle of effects is particularly concerning given the limited protections afforded to, and unique structural experiences of, agricultural workers. These will be discussed below.

While these impacts are notable, taken by themselves they may miss some other important social concerns. First, the findings above might under-represent the real impacts, as the downscaled climate models that inform these analyses fail to account for local effects, e.g., heat islands, which could, in fact, result in more intense local temperature increases, driving more lost work-days, larger reductions in productivity, and more days of high-risk working conditions (Licker, Dahl, and Abatzoglou 2022). Second, as was mentioned above, heat is not the only impact of climate change. Other factors interact with heat—for example increased pesticide use and increased exposure to fire smoke—to compound the scope for dangerous working conditions under future climate change (Gubernot, Anderson, and Hunting 2014). Models tend to leave out these interacting factors. Third, as was mentioned above, many outdoor workers are from already marginalized groups, disproportionately representing Black and Hispanic/Latinx workers, who often earn below the median wage, have worse health outcomes, and experience higher rates of poverty. The impact of further reduced earnings stands therefore to be particularly damaging (Licker, Dahl, and Abatzoglou 2022). Together, the significance of these impacts has led to calls for heat impacts to be included in integrated assessment models aimed at appropriately determining the true cost of carbon (Heal and Park 2016).

AGRICULTURAL WORKERS

- Agricultural workers in the US are currently excluded from a host of protections and bargaining rights afforded to other workers.
- The contemporary vulnerability of agricultural workers has its roots in long-standing historical processes, with contemporary marginalization stemming from systems of slavery, immigration policies, and racism.
- Limitations on protections stem from: lack of minimum wage protections; exclusion from the right to organize; limited protections under OSHA; the limitations of the EPA as a vehicle for protecting workers; a general failure to protect migrant workers; lack of enforcement of existing protections; limited scope for complaint/reporting; lack of access to healthcare; and poor health outcomes.
- Pesticides are the best-regulated hazard, though gaps still remain, while protections against heat and air pollution are extremely limited.
- Immigrant workers on "small farms" face the greatest deficits in terms of meaningful protections.
- Regardless of the state of formal protection, failures of enforcement significantly undermine the landscape of potential protections available to agricultural workers.

Having discussed the risks posed by climate change in general to outdoor workers, the report now moves to discuss the specific risks faced by agricultural workers. Agricultural workers are highly exposed to climate impacts and, in the context of the US political landscape, are a more vulnerable workforce than other outdoor workers. As will be discussed in more detail, there have been significant efforts to disenfranchise agricultural workers, including limiting their protections and wages, and undermining their capacity to organize. Relatedly, the majority of agricultural workers are of lower income status, and comprise racial, ethnic, and in some cases linguistic minorities who often occupy temporary or immigrant status. These realities compound their vulnerability to climate change and provide important context for any efforts to address such vulnerability. The next section therefore provides the history of agricultural workers in the United States, giving the context for their legislative exclusion and continued vulnerabilities to climate change and the sources of their socioeconomic marginalization. It then goes on to describe the state of protections (or lack thereof) currently experienced by farmworkers. The next sections of this report discuss options for, and limitations to, adaptation, before identifying priority areas for policy reform to improve the well-being of agricultural workers in a context of climate change.

A HISTORY OF US AGRICULTURAL LABORERS AND FARMWORKER EXCLUSIONS

The long history of farmworker labor in the United States, and the many ways the US federal government intervened on behalf of the growers in key policy decisions and not on behalf of the workers, has resulted in the continued exclusion of farmworkers from key federal protections. Agricultural labor in the US began largely with indentured labor from Europe before shifting to chattel slavery for the next several centuries. Even before the chattel slavery system ended, the West Coast began another form of labor exploitation, first through indenture and later via contract systems, which saw the literal importation of workers from East Asia, largely China, to work in the US West. After the abolition of slavery in 1865, and during the turn of the century, with westward expansion continuing and land grants being offered to white immigrant settlers, the agricultural industry continued to thrive throughout the United States, as an industry that required large numbers of workers, especially for seasonal harvests. As demonstrated by scholars such as Cindy Hahamovitch, the 20th-century evolution of farmworker policy by state and federal governments reflected not

only deep-seated racial prejudices but also a policy of agricultural exceptionalism whereby farmers or growers were deserving of governmental intervention and support, but their laborers were not (Hahamovitch 1997; Beyranevand and Skipper Nelson 2021).

During World War I, for example, Black men in the South lived under the purview of "work-or-fight" laws whereby either they were conscripted into military service or lent to farmers to provide labor. These conscriptions were the means of keeping white men, and even white women, from having to partake of agricultural labor, the fields being a place southern whites only associated with Black workers. These policies were devised and underwritten by the US Department of Agriculture (USDA), an entity that was established in 1862 by President Lincoln, but had evolved by the turn of the 20th century to become an agency predominantly based in the South. As an agency that states could opt into so long as they matched federal dollars, the USDA had a huge presence in the South, reflecting the region's strong economic emphasis on agricultural production. By the eve of World War I, the USDA predominated in the former Confederacy, and its members and leaders were white southern men who advocated for forced Black labor. White southern planters, some of whom were themselves members of the USDA, believed that Black laborers worked less when paid more and created policies to reflect that belief (Hahamovitch 1997).

This legacy continued into the middle of the 20th century, when farmworkers were left out of the Fair Labor Standards Act (FLSA), a legislative part of the New Deal that mandated minimum wages, limited overtime and working hours, and outlawed child labor. Furthermore, farmworkers were excluded from the right to organize under the National Labor Relations Act (NLRA), another piece of New Deal legislation that established the right of workers to bargain collectively (Goldman et al. 2021; Guild and Figueroa 2018). Underlying these exclusions were the same dynamics of the US South that characterized the formation and operation of the USDA up to this point. In order to achieve passage, Roosevelt's New Deal required compromise with southern senators, which manifested as the exclusion of (largely Black) agricultural and domestic workers from such protections. These same exclusions, a true reflection of Jim Crow-era politics, were later replicated in federal policies. In 1970, when Congress passed the Occupational Health and Safety Act, which established the Occupational Health and Safety Administration (OSHA) and created greater protections for workers from workplace injury, farmworkers were not covered, and they continue to be excluded from federal workers' compensation (Goldman et al. 2021; Guild and Figueroa 2018).

Not only were farmworkers barred from the protected right of collective action by their exclusion from the NLRA, but with the onset of World War II and drafting of men into the war effort, the federal government created a new program of labor importation that undermined domestic farmworkers' ability to bargain collectively for higher wages and better treatment. When, in the early 1940s, largely Black farmworkers began to successfully strike or simply leave one farm for another in the search for higher wages and better treatment, growers successfully advocated the federal government to create a new program for bringing workers into the US from other countries—Jamaica, Mexico, Haiti, Barbados—creating the possibility to simply deport workers who advocated for themselves (Hahamovitch 1997). This labor importation program, sometimes referred to as guestworkers or the "Bracero" program (a term specifically used in relation to temporary agricultural workers from Mexico) created a new labor landscape for farmworkers after the start of World War II. In the first wave of the Bracero program, beginning in 1942, the US government itself was considered the employer of these migrant workers and held labor contracts with the Mexican government for its laborers. Since the Mexican government itself was negotiating on behalf of its citizens, the terms of the first labor contract were some of the strongest and most comprehensive terms in support of workers "in the history of American agriculture"(Hahamovitch 1997, 168). Beyond establishing strong wage laws, coverage for housing and transportation, and a guarantee of a certain number of work-days, the contract uniquely included a pay guarantee: "If weather or other factors cut short their need for labor, growers would still have to pay the transported workers for 75 percent of the period covered by the contract" (Hahamovitch 1997, 168). Despite the strong protections offered in these early labor contracts, the enforcement of the terms was

weak, and the constant threat of deportation for all workers, including those from Mexico who were theoretically protected by their government's contract, loomed large. The importation of workers reached another level of complication when the program expanded in 1944 to include Puerto Ricans, who, as US citizens, could not be deported to their home country. Rather, a system was created whereby a proportion of Puerto Rican migrant workers' pay was deposited in Puerto Rican banks, requiring these workers to return to the island to access their wages (Hahamovitch 1997; Suárez Findlay 2014; Griffith 2022).

The Bracero program ended by the early 1960s through a confluence of shifting domestic US politics, shifting public opinion against farm owners and their poor labor practices (brought on by public campaigns and even documentary films such as "Harvest of Shame"), and a breakdown in negotiations between the US and Mexican governments (Cohen 2011). Beyond the end of the official labor exchange system created between the US and Mexican governments, the program itself was marred by accusations of worker abuse and mistreatment, ranging from wage theft to physical abuse (Guild and Figueroa 2018; Goldman et al. 2021; Cohen 2011).

As the Bracero program marched toward its eventual demise, in 1952 the US government established the H-2 visa program, a new guestworker program created for temporary migration of foreign nationals to provide labor that no US citizen could (or would) do. While minimum wages for H-2 workers are calculated to prevent negative impacts on wages or working conditions of similarly employed US workers, they have been found to suppress farmworker wages and drive human rights violations. Notably, H-2 workers cannot switch employers, which can force them to remain in substandard conditions (Goldman et al. 2021).

