CJP CLIMATE JUDICIARY PROJECT™

CLIMATE SCIENCE AND LAW FOR JUDGES

Climate Justice

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ENVIRONMENTAL LAW INSTITUTE

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Climate Justice

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I. Introduction

As discussed in the previous modules, global climate change is already affecting the health and well-being of communities in the United States and around the globe. It is important to understand these consequences of climate change as a fundamental issue of environmental justice, which manifests in two ways: specific communities experience disproportionate burdens relative to others, and those who feel the bulk of the burden of disease associated with climate exposures are rarely those who benefit from the anthropogenic activities that drive climate change. Patterns of disproportionate burden and unequal contributions to fossil fuel emissions exist globally, with notable disparities between the Global North and Global South (Figure 1), as well as within the United States. Communities of color, low-income communities, urban communities, migrants, Indigenous peoples, and those with underlying health conditions are among the groups most affected by extreme climate exposure, and these disparities will become more pronounced as the world continues to warm.

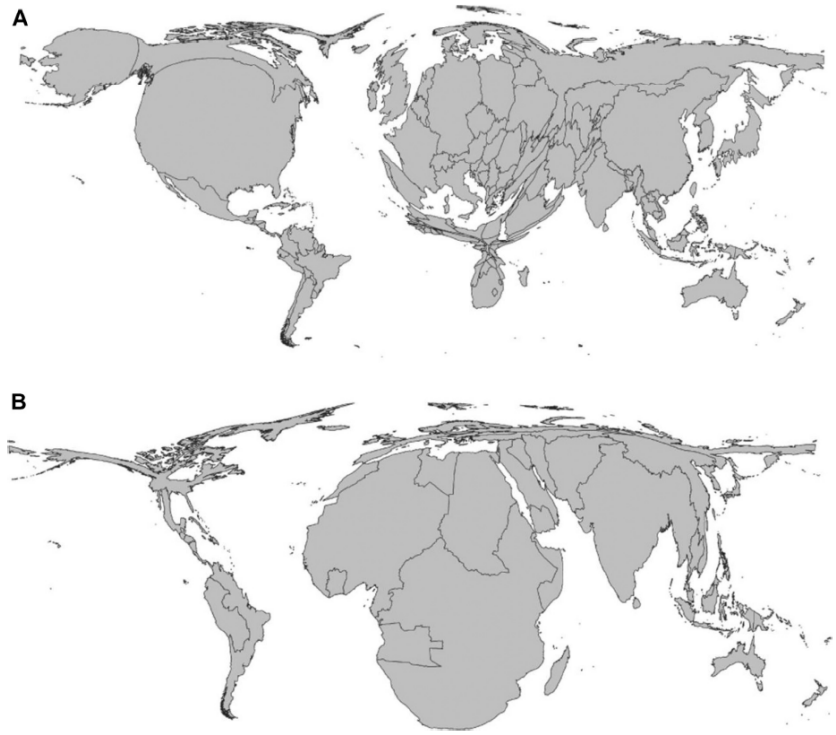

Figure 1. Maps of the world with country sizes corresponding to (A) relative proportions of cumulative carbon dioxide emissions by country, and (B) the magnitude and severity of climate-related mortality including malaria, malnutrition, diarrhea, and inland flood-related drownings by country. Adapted from Jonathan A. Patz et al., *Climate Change and Global Health: Quantifying a Growing Ethical Crisis*, 4 ECOHEALTH 397, 400 (2007).

This module summarizes the state of the evidence on climate injustices, primarily in the United States, drawing on specific examples of climate-related extreme exposures including heat, storms, drought, flooding, and wildfires (Figure 2). We rely on case studies of events and communities to illustrate the environmental justice issues posed by climate change, and we build on the previous discussion pulled from interagency reports including the Intergovernmental Panel on Climate Change (IPCC) reports, the National Climate Assessment (NCA), and the National Academies of Sciences, Engineering, and Medicine (NASEM) reports. Additionally, we describe the communities that are consistently most vulnerable to extreme exposures across climate hazards.

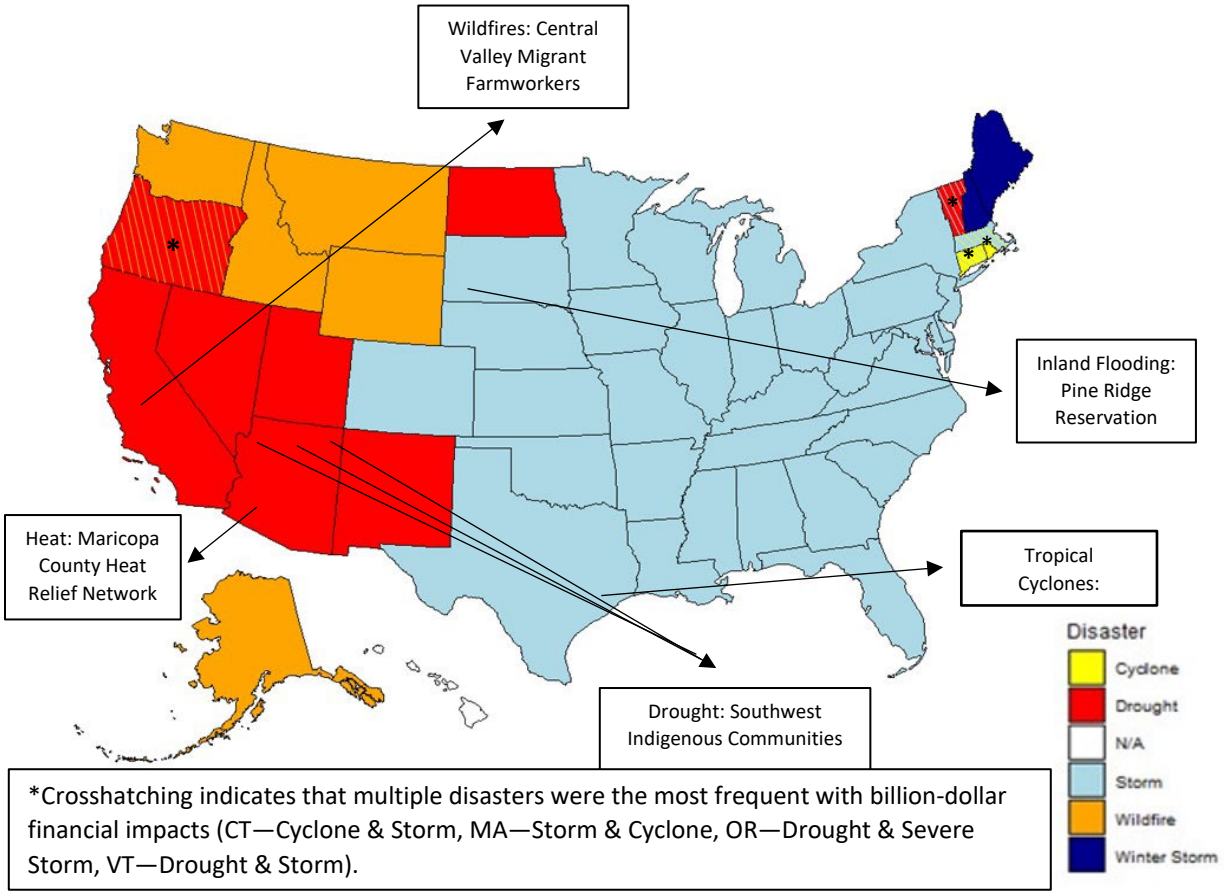

Figure 2. Climate hazards of concern across the United States shown as the most frequent billion-dollar disasters by state, 2012-2022.

