Farmworkers at Risk

The Growing Dangers of Pesticides and Heat

HIGHLIGHTS

The estimated 2.4 million farmworkers in the United States are vital to US food production. However, these workers are exploited, undervalued, and vulnerable to compounding climate change threats. The Union of Concerned Scientists (UCS) assessed how pesticide exposure and heat stress conditions combine to present significant risks to farmworkers' health and safety. We focused on California, Florida, and Washington—states that lead the nation in pesticide use, farmworkers, and production of labor-intensive fruits, nuts, and vegetables. We found that farmworkers in these states already experience substantial threats and that these are likely escalating. Policies to protect farmworkers' well-being from the dangerous consequences of extreme heat and pesticides are urgently needed.

Introduction

Farmworkers are vital to the agricultural system that brings food to dinner tables in the United States every day. Some 2.4 million workers perform two-thirds of all labor in US agriculture, producing and packing crop and livestock products (NASS 2019; Lacey et al. 2017). Despite this, they remain largely invisible to many. Distinct from farmers, farmworkers do not typically own or operate farm businesses, nor do they own or rent the land. They perform difficult and dangerous work for insufficient wages and with few legal protections (Guild and Figueroa 2018; Clemens 2013; Quandt et al. 2013a). At best, their labor is undervalued, and at worst, they are brutally exploited. And now, their work is becoming even more hazardous as a result of climate change.

Weather extremes associated with climate change are creating increasingly uncertain and life-threatening working conditions. Rising summer and winter temperatures and shifting rainfall patterns alter the timing and length of growing seasons (Lane et al. 2019; Doll, Petersen, and Bode 2017), extreme heat is becoming more common and deadly, and expanding pest activity may increase the likelihood of farmworkers' exposure to dangerous pesticides (USGCRP 2018). In this report, we examine US farmworkers' vulnerability to compounding climate change threats due to the nature of their work and their social and political standing.

Rightdx/iStock

Farmworkers harvest strawberries in California. Such work is often done under grueling conditions, elevating the likelihood of injury from pesticide exposure and heat stress, among other hazards.

Union of Concerned Scientists

We focus on two threats—pesticide exposure and heat stress conditions—and explore how these are affecting US farmworkers' health and safety as climate change takes hold. This report provides recommendations for action, at both the state and federal levels, to protect the most vulnerable workers now. It also urges bold policy measures to create resilient, regenerative farming systems that are less reliant on pesticides, along with swift action to reduce the nation's heat-trapping emissions in order to begin limiting and reversing climate change for the long term.

Farmworkers Are Undervalued and Highly Vulnerable

Farmworkers often conduct their work under grueling conditions, putting their health and safety at risk. While mechanization has reduced the role of farm labor for grain production (Dimitri, Effland, and Conklin 2005), other parts of the agricultural sector remain labor intensive. The food system heavily relies on farmworkers for the production of berries and other fruits, dairy products, tree crops, and vegetables, and to manage livestock (Zahniser et al. 2018).

AP Photo/Luis M. Alvarez

Farmworkers, like these shown harvesting tomatoes in Florida, may resort to rudimentary and inadequate personal protection against pesticides and other airborne hazards.

Multiple forms of disenfranchisement enable the food system's reliance on cheap, exploited labor. The US farm labor market heavily depends on immigrants and seasonal guest workers to fill jobs that domestic workers generally find undesirable (Bronars 2015).[1] In 2015–2016, only 24 percent of US farmworkers were born in the United States, and three-quarters were people of color (Hernandez and Gabbard 2018). Farmworkers leave their countries to do jobs that most US citizens will not do, to earn an average of $10.80 per hour (Hernandez and Gabbard 2018; O'Brien, Kruse, and Kruse 2014). The National Agriculture Workers Survey found that only 32 percent of farmworkers reported a personal annual income of $30,000 or more (Hernandez and Gabbard 2018).

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Farmworkers are typically hired by farmers or, in many cases, by contractors who coordinate labor for farmers and act as intermediaries between farmers and farmworkers. The use of farm labor contractors can insulate farmers from charges of hiring undocumented workers and creates a situation ripe for abuse (Hernandez and Gabbard 2018; Perea 2010).

Economic hardship, immigration status, spoken language, national origin, race, socioeconomic status, and other issues all contribute to farmworkers being the targets of systematic exploitation and exclusion (Guild and Figueroa 2018; Hernandez and Gabbard 2018; Robinson et al. 2011; UFW 2011). Cultural differences, lack of transportation, language barriers, and physical isolation in work camps all combine to create many obstacles that keep farmworkers from accessing whatever scarce resources and services may be available.

More fundamentally, lack of legal protection and political and socioeconomic power limits farmworkers' ability to seek redress for abuses and violations of labor law. This absence of protection and power highlights the need for the expansion of basic rights and protections to these workers, who help build wealth for so many others, throughout the food system (Wadsworth, Courville, and Schenker 2018; Courville,

1 *The H2-A guest worker program gives agricultural employers permission to bring foreign workers to the United States temporarily, for seasonal labor. In recent years, use of the H2-A program has more than doubled in size, and the program has been the target of criticism from both farmworker advocates and farmers (USDL 2019; Wozniacka 2019).*

BOX 1.

Lack of Data Makes It Harder to Protect Farmworkers

Researchers face a lack of reliable and accessible public information about the lives and working conditions of farmworkers. There are multiple reasons for the scarcity of good data (UFW 2011). The informal, seasonal, and subcontracted nature of agricultural labor makes it difficult to count farmworkers. Some surveys on occupational injury omit small farms (with fewer than 11 employees) (Ruser 2008). Undocumented farmworkers and their employers may be reluctant to share information, and employers may refuse to allow access for researchers and surveyors. Workers with health concerns may not report their experiences due to lack of reporting systems, fear of retaliation, or failure to recognize symptoms.

Thus, information about farmworkers—including the number and rate of occupational injuries caused by pesticides and heat—is underreported (Prado et al. 2017; Jackson and Rosenberg 2010). Researchers have estimated that US government reports of occupational injuries in agriculture miss 79 percent of nonfatal injuries and 74 percent of deaths (Leigh, Du, and McCurdy 2014; Leigh, McCurdy, and Schenker 2001). The lack of accurate and complete data makes every aspect of research, education, and advocacy on farmworker issues more difficult.

Wadsworth, and Schenker 2016). Political and social marginalization of farmworkers make them especially vulnerable to abuse and neglect, in and out of the workplace (Wadsworth, Courville, and Schenker 2018; Summers et al. 2015).