During the Reagan administration, the Immigration Reform and Control Act of 1986 passed, which split the H-2 program into agricultural workers (H-2A) and nonagricultural workers (H-2B). At the time of its passing, the bill provided amnesty for undocumented immigrants living in the country since before 1982, which led to about 2.7 million previously undocumented migrants becoming lawful permanent residents (Goldman et al. 2021). In the early 20th century, the Mexican government initially agreed to the Bracero program as a means to modernize the national workforce through skills training in the agricultural sector of the United States as a way to expand agricultural production in Mexico (Cohen 2011). However, in the late 20th century, the North American Free Trade Agreement (NFTA) flooded hemispheric markets with subsidized US products, undermining local production and leading to an ever-greater increase in agricultural migrants to the United States and a greater demand for cheap labor (Goldman et al. 2021). Despite the laws, H-2A workers only comprise about 12–18 percent of the US workforce, with nearly 50 percent of the farm labor force coming from undocumented workers. Policies that crack down on undocumented workers have been identified as contributing to ongoing labor shortages in the sector (Goldman et al. 2021). Although H-2A contracts and paperwork are so cumbersome many farmers do not pursue them, for others using only some H-2A contracts insulates them from accusations of hiring undocumented workers, creating what some scholars call "a situation ripe for abuse" (Quoted in Ferguson, Dahl, and DeLonge 2019, 2; see also Goldman et al. 2021). As with the early-20th century policy landscape, where growers successfully advocated the federal government in their interests to the detriment of workers, migration policies serve growers by creating an unprotected labor force (Goldman et al. 2021).

MODERN FARMWORKERS AND THE IMPACT OF GENERATIONAL EXCLUSIONS

In 2021, there were an estimated 2.6 million farmworkers in the United States (USDA 2023), the vast majority are foreign born (70 percent in 2020), with the majority of those workers from Mexico (63 percent of the total)

(DoL n.d.). As of 2020, 66 percent of farmworkers were men, reflecting a general upward trend in the feminization of US agricultural work (in 1998–2000 that number was 80 percent). Half of them identify as parents, and 56 percent are married (DoL n.d.) . Almost half (~45 percent) of "hired crop workers" are classified as "unauthorized" (DoL n.d.). Farmworkers are also over-represented in measures of poverty. At the time of publication of this report, 20 percent of farmworkers live below the federal poverty level (DoL n.d.; Guild and Figueroa 2018), with conditions being worse among immigrant workers. In general, farmworkers remain vulnerable to an array of stresses. For example, access to healthcare is systematically lacking. Estimates vary but suggest that between 52 percent to 71 percent of adult migrant farmworkers are uninsured (Goldman et al. 2021; DoL n.d.), and 41 percent of all farmworkers have not received formal medical care in the last two years. This is compared to less than 17 percent of the general population in the US who have not received medical care in that time frame (Goldman et al. 2021) .

Climate change is a real and growing concern for farmworkers. According to the literature reviewed for this work, the primary climate change hazards concerning farmworkers and their well-being are heat, pesticide poisoning, and air pollution (resulting from dust and wildfires). Considering the physical nature of the work and the fact that it takes place outside, primarily during the summer months and often in heavy clothing, it is unsurprising that HRI is common among farmworkers. A 2010 study found that 40 percent of farmworkers reported experiencing at least one HRI symptom over the course of their career. Another study from 2013 found that 64 percent of farmworkers reported experiencing at least one HRI in the previous week while working in hot weather (Goldman et al. 2021). The seasonal nature of the work (with an emphasis on summer months) and heavy clothing requirements for worker safety lead scholars to suggest construction workers and farmworkers will be most impacted by rising temperatures as it relates to their workplace safety and their risk of injury (Chirico and Taino 2018). The prevalence of poisoning is extremely high, with EPA estimates stating that up to 3,000 farmworkers a year experience "acute chemical poisoning" while on the job, a number largely considered an underestimate (Farmworker Justice 2018). Finally, the impacts of wildfire smoke and air pollution are relatively novel concerns but are of increasing relevance, as wildfire seasons continue to lengthen and intensify in the western states. As indicated above, there are few studies on the impact of air pollution and wildfires on air quality for outdoor workers, especially as there are insufficient air quality monitoring sites in the US. This is a basis for future study, as climate events negatively impacting air quality are anticipated to increase. As of now, there appear to be very little data on the current health burden and concomitant impacts of air pollution for outdoor workers, including farmworkers.

These same rates of vulnerability, especially for construction workers and farmworkers, are made more extreme when taking race into consideration. There were higher rates of illness and fatalities among Black and Latinx workers, communities that are disproportionately over-represented among outdoor workers (Dong et al. 2019; Dahl and Licker 2021). In the 10-year period between 2000 and 2010, Latinx workers were three times more likely to die of heat exposure than non-Latinx people (Chirico and Taino 2018). Communities of color, therefore, are doubly exposed to climate change hazards by their disproportionate representation in vulnerable workforces and their underlying vulnerability to climate hazards made more acute by continued systemic marginalization in the areas of housing, healthcare, and food deserts, among others.

Explanations for the high rates of poverty, exposure, and vulnerability experienced by farmworkers lie, in part, in farmworkers' exclusion from many of the protections afforded to other workers. Below we outline the continued exclusions of farmworkers and the repercussions of these legislative choices. The long history of these exclusions, outlined above, continues to echo today as farmworkers continue to face marginalization via: i) a lack of minimum wage protections; ii) exclusion from the right to organize; iii) effective exclusion from the purview of OSHA; iv) limitations of the EPA to protect workers; v) failure of the Migrant and Seasonal Agricultural Worker Protection Act (MSPA) to protect migrants; vi) limited enforcement of the protections that do exist; vii) structural impediments to reporting on violations of the limited existing rights and protections; and viii) limited access to healthcare. Each of these is discussed in detail below.

LACK OF MINIMUM WAGE PROTECTIONS

As mentioned above, the FLSA was created in 1938 as the basis for the right to a minimum wage, limits on working hours, limits on overtime, and limits on child labor. However, upon its creation, agricultural workers were one of the groups excluded from the FLSA, and they lacked access to its basic protection for years. All agricultural workers were excluded from the FLSA minimum wage provision until 1966 when farmworkers with 500 "man days" or more were given a subminimum wage. Farmworkers were more substantively included in 1977 when the lower minimum wage for workers of large agricultural employers was eliminated (U.S. Department of Labor, Wage and Hour Division 2020).[3] Today only large agricultural employers are required to pay the federal minimum wage, with small employers exempt from the FLSA. Employers who did not utilize 500 "man days" of any quarter of the preceding year; piece-rate harvest workers, working less than 13 weeks per year; minors (those 16 years of age and under, who hand-harvest for piece-rate pay and work with their parents); agricultural employer family members; and range workers for livestock are all exempt from minimum wage requirements (U.S. Department of Labor, Wage and Hour Division 2020). Among piece-rate agricultural workers—who are paid based on the volume harvested per day—minimum wages remain unenforced. With the exception of California, farmworkers are disincentivized to take rest or water breaks for fear of seeing reduced earnings (Department of Industrial Relations 2022). The exclusion of farmworkers from FSLA not only allows piece-rate payment but also denies farmworkers overtime pay. As a result, surveys suggest the average farmworker logs 45 hours per week, but those harvesting field crops tend to work 54 hours per week, all without overtime pay (Goldman et al. 2021).

While the extent of wage exploitation among US farmworkers is, in general, extremely concerning, the issue is even more dire among H-2A visa holders. Wages among H-2A holders are often set at the Adverse Effect Wage Rate (AEWR) created under the Bracero program, a "regional average hourly wage for nonsupervisory field and livestock farmworkers combined." In 2020, this wage ranged from $11.71 per hour in some southern states and to $15.83 in Washington State (Goldman et al. 2021). For non-H-2A farmworkers, the average hourly pay in 2019 was $13.99 (Goldman et al. 2021). To put that into context, according to the US Bureau of Labor Statistics, in 2021 the average hourly wage for US workers regardless of industry was $30.52 (U.S. Bureau of Labor Statistics, Department of Labor 2022).

For H-2A visa holders, there are many issues when it comes to compensation beyond the low wages typically associated with farmworkers. Often H-2A workers are charged by recruiters for costs that recruiters are legally required to cover, such as transportation and employment placement. Thus, many migrant farmworkers arrive at their positions already in debt, with amounts ranging from $500 to $10,000. If these same workers experience any wage-withholding from their employers, they are essentially working in "debt bondage," a form of coerced labor (Goldman et al. 2021, 24–25). The reality of employers withholding wages, or practicing other forms of wage theft, is alive and well for farmworkers. In fiscal year 2021 alone, the Department of Labor's Wage and Hour Division recovered $8.4 million in back wages for agricultural workers (DoL 2022). Alarming as this figure is, it should be recalled that this amount is what was recovered, not the actual amount taken from workers.