II. Background and Glossary

The environmental justice movement was born out of the civil rights movements in the 1960s to address the disproportionate harm facing poor and marginalized communities from resource extraction, industrial processes, and land use practices. Over time, it has expanded from a grassroots movement to a more formal element of regulatory and legal processes. In the 1980s, there were multiple high-profile cases of environmental racism, including protests in Warren County, North Carolina, related to the siting of a hazardous waste landfill in a Black community. A landmark study was published in 1987 by the United Church of Christ that demonstrated that toxic waste sites were disproportionately placed in communities of color in the United States.[1] Following multiple calls for action, including at the First National People of Color Environmental Leadership Summit in 1991, President Bill Clinton issued an Executive Order in 1994 that required federal agencies to "identify and address the disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations."[2] The Executive Order referenced the need for

[1] COMM'N FOR RACIAL JUSTICE, UNITED CHURCH OF CHRIST, TOXIC WASTES AND RACE IN THE UNITED STATES (1987), https://www.ucc.org/wp-content/uploads/2020/12/ToxicWastesRace.pdf.
[2] Exec. Order No. 12,898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Feb. 11, 1994).

equitable enforcement and public participation as well as equitable health outcomes, reinforcing that environmental justice relates to both process and outcomes. Environmental injustice issues persist today as communities of color, Indigenous communities, and low-income communities continue to bear greater exposure to environmental hazards compared to white and wealthy communities.

The climate justice movement was established in the early 2000s at the international climate conference, COP6, through a coalition of environmental, climate justice, religious, policy, and advocacy groups. They used the basis of environmental justice to define 10 climate justice principles that, 20 years later, are still the basis of the movement today.[3] Climate justice is built on the foundation that marginalized communities are more vulnerable to the impacts of climate change, that these communities have contributed significantly less to the processes that drive climate change, and that if not addressed equitably, strategically, and deliberately, the climate crisis will drastically increase global inequities. As discussed in the Fundamental Rights module, climate justice is fundamentally an extension of environmental justice within the context of climate change. As such, some aspects of climate justice are captured within the formal regulatory and legal structures developed to examine environmental justice, while others (including global and intergenerational dimensions) have not yet been incorporated in this manner.

The environmental justice dimensions of climate change at the community level intersect in complex ways with structural racism and social determinants of health (see Box 1 for definition). For example, U.S. housing practices such as redlining—discriminatory lending practices that occurred from the 1930s to the 1960s in which financial risk was assessed by neighborhood and creditworthy applicants from communities deemed high risk (mostly communities of color) were denied loans—have led to residential segregation and decades-long inequities in exposures and infrastructure. The practice of redlining and other discriminatory housing policies greatly influenced home ownership rates among people of color and the neighborhoods in which people of color could own homes, leading to lasting impacts on the ability of families of color to acquire intergenerational wealth and access quality schools, healthcare, and jobs. The historical lack of investment in redlined neighborhoods has led to increased environmental exposures in many of these same neighborhoods today, including elevated exposure to heat, flooding, vehicular traffic, hazardous materials and pollutants, decaying civic infrastructure, poverty, and crime.

[3] DAVID SCHLOSBERG, DEFINING ENVIRONMENTAL JUSTICE: THEORIES, MOVEMENTS, AND NATURE (2007).

Box 1: Glossary of Selected Terms

Hazard: Defined by IPCC as "the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposure elements."

Exposures: Defined by IPCC as "the inventory of elements in an area in which hazard events may occur"; a necessary but not sufficient determinant of risk.

Vulnerability: Defined by UN International Strategy for Disaster Reduction (UN ISDR) as increased probability of exposure to a hazard. Vulnerability is influenced by extrinsic factors such as social factors (e.g., racism, socioeconomic status), behavior, and geography.

Susceptibility: Defined by UN ISDR as the increased response following exposure to a hazard. Susceptibility is influenced by intrinsic factors such as age, genetics, and health status.

Environmental justice: Defined by U.S. EPA as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." (See Fundamental Rights module.)

Climate justice: Defined by the Mary Robinson Foundation as "[linking] human rights and development to achieve a human-centered approach, safeguarding the rights of the most vulnerable people and sharing the burdens and benefits of climate change and its impacts." (See Fundamental Rights module.)

Intersectionality: First defined in 1989 in an article by Kimberlé Crenshaw, it reflects "the complex, cumulative way in which the effects of multiple forms of discrimination (such as racism, sexism, and classism) combine, overlap, or intersect especially in the experiences of marginalized individuals or groups."

Social determinants of health: Defined by the World Health Organization as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life."

Climate justice recognizes differential susceptibility, vulnerability, and capacity among certain communities to prepare, adapt, and recover from climatic hazards (see Box 1 for definitions and for more, the Risks and Costs module). Although race and socioeconomic status have been the traditional areas of focus within the environmental justice movement, the inequities experienced in climate injustice are products of systemic and policy-driven oppression that can influence multiple groups. Any policy, precedent, or process that prevents social progress of a group of people, whether that be by race, gender, sexual orientation, ability, age, religion, or immigration status, can limit that group's ability to adapt and respond to climate change by placing them at greater risk of hazards, contributing to health disparities, preventing financial security, and reducing access to health care and recovery resources.

There is little legal precedent related to climate justice at the time of publication, but environmental justice has been woven into numerous regulatory schemes and legal proceedings, stemming from the Clinton Executive Order. For example, environmental justice must be formally considered during regulatory impact analyses or within any activities conducted under the National Environmental Policy Act (NEPA).