Farmworkers were excluded from the rights and protections secured for most private sector workers in the United States by the 1930s New Deal legislation, which established child labor protections, collective bargaining, minimum wage, overtime pay, protection from hazards in the workplace, and unemployment insurance (Guild and Figueroa 2018). The exclusion of farm labor enabled the continued exploitation of Black sharecroppers in the Southern plantation system, created barriers to the accumulation of wealth by the descendants of slaves, and helped maintain white economic dominance in the United States (Perea 2010; Linder 1987). Some protections have since been extended to some farmworkers, but exceptions have been maintained. For example, at the federal level, the minimum wage has been extended to workers on large farms, but overtime pay has not. Small farms remain exempt from minimum wage requirements.

Farmworkers at Risk

Farmworkers undertake some of the most challenging work: cultivating, harvesting, maintaining, packing, and planting fruits and vegetables, and handling livestock. Often, they work under grueling conditions. While farmworkers face numerous threats to their health and safety, pesticides and heat stress conditions are among the most serious.

PESTICIDE DEPENDENCE PUTS FARMWORKER HEALTH AND SAFETY AT RISK

During the 20th century, through a combination of technological development, market forces, and policies, US agriculture became overwhelmingly dependent on synthetic pesticides (Aspelin 2003). The use of these toxic compounds to control fungi, insects, weeds, and other pests has become commonplace in intensive monoculture farming—a system in which single crop species are grown across vast areas of farmland, often year after year. The resulting diminished biodiversity creates ideal environments for insects and plant diseases to propagate, while exposed soils and extensive fertilizer use—also hallmarks of today's dominant agricultural system—create welcoming habitats for weeds.

However, heavy reliance on pesticides is not the only option for dealing with agricultural pests—the science and practice of agroecology incorporates many alternative approaches to crop protection (see Box 2, p. 4). Despite the existence of these alternatives, the area of farmland treated with pesticides increased 65 percent between 1997 and 2017 (NASS 2019). In 2017, farmers spent more than $17.5 billion on pesticides—$37 for every acre treated, up from $27 per acre in 1997 (NASS 2019).

While intensive pesticide use has been an integral part of the strategy to increase yields per acre, it has had disastrous consequences for many communities and the environment (Bourguet and Guillemaud 2016; Pimentel and Burgess 2014). Farmworkers and their families face both immediate and long-term harm from pesticides. Although data are limited, estimates suggest that thousands of workers suffer acute pesticide poisoning every year (EPA 2015).[2] Farmworker

2 *Assessing pesticide poisoning is difficult, as federal agencies that track instances have released data only until 2011. These data do not capture potential changes due to improvements in the Agricultural Worker Protection Standard for pesticides in 2015. Furthermore, interpretation of these data is limited by known underreporting issues as well as differences in reporting practices across states (Prado et al. 2017).*

pesticide poisonings are likely to be more severe than pesticide poisonings that occur in other occupations: considering all exposure cases, farmworkers are twice as likely to suffer severe injury or death (Calvert et al. 2016).

Farmworkers face risks of injury and death whether or not they are directly involved with handling pesticides, and field-workers who are *not* working directly with pesticides account for the majority of reported poisonings (CDC 2019; CDPR 2019). 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 (EPA 2019; Calvert et al. 2008, 2004; Arcury et al. 2001). The 2015–2016 National Agriculture Workers Survey indicated that only 57 percent of farmworkers had received any pesticide safety training in the previous 12 months.

Chronic health effects from long-term exposure to pesticides are also an issue. Farmworkers repeatedly endure exposure to pesticides through contact with airborne drift or through residues on equipment, soil, plants, or clothing. Farmworkers' families also are exposed to pesticide residues when these are brought home on workers' bodies, clothes, and shoes (Hyland and Laribi 2017). Chronic pesticide exposure has been associated with devastating health issues, including cancer, depression, diabetes, neurodegenerative diseases, and reproductive issues (Kim, Kabir, and Jahan 2017; Muñoz-Quezada et al. 2016; Beard et al. 2014; Starling et al. 2014; Bassil et al. 2007; Frazier 2007). Some of these conditions are associated even with very low levels of exposure over long periods (Alleva et al. 2018; García et al. 2017; Sánchez-Santed, Colomina, and Herrero Hernández 2016; Son et al. 2010).

Farmworkers die of heat-related causes at roughly 20 times the rate of workers in all other civilian occupations.

HEAT STRESS CONDITIONS ALSO THREATEN FARMWORKER HEALTH AND SAFETY

Over the past 30 years, exposure to extreme heat was, on average, the top cause of weather-related deaths in the United States (NWS 2019). Between 1992 and 2017, heat was estimated to be responsible for an average 2,700 serious injuries and 30 deaths per year among all US workers (Tanglis and Devine 2018). Farmworkers die of heat-related causes at roughly 20 times the rate of workers in all other civilian occupations (CDC 2008).

Farmworkers' high risk of heat stress is related to the nature of their labor: they do hard work under the sun and often through the hottest parts of the year. Direct sunlight can increase the heat index (which combines temperature and humidity to give a "feels like" temperature) by up to 15°F (NWS n.d.). Further, to protect against chemicals (including pesticides), insects, and sun, farmworkers typically wear long sleeves and often wear multiple layers. Such clothing can add up to 12°F to the "feels like" temperature (WSL 2018). Nonbreathable coveralls—used to protect pesticide handlers against the most toxic pesticides—can increase the "feels like" temperature even more, by up to 27°F (CHEMM 2019). Another factor that exacerbates heat injury is the way many farmworkers are paid. When employers pay farmworkers based on "piece rate," the workers earn according to how much they harvest (Guild and Figueroa 2018), and this disincentivizes taking breaks to rest, seek shade, or drink water (Lam et al. 2013).

The federal Occupational Safety and Health Administration (OSHA) endorses a set of clear heat stress prevention

BOX 2.

Agroecology Can Help Protect Farmworkers and Fight Climate Change

The science and practice of agroecology can help address many of the problems identified in this report. Agroecology applies ecological principles to farms and is premised on working with nature rather than against it (Gliessman and Tittonell 2015). For example, practices such as crop rotation, multi-cropping, and use of cover crops can discourage weeds and insect pests, thereby reducing the need for pesticides. In addition, diversified farms can be designed to improve occupational safety for both farmers and farmworkers. For example, cropping systems that provide tree shade or shift some labor to cooler seasons may prevent farmworker exposure to dangerous conditions. Finally, some farming practices can directly mitigate climate change by reducing heat-trapping gas emissions and sequestering carbon in the soil (Harden et al. 2018; Feliciano et al. 2017).