[3] "Man days" are any day an employee performs agricultural work for at least one hour.

EXCLUSION FROM THE RIGHT TO ORGANIZE

The passage of the NLRA in 1935 solidified private sector employees' freedom of association, guaranteeing the right to organize into trade unions, engage in collective bargaining, and take collective actions such as striking. Much like the FLSA, when the NLRA passed it excluded specific sectors from the guaranteed freedom of association, including agricultural and domestic workers. This strategic exclusion was a move to restrict largely Black workers in the South from organizing against their employers. And this highly racialized exclusion continues to this day. Agricultural workers remain excluded from the NLRA. And while during its creation the NLRA targeted Black workers in its exclusion, today the continued exclusion of agricultural and domestic workers from the right to organize further marginalizes Black, Indigenous, People of Color (BIPOC) and immigrant workers.

Though excluded from the NLRA, agricultural workers have still fought for their right to organize, perhaps most famously through the movement led by Cesar Chavez, Dolores Huerta, and others to organize farmworkers in California into the National Farmworkers Association in the early 1960s (Library of Congress n.d.). This movement was followed by others, including the Farm Labor Organizing Committee (FLOC) and the Coalition of Immokalee Workers (CIW), showing that collective action is possible even without protection from the NLRA (Guild and Figueroa 2018; Coalition of Immokalee Workers 2013). Yet despite the success of some farmworker organizing, the exclusion from federal protections leaves the sector more vulnerable than many. Furthermore, the mechanisms created for sourcing immigrant agricultural workers undermine the scope for organization, as an abundance of cheap labor reduces the negotiating position of US citizens and residents who work in the agricultural sector. Among H2-A visa holders, there are numerous obstacles to worker organization. Chief among them is that work is linked to immigration status, meaning that if workers are dismissed from their jobs for organizing or contesting their rights, they risk deportation. The lack of recourse for migrant workers is a notable power imbalance. See section below on the structural impediments to complaining/reporting.

LIMITED OSHA PROTECTIONS

As previously mentioned, OSHA was created in 1970 with the Occupational Safety and Health Act, which established the entity within the Department of Labor to ensure and enforce workplace safety standards. States must, at a minimum, incorporate federal standards into their worker protection laws—with the capacity to adopt more rigorous standards should they deem it necessary (Beyranevand and Skipper Nelson 2021). OSHA sets the floor when it comes to jurisdiction over ensuring a safe workplace for agricultural workers, though to this day any "small farms" or farms that employ 10 or fewer workers are exempted from OSHA oversight or enforcement (Beyranevand and Skipper Nelson 2021).[4] Congress annually inserts a rider into the federal budget, via the appropriations process, which prohibits the use of any federal funds in the execution of OSHA's mandate on "small farms" (Guild and Figueroa 2018). While small farms are totally unprotected by OSHA, even workers on large farms experience significant protection deficits. OSHA lacks any formal heat standard, has no standards mandating protections in the context of pesticide use (this is left to the EPA—see below), and lacks any protections limiting the risks to outdoor workers from exposure to air

[4] Though our partner organization, Farmworker Justice, often points out that one way farmers flout this rule is by subcontracting or hiring "contract" workers from contractors or growers associations. By using contract work, farmers can claim they only "directly hire" 10 or fewer workers and are therefore excluded from OSHA but also from employment standards around wages or protections. For more, see https://www.farmworkerjustice.org/advocacy_program/sub-contracted-workers/.

pollution. Notably, concerns about heat are long-standing. The CDC first identified hazardous heat as a health concern as far back as the 1950s. Despite the National Institute for Occupational Safety and Health (NIOSH) recommending a specific heat exposure standard as far back at 1972 (and updating this recommendation in 1986 (Gubernot, Anderson, and Hunting 2014)), up until recently OSHA had not developed any specific standards that protect workers from heat.[5] Instead, OSHA has developed nonbinding guidance that details protective measures for workers depending on the heat index, starting when temperatures exceed 90°F.[6] Strangely, however, OSHA's heat index does not match up with CDC guidance.[7] OSHA invokes cautions at lower levels than the CDC and allows work at temperatures beyond what the CDC suggests is safe (Dahl and Licker 2021). Notably, in October 2021, OSHA initiated a process to consider a heat-specific workplace rule[8] (DoL 2021).

OSHA's general duty clause offers some theoretical protection for heat and air pollution as they relate to issues of worker training, proper sanitation, and maintaining a workplace free of "hazards" or things with obvious ability to harm a worker (Goldman et al. 2021; Beyranevand and Skipper Nelson 2021; Gubernot, Anderson, and Hunting 2014; Guild and Figueroa 2018; Ferguson, Dahl, and DeLonge 2019; Licker, Dahl, and Abatzoglou 2022). Under the general duty clause, all employers are required to "provide a work environment 'free from recognized hazards that are causing or are likely to cause death or serious physical harm'"(NIOSH and CDC 2020). A "recognized hazard" is considered something an employer knows or should know could cause serious injury. In the case of agricultural workers, "heavy physical activity, warm or hot environmental conditions, lack of acclimatization, and wearing clothing that holds in body heat" are recognized hazards (Beyranevand and Skipper Nelson 2021, 11). There is no federal guideline or standard that makes reference to outdoor air quality (though Nevada does have an outdoor air quality standard (State of Nevada 2022)). However, there is a federal standard for indoor air quality, and as such poor air quality is clearly a recognized hazard, in that an employer knows, or should know, it can cause serious injury. The general duty clause should therefore apply to outdoor air quality. That said, as will be pointed out below, the protections afforded by the general duty clause are limited, especially in instances when there is any ambiguity regarding the hazard. The lack of any guidelines or standard compounds this issue of ambiguity.

The general duty clause applies to both US citizens and temporary or migrant workers (Beyranevand and Skipper Nelson 2021), though it excludes public sector workers not working for the federal government (i.e., state and local workers) (Constible et al. 2020; Beyranevand and Skipper Nelson 2021) and gives OSHA the ability to cite employers based on breaches of these terms. The OSH Act further includes protection from retaliation toward workers reporting failures to abide by the requirements of the Act (Beyranevand and Skipper Nelson 2021).

Despite seeming like a significant avenue for providing protections, in practice OSHA's general duty clause is significantly lacking for a number of reasons. First, OSHA is understaffed. As of 2018, there was only one state inspector for every 79,262 workers. For context, the International Labour Organization (ILO) recommends that among developed nations this number should be closer to 1:10,000. Worse, OSHA workplace inspections for heat violations specifically declined by 43 percent between 2016 and 2018. Reflecting this chronic

[5] Notably, the Mine Safety and Health Administration (MSHA) has also not promulgated a standard despite mine workers being identified as extremely vulnerable to hazardous heat.
[6] These include: "Lower" (caution) (< 91°F) suggesting basic heat safety and planning; "Moderate" (91°F–103°F) suggesting implementing precautions and heightening awareness; "High" (103°F–115°F) suggesting additional precautions to protect workers; "Very high to extreme" (> 115°F) suggesting triggering even more aggressive protective measures. The CDC only recommends precautions for workers when temperatures exceed 100°F, but then recommends cancelling or fully rescheduling work when temperatures exceed 108°F.
[7] NIOSH sits under the CDC.
[8] No further details on the status of this process were available at the time of writing.

understaffing, OSHA only investigated a quarter of occupational deaths that were reported between 2014–2017 (Constible et al. 2020).

Second, there are concerns as to whether OSHA's current sanctions are sufficient. Currently, fines are $13,494 per violation and $134,937 for repeated or willful violations. While these might seem like sufficient penalties to some, there is no requirement to examine whether the fine amount is sufficient to deter noncompliance (Constible et al. 2020). Further, OSHA is believed to be reluctant to seek maximum fines because of the likelihood that they will be contested, resulting in lengthy and expensive proceedings (Constible et al. 2020).

Third, general duty clause citations are the most commonly contested OSHA citations, due to the legal ambiguities created in cases where "hazards" have not been clearly defined (Beyranevand and Skipper Nelson 2021). As an illustrative example, take the case where an individual died from a heat-related complication experienced on a jobsite (Beyranevand and Skipper Nelson 2021). The citation for breach of the general duty clause was overturned because the heat index score was at a "caution" rating, which warns against "prolonged exposure" and "strenuous work." While the "caution" rating is specified, neither "prolonged exposure" or "strenuous work" had been clearly defined, and were not immediately obvious. As such, the citation was thrown out. Notably, in the same case, the citing commissioner interpreted the clause as a stop-gap measure only intended to operate while specific protections are being enacted. This set precedent whereby commissioners are loath to enact citations under the general duty clause (only 1.5 percent of total citations relate to violations of the general duty clause (Beyranevand and Skipper Nelson 2021)) to prevent it from being used in lieu of rule-making—as doing so would risk confusion for employers and generate inadequate protections for workers. While the intention behind this interpretation of the general duty clause makes sense as part of an effort to enact effective legislation, in a context in which there are no specific standards around heat or outdoor air quality, outdoor workers in general, and farmworkers in particular, remain effectively without federal protection from two major climate hazards (Beyranevand and Skipper Nelson 2021).