Multiple court cases have invoked or been illustrative of issues related to environmental justice. With the case of *Bean v. Southwestern Waste Management Corp.* (1979), residents in an East Houston community claimed that the city's decision to place a "sanitary dump" in their neighborhood was racially motivated and a violation of their civil rights.[4] At the time of the hearing, over 80% of Houston's landfills and incinerators were in predominantly Black neighborhoods, despite Black residents representing just 25% of the total Houston

[4] Bean v. Southwestern Waste Mgmt. Corp., 482 F. Supp. 673 (S.D. Tex. 1979).

population.[5] While the court ultimately did not rule in favor of the plaintiffs and the dump was built, *Bean* still represented a critical moment for environmental justice in which marginalized communities could utilize the courts to seek justice for the historical, ongoing, and proposed discriminatory practices and policies relevant to environmental justice.[6]

In another case in Virginia, environmental justice served as the legal reasoning for the courts' denial of multiple permits for the construction of compressor stations. Both the U.S. Court of Appeals for the Fourth Circuit in 2020,[7] and the Virginia State Air Pollution Control Board in 2021,[8] voted to deny compressor station permits to extend pipelines in the predominantly Black community of Union Hill, Virginia. In both cases, the rulings held that sufficient environmental justice evaluations were not conducted by the pipeline developers and that the building of the compressor stations would result in environmental harms and injustices for the Union Hill community.
The case of *Juliana v. United States,* one of few climate justice cases with a judicial decision, involved a group of youths suing the federal government because they believe it had violated their

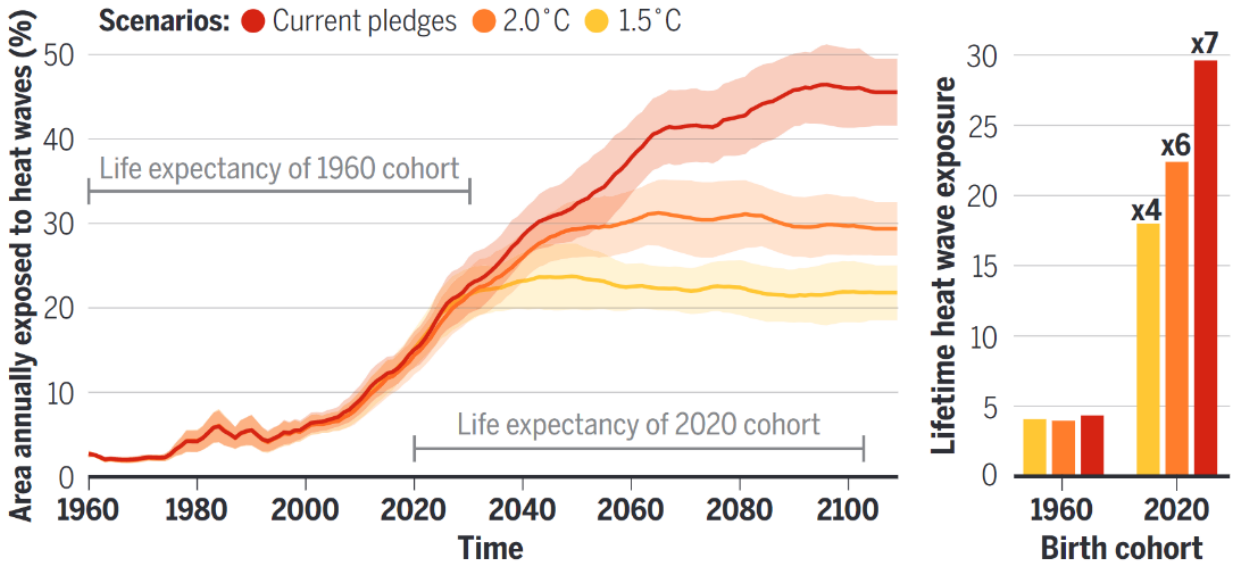

Figure 3. Exposure to climate extremes will differ drastically among generations, as shown in this example of heat wave exposure for people born in 1960 compared to people born in 2020 under three different climate scenarios. Adapted from Wim Thiery et al., *Intergenerational Inequities in Exposure to Climate Extremes*, 374 SCI. 158, 159 (2021).

constitutional right to life, liberty, and property by promulgating policies that have allowed harmful levels of carbon dioxide to be released into the atmosphere and ultimately exacerbate the climate crisis. While this was not strictly framed as an environmental justice case, intergenerational justice was central given the argument that people who are currently children will be disproportionately

[5] Robert D. Bullard, *Environmental Justice for All*, NATURE TRANSFORMED, NAT'L HUMANITIES CTR. (last updated May 2008), http://nationalhumanitiescenter.org/tserve/nattrans/ntuseland/essays/envjust.htm.
[6] *What Is Environmental Justice?*, Chapter 2, *in* U.S. COMM'N ON CIVIL RIGHTS, NOT IN MY BACKYARD: EXECUTIVE ORDER 12,898 AND TITLE VI AS TOOLS FOR ACHIEVING ENVIRONMENTAL JUSTICE (2003), https://www.usccr.gov/files/pubs/envjust/ch2.htm.
[7] Friends of Buckingham v. State Air Pollution Control Board, 947 F.3d 68, 86 (4th Cir. 2020).
[8] State Air Pollution Control Board Decision Minor New Source Review Permit for Mountain Valley Pipeline, LLC Lambert Compressor Station (MVP), Registration No. 21652 (Dec. 3, 2021), https://www.deq.virginia.gov/home/showpublisheddocument/12757/637741469779416054.

impacted by climate change in future decades, despite having had no involvement in the proliferation of fossil fuel use (Figure 3). The case was ultimately dismissed in early 2020 by a 2-1 decision in the U.S. Court of Appeals for the Ninth Circuit with the majority asserting that the plaintiffs didn't have legal standing and the climate policies the plaintiffs were seeking as retribution must come from the legislative, not judicial, branch.[9] Several similar cases, filed by youth plaintiffs against state governments, are currently pending in state courts. More information about them can be found in the Overview of Climate Litigation and Fundamental Rights modules.

Until very recently, there had been no substantial federal legislation in the United States aimed at mitigating the climate crisis. That changed, however, when President Joe Biden signed the Inflation Reduction Act (IRA) into law on August 16, 2022. This bill will invest $369 billion toward climate solutions and environmental justice, with the goal of reducing emissions by 40% by 2030 and advancing the president's Justice40 Initiative, which requires that 40% of climate and clean energy benefits be delivered to disadvantaged communities. Specifically, the IRA allocates $3 billion toward block grants that will fund community-led projects to better understand disadvantaged communities' exposures to air pollution and to develop adaptation plans accordingly. Similarly, $315.5 million will be utilized for air pollution and water quality monitoring in environmental justice communities, with schools and fenceline communities (i.e., neighborhoods near known polluting sites) receiving specific funds. Another $9 billion will go toward home energy rebate programs for low-income families to electrify their homes, with individual tax credits up to 30% for installing residential solar panels to help transition reliance toward clean energy. Estimates find that the IRA provides $40 billion of direct benefits for environmental justice communities.

However, the IRA also includes provisions that may ultimately result in more negative health impacts for these communities, such as tax credits for carbon capture and sequestration, which can extend the life of coal plants. It is also unclear how these funds will be distributed to communities. If the money is routed through individual states, there are concerns of gatekeeping and equity, especially in states that have documented hostile or discriminatory legislative action toward environmental justice communities. Nonetheless, the historical significance of the IRA for environmental justice communities should not be understated. Collectively, these provisions of the IRA advance environmental justice in the United States by funding initiatives aimed at minimizing disadvantaged communities' environmental health exposures and reducing the barriers for individual families to adapt to the climate crisis.