Bob Nichols/USDA

In full sun and wearing multiple layers of clothing, these workers harvesting lettuce in California are at risk of heat stress.

measures and remedies. These include allowing new workers time to acclimatize to hot conditions; providing additional hydration, rest, and shade as heat increases; and training workers and supervisors to recognize and respond to signs of heat stress (Jackson and Rosenberg 2010). However, many employers fail to offer such remedies (Arbury, Lindsley, and Hodgson 2016). In the absence of training, many farmworkers are not aware of the critical importance of hydration and acclimatization (Stoecklin-Marois et al. 2013).

The confusion and impaired coordination that accompany heat stress can put workers at additional risk for other kinds of traumatic injury (Varghese et al. 2018; Spector et al. 2016). Moreover, farmworkers can face additional heat stress risks even outside of the work environment. Employer-provided housing often lacks air-conditioning or fans, eliminating important overnight recovery time and, in some cases, meaning that farmworkers start their day already experiencing heat stress (Quandt et al. 2013b). All of this is further compounded by the fact that the majority of farmworkers do not have access to health insurance coverage or workers' compensation, and are unlikely to receive care for heat-related (or other) injuries (Arcury and Quandt 2011, 2007).

Combined Pesticide and Heat Effects Are Worse Than the Sum of Their Parts

While pesticide exposure and heat stress conditions each already represent a threat to farmworkers' health, climate change promises to compound these threats. For example, climate change is likely to increase pesticide use due to expanding ranges and impacts of pests and pathogens, increasing vigor of weeds compared with crops, and decreasing efficacy of pesticides under increasing temperatures (Taylor et al. 2018; Ziska 2016; Delcour, Spanoghe, and Uyttendaele 2015; Bebber, Holmes, and Gurr 2014). Higher temperatures also increase pesticide volatilization rates, meaning more of the pesticides applied will be lost as vapor, potentially leading to even higher application rates to achieve the same effect (Delcour, Spanoghe,

TABLE 1. Agriculture, Pesticide Use, and Heat Stress Conditions in Key Agricultural States

		CA	WA	FL
Farmworkers[a]	Statewide	377,593	228,588	96,247
	10 Top Counties[b]	210,083	182,376	56,983
Value of Crop Sales	Statewide	$33.4 billion	$7.0 billion	$5.7 billion
	10 Top Counties	$22.4 billion	$5.6 billion	$3.8 billion
Acres Harvested	Statewide	7.9 million	4.5 million	2.1 million
	10 Top Counties	4.7 million	2.8 million	0.9 million
Pesticide Application Rate[c]	Statewide	8.1 kg/acre	7.6 kg/acre	11.7 kg/acre
	10 Top Counties	9.3 kg/acre	11.1 kg/acre	15.4 kg/acre
	Statewide Mandatory Pesticide Use Reporting	Yes	No	No
Days with Heat Index[d] over 80°F, April–October	Statewide	102 days	31 days	193 days
	10 Top Counties	115 days	42 days	202 days
	Statewide Worker Heat Protection Regulations	Yes	Yes	No

California, Washington, and Florida are the top three states with the greatest sales of labor-intensive fruits, nuts, and vegetables. They also lead the nation in numbers of farmworkers and average pesticide application rates (see Table A1 in Technical Appendix II). Farmworkers in these states are at risk due to both pesticide exposure and heat stress conditions, compounding threats likely to worsen as climate change continues.

Notes: a. "Farmworkers" refers to hired farm labor as estimated by the 2017 Census of Agriculture. Hired labor is distinct from the labor of farmers and their families, who are generally categorized as self-employed and unpaid labor, respectively. b. Top 10 counties are determined by crop sales. For list of counties and detailed results, see Table A2 in Technical Appendix II. c. "Pesticide application rate" is the total agricultural pesticides applied for all crops and counties divided by total harvested cropland acres. d. "Heat index" is calculated as the average from 1971 to 2000 (see Technical Appendix I for more details).

SOURCES: NASS 2019; USGS 2018.

and Uyttendaele 2015). Increasing volatilization also raises airborne concentrations and leads to a higher risk of pesticide exposure and injury for farmworkers as well as nearby communities (Houbraken et al. 2016).

As the potential for exposure to pesticides increases, farmworkers may also become more vulnerable to them: a growing body of research shows that heat stress increases the human body's susceptibility to pesticides and other toxicants, magnifying the potential for both acute and long-term health effects (Johnson, Wesseling, and Newman 2019; Wang et al. 2018; Fortes et al. 2016; Gordon and Leon 2011). In the case of widely used organophosphate pesticides, warmer temperatures have been shown to increase the rate of chemical transformation into more toxic compounds (Mackay, Giesy, and Solomon 2014; Armstrong et al. 2013).[3] Finally, the increasing use and toxicity of pesticides amplify the need for protective clothing, which can, as noted earlier, dramatically increase the risk of heat-related injury (Bernard et al. 2007).

Risks for Farmworkers: A Closer Look in Three States

We aimed to assess how farmworkers experience compounding threats from pesticide use and heat stress conditions. While dangerous heat is an issue for farmworkers in every kind of agriculture, pesticide use is more concentrated in crop

> ***Climate change will not only cause increased severity and frequency of dangerous heat, but will likely lead to increased pesticide use as well.***

3 *Studies showed that warmer temperatures increased the rate of transformation of organophosphorus pesticides into oxon metabolites, which can be 5 to 100 times as toxic as the parent pesticide.*

production than in animal agriculture. We therefore focused our attention on crop agriculture.