Adding to the limitations of the general duty clause, OSHA enforcement and investigation bodies are not applicable on agricultural sites that employ fewer than 10 people. As a result, "93 percent of farms collectively employing 1.2 million workers … are completely exempt from OSHA enforcement and investigation" (Beyranevand and Skipper Nelson 2021, 10). This means that even if, and hopefully when, OSHA standards are expanded to more explicitly protect outdoor and agricultural workers from harm, the standards will still not apply to essentially half the farmworkers in the US.

In describing the limitations of OSHA in the context of climate change, we would be remiss not to mention the degree to which agriculture is explicitly exempted from most occupational health and safety standards. As Guild and Figueroa (2018) point out, "Some of the standards that exempt agriculture include protections against electrocution and unguarded machinery and requirements for ladder safety. Some other serious safety and health hazards farmworkers face include lack of adequate sanitation … musculoskeletal injuries caused by lengthy stooping, lifting, and cutting in harvesting crops; injuries from farm machinery or equipment; and exposure to pesticides" (Guild and Figueroa 2018, 177). This very worrisome list of exclusions only helps demonstrate how OSHA has long neglected farmworkers. For example, it took a federal court mandate to provide the sanitation requirement for farmworkers, requiring that employers provide the most basic facilities: "accessible toilets, potable drinking water, and hand-washing facilities to hand-laborers in the field" (Guild and Figueroa 2018, 177). It is worth reiterating that these requirements still only extend to farm owners with more than 10 employees, leaving many farmworkers in a gap of federal protection.

While OSHA effectively leaves agricultural workers unprotected from heat and smoke, it should be noted that as of 2022, California, Oregon, and Washington have all created heat standards for all outdoor workers;

Minnesota has created a heat standard for indoor workers; and in Colorado there is a heat standard specific to agricultural workers (Constible 2022). California and Washington are two of the country's biggest agricultural producers, ranking first and third respectively, so the states' move to create a heat standard for outdoor workers creates an important precedent for what a federal standard could entail (Ferguson, Dahl, and DeLonge 2019). Finally, Washington, Oregon, and California have developed and implemented a "wildfire smoke standard" that requires that employers provide an N95 mask when air quality index scores exceed 151. While this standard is positive, it is notable that there is no specific standard around PM2.5. Further, implementation challenges remain. A pilot study of 18 agricultural workers in central Washington State showed no change of routine or behavior in the context of fire smoke and indicated that farmworkers showed little appreciation for the value of a mask when working in smoky conditions (Austin et al. 2021).

LIMITATIONS OF THE EPA AS A FORM OF WORKER PROTECTION

OSHA today provides no standards regulating the use of pesticides. OSHA did promulgate an emergency temporary standard in the 1970s, focused on the safety of 21 different pesticides, as well as the reentry times for areas treated by pesticide. The standard was never implemented, however, after the growers associations brought lawsuits contesting the standard. After its withdrawal, farmworker advocates sued for reinstatement of the standard, but by this time the EPA had developed a worker protection standard on pesticides, formalized under the Agricultural Worker Protection Standard (WPS) of 1974 (last amended in 2015). Since the OSH Act prevents OSHA from exercising jurisdiction over hazards covered by other federal agencies, this act effectively gave the EPA jurisdiction over pesticide use and worker safety (Beyranevand and Skipper Nelson 2021).

Congress enacted the EPA's authority to regulate pesticide use via the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), with the focus on providing farmers with information about pesticide use, primarily via creating authority over the labelling of pesticides. Notably, such requirements can include effective protections for workers, such as requiring the use of PPE or the posting of warning signs and notifications of pesticide application. FIFRA also requires the development of agricultural workplace standards "to reduce the risks of illness or injury resulting from workers' and handlers' occupational exposure [to pesticides]" (Beyranevand and Skipper Nelson 2021, 14).

The EPA further developed the Agricultural Worker Protection Standard (WPS) as the main federal law aimed at protecting workers and limiting the risks associated with pesticide use. The WPS is believed to cover more than two million workers on 600,000 farms (Beyranevand and Skipper Nelson 2021). It requires that pesticides be applied in accordance with their labels and that workers be informed regarding the protection afforded to them. Labelling requirements can include, among other things: whether or not a specific pesticide is general use or restricted/regulated (the latter requiring more rigorous application standards); field entry interval requirements following pesticide application; and the need for any application exclusion (i.e., buffer) zone around an area receiving a specific pesticide (Beyranevand and Skipper Nelson 2021). FIFRA further requires that employers provide annual training in pesticide safety in a language workers can understand and requires a minimum age for individuals to apply pesticides (18 years old). The standard also requires the provision of decontamination supplies, and, for some pesticide handlers working with certain pesticides, it requires medical evaluations. Finally, the standard requires the creation of a designated representative who can act on the workers' behalf to seek information on pesticides from the employer, with minimum requirements for

what information must be provided (for a helpful table of requirements, see page 16 of Beyranevand and Skipper Nelson (2021), from which this section primarily draws).

Finally, FIFRA prohibits employers from preventing or discouraging employees from complying with the law and precludes retaliation should they do so. With the exception of Wyoming, states are primarily responsible for enforcing the WPS. However, the EPA is required to ensure states' monitoring is adequate. To support this effort, the Pesticide Registration and Improvement Act (PRIEA), which amended FIFIRA, set fees for registering new pesticides, and apportioned funding for farmworker protection activities, including oversight and monitoring, and surveys of farmworker employment, living conditions, and well-being.

Despite these significant protections, the EPA standards face some limitations. First, OSHA is a governing body within the purview of the Department of Labor while the EPA is a federal entity sitting within the Department of Interior. The lack of consistency between the two entities creates problems for farmworkers when the double exposure of heat and pesticides (which can interact—see above) impact the health and well-being of farmworkers. This is obviously a growing concern in the context of climate change. Second, FIFRA excludes cases where pesticides are applied to livestock, or other animals, or in or about animal premises, and therefore all agricultural workers operating in such contexts are entirely unprotected (Beyranevand and Skipper Nelson 2021). Third, the EPA has long understood its regulatory role to include consideration of the overall economic, social, and environmental risks and benefits of potential actions. Thus, while FIFRA requires that pesticides do not have an unreasonably detrimental effect on the environment, under the rubric of the EPA, negative effects on a single worker need to be balanced against the economic or health benefits to society at large. This balancing of individual risks against collective rights can leave individual workers with partial protection and highlights the limitations of having an environmental agency undertake worker protections. Fourth, the EPA does not account for "chronic exposure for certain industries, risks specific to pregnant women and children, or the interactions between multiple pesticides when engaged in risk assessment" (Beyranevand and Skipper Nelson 2021, 14).

The overall outcome is that farmworkers are systematically overexposed to the dangers of pesticide use. Pesticides are not classified at the correct level of danger, field reentry times are not long enough, and farmworkers remain exposed to pesticide drift (when pesticides applied in one field where workers are not present carries over to areas where they are present). Notably, drift protection exists for residential properties, but workers are excluded from this protection, even in cases where pesticide drift is occurring from another farm (Beyranevand and Skipper Nelson 2021). Furthermore, record keeping on pesticide use is only required for the use of pesticides deemed regulated, which is compounded by the lax regulation that stems from the EPA's mandate to balance regulations with overall economic benefit (Beyranevand and Skipper Nelson 2021). Making matters worse, even for pesticides actually given the classification of "regulated," record keeping is not enforced beyond random checks. Finally, FIFRA makes no requirement for exposure monitoring. The CDC and NIOSH did set up an exposure monitoring database. However, the data for this database have not been updated since 2011 (Beyranevand and Skipper Nelson 2021). Pesticide illness reporting is also not mandated. The lack of monitoring and reporting on application, exposure, and illness from pesticides makes it impossible to evaluate the degree to which current regulations and protections are sufficient and working (Beyranevand and Skipper Nelson 2021).

While FIFRA prevents states from creating novel labelling requirements, states do have authority to regulate the sale and use of pesticides. They can create their own standards to address workplace hazards. Due to the risk posed to workers that results from the operational logic of the EPA, several states have taken additional measures. California, for example, emphasizes language accessibility for labeling standards of pesticides as a means of protecting more workers. Florida has also established a requirement that, 48 hours ahead of pesticide usage, farmworker supervisors must provide oral directions to workers on pesticide safety in a language they understand. Beyond efforts to improve labeling and communication around pesticides at the

state level, California, Oregon, Washington, and Florida have increased regulations around pesticide drift, and certain states have banned the use of a pesticide known for its poor health impacts—chlorpyrifos—altogether. And several states, such as California, Washington, and even Louisiana, go beyond federal standards with state mandates for illness reporting as it relates to pesticide exposure. In general, much like California's OSHA, California's approach to pesticide regulation is considered one of the most advanced in the country (Beyranevand and Skipper Nelson 2021).