Overcoming the disproportionate harms caused by climate change requires formal examination of structural and social determinants of health (e.g., residential segregation and differential attributes of the built environment) that confer vulnerabilities to multiple climate-related exposures, as well as factors that may be specific to individual stressors (e.g., disparities in asthma prevalence, which lead to differential effects from wildfires). Similarly, differential ability to recover from extreme climate events can also depend on the social and economic resources available to affected communities (e.g., access to capital for rebuilding or repairing structures following a flood). Finally, identifying disproportionate impacts of climate exposures requires a comprehensive assessment of intersectionality, understanding that multiple factors may contribute to an individual's or community's vulnerability and susceptibility (Figure 4). In the following sections, we describe the disproportionate health burdens and other impacts specific to individual climate stressors given the

[9] Juliana v. United States, 947 F.3d 1159 (9th Cir. 2020).

nature of the exposures and associated health outcomes, as well as attributes of communities that are consistently vulnerable across many climate stressors.

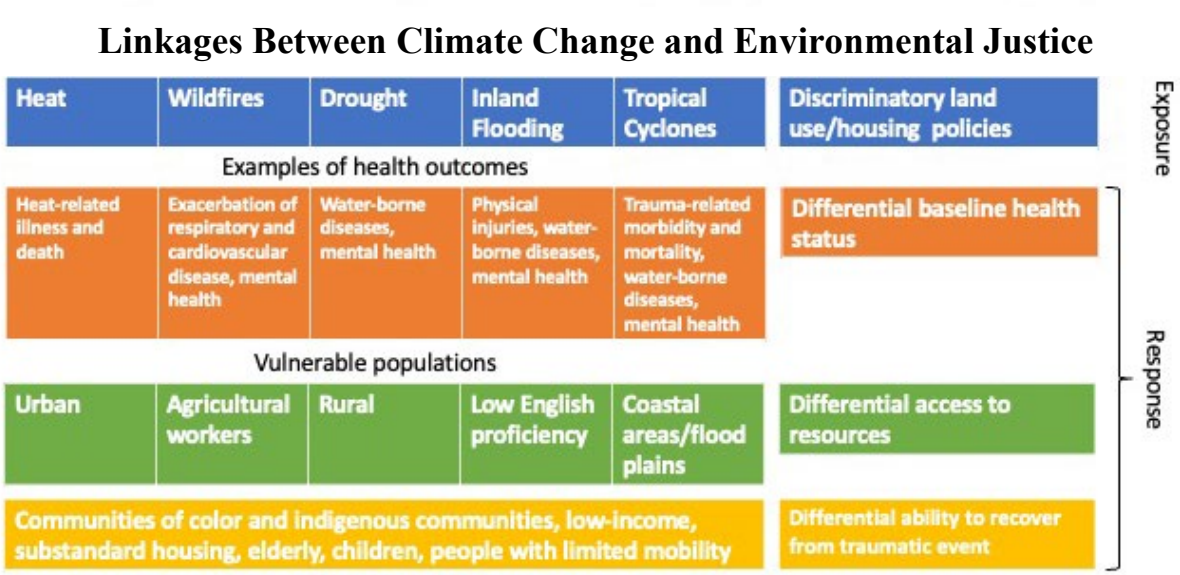

Figure 4. An overview of climate hazards, health outcomes, and links to environmental justice. Adapted from Andy Haines & Kristie Ebi, *The Imperative for Climate Action to Protect Health*, 380 NEJM 263 (2019).

III. Heat

A. History and Background

Heat waves represent some of the most dangerous extreme weather events from a health perspective. Studies estimate that over 5,000 deaths are attributable to extreme heat exposure each year in the United States alone.[10] Historically, some of the most well-known heat waves have occurred in temperate mid-latitude regions of the world, where people are infrequently exposed to extreme heat. Extreme heat is not experienced equally and varies based on the infrastructure and preparation measures in place to handle heat safely, in addition to individual susceptibility and social factors that increase vulnerability to the adverse health effects of heat exposure.

The Chicago heat wave of 1995 provides a clear example as one of the deadliest heatwaves in the United States, killing over 739 individuals as a result of unbearable heat and humidity and lack of extreme heat preparedness. This heatwave, among many others like it, disproportionately affected elderly and low-income residents who live alone and do not own or are unable to use air conditioning (A/C). Similarly, the 2003 European heatwave exhibited record temperatures well

[10] Kate R. Weinberger et al., *Estimating the Number of Excess Deaths Attributable to Heat in 297 United States Counties*, 4 ENV'T EPIDEMIOLOGY 1 (2020), https://doi.org/10.1097%2FEE9.0000000000000096.

above the seasonal average and killed over 52,000 people, many of whom were elderly and/or lacked A/C.[11]

Until recently, heat waves were rarely linked to climate change, but with rapidly increasing global temperatures, it is evident that heat waves are increasing in both frequency and intensity. (For more on the relationship between climate science and heatwaves, see the Drawing the Causal Chain module.) Heat is particularly dangerous for health when coupled with high humidity, which increases the moisture in contact with the skin, making it more difficult for the body to cool itself. Rising temperatures associated with climate change increase the amount of water vapor that the air can hold (there is a roughly 7% increase in water vapor for every 1˚C of warming), making the air more humid and more harmful to human health. Similarly, rising nightly minimum temperatures allow for a compounding effect of hot temperatures, providing people with little or no relief from the heat.

The health effects of heat are challenging to comprehensively quantify because extreme heat can exacerbate preexisting health conditions triggering deaths that are infrequently recorded as heat-related. The incomplete understanding of the health effects of extreme heat may also result from the lack of a uniform definition of heat waves, leading to a potentially vast underestimation of the health burden of heat depending on which heat wave definition is ultimately chosen.

B. Urban Heat Island Effect

People living in urban centers are exposed to higher extreme temperatures compared to residents of rural areas because of the heat island effect, wherein greater impervious surface area and darker (less reflective) surfaces, in addition to less vegetation, leads to greater heat retention. However, this heat island phenomenon goes beyond an urban/rural comparison, with temperature gradients found within cities as a function of attributes of the built and natural environment (e.g., amount of green space).[12] Environmental injustice in urban heat island exposures stems from historical and contemporary structural racism, including redlining. Studies have shown that redlined

[11] Anne Fouillet et al., *Excess Mortality Related to the August 2003 Heat Wave in France*, 80 INT'L ARCHIVES OCCUPATIONAL & ENV'T HEALTH 16 (2006), https://doi.org/10.1007%2Fs00420-006-0089-4.
[12] Sharon L. Harlan et al., *In the Shade of Affluence: The Inequitable Distribution of the Urban Heat Island*, *in* EQUITY AND THE ENVIRONMENT (Robert C. Wilkinson & William R. Freudenberg eds., 2007), https://doi.org/10.1016/S0196-1152(07)15005-5.

neighborhoods have lesser tree canopies[13] and reduced green space,[14] with corresponding higher temperatures during heat waves and higher chronic exposure to heat in general (Figure 5).