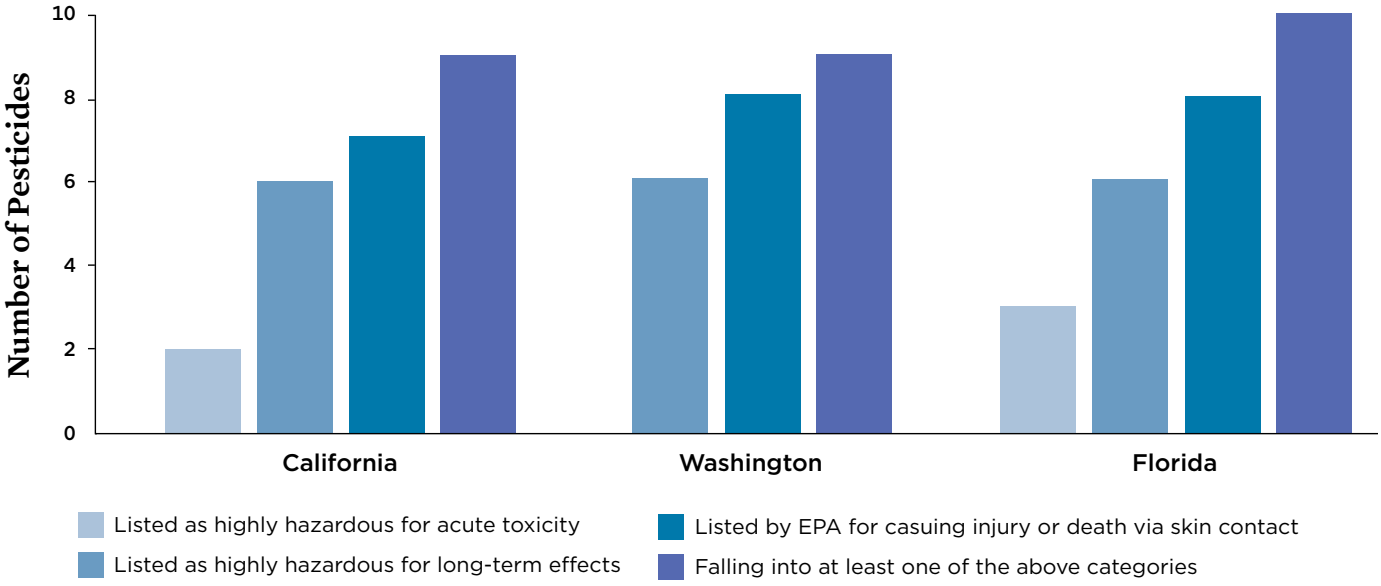
Heat and pesticide use vary from state to state. We assessed three key states in depth: California, Florida, and Washington (see Table 1). We chose these states based on their high rates of pesticide use and the importance of agriculture, especially labor-intensive fruit, nut, and vegetable crops, to their economies. These states also have among the highest numbers of farmworkers.

For each state, we examined the intersection between risks of pesticide use and heat stress conditions, situating our analysis in the context of the state's agricultural economy and regulatory environment. Since agriculture and climate conditions are highly variable within any given state, we also identified the top 10 agricultural counties in each state and conducted a similar analysis focusing on just those counties (see Technical Appendices I and II).

We calculated the average rate of pesticide use (kilogram per harvested cropland acre) at state and county levels, using estimates of agricultural applications in 2016 from the US Geological Survey Pesticide National Synthesis Project (USGS 2018) and acres of crops harvested from the 2017 Census of Agriculture (NASS 2019). To better understand the nature of acute and long-term health threats faced by farmworkers, we also identified the top 10 pesticides used in labor-intensive agriculture in each state and assessed the risks associated with them (see Figure 1, and Table 2, p. 8); see Technical Appendix I for methods; see Table A3 in Technical Appendix II for detailed results).

Finally, we used heat data from recent historical conditions (1971–2000) based on the Union of Concerned Scientists report, *Killer Heat in the United States*, focusing on the 214 days between April 1 through October 31 (Dahl et al. 2019b). As in that work, we used the heat index used by the National Weather Service—also known as the "feels like" temperature—which accounts for both temperature and relative humidity (NWS, n.d.). While susceptibility to heat risks is highly individual and depends on many factors, National Weather Service guidance and other research suggests that at a heat index above 90°F, people exerting themselves or working outdoors become increasingly susceptible to heat illness or injury (NWS, n.d.).

FIGURE 1. Health Hazards of Top Pesticides Used on Labor-Intensive Crops in California, Washington, and Florida



The top 10 pesticides applied (by weight) in California, Florida, and Washington include several that are highly dangerous to human health, according to three key indicators.

Note: Pesticides listed for acute toxicity can cause a broad range of symptoms, depending on the compound and the level of exposure (see Table 2, p. 8). Pesticides listed for long-term health effects are known potential carcinogens and endocrine disruptors. See methods for identifying and characterizing the pesticides in Technical Appendix I, and see Table A3 of Technical Appendix II for detailed results of the analysis.

SOURCES: PANI 2019; SEE PESTICIDE SOURCE DOCUMENTS IN TECHNICAL APPENDIX 1.

TABLE 2. Acute Health Hazards of Top Pesticides Used on Labor-Intensive Crops in California, Washington, and Florida

Pesticide	Selected Label Text
Sulfur	"Harmful if swallowed, inhaled or absorbed through skin."
Dichloropropene	"May be fatal if absorbed through the skin."
Petroleum Oil	"Harmful if swallowed or absorbed through skin or inhaled."
Metam Potassium	"POISON. Fatal if absorbed through skin. Corrosive. Causes skin burns and irreversible eye damage."
Chloropicrin	"Poisonous liquid and vapor. Inhalation may be fatal. . . . Liquid will cause chemical burns to skin or eyes."
Glyphosate	"Causes moderate eye irritation."
Kaolin Clay	"Causes moderate eye irritation."
Metam	"Corrosive. Causes skin damage. May be fatal if absorbed through the skin."
Copper Hydroxide	"May be fatal if swallowed. . . . Harmful if inhaled."
Petroleum Distillate	"Harmful if absorbed through skin."
Calcium Polysulfide	"Corrosive. Causes irreversible eye damage. Causes skin burns. Harmful if swallowed or absorbed through skin."
Mancozeb	"Harmful if absorbed through skin."
Chlorothalonil	"Corrosive. Causes irreversible eye damage. May be fatal if inhaled."
Sulfuric Acid	"Corrosive. Causes irreversible eye damage and severe skin burns. May be fatal if swallowed or absorbed through skin or inhaled."
Allyl Isothiocyanate	"Corrosive. Causes irreversible eye damage and skin burns. May be fatal if swallowed, absorbed through skin, or inhaled."

The Environmental Protection Agency (EPA) mandates specific text that must appear in the safety warnings on product labels for pesticides in the United States. These selections from the mandated safety text for the top pesticides applied (by weight, in descending order) in California, Florida, and Washington illustrate some of the dangers faced by farmworkers working with labor-intensive crops. These warnings do not reflect long-term health hazards associated with these pesticides.

Note: See methods for identifying and characterizing the pesticides in Technical Appendix I and detailed results of analysis in Table A3 of Technical Appendix II.