FAILURE TO PROTECT MIGRANT POPULATIONS

Compounding the vulnerability of farmworkers is the status of many as migrant workers. As mentioned above, a majority of farmworkers are migrants, predominantly from Latin America. This population includes temporary worker visa holders, documented immigrants, and those without legal documentation. All these workers are, to varying degrees, vulnerable to having an irresponsible employer who fails to provide substantive protections. Workers' immigrant status compounds vulnerability, with individuals afforded fewer protections, at risk of deportation, and frequently running into language barriers that make advocacy, training, labelling, and warnings all more difficult to operationalize. In theory, migrant farmworkers should receive protections via the Migrant and Seasonal Agricultural Worker Protection Act (MSPA) of 1983 (Goldman et al. 2021). This bill replaced an earlier iteration, called the Farm Labor Contractor Registration Act (FLCRA), which was widely seen as a failed attempt to get employers and/or recruiters of migrant workers to register, effectively leaving workers without protection from mistreatment or abuse. The FLCRA was in effect from 1964 until 1983 when it was repealed in favor of the MSPA (Whittaker 2007). The MSPA requires that agricultural employers "disclose terms of employment at the time of recruitment and comply with those terms; employers, when using farm labor contractors to recruit, supervise or transport farmworkers, must confirm that the contractors are registered with and licensed by the US Department of Labor; providers of housing to farmworkers must meet local and federal housing standards; and transporters of farmworkers must use vehicles that meet basic federal safety standards and are insured" (Farmworker Justice 2022).

While the protections of the MSPA are significant, there are again limitations. First, as with the OSH Act, its provisions exclude small farms (any farm employing fewer than seven workers in a calendar year). Further, studies of the state of farmworker housing indicate that the terms of the MSPA are outdated and no longer fully applicable to the housing conditions in which farmworkers find themselves, leaving farmworkers vulnerable to housing violations (Moss Joyner et al. 2015). Finally, the Act is frequently unenforced (Goldman et al. 2021). For example, Arcury et al. (2012), who studied 183 farmworker camps in North Carolina in 2010, found that housing violations were common in farmworker camps and ranged from 4–22 percent per camp (a mean of 11.4 percent).

LACK OF ENFORCEMENT

A reading of the above makes clear the limited protections available to agricultural workers in general and the almost complete lack of protections on the issues of heat and air quality, both of which will be exacerbated by climate change. Risks from pesticide use are better covered, but issues remain. The lack of protections is even more acute in the context of small farms, where farmworkers have almost no protections, outside of those provided by the EPA (Goldman et al. 2021).

Notably, however, issues of limited formal protections are even worse when one considers the lack of enforcement of these limited protections. As mentioned above, OSHA citations of breach of the general clause are relatively rare and commonly challenged in court. There is also evidence that the requirements of the MSPA are frequently unenforced (Beyranevand and Skipper Nelson 2021). Even when one considers effective citations executed by OSHA, these reveal numerous instances where employers have failed to monitor the heat index or refused modification of work/rest cycles that allow workers to take needed rest. Failure to provide for acclimatization periods are particularly egregious, with OSHA reporting that over 45 percent of heat-related fatalities happened on the first day of work, when none of the employers provided opportunities for acclimatization and none had mandatory rest breaks (Dong et al. 2019; Goldman et al. 2021). Finally, while OSHA does require that workers receive sanitation breaks, specifically bathroom breaks, these are also frequently not provided (Goldman et al. 2021). No bathroom breaks result in workers consuming less water than is safe or ideal, thereby compounding the dangers regarding a lack of a heat standard.

Issues of enforcement are not limited to OSHA. FIFRA also sees major enforcement gaps. While FIFRA can mandate labelling of pesticides, the enforcement of the terms laid out on these labels is frequently lacking. According to several studies, "many employers do not post adequate notices that fields have been sprayed with pesticides, fail to enforce 'no entry' periods after spraying, fail to provide required protective gear and training on how to use it, or discourage the use of protective gear" (Ferguson, Dahl, and DeLonge 2019, 4). The lack of enforcement on safety precautions for pesticide use for workers is an expensive oversight due to the high cost of chronic treatment associated with illnesses created by prolonged pesticide exposure. The onus remains on the EPA to increase monitoring, not only to ensure worker health and well-being, but also to help alleviate the financial burden placed on individuals and bureaucratic systems such as the Social Security Administration for work-related illnesses (Beyranevand and Skipper Nelson 2021).

Issues of enforcement also plague state-based efforts to create protections, such as the heat standards in California, Washington, and Oregon. For Oregon and Washington, states whose outdoor heat standards were more recently implemented, issues of training and enforcement continue. Nonprofit organizations that are tracking implementation and enforcement have found that, in speaking with farmworkers, especially in Oregon a few months after the standard was made effective, many workers expressed not noticing the effects of the new standard. However, official complaints to state-level OSHAs based on heat are also increasing, indicating workers' increased awareness of their rights and the wish for greater protection and enforcement (Bolstad 2022). Though imperfect, these state heat standards offer a model for what a federal standard could include, ideally with lessons learned at the local level for how implementation and enforcement can be improved when a federal standard is created.

LIMITED SCOPE FOR COMPLAINT/REPORTING

While the literature highlights the lack of enforcement as a core issue, it is also important to appreciate the degree to which structural factors play a role in limiting worker's capacity and willingness to report workplace violations when they occur. Fear of employer retaliation, such as the withholding of wages, keeps many workers from seeking to hold employers accountable or asserting their rights in the workplace (Dahl and Licker 2021; Beyranevand and Skipper Nelson 2021). Such workers are in a particularly perilous position given their low-wage status and the extent to which they live paycheck-to-paycheck (Pedersen et al. 2021). Many migrant workers in the US under special labor visas, specifically the H2-A visa, experience greater precarity, as they rely on employers for housing, transportation, and access to medical care, along with the ability to remain in the US (Beyranevand and Skipper Nelson 2021; Guild and Figueroa 2018). The threat of losing such security further dissuades reporting among this group. As above, issues of language further compound

possibilities for complaint (Beyranevand and Skipper Nelson 2021; Guild and Figueroa 2018), as workers don't know the rights afforded to them or the recourse they have available. Importantly, however, as of January 2023 there is a new policy from the Department of Homeland Security (DHS) that protects migrant workers from deportation for up to two years if they have been the victim of workplace labor violations or act as whistleblowers for others (Santana 2023).

LACK OF ACCESS TO HEALTHCARE AND POOR HEALTH OUTCOMES

Together, this lack of protections in an (increasingly) hazardous work environment has resulted in significant negative health impacts for agricultural workers. All individuals in the US, including farmworkers, are eligible to receive healthcare from federally qualified health centers, regardless of their immigration status, ability to pay, or insurance status. Further, most individuals, with the exception of undocumented workers and Deferred Action for Childhood Arrivals (DACA) grantees, are eligible to enroll in health insurance through the Affordable Care Act (ACA) marketplaces and are eligible for tax credits to lower the cost. Finally, H-2A workers are eligible for ACA insurance and tax credits. Despite this, farmworkers are frequently reluctant to seek medical help, take breaks, or flag issues such as lack of ventilation or cooling systems in employer-provided housing (Beyranevand and Skipper Nelson 2021; Guild and Figueroa 2018; Licker, Dahl, and Abatzoglou 2022; Goldman et al. 2021). Challenges can be acute among women, with pregnant workers continuing in hazardous conditions that could put themselves and/or their pregnancies at risk (Goldman et al. 2021). Together, these issues lead to exacerbated health impacts. The high cost of healthcare in the United States limits citizens and noncitizens from seeking proper care, especially for farmworkers who are almost exclusively low wage workers. As above, undocumented and even recently documented migrants are ineligible for certain public services intended to increase access to healthcare, such as Medicaid. Yet with increasing average temperatures, and the risk of extreme heat and air pollution, the resultant health impacts for farmworkers continue to worsen (Goldman et al. 2021; Guild and Figueroa 2018). As already mentioned, farmworkers are federally excluded from workers compensation policies under OSHA such as coverage for work-related injuries, and only agricultural employers of more than 50 full-time workers are required to provide their employees with healthcare under the Affordable Care Act (Goldman et al. 2021). This is especially limiting for farmworkers, as many, especially migrant farmworkers, are seasonal laborers and do not work full time for the same employer. Finally, negative experiences within the US healthcare system—often worsened by systemic racism—prevent many workers from seeking care, what some scholars refer to as "self-exclusion" (Goldman et al. 2021).

Even for those farmworkers who do wish to pursue medical treatment, there are more obstacles beyond the lack of affordable healthcare options. Often farmworkers do not have sufficient time off to seek medical care, especially given their working hours. There is also significant evidence of workers fearing retaliation or dismissal for reporting an injury or seeking assistance. Furthermore, many workers feel unable to miss even one day of work due to economic precarity, even if conditions are extreme based on a high heat index or low air quality (Pedersen et al. 2021). Adding to this structural marginalization is age. Older workers are more likely to experience injury and to accept lower pay than others, as they cannot keep pace with younger piece-rate workers. Yet the average age of hired migrant farmworkers has risen over the last 15 years—from 35.7 to 41.6 years old, due to a decline in new immigrants into the country (Goldman et al. 2021; Hertz 2019). Beyond discrimination based on age and immigration status, scholars have also pointed to indigenous immigrant

workers as experiencing another layer of discrimination from other migrants and employers based on their linguistic and cultural difference (Goldman et al. 2021).