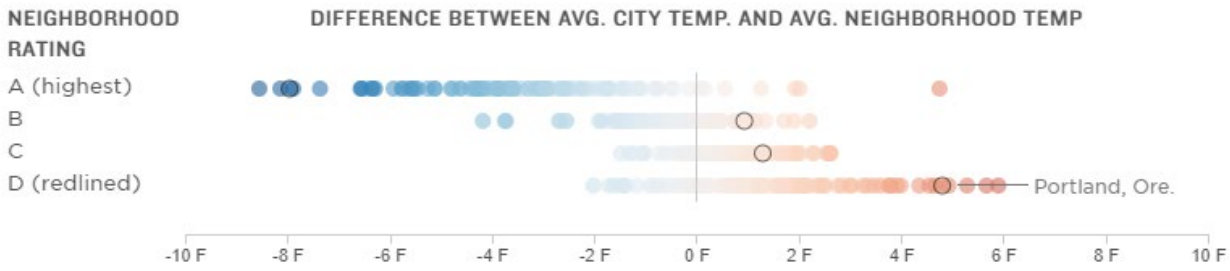

Figure 5. A study of 108 U.S. cities found that formerly redlined neighborhoods tend to experience hotter average temperatures than the city average, with the most drastic disparities found in Portland, OR. Adapted from Meg Anderson, *Racist Housing Practices From the 1930s Linked to Hotter Neighborhoods Today*, NPR (Jan. 14, 2020), https://www.npr.org/2020/01/14/795961381/racist-housing-practices-from-the-1930s-linked-to-hotter-neighborhoods-today.

C. Heat Action Plans

Initial efforts to mitigate the impacts of extreme heat events have focused on the development of city-specific heat action plans (HAPs) in many communities in both the United States and globally. HAPs are critical components of public health infrastructure, especially in locations where climate change will continue to increase the frequency of extreme heat waves and will only be successful in reducing the health burdens of extreme heat events if they are able to protect those most vulnerable. For example, one component of HAPs is heat warning systems that convey information on predicted periods of extreme heat to the public and local officials. These forecasts of extreme heat can inform local emergency responses including messaging, outreach to vulnerable groups, the opening of cooling centers, distribution of water, or other adaptive strategies, all of which must be tailored to the communities in greatest need of support.

[13] Leah H. Schinasi et al., *Associations Between Historical Redlining and Present-Day Heat Vulnerability Housing and Land Cover Characteristics in Philadelphia, PA*, 99 J. URBAN HEALTH 134 (2022), https://doi.org/10.1007/s11524-021-00602-6.
[14] Anthony Nardone, *Redlines and Greenspace: The Relationship Between Historical Redlining and 2010 Greenspace Across the United States*, 129 ENV'T HEALTH PERSP. 1 (2021), https://doi.org/10.1289/EHP7495.

Opening cooling centers on days of extreme heat has an implicit emphasis on environmental justice, as communities who lack A/C or cannot afford to run it are disproportionately lower-income communities, often living in urban heat islands or other settings without adequate cooling capacity. In the United States, cooling centers, designated by city/town or county officials, make use of existing publicly accessible locations with A/C (e.g., community centers, libraries, senior centers, churches, synagogues, mosques, police stations, and schools). A critical feature from an environmental justice perspective is to ensure that the cooling centers are accessible (e.g., free to enter, reachable on public transportation) and that they provide the necessary infrastructure to make it viable for people to stay for long periods of time. This could include medical services, food and water, and forms of entertainment, and can also provide the opportunity to distribute fans and drinking water for when people return home. While cooling centers are an important intervention, there are some notable limitations including lack of awareness of available cooling centers, lack of adequate public transportation to these locations, or inability to spend sufficient time at a cooling center to reduce heat-related health risk. In addition, displacing people from their homes for an extended period of time contributes to another form of environmental injustice.

Box 2: Case Study—Maricopa County Heat Relief Network

To go beyond cooling centers and support people who cannot viably spend the day in a cooling center, communities that are facing heat wave periods may choose to provide air conditioning subsidies for low-income residents, make drinking water accessible to the general public in high traffic areas, or identify green spaces rather than air-conditioned buildings as cooling centers. The Maricopa County Heat Relief Network (MCHRN), encompassing the city of Phoenix, AZ, presents a relevant case study of a heat relief network that expands activities beyond cooling centers to provide drinking water at designated hydration stations, as well as donation sites for drinking water drop-offs during times of extreme heat. A 2016 study found that the MCHRN offered various services for at least 1,500 individuals daily. Many visitors to the facilities provided by the MCHRN were unemployed and/or experiencing homelessness, indicating that the cooling centers provided a valuable service to some of the region's most vulnerable communities. Vjollca Berisha et al., *Assessing Adaptation Strategies for Extreme Heat: A Public Health Evaluation of Cooling Centers in Maricopa County, Arizona*, 9 WEATHER, CLIMATE, & SOC'Y 71 (2017).

IV. Wildfires

A. History and Background

The increasing threat of wildfire in the United States is due to a century of wildfire suppression, climate change, and expanding residential development in the wildland-urban interface (WUI), generally defined as the zone where homes and wildland vegetation meet or intermingle. For centuries prior to colonization, Indigenous peoples used fire management practices, termed "cultural burning," as a tool to maintain the health of their ecosystems while minimizing the threat of catastrophic wildfire. Upon European colonization, Indigenous land use practices decreased dramatically, with the aggressive implementation of fire suppression practices from the early 1900s to the 1980s. While current land management practices utilize prescribed burns and even incorporate some, albeit limited, partnerships with Tribal Organizations, ecosystems and affected communities are still suffering the consequences of almost a century of biomass accumulation.

B. Incidence

In the last four decades, the area burned by wildfire in the United States has roughly quadrupled.[15] Since 2000, wildfires have burned an average of 7 million acres every year, which is more than double the annual average of acreage burned in the previous decade.[16] The number of houses in the WUI increases by 350,000 every year, with a total of 50 million houses currently at heightened risk of wildfire damage.[17] While higher-income households have historically been overrepresented among the homes at higher risk of wildfire exposure due to high property values in WUI areas,[18] these patterns will likely change over time as the geographic domain affected by wildfires increases. In addition, there are pronounced environmental justice dimensions related to who has the capacity to evacuate quickly in the event of a wildfire, who has the resources to endure displacement or property damage, as well as who would be at higher risk of exposure to air pollution from wildfires and most vulnerable to the associated health effects.