SOURCES: SEE PESTICIDE SOURCE DOCUMENTS IN TECHNICAL APPENDIX 1.

For farmworkers, however, heat does not have to be extreme to be dangerous. The heat index used by the National Weather Service is calibrated for a healthy, hydrated, and unmedicated person who is five-foot-seven and 147 pounds, wears short sleeves, and does light work in the shade with a slight breeze (Rothfusz 1990). With farm work, however, heat becomes dangerous at lower temperatures, including temperatures that probably feel quite comfortable for those of us who match the descriptions listed above: doing light work in comfortable clothes in a shady, breezy area.

A recent study identified a heat index of just 80°F as a critical threshold for outdoor workers, defining the lower end of the range in which 99 percent of injuries and 100 percent of deaths occur (Morris et al. 2019). Therefore, in this report, we used an 80°F heat index threshold. This threshold makes it clear that the season of risk for farmworkers extends far beyond the very hottest part of the year.

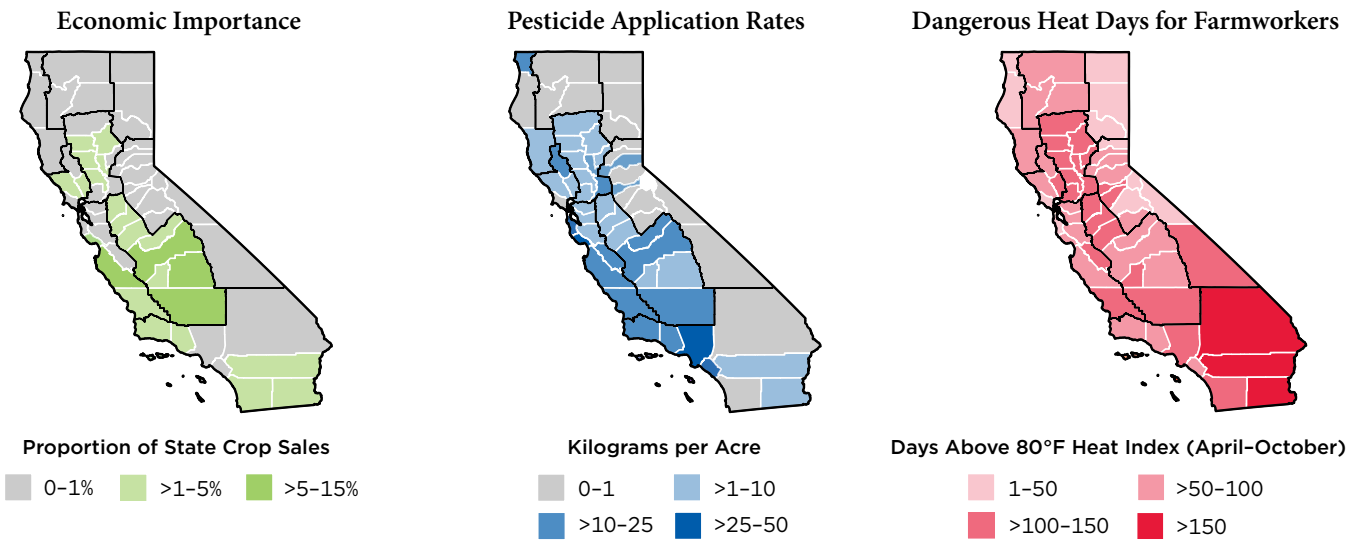
CALIFORNIA

California leads the nation in total value of agricultural products sold, as well as in labor-intensive commodities such as fruits, nursery products, tree nuts, and vegetables (NASS 2019; see Table 1, p. 6). Fruit, tree nut, and vegetable production make up 84 percent of California's crop sales, more than any other state. Further, the state's crop production uses nearly 8 million acres (NASS 2019). The 2017 Census of Agriculture estimated California's farmworker population to be 377,593, but as with other farmworker data, this may reflect significant underreporting (NASS 2019). A recent analysis of California employment records estimates there are more than twice that number: 829,000 (Martin et al. 2016).

California's average rate of pesticide use on harvested croplands, 8.1 kg per acre, is more than 4.5 times the national average (1.7 kg per acre). Despite recent declines in statewide pesticide use and pesticide injury, acute pesticide poisoning remains a regular occurrence, with an average of 88 cases per year between 2010 and 2015 (CDPR 2019; USGS 2018). Nine of the top 10 pesticides used on California's labor-intensive crops have dire implications for farmworker health. The Pesticide Action Network (PAN) associates six with long-term health effects and two with acute toxicity. The Environmental Protection Agency (EPA) lists seven as causing injury or death through contact with the skin.

California farmworkers' risk of pesticide injury is compounded by the risk of heat stress conditions. From 1971 to 2000, the average number of days per year over the heat risk threshold of 80°F stood at 102. Extreme heat, driven by climate change, is a mounting public health concern in California for much of the population and especially those,

FIGURE 2. Agricultural Economy, Pesticides, and Heat Stress Conditions in California



In California's top agricultural regions, farmworkers face even greater threats from both pesticide exposure and heat stress conditions than across the state as a whole.

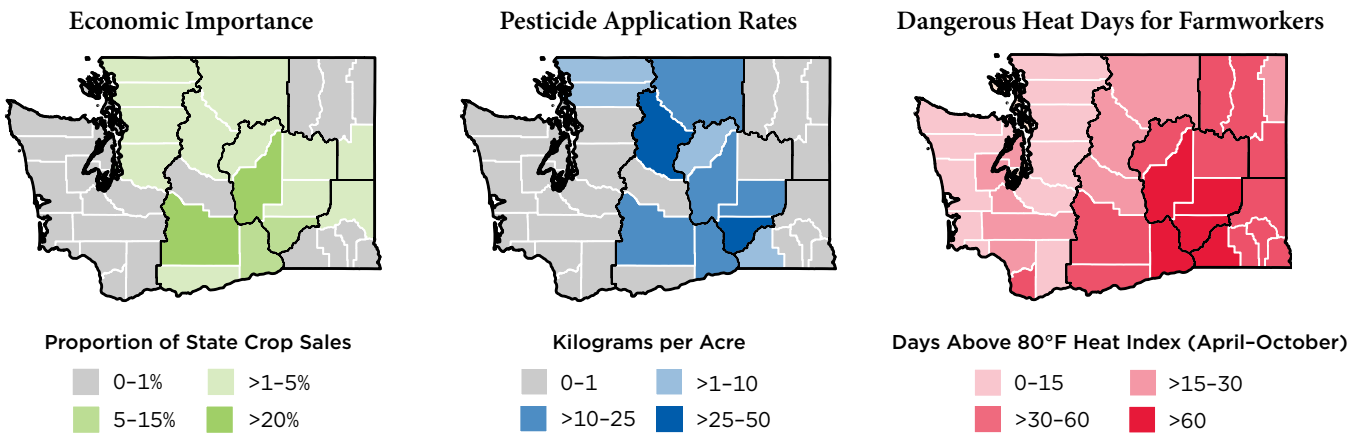
Notes: Light lines represent county boundaries and dark lines represent agricultural district boundaries. Figures show (left) county crop sales as a proportion of total state crop sales, (center) pesticide application rates per acre of harvested cropland, and (right) average days per year with a heat index above 80°F from April to October, 1971–2000 (see Technical Appendix I for methods). Areas in white on pesticide map indicate counties for which application rates could not be calculated due to lack of available census data on acres of crops harvested.