Overall, farmworkers remain "essentially unprotected" (Beyranevand and Skipper Nelson 2021) when it comes to exposure to heat and air pollution. This is acutely true among immigrant workers employed on small farms. Regarding pesticides, some protective measures exist. However, gaps remain, primarily regarding enforcement—which stems significantly from understaffing of the EPA. While issues of heat and pesticides attain the most focus in the literature, due to their long-standing prevalence, issues of air pollution present a novel concern of the notably worsening climate crisis. The last section of this paper turns to discussing the scope for adaptation and priority policy interventions for addressing the vulnerability of agricultural workers in a context of climate change.

ADAPTATION OPTIONS

- Adaptation options exist and should be pursued.
- Nonetheless, there are major limitations to adaptation, which can both lead to other unintended consequences and simply be impractical to implement.
- As a result, there is an urgent need to reduce global emissions and limit the increase in average temperature.

The literature on adaptation options for addressing extreme heat (and to a lesser extent air quality) focus on a few core approaches. These include: shifting work hours to cooler times of the day (Licker, Dahl, and Abatzoglou 2022; Dillender 2021; Runkle et al. 2019); curtailing work hours and/or lightening workloads during hazardous times (Licker, Dahl, and Abatzoglou 2022); requiring acclimatization periods (Gubernot, Anderson, and Hunting 2014); mandating paid breaks (with water and shade) (Beyranevand and Skipper Nelson 2021); training people on the occupational hazard posed by heat and smoke (Runkle et al. 2019); and providing early warnings, as well as posting warnings, for heat and low air quality events (Runkle et al. 2019). Notably, the scope for adaptation is potentially significant. For example, Licker et al. (2022) found that, among outdoor workers, the universal adoption (in the US) of just two adaptation measures—shifting work times and reducing workloads—could reduce mid-century and late-century economic risks by 90 percent and 93 percent respectively, compared to taking no action. Of further note, they found that while the individual application of these approaches was effective, combining them led to the greatest positive impacts. Further reason for optimism lies in the scope for novel technologies—for example deploying low-cost sensors and combining them with big weather data via accessible IT architectures—to increase the ability for earlier warnings and better decision-making regarding worker adaptations. Notably, some of these technologies are already being used by farmers to support agricultural management decisions, and thus initial barriers to use are potentially reduced (Austin et al. 2021).

At the same time, pursuing adaptation is not without its complications. Initially, obvious approaches might result in complex outcomes. For example, as was described above, Runkle et al. (2019), using biological sensors to determine heat stress events among grounds staff, found that heat stress events confoundingly correlated with education. The hypothesized explanation was that education correlated with management positions, which meant spending more time indoors in air-conditioned rooms. When these individuals went outside, their lack of acclimatization resulted in an increased number of biological heat stress responses compared to workers who were outdoors all the time and undertaking autonomous adaptation responses, such as shifting work hours and managing workloads (Runkle et al. 2019). In a similar vein, while Licker et al. (2022) find that work shifting is a highly effective adaptive strategy, such work shifting is correlated with other negative health outcomes, such as a worsening diet. Thus, initially obvious strategies such as shifting work hours or increasing rest periods might, under certain conditions, increase HRI.

Also challenging is the clearly limited scope for adaptation. Most of the literature talking about occupational health and adaptation to heat focuses on the provision of active cooling, which is simply not possible for outdoor workers (Dillender 2021). While work-shifting can be effective (Licker, Dahl, and Abatzoglou 2022), Dillender (2021) points to its limitations, with empirical work showing that it is a less-used strategy in hotter (southern) regions of the US, as missing large amounts of work is simply not possible. In this respect, despite Licker et al. (2022) highlighting the scope for adaptation via work-shifting, they too note the limitations of the approach and point to the urgent need for emissions reductions and climate mitigation. Finally, acclimatization, while having real effects on reducing heat stress (Gubernot, Anderson, and Hunting 2014; Runkle et al. 2019), takes time to achieve (four to six days of repeated exposure over a two-week period) and loses its efficacy after a relatively short time-period. Acclimatization therefore faces limits as a means for

addressing abrupt changes in temperature, such as earlier onset times of hazardously warm weather (Gubernot, Anderson, and Hunting 2014).

Finally, it should be pointed out that for such adaptive measures to have a plausible effect, approaches such as changing or curtailing work hours, lightening workloads, requiring acclimatization, and mandating breaks will require remuneration. Evidence suggests that the likelihood of outdoor agricultural workers foregoing income for their own safety is small (Licker, Dahl, and Abatzoglou 2022). Notably, policy that requires remunerating rest periods and the curtailment of work hours, etc. will increase the costs for employers and the overall economy. Measures to address these impacts will likely to be necessary if we are to see effective adoption of adaptation measures (Licker, Dahl, and Abatzoglou 2022).

Overall, while there is scope for adaptation, there are clear limits to what adaptation can achieve. As such, global emissions reductions are essential. At the same time, since we are already committed to some degree of (future) warming, greater effort needs to be invested in identifying more appropriate adaptive practices. Adaptation approaches might have unintended consequences, and adaptive policies should be pursued with care, and monitored for their impacts. Finally, effective adaptation will likely require material and legislative support to ensure that agricultural workers adopt such practices. Achieving this will take political will. A core focus should be on galvanizing that political will. Having now discussed the array of potential adaptive responses, this report moves to the final section, which discusses specific proposed policy changes mentioned in the literature.

PROPOSED POLICY CHANGES

- The primary focus within the literature is on creating a federal heat standard.
- There is an additional focus on reforming the manner in which occupational health and safety is realized and the manner in which pesticides are regulated.
- Concerns around wildfire smoke receive far less attention than heat, occupational health, and pesticide use.
- Regulation and policy will be of no use without enforcement. To this end, creating the conditions for meaningful enforcement is essential.
- There is a need to see occupational health from a wider vantage point than just the workplace. This should include addressing structural causes of vulnerability, such as limited access to healthcare and poor-quality housing.

Much of the policy focus in the literature involves creating standards, addressing exclusions, and formalizing the types of adaptive responses mentioned above. Regarding standards, the literature focuses on creating a federal heat standard via OSHA (Ferguson, Dahl, and DeLonge 2019; Dong et al. 2019; Constible et al. 2020; Dahl and Licker 2021; Beyranevand and Skipper Nelson 2021). There are varied calls for what this standard should look like, with the standards created by California and Washington often serving as a model for a federal standard (Beyranevand and Skipper Nelson 2021; Gubernot, Anderson, and Hunting 2014). Specific asks include:

- Remove the exclusions that prohibit the enforcement of OSHA standards on small farms (Beyranevand and Skipper Nelson 2021).
- Stop putting in place a rider during the appropriations process that prevents federal funding for OSHA from being used in pursuit of OSHA's mandate among small farms (Guild and Figueroa 2018).
- Mandate free access to water (Beyranevand and Skipper Nelson 2021; Dong et al. 2019; Pal, Patel, and Banik 2021; Constible et al. 2020; Farhang Dehghan et al. 2020).
- Mandate shaded breaks (Beyranevand and Skipper Nelson 2021; Dong et al. 2019; Pal, Patel, and Banik 2021; Constible et al. 2020), including calling for the use of incentives for employers (Applebaum et al. 2016).
- Provide trainings on the dangers of heat (Beyranevand and Skipper Nelson 2021; Dong et al. 2019; Pal, Patel, and Banik 2021; Jacklitsch et al. 2016; Constible et al. 2020; Farhang Dehghan et al. 2020).
- Provide access to aid and emergency services (Beyranevand and Skipper Nelson 2021; Dong et al. 2019).
- Incorporate routine medical screenings (Jacklitsch et al. 2016; Constible et al. 2020; Farhang Dehghan et al. 2020).
- Formally adopt shifted work hours (Dong et al. 2019; Applebaum et al. 2016; Pal, Patel, and Banik 2021; Gubernot, Anderson, and Hunting 2014; Jacklitsch et al. 2016; Constible et al. 2020; Farhang Dehghan et al. 2020).
- Adopt measures to ensure that PPE does not contribute to heat stress (Beyranevand and Skipper Nelson 2021; Applebaum et al. 2016), and provide PPE and training (Farhang Dehghan et al. 2020) to handle excessive heat, e.g., water-cooled garments, cooling vests etc. (Constible et al. 2020; Dahl and Licker 2021).
- Create an effective early warning system on dangerous environmental conditions for workers (Jacklitsch et al. 2016; Constible et al. 2020; Runkle et al. 2019), and make it the responsibility of the federal government to administer it (Ferguson, Dahl, and DeLonge 2019).
- Incorporate humidity into the determination of heat thresholds (Beyranevand and Skipper Nelson 2021).
- Require acclimatization periods (Beyranevand and Skipper Nelson 2021; Jacklitsch et al. 2016; Constible et al. 2020).
- Invoke additional provisions when temperatures exceed 95°F. Specifically these include (Beyranevand and Skipper Nelson 2021):

    - A break for 10 minutes every two hours.
    - Compensating piece work during recovery periods.
    - Paying for an additional hour or work if rest periods are not given.