One study of wildfires found that perceived cost, lack of time, and physical ability were key barriers to taking steps to reduce wildfire risk around one's home.[19] In the state of Washington, poor households at risk to wildfire were more likely to be in fire districts with less suppression capability than wealthier communities. While understudied, racial and ethnic disparities in wildfire vulnerability also exist. In another study assessing wildfire potential and adaptive capacity, a much higher proportion of Native Americans live in the most vulnerable regions (A, B, D), while white people live in the least vulnerable regions (C) (Figure 6).[20]

A positive feedback loop between wildfires and climate change exists. Climate change results in more frequent and longer droughts creating conditions with less moisture and more dried vegetation to fuel wildfires. When wildfires occur, emissions contribute to the greenhouse effect, worsening climate change.

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[15] Marshall Burke, *The Changing Risk and Burden of Wildfire in the United States*, 118 PNAS 1 (2021), https://doi.org/10.1073/pnas.2011048118.
[16] CONG. RSCH. SERV., IF10244, WILDFIRE STATISTICS (Dec. 2, 2022).
[17] Burke, *The Changing Risk*, *supra* note 15.
[18] Alyssa S. Thomas et al., *A Burning Issue: Reviewing the Socio-Demographic and Environmental Justice Aspects of the Wildfire Literature*, 17 PLOS ONE 1 (2022), https://doi.org/10.1371/journal.pone.0271019.
[19] James David Absher & Jerry J. Vaske, *Modelling Public Support for Wildland Fire Policy*, *in* SUSTAINABLE FORESTRY: FROM MONITORING AND MODELLING TO KNOWLEDGE MANAGEMENT AND POLICY SCIENCE 159 (K.M. Reynolds et al., eds., 2007).
[20] Ian P. Davies et al., *The Unequal Vulnerability of Communities of Color to Wildfire*, 13 PLOS ONE 1 (2018), https://doi.org/10.1371/journal.pone.0205825.

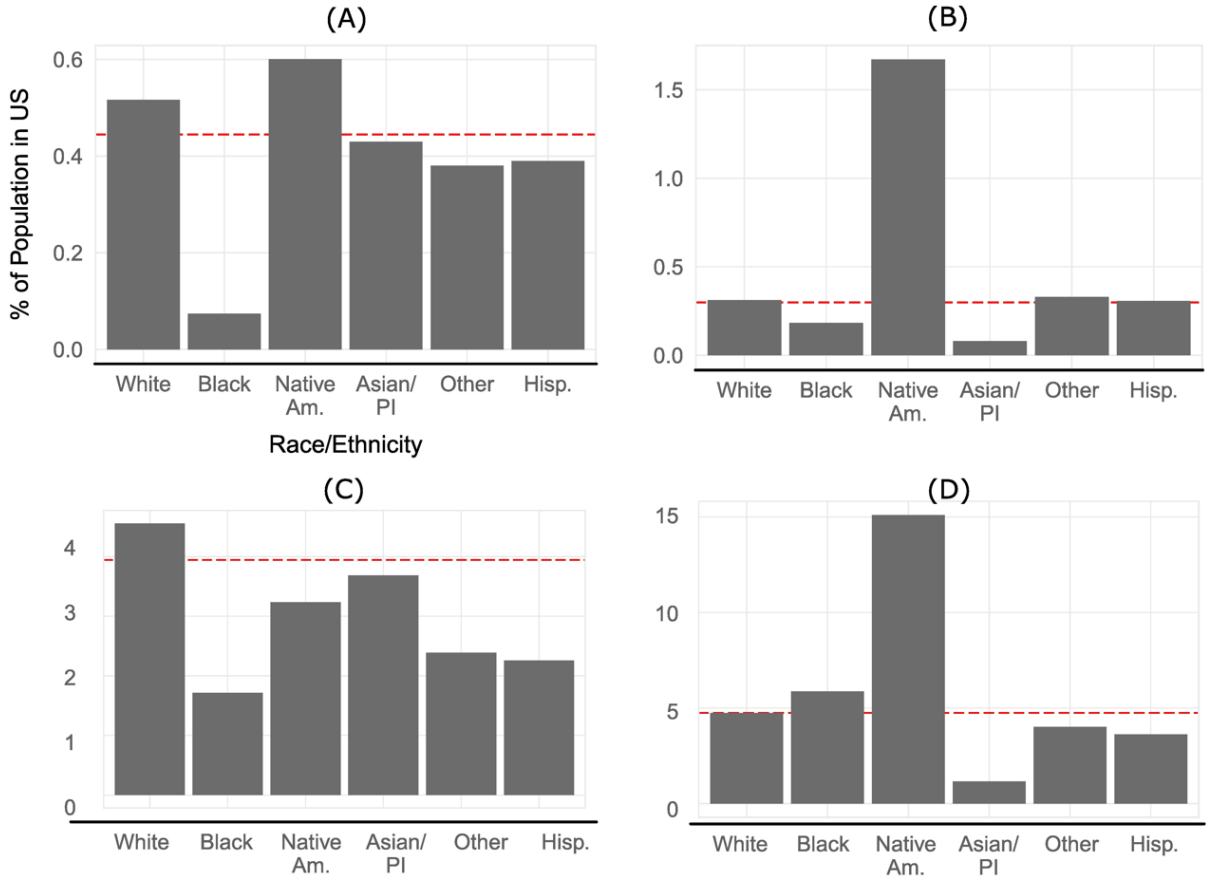

Figure 6. Race/Ethnicity in different vulnerability scenarios, (A) high fire potential—low adaptive capacity, (B) high fire potential—high adaptive capacity, (C) moderate fire potential—low adaptive capacity, (D) moderate fire potential—high adaptive capacity. The dotted red line represents the expected share of equally distributed population. Source: Ian P. Davies et al., *The Unequal Vulnerability of Communities of Color to Wildfire*, 13 PLOS ONE 1, 10 (2018).

C. Health Implications

Apart from the most severe physical effects of burns suffered by those that have direct contact with fire, exposure to fine particulate matter (i.e., $PM_{2.5}$) from wildfire smoke can have both acute and chronic impacts. Individuals may experience coughing, wheezing, difficulty breathing, bronchitis, asthma exacerbation, reduced lung function, heart attack, stroke, and even premature death from short-term exposure to wildfire smoke.[21]

[21] *Health Effects Attributed to Wildfire Smoke*, U.S. ENV'T PROT. AGENCY (last updated Nov. 7, 2022), https://www.epa.gov/wildfire-smoke-course/health-effects-attributed-wildfire-smoke.