SOURCES: NASS 2019; USGS 2018.

NNehring/iStock

Workers spot-spraying artichokes with herbicide in California illustrate gear used by pesticide handlers. While protective clothing reduces exposure to chemicals, it can also increase the risk of heat stress.

FIGURE 3. Agricultural Economy, Pesticides, and Heat Stress Conditions in Washington



Washington's top agricultural regions are also areas where farmworkers face significant threats from both pesticide exposure and heat stress conditions. Although the state is much cooler than California and Florida, it still experiences a large number of dangerous days, especially in the counties with the greatest crop sales.

Note: Light lines represent county boundaries and dark lines represent agricultural district boundaries. Figures show (left) county crop sales as a proportion of total state crop sales, (center) pesticide application rates per acre of harvested cropland, and (right) days with a heat index above 80°F from April to October, 1971–2000 (see Technical Appendix I for methods).

SOURCES: NASS 2019; USGS 2018.

like farmworkers, who must exert themselves outdoors (Dahl et al. 2019b, Mera et al. 2015).

The situation in the state's leading agricultural counties is even more severe (see Figure 2, p. 9). The top 10 agricultural counties—which account for 67 percent of all crop sales and 60 percent of all harvested acres—have higher pesticide use rates than the state average, as well as more days with risk of heat injury (an average of 115 days per year between April and October from 1971 to 2000). In addition, cities such as Fresno, located in the agriculture-rich Central Valley region, have already seen an increase in the number of days with a high heat index since the 1970s (CC 2016).

WASHINGTON

Washington is a major producer of labor-intensive crops, ranking second in the nation for total crop sales for fruits, tree nuts, and vegetables (see Table 1, p. 6 and Table A1 in Technical Appendix II). In terms of production, it ranks second in the nation for fruits and tree nuts, third for vegetables, and fifth for Christmas trees and short rotation woody crops (NASS 2019). The Washington agricultural industry relies on 228,588 farmworkers for its agriculture

Washington's average pesticide application rate is 4.5 times the national average.

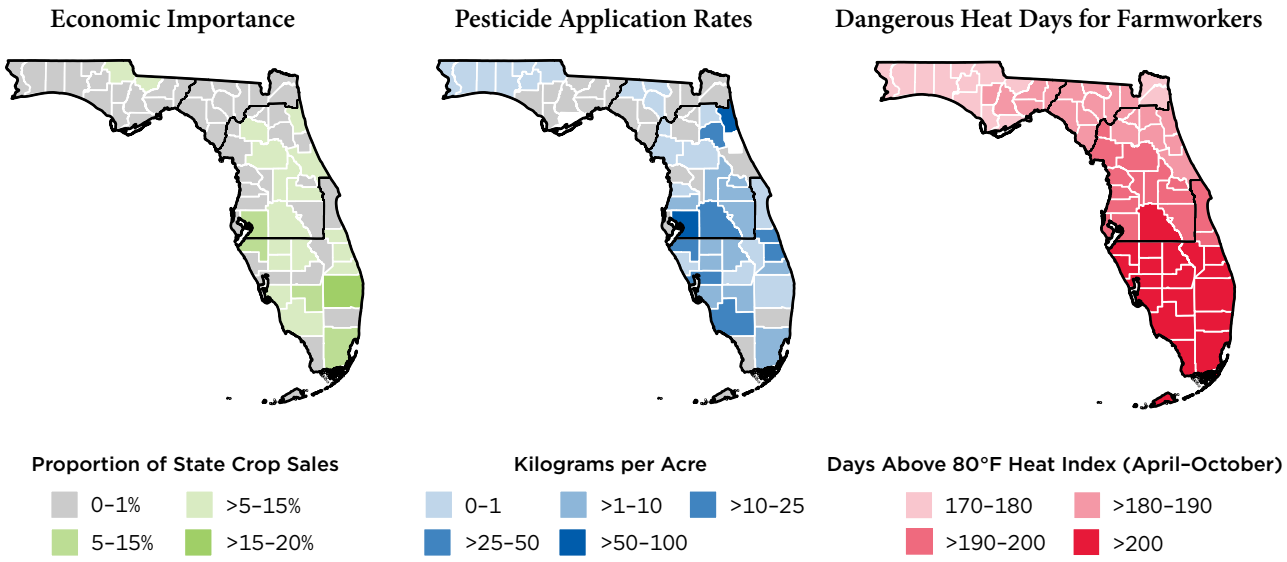
(NASS 2019). Overall, Washington has the second highest number of farmworkers in the nation after California.

Washington's average pesticide application rate of 7.6 kg per harvested crop acre is 4.5 times the national average. Nine of the 10 most common pesticides applied to fruit, orchard crops, and vegetables have dire implications for farmworker health: PAN associates six with long-term health effects, and the EPA lists eight as causing injury or death through contact with the skin.

Farther north and cooler than California and Florida, Washington has historically averaged only 31 days with risk of heat-related injuries (i.e., days with a heat index above 80°F) between April and October.[4] However, conditions have been worsening. The Pacific Northwest today is, on average, more

4 *Note that Washington's own Outdoor Heat Exposure Safety Standards for Agriculture mandate an action threshold of 77°F for workers wearing the double-layer long-sleeve clothing that is very common among farmworkers.*

FIGURE 4. Agricultural Economy, Pesticides, and Heat Stress Conditions in Florida



Florida's agricultural value is spread throughout the state, and many areas of the state have high pesticide use rates. While heat stress conditions are most severe in the southernmost areas, the majority of the state already faces dangerous heat during most of the period from April to October.