Further to the creation of a federal heat standard at OSHA, there are also a number of proposed reforms to the manner in which occupational health and safety is realized. These include:

- Fund OSHA so as to ensure it has the budget and staff resources necessary to pursue and achieve timely enforcement of standards (Constible et al. 2020).
- Create a fund—via contributions from USDA—to support the protection of farmworkers (Ferguson, Dahl, and DeLonge 2019).
- Create a publicly accessible surveillance system run by Bureau of Labor Statistics and the CDC that monitors workplace injuries and illnesses (Constible et al. 2020; Dahl and Licker 2021), including the possible use of wearable heat sensors to monitor heat stress (Dahl and Licker 2021; Runkle et al. 2019).
- Create a joint taskforce comprised of OSHA and NIOSH that generates plans and recommendations for heat stress (Dahl and Licker 2021).
- Amend the OSH Act so as to direct the CDC to expand climate research at NIOSH (Constible et al. 2020), or direct USDA to do so (Dahl and Licker 2021), so as to advance our understanding of the risks posed by climate change beyond heat.
- Develop a comprehensive cross-agency plan to address the cumulative threats posed by climate change to outdoor workers (Constible et al. 2020; Dahl and Licker 2021).
- Undertake a congressional evaluation of OSHA's use of maximum penalties as well as a review of whether these are sufficient (Constible et al. 2020).
- Enact the Asunción Valdivia Heat Illness and Prevention Act of 2021 (H.R. 2193/S. 1068), which directs the US secretary of labor to develop and set a mandatory heat health protective standard for workers, enforceable by OSHA, within 42 months (Dahl and Licker 2021).[9]

Regarding pesticide use, the following recommendations dominate the literature:

- Update the EPA pesticide assessments such that they reflect the risk to the worker (Ferguson, Dahl, and DeLonge 2019) and are not balanced against the well-being of the overall economy. For example, place more pesticides on the regulated list, increase field reentry requirements, and enlarge application exclusion zones (Beyranevand and Skipper Nelson 2021). Such an update could include outright bans of certain pesticides (Beyranevand and Skipper Nelson 2021; Ferguson, Dahl, and DeLonge 2019).
- Require drift protection mechanisms for workers. The most obvious means for achieving this is through labelling that specifies the risk of drift and puts in place preclusions on certain types of pesticides and/or application methods under certain weather conditions and/or in certain environments (Beyranevand and Skipper Nelson 2021).
- Improve labelling, especially regarding the accessibility of labelling (Beyranevand and Skipper Nelson 2021).
- Improve communication of no-entry requirements (signs posted in fields) by ensuring they are in the relevant languages for the workers onsite (Beyranevand and Skipper Nelson 2021).
- Improve worker training on the risks of pesticide use as well as the correct methods of application and personal safety (Beyranevand and Skipper Nelson 2021).
- Mandate record keeping (for an expanded number of pesticides, as required by the updated assessment mentioned above) and improve enforcement thereof, through sanctions for failure to keep records (Beyranevand and Skipper Nelson 2021).
- Improve exposure and illness monitoring, including making it a potentially legal requirement or by linking it to compensation (Beyranevand and Skipper Nelson 2021).

[9] This is a bill that Oxfam has previously signed letters in support of and was mentioned in the 2021 and 2022 Best States to Work Index as a policy recommendation that could address the lack of federal heat standards for workers.

Beyond efforts to reform how pesticides are applied, authors have also called for a wider rethink of farming methods that create such a significant reliance on pesticides. Approaches mentioned include changing growing patterns, improving soils, and increasing agricultural diversity (Ferguson, Dahl, and DeLonge 2019). We note that such an account understates the enormous challenges that would be involved in overhauling the way agriculture takes place in the United States, and that a full discussion of this topic is beyond the scope of this paper. We simply make note of the possible need for a more radical approach to agriculture beyond simply improving the regulation of pesticides. Notably for the purposes of this paper, however, given the manner in which climate change is anticipated to increase the need for pesticides, realizing reduced pesticide use will also require more aggressive action on climate change (Ferguson, Dahl, and DeLonge 2019).

Further, while the above focuses on regulatory approaches to improving worker well-being, and while we believe these should be the focus, it is also worth noting that some voluntary standards do exist—though authors point out their limited efficacy (Beyranevand and Skipper Nelson 2021). These include the Fair Food Program, which charges a premium to certified products, and multistakeholder initiatives that rely on civil society, e.g., the Equitable Food Initiative[10] (Beyranevand and Skipper Nelson 2021).

Regarding air pollution and fire risk, the much more-nascent nature of this hazard means that there is far less literature advocating for improvements. What does exist is focused on increasing the number of air quality monitoring stations. This is needed to both improve understanding of the problem and to increase scope for anticipatory measures (Austin et al. 2021).

It goes without saying that all the above recommendations are of little value without implementation or enforcement. To this end, some authors have also called for the strengthening of whistleblower protections, for example through the creation of an independent whistleblower protection program, with OSHA overseeing the template for how this program should operate (Constible et al. 2020).

Finally, as was laid out at the beginning of this paper, climate does not just impact outdoor workers through the specific hazards relating to climate. Rather these hazards interact with a variety of structural vulnerabilities already apparent in the outdoor workforce in general and among agricultural workers in particular. Thus, in addition to the specific protections around heat, pesticides, and air quality, core exclusions need to be addressed. Doing so includes the ending of farmworker exclusions from worker protection policies and minimum wage provisions (Ferguson, Dahl, and DeLonge 2019; Dahl and Licker 2021), and advancing the right of farmworkers to unionize and engage in collective bargaining (Constible et al. 2020). Further, a host of actions are needed to address the long inequalities in the social determinants of health and socioeconomic well-being of workers, especially among Black and Latinx populations. In particular, issues of safe housing, medical care, and access to legal recourse in cases where workers' rights have been violated should be priorities (Dahl and Licker 2021). Specifically in this regard, the regulations of the MSPA should be looked at and updated (Moss Joyner et al. 2015; Arcury et al. 2012).

Finally, a point made above is worth reiterating here. Possibilities for adaptation are inevitably limited. Further, the risks to farmworkers, not only from increased hazards but also from a failure to implement adaptation measures, are substantial. As such, much more aggressive action is necessary to curb emissions and halt dangerous climate change (Runkle et al. 2019; Ferguson, Dahl, and DeLonge 2019; Dahl and Licker 2021; Beyranevand and Skipper Nelson 2021).

[10] The Equitable Food Initiative (EFI) is an organization that was originally incubated at Oxfam under the USRO (US Regional Office—the precursor to US Domestic Program at Oxfam America) under the leadership of Minor Sinclair. EFI includes a certification process for farmers that provide safe, healthy, and fairly paid workplaces for farmworkers and high health standards for the produce itself. Produce is then branded with an EFI stamp, indicating to consumers that they are purchasing produce or supporting a producer that is more of a high-road employer. Oxfam staff are still members of the board at EFI.

CONCLUSION

The increased prevalence and severity of climate events in the US, ranging from fires to heat to weather events such as hurricanes and tropical cyclones, will only continue to worsen without collective action to address emissions. While everyone will be impacted by this worsening climate crisis, outdoor workers are particularly exposed. Farmworkers especially, given their significant exposure and long history of structural marginalization, experience an acute risk of harm. The literature places particular focus on the risks to occupational health posed by extreme heat, with other changes in weather and climate receiving less coverage. Furthermore, though the physical safety of workers is discussed, as is the economic impact of worsening climate change and severe weather events, there is a notable gap regarding the impact on worker livelihoods beyond their occupational activities. The literature does not touch on how families are impacted by the loss of harvests, the increased need for worker mobility, the increased safety risks for workers in outdoor spaces, and the possible loss of income that could result from weather events.

Within the focus on extreme heat and agricultural workers, there is a strong emphasis on the economic and physiological impact, as well as the potential interactions between heat, pollution, and pesticides. Overall, the literature highlights the degree to which agricultural workers lack safety standards and protections from the federal government. OSHA lacks any heat standard, its heat guidelines are not comprehensive, and they are not aligned with the guidance from the CDC. OSHA lacks any standards or guidelines for outdoor air quality. While the OSHA general clause's reference to protecting workers from "known hazards" should cover both heat and air quality concerns, limitations of the general clause mean that in effect workers lack meaningful protections from threats from heat and pollution. All of these limitations are compounded by a lack of enforcement, while the agency is insufficiently staffed to execute their mandate. The limitations just described are even more concerning in the case of the approximately two million farmworkers working on small farms, who are excluded from OSHA's mandate and see an annual rider invoked during the appropriations process that prevents federal funding from being used to support OSHA's mandate on small farms. The EPA's jurisdiction over pesticides should reflect greater protections for workers, but again there remain notable gaps, specifically their lacking emphasis on workers themselves. There is lax oversight of pesticide safety, ranging from language diversity in labeling to properly marked fields and time delays before sending workers back into fields.