Box 3: Case Study—Migrant Farm Workers in California

Migrant farmworkers in California's Central Valley are among the most vulnerable to both the direct and indirect impacts of wildfires. Already being in one of America's most dangerous jobs, with nearly 12,000 documented injuries in agricultural production that resulted in missed work in 2020, the occupational health risks faced by this group will undoubtedly rise as anthropogenic climate change continues to increase the frequency and intensity of wildfires in the western United States. Inhalation of PM2.5 from wildfire smoke and exposure to extreme heat are of particular concern.

A recent study examining the health burdens among agricultural workers in Washington State found that (1) the greatest $PM_{2.5}$ exposures occurred during summer when wildfires were burning and (2) counties with the largest populations of farmworkers also had the greatest concurrent exposures of high heat and $PM_{2.5}$.[22] While this study was conducted in Washington, similar, if not amplified, effects would likely be found in California. Further, since farmworkers are considered "essential," some California counties exempt these workers from mandatory evacuations during wildfires and other natural disasters.[23]

As these workers tend to have little financial cushion and are typically paid based on the quantity of product they harvest, most will continue to work despite present health and safety threats. A recent report found that this "ag pass" puts workers at risk in multiple ways during wildfires: lack of hazard training for employers or workers, improper documenting of workers onsite, and lack of emergency plans, insurance, and exposure monitoring.[24]

In efforts to protect the health and rights of these workers, advocates are calling for unemployment insurance for migrant workers, many of whom may be undocumented, so they do not feel compelled—even coerced—to work when conditions are too dangerous, especially during times of wildfires.[25]

Wildfire smoke can affect a broad geographic region, and there are at least two important environmental justice dimensions associated with wildfire-related $PM_{2.5}$. The first relates to personal exposure, where individuals living in homes with good air filtration systems (positively correlated with socioeconomic status) will have lower exposures, and individuals who work outdoors in industries such as agriculture or construction will have higher exposures.[26] The second relates to underlying health status, where individuals with diseases such as asthma or cardiovascular disease, which disparately impact various socioeconomic and demographic groups, will be at increased risk of the health effects listed above.[27] Individuals with preexisting respiratory diseases, such as asthma or COPD, and mental health

[22] Elena Austin et al., *Combined Burden of Heat and Particular Matter Air Quality in WA Agriculture*, 26 J. AGROMEDICINE 18 (2021).
[23] Sarah Sax, *Farm Workers Exposed to Climate Change Effects Are Demanding Protections*, NEXUS MEDIA NEWS (May 2, 2022), https://nexusmedianews.com/farm-workers-climate-change-right/.
[24] Michael Méndez & Carlo Chunga Pizarro, *Addressing Disparities in Sonoma County's Agriculture Pass Program*, UNIV. OF CAL. IRVINE (May 18, 2022).
[25] Liza Gross, *Fires Fuel New Risks To California Farmworkers*, INSIDE CLIMATE NEWS (Sept. 21, 2021), https://insideclimatenews.org/news/21092021/wildfires-california-farmworkers-smoke-health/.
[26] Savannah M. D'Evelyn et al., *Wildfire, Smoke Exposure, Human Health, and Environmental Justice Need to Be Integrated Into Forest Restoration and Management*, 9 CURRENT ENV'T HEALTH REP. 366 (2022), https://doi.org/10.1007/s40572-022-00355-7.
[27] Colleen E. Reid et al., *Critical Review of Health Impacts of Wildfire Smoke Exposure*, 124 ENV'T HEALTH PERSP. 1334 (2016), https://doi.org/10.1289/ehp.1409277.

conditions, are particularly susceptible to adverse health impacts of wildfire exposure.

In addition to physical health effects, individuals may suffer profound mental health impacts following wildfire exposure. Individuals impacted by wildfires, whether by proximity, evacuation, or property loss, are at an elevated risk for developing anxiety, post-traumatic stress disorder (PTSD), depression, and substance use disorder.[28]

V. Drought

A. History and Background

The United States has a long history of extreme droughts, which are defined as deficiency of water availability over an extended period of time. Droughts have historically been linked to persistent high atmospheric pressure contributing to periods of below-average rainfall. However, droughts can also be caused by environmental degradation and human-caused climate change. High temperatures increase rates of evaporation from soils and plant respiration, further exacerbating droughts by releasing soil moisture into the atmosphere. Additionally, the prevalence of extreme rainfall has increased, leading to more water runoff in drought-stricken areas, followed by erosion and eventual decreased capacity to absorb water. In other words, climate change is expected to increase both drought in agriculturally important regions of the world and extreme rainfall. The Dust Bowl remains the most significant drought in U.S. history, caused by high temperatures and poor agricultural practices. The Dust Bowl resulted in extreme environmental degradation, economic loss, and long-lasting health burdens among the rural poor of the Great Plains.

B. Incidence

In recent decades, the United States has experienced more extensive and more persistent droughts. The western and southeastern regions of the United States have especially experienced recurring droughts. Water shortages in the Colorado River and the Apalachicola-Chattahoochee-Flint River basins have led to interstate water supply negotiations, threatened electricity-generating capacity, produced agricultural water shortages, and put aquatic wildlife at risk.[29] The southwestern region of the United States is generally more susceptible to droughts and has experienced a decrease in precipitation over the last several decades. Under future climate change scenarios, models suggest that even in a low-emissions future, the number of drought months experienced over the next 30 years will likely increase significantly in much of the southwestern United States; under higher emissions scenarios, almost every river sub-basin in the contiguous United States has a projected increase in drought frequency.[30]

Under severe water shortage conditions, water uses have to be prioritized and resources distributed accordingly. The extreme 2014-2016 drought in California provides a recent example of how such

[28] Patricia To et al., *The Impact of Wildfires on Mental Health: A Scoping Review*, 11 BEHAV. SCI. 1 (2021).
[29] Kenneth Strzepek et al., *Characterizing Changes in Drought Risk for the United States From Climate Change*, 5 ENV'T RSCH. LETTERS 1 (2010).
[30] *Id.*

choices on water distribution can affect vulnerable communities. The Tuolumne River watershed provides water for agricultural users in Central Valley, urban users in the San Francisco Bay Area, and downstream aquatic habitats that support salmon migration. During this period of severe drought, the urban users in the economically affluent region of San Francisco experienced no reduction in water resources, while the water available for agricultural and urban users in the Central Valley was decreased by 30%.[33] Loss of agricultural work during this same period of drought in the Central Valley primarily impacted low-income migrant farmworkers,[34] furthering the disparate impacts of severe drought on vulnerable communities.

Box 4: Case Study: Indigenous Communities in the Southwestern United States

The Southwestern United States is home to 170 federally recognized Native American Tribes.