Note: Light lines represent county boundaries and dark lines represent agricultural district boundaries. Figures show (left) county crop sales as a proportion of total state crop sales, (center) pesticide application rates per acre of harvested cropland, and (right) days with a heat index above 80°F from April to October, 1971–2000 (see Technical Appendix I for methods). Areas in white on pesticide map indicate counties for which application rates could not be calculated due to lack of available census data on acres of crops harvested.

SOURCES: NASS 2019; USGS 2018.

than 1.5°F warmer than it was during the first half of the 20th century (USGCRP 2017). Average summer temperatures in Washington have increased by about 0.6°F since 1970, though the increase has been as much as 1°F for many Washington locations in that time frame (OWSC 2019).

In Washington's top 10 agricultural counties, pesticide use rates are higher than the statewide average, with a rate of 11.1 kg per acre, or 6.5 times the national average (Figure 3). The number of days with a high risk of heat-related injuries has also been higher in these counties, averaging 42 days per year between 1971 and 2000.

FLORIDA

Florida ranks third in the nation for total sales of fruits, tree nuts, and vegetables—behind California and Washington—and is first in the nation in production of oranges (NASS 2019, see Table 1, p. 6, and Table 1A in Technical Appendix II). The 2017 Census of Agriculture estimated that Florida's farmworker population is 94,247 (NASS 2019), but a recent state-level analysis of labor and employment data for Florida produced a higher estimate: 110,000 (SCHS 2019).

Florida's dependence on agricultural pesticides puts the state's farmworkers at risk. Despite nearly 20 years of gradual decline in Florida's average pesticide application rates, the rates remain the highest in the nation, at almost seven times the national average. Further, every one of the 10 most common pesticides applied to fruit, orchard crops, and vegetables in Florida have dire implications for farmworker health, more than in either California or Washington. PAN associates six with long-term health effects and three with acute toxicity, and the EPA lists eight as causing injury or death through contact with the skin.

Dangerous levels of heat compound the risk of pesticides for Florida's farmworkers. Historically, these workers have

> ***Florida workers have experienced an average of 193 days between April and October with a heat index over 80°F.***

experienced an average of 193 days between April and October with a heat index over 80°F. Further, current heat conditions already pose a serious threat to Florida's population—from 2001 to 2010, Florida had the greatest increase of hospitalizations for heat illness out of 20 states in the Centers for Disease Control and Prevention's National Environmental Public Health Tracking Program (Choudhary 2014). Farmworkers are no exception, with 84 percent of those surveyed in 2015–2016 reporting at least one symptom of heat illness and 40 percent reporting three or more symptoms (Mutic et al. 2018).

In this state, where so much of the April–October interval climate is already over a heat index of 80°F, our threshold does not reveal the full story of increasing heat risk, because both the frequency *and* the severity of heat risk conditions are expected to rise (Dahl et al. 2019b).

As in the cases of California and Washington, farmworkers in Florida's top agricultural counties face relatively greater threats than those in other areas across the state (Figure 4, p. 11). In these counties, the pesticide application rate reaches an average 15.4 kg per acre, and farmworkers have historically faced 202 days with a heat index above 80°F from April to October.

Protections for Farmworkers Are Uneven and Inadequate

While some progress has been made since the 1930s, farmworkers continue to suffer from inconsistent and insufficient worker protection standards.

Federal pesticide regulation is the responsibility of the EPA. Currently, the agency assumes that workers handling pesticides will be trained, equipped, and able to follow the full specified safety requirements. Evidence suggests that, on the contrary, farmworkers have often received no training in pesticide handling and may not even know the names of the chemicals with which they are working (Hernandez and Gabbard 2018, Arcury et al. 2001). As noted earlier, employers frequently fail to provide the full set of specified protective gear (Calvert et al. 2008). While the EPA has made strides in restricting the use of some of the most toxic pesticides, the agency's overall approach fails to consider the potential for heat stress associated with protective gear (Regulations.gov 2019; Aspelin 2003).

Farmworkers who are not fully aware of the risks associated with the pesticides in use may choose not to wear protective equipment to avoid the increased risk of heat illness (Arbury, Lindsley, and Hodgson 2016). Even farmworkers who are fully aware of the risks are put in the dangerous position of having to choose between risking harm from pesticides or heat.

> ***California is the only state with a comprehensive heat illness protection program for outdoor workers.***

There is no federal standard that specifically protects workers from dangerous heat. Although OSHA provides suggested guidelines for heat safety, the only legal requirement is OSHA's general duty clause, which obligates employers to provide workplaces that do not expose workers to recognized hazards that could cause death or serious physical harm. The lack of any specific heat standards makes enforcement of the general duty clause very difficult (Tanglis and Devine 2018).[5] State-level regulations for outdoor workers exist only in California and Washington.

California is the only state with a comprehensive heat illness protection program for outdoor workers. California adopted the country's first heat protection standard on an emergency basis in 2005 and permanently in 2006 (DIRSC n.d.). It requires employers to provide water and shade and, as the temperature rises, to enforce a work-rest schedule that dictates mandatory breaks. It also requires training for supervisors and employees on prevention, recognition, and treatment of heat illness.

Washington followed California in adopting heat illness prevention regulations on an emergency basis in 2006 and 2007. Washington then adopted permanent regulations in 2008, which require employers to provide drinking water but do not specify the provision of shade (WSL 2018). They do, however, require that employers supply the means to cool off or have written plans for preventing and dealing with symptoms of heat stress. Unlike those for California, Washington's regulations apply only from May to September, and then only when the temperature exceeds one of several thresholds: 89°F regardless of clothing, 77°F if workers are wearing double-layer clothing (typical farmworker attire), and 52°F if workers are wearing nonbreathable coveralls,

5 *Review of OSHA enforcement cases has shown that 58 percent of employers failed to have any kind of heat illness prevention program, and even fewer follow the full guidelines for preventing heat illness (Arbury, Lindsley, and Hodgson 2016). For more information on the General Duty Clause, see* https://www.osha.gov/laws-regs/oshact/section5-duties.

Alexandria Jonas/National Farm Worker Ministry/Creative Commons (Flickr)

Farmworkers rally for justice in Bellingham, Washington in 2018. Fear of deportation marginalizes migrant farmworkers and makes them less likely to report dangerous working conditions.

such as those worn to protect against particularly toxic pesticides.