The current state of vulnerability to climate change among agricultural workers reflects a long history of exclusion: exclusion from protections affording access to a minimum wage, to protections of the right to organize, to occupational health and safety. These exclusions and this long history reflect long-standing prejudicial views around race, gender, and immigration status, and compound vulnerability by exposing farmworkers to improper housing, inadequate sanitation, and insufficient healthcare. In the case of migrant farmworkers, there is added challenges of ensuring communications in workers' preferred language, the constant threat of deportation, and reliance on employers for basic access to housing and transportation. While some policies exist to try and protect workers from mistreatment, namely the MSPA, this does little to ensure workers are protected.

There is a clear emphasis on farmworkers in the literature, and the unique ways government systems have failed this population and will continue to do so with worsening climate change if no action is taken. The impacts are human (negative health impacts), fiscal (lessened economic output with increased heat and illness), and social (negative impact on food production). There are many policy solutions for this reality, as outlined above, and options for several different parts of government to step into clear voids to protect workers, especially from the threat of increased heat—one of the clearer and more well-studied environmental threats.

Solutions for the current and worsening problem of increased climate risk, largely posed by increased heat and the lack of worker protections for outdoor workers, notably farmworkers, include suggestions for climate adaptations, improved state and federal health standards, increased enforcement of existing standards, and expansion of legal rights and protections for all workers, especially farmworkers. The literature does not suggest any new or unique policy solutions, but rather provides a consistent and collective overview of the consensus among those in the field on the need for multifaceted approaches to the complex problem of worsening climate change. There is need for a collective standard from the federal government, a consistency across all agencies, and a clearer understanding of the risks posed to people by climate change in general, and heat in particular.

The goal of this paper was to provide an overview of the literature to create a foundation of understanding should Oxfam decide to build a new body of work focused on the intersection of climate and labor within the United States. Oxfam has a strong reputation in the space of US labor issues and has a history of working with farmworkers as a community. While Oxfam has done little-to-no work on climate issues within the United States, the impact of climate change and increasing climate disasters will have a clear and obvious impact on all workers, but especially farmworkers who remain outside the bounds of many governmental protection mechanisms. There is clear overlap between climate and labor as a body of work, and a very clear emphasis on farmworkers as a whole, and migrant farmworkers as a specific community of vulnerable workers within the bounds of farmworkers more broadly.

APPENDIX 1: CHANGES IN WEATHER AND CLIMATE IN THE US

TEMPERATURE

According to the latest National Climate Assessment, as of 2016, average temperature in the US was estimated to have risen by between 0.7°C–1°C (1.2°F–1.8°F) since 1895. All assessment regions saw increased temperatures, as did 95 percent of the land surface of the contiguous US. Minimum temperatures tended to increase more than maximum temperatures. Yearly lowest minimum temperatures have seen increases in most locations in the contiguous US. Increases have been relatively constant, with a slight acceleration in recent decades. Cold wave frequency likewise showed a notable decline. For warm extremes, the picture is more nuanced. Single warmest day records only increased in some parts of the West, but saw decreases almost everywhere east of the Rocky Mountains, with all eastern regions showing a decrease. Heat wave frequency showed increases up until the 1930s, decreased through the mid-1960s, and showed an increase thereafter. This is true for most of the country other than the Midwest and Great Plains. The number of hot records, however, has been rising, while cold record days have been falling (Vose et al. 2017).

PRECIPITATION

The US has seen an increase in average precipitation of approximately 4 percent, on average, across the country. Such an increase is explained by increasing temperatures, which allow more moisture to build up prior to saturation. Notably, average increases show significant regional variations: the Northeast, Midwest, and Great Plains show increases, while South and Southwest show decreases. Fall has seen the greatest increase in rainfall, while winter has seen the least, with the greatest reductions in the West. The Northwest has seen reduced streamflow. Spring has become wetter in the northern half of the country and drier in the South. Summer changes have been variable across the country. Snow coverage extent has declined, overall, due to large reductions in the spring caused by increased melting (with implications for run-off rates and timing). The frequency of extreme precipitation events[11] has increased, with the index value for 2015 showing as 80 percent above the 1901–1960 average. Increases are greatest over the East, especially the Northeast, and smaller in the West, with the Northwest and Southwest showing little increase (Easterling et al. 2017).

HURRICANES

Poor data on hurricanes (technically termed "tropical cyclones") make trend identification extremely difficult. The IPCC and the 4th National Climate Assessment of the US both note that poor data do not indicate no trend. It simply indicates that no trend can reliably be identified (Kossin et al. 2017; Seneviratne et al. 2021). Nonetheless, it is believed likely that the number of large tropical cyclones has increased, as has the frequency of rapid intensification events, over the last 40 years. Similarly likely is that the speed of cyclones has decreased over the US since 1900, with implications for increased wind and flood damage (as systems "stall" in place, increasing the duration of exposure) (Seneviratne et al. 2021). Models suggest it is likely that maximum wind speeds and precipitation rates will increase. However, it is more than likely that the overall number of tropical cyclones will remain the same (Seneviratne et al. 2021).

[11] Defined as two-day precipitation events exceeding the threshold for a five-year recurrence.

EXTRATROPICAL CYCLONES

There is similar uncertainty about the future changes in extratropical cyclones. Summertime activity has decreased, and models predict an ongoing pattern for the future. Notably, this could impact extreme rainfall in the Northeast, as many of these events are associated with extra-tropical cyclones. However, increasing air temperatures and water vapor could outweigh any declines due to reduced cyclonic activity. Some idealized climate models show reduced extra-tropical cyclone activity but greater precipitation from the most-intense cyclones, due to the increased water vapor in the atmosphere. The idealized nature of such models means that they should be interpreted with care. However, the impact of increased water vapor intensifying those storms that do occur is thought likely to be realized (Easterling et al. 2017). In addition to cyclonic activity, convective rainfall events are observed to have increased in terms of both frequency and intensity in the central US. Such events are associated with the majority of warm-season, extreme rainfall events. As of 2018, there was believed to be medium confidence that such increased precipitation trends are attributable to anthropogenic climate forcing. Projections of future trends are uncertain in terms of average precipitation. However, there is strong confidence in the trend of increasing precipitation due to increasing atmospheric water vapor caused by atmospheric warming (Easterling et al. 2017).

CONVECTIVE STORMS (THUNDERSTORMS AND TORNADOES)

Convective storms (thunderstorms and tornadoes) also suffer from data challenges. However, there is confidence that there is an increasing prevalence of tornadoes. The season of high activity is lengthening, and while the number of days on which tornadoes form is decreasing, more tornadoes are increasing on those days (i.e., there are increasing tornado clusters). Modelling projections for thunderstorms consistently show increased frequency of severe thunderstorms. Modelling thunderstorm activity is a proxy for the computationally intensive process of modelling individual tornado formation (Kossin et al. 2017).

DROUGHT

Drought ("meteorological," "agricultural," and "hydrological")[12] refers to a deficit of water/moisture. Climate change and increased temperatures will increase evapotranspiration and therefore will reduce the availability of surface soil moisture. Impacts on run-off, however, are variable, driven by changing precipitation and melt. The fifth IPCC assessment concluded that there is low confidence in any change in the prevalence of meteorological drought, based on the historical record. Further attribution of recent drought events to anthropogenic changes has yielded mixed and contradictory results. That said, some studies indicate that under a changed climate, the impacts of meteorological drought on reducing available moisture have been exacerbated by the increased rate of evapotranspiration caused by higher temperatures. Hydrological flows on the other hand show evidence of anthropogenic impacts, with warming increasing the spring melt and altering run-off patterns, with implications for both floods and droughts. Further, changes in rainfall discussed above will alter run-off patterns. Soil moisture is anticipated to be reduced overall by increased temperatures. The mountainous West is anticipated to see significant spring and fall drying, with implications for fire risk. The same pattern has implications for agriculture in the Midwest (Wehner et al. 2017). The sixth IPCC report suggests likely increased drought risk in the West (IPCC 2021).

[12] "Meteorological' refers to a rainfall, "agricultural" refers to soil moisture, and "hydrological" refers to run-off. All are important considerations.

WILDFIRES

Wildfire activity has shown a profound increase in recent decades, including increases in the number of large fires. While fires are the outcome of complex processes—ignition sources, wind speed, vegetation management, relative humidity, etc.—anthropogenic climate is identified as having played a role in this increase due to the impact of drying forests during fire season (Wehner et al. 2017). Numerous efforts to model future fire risk show increased incidence, with the only uncertainties deriving from other climate impacts that reduce forest growth, e.g., insect infestations (Wehner et al. 2017; IPCC 2021).

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