California and Washington may be the two states doing the most to protect farmworkers. In addition to protecting against heat, they are also two of the states with the most stringent regulation of pesticides. Both states have maintained public health programs that have monitored pesticide injury since the early 1970s, and both states have processes to report pesticide injury through state workers' compensation systems (Calvert et al. 2008; Calvert et al. 2004).[6] Unfortunately, numerous barriers—including fear of firing or deportation, lack of access to health care, language barriers, and lack of familiarity with pesticide injuries among clinicians—continue to limit adequate reporting of pesticide illness among farmworkers (Prado et al. 2017).

> ***Numerous barriers—including fear of firing or deportation—continue to limit adequate reporting of pesticide illness among farmworkers.***

6 *In California, doctors are required to report all pesticide-related injuries and illnesses, whether known or suspected. For further information, see* https://oehha.ca.gov/pesticides/pesticide-illness-surveillance-pesticide-illness-reporting.

Policy Recommendations

Over the long term, addressing the threats to farmworkers posed by climate change requires rapid action to reduce heat-trapping emissions. However, given that farmworkers are already subject to injury and death from pesticide exposure and heat stress conditions—and that these threats are likely to increase, even with rapid and aggressive emissions reductions—additional measures are needed to protect farmworkers now (Dahl et al. 2019b).

Additionally, farmworker communities are already especially vulnerable to climate impacts, so it is critical that measures to address climate change do not come at the further expense of farmworker wellbeing. The science and practice of agroecology encompasses a diverse set of strategies for addressing medium- and long-term objectives at the same time—with the potential to reduce reliance on pesticides, build climate resilience through soil health and diversification, reduce heat-trapping emissions, and sequester carbon in the soil (see Box 2, p. 4).

> ***It is critical that measures to reduce climate change do not come at the further expense of farmworker health and safety.***

To directly and rapidly protect farmworkers who face unsafe and deteriorating working conditions, the Union of Concerned Scientists recommends the following:

- **Congress should direct OSHA to set and enforce standards that protect farmworkers from heat-related injuries.** Safety protocols for these workers should be consistently implemented when the heat index reaches 80°F, to protect against 99 percent of injuries and 100 percent of deaths (Morris et al. 2019). Further,

AP Photo/Marcio Jose Sanchez

Relatives of farmworker Maria Isavel Vasquez Jimenez—who died of heat-related injuries in California—seek justice outside a courtroom in 2011. Expanded protections are needed as heat and pesticide dangers increase.

farmworkers should be guaranteed the right to sufficient rest, shade, and water, the need for which will increase as extreme heat becomes more common. These rules should apply to all farms, including those with fewer than 11 employees.

- **Congress should end the exclusion of farmworkers from legal protections afforded to other workers, including minimum wage, overtime pay, the right to organize, and robust child labor standards.** Protections such as the Fair Labor Standards Act and the National Labor Relations Act should be extended to include farmworkers. In addition, as mandated rest breaks grow more frequent with increasing extreme heat (as per the aforementioned worker heat protection standards), Congress must protect farmworkers' right to be paid for all hours worked.
- **The EPA must make rigorous and timely assessments of risk when considering whether to allow, ban, or restrict the use of pesticides.** Given the evidence of noncompliance with existing safety standards, the EPA should assess risk based on realistic rather than idealized use scenarios. Further, use scenarios and risk assessments should account for the amplified risk of heat stress associated with the use of personal protective equipment.
- **The US Department of Agriculture (USDA) should fund and develop programs that protect farmworkers** by ensuring that all vulnerable communities have equitable access to disaster preparedness and disaster relief in the wake of extreme weather events, including extreme heat. Examples include the USDA's Disaster Assistance Program.
- **The USDA should work with other federal agencies to develop and improve a warning system that alerts farmers and farmworkers of current and forecasted dangerous conditions.** This effort may involve close coordination with numerous federal agencies, especially the National Weather Service. Research investments would be needed to improve this system over time and to enable more effective and targeted interventions.

To improve working conditions and decrease risks for farmers, farmworkers, and society at large in the long-term, the following actions should be taken:

- **Congress and the USDA should identify ways to help farmers develop, implement, and share knowledge about farming systems that reduce reliance on and exposure to pesticides, ameliorate extreme heat, and help with climate change mitigation and adaptation.** This effort should include increasing the availability of technical assistance through university-based cooperative extension services, including county extension offices, and ensuring that the USDA is actively providing growers with all relevant information on federal farm programs that support such practices. Resources should be targeted to prioritize improving conditions for the most farmworkers, while supporting young, beginning, socially disadvantaged, and other limited-resource farmers whenever possible.

> ***Protections such as the Fair Labor Standards Act and the National Labor Relations Act should be extended to include farmworkers.***

- **Congress and the USDA should increase investments in public agricultural and agroecological research programs, particularly those that reduce exposure to extreme heat, heat-trapping emissions, and reliance on pesticides.** For example, participatory research and farmer-to-farmer learning could be facilitated to identify farming systems that are more resilient to pests, have safer planting and harvest seasons or conditions, incorporate more shade (e.g., through agroforestry), and contribute to climate change mitigation through reduced emissions or increased carbon sequestration. Public research programs—including the USDA's Agriculture and Food Research Initiative, Sustainable Agriculture Research and Education Program, and Organic Agriculture Research and Extension Initiative—need to be continually improved and expanded to address evolving challenges. Social science research is also needed to center farmers in learning how improved practices can be effectively adopted and scaled up to benefit farmers, rural communities, and, especially, farmworkers.
- **Federal and state policymakers should take aggressive actions to fight climate change and prevent drastic increases in dangerous heat conditions.** These include implementing and strengthening the Paris Agreement and achieving deep cuts to US heat-trapping

emissions while protecting and increasing the levels of carbon stored in plants and soils. Such policies must be designed and implemented to explicitly consider and center the most vulnerable groups.

Conclusion

More than 2.4 million farmworkers in the United States make fundamental contributions to our health, social well-being, and the economy by producing the food we eat every day, and they deserve to work in safety and dignity. However, the systematic exploitation of farmworkers and their exclusion from legal protections leave them especially vulnerable to hazardous workplace conditions. Our analysis reveals how farmworkers' health and safety are already at risk. In a rapidly warming world, climate change threatens to amplify the harms farmworkers already face from exposure to pesticides and heat-related injury.

Threats to farmworkers are a threat to the nation—to our economy, food security, health, and rural communities. Farmworkers deserve the respect, rights, and safeguards available to other workers, and recognition of their essential role in building a more resilient food and agriculture system.

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