Livelihoods range from ranching and agriculture to mining, tourism, and other industries. Many tribal lands in the Southwest have experienced drought in recent years, leading to disruptions in tourism, ranching, and forestry among the Hualapai Tribe in Arizona; loss of infrastructure and land due to extension and migration of sand dunes on Navajo and Hopi lands in Arizona; and increased distance and cost of hauling water for homes on Navajo Nation.[31]

Droughts are expected to become more common and severe in the Southwest under future climate scenarios, further threatening economic activities, water resources, subsistence use, and cultural connection to the land among Indigenous communities.[32]

C. Health, Livelihood, and Well-Being

The human impacts of drought are numerous and range from diminished water and electricity supply to worsened public health. Notably, droughts contribute to a number of secondary environmental and health impacts including wildfire, crop failure, drinking water shortages, and severe flash flooding. Droughts contributed to significant economic setbacks and are among the most expensive extreme weather events. In 2020, two U.S. droughts resulted in $14.4 billion in damages. Drought can contribute to food insecurity, loss of crops, reduce electrical production from hydroelectric dams and power plants, reduce access to clean water, and increase prevalence of water-borne diseases.

[31] Karen Cozzetto et al., *Climate Change Impacts on the Water Resources of American Indians and Alaska Natives in the U.S.*, *in* CLIMATE CHANGE AND INDIGENOUS PEOPLES IN THE UNITED STATES 61 (Julie Koppel Maldonado et al., eds., 2013).
[32] Patrick Gonzales et al., *Southwest*, Chapter 25, *in* U.S. GLOBAL CHANGE RSCH. PROGRAM, FOURTH NATIONAL CLIMATE ASSESSMENT VOL II: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES (2018), https://nca2018.globalchange.gov/.
[33] Iris T. Stewart et al., *Water Security Under Severe Drought and Climate Change: Disparate Impacts of the Recent Severe Drought on Environmental Flows and Water Supplies in Central California*, 6 J. HYDROLOGY 1 (2020).
[34] RICHARD HOWITT ET AL., ECONOMIC ANALYSIS OF THE 2014 DROUGHT FOR CALIFORNIA AGRICULTURE (2014).

Further, dry conditions can contribute to dust storms, which can carry heavy metals, bacteria, fungi, viruses, pollen, and other toxic pollutants. For example, record low water levels in the Great Salt Lake has exposed surrounding communities to dust plumes containing toxins like mercury and

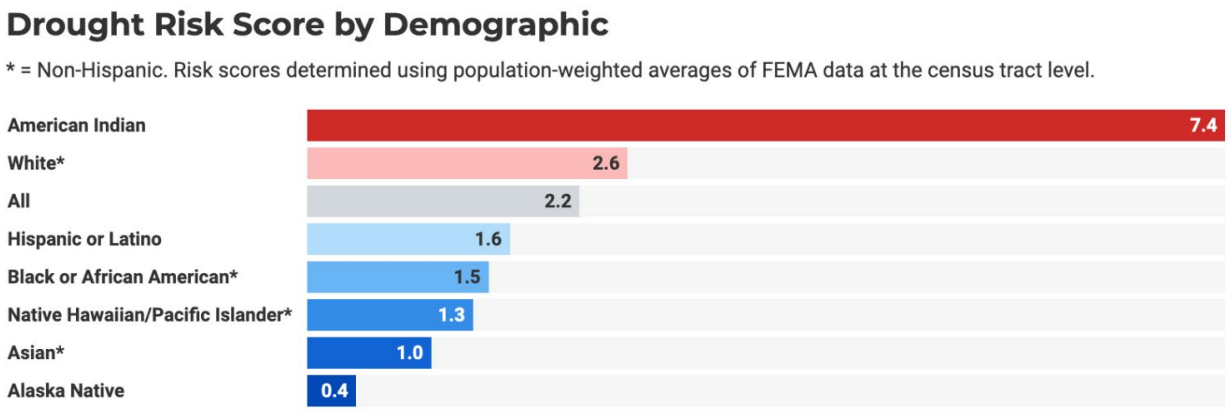

Figure 7. Drought risk score demographic calculated using population-weighted averages of Federal Emergency Management Agency (FEMA) data. American Indians' risk of experiencing drought is many times greater than that of any other demographic group in the United States. Source: Steven Ross Johnson, *The Demographics of Disaster*, U.S. NEWS & WORLD REP. (June 22, 2022), https://www.usnews.com/news/health-news/articles/2022-06-22/disaster-disparities-natural-hazards-climate-change-threaten-underserved-communities.

arsenic. Drought conditions in urban areas also allow for the pooling of stagnant water, increasing the quantity of breeding sites for certain mosquito species such as those that transmit West Nile virus.[35] Additionally, the lack of precipitation associated with drought can cause pathogen concentrations to build up in drinking water sources, facilitating the spread of water-borne infections.[36]

VI. Inland Flooding

A. History and Background

Inland flooding—caused by heavy rain in river catchments, melting snow or ice, or structural failure of water infrastructure—often receives less attention in the media than hurricanes or tropical cyclone-related flooding. However, inland flooding is more common in the United States than hurricanes and is also linked to climate change as increasing global temperatures allow the air to hold more moisture, leading to more intense rainfall. Annual precipitation increased approximately 4% in the United States from 1901 to 2015, particularly affecting the Great Plains, Midwest, and Northeast.[37] Rainfall events have increased in both their intensity and frequency in impacted regions,

[35] Lisa Brown et al., *Impact of Drought on Vector-Borne Diseases—How Does One Manage the Risk?*, 128 PUB. HEALTH 29 (2014), https://doi.org/10.1016/j.puhe.2013.09.006.
[36] Karen Levy et al., *Climate Change Impacts on Waterborne Diseases: Moving Toward Designing Interventions*, 5 CURRENT ENV'T HEALTH REP. 272 (2018), https://doi.org/10.1007/s40572-018-0199-7.
[37] David R. Easterling et al., *Precipitation Change in the United States*, Chapter 7, *in* U.S. GLOBAL CHANGE RES. PROG., CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT, VOL. 1 (2017), https://science2017.globalchange.gov/chapter/7/.

contributing to inland flooding. Aging and often deteriorating infrastructure is more likely to fail under the pressure of increased precipitation, compounding the impacts of heavy rainfall events.[38] These increases in precipitation are projected to continue overall.[39] Floods can impact communities in many forms, including large floods across whole watersheds, localized flash floods, and overwhelmed urban stormwater systems. Direct effects of floods include exposure to floodwaters and debris, and indirect effects include damage that occurs to the natural and built environments.[40]

B. Incidence

Inland flood events are occurring more frequently and resulting damages have increased in the United States since the middle of the 20th century.[41] Further, nationwide modeling of 100-year floods, or floods previously predicted to occur once every one hundred years in a world without human-caused climate changes, indicates that the number of flood events will continue to increase over the 21st century with billions of dollars of additional losses, concentrated especially in the Southeast and Northeast.[42] Increased frequency of flood events corresponds to patterns of increased frequency of heavy rainfall days, but rainfall is not the only factor contributing to the escalating impact that floods have on communities. Impervious surfaces in urban areas that reduce natural resilience to flooding, development in flood plains, and increasing population density in many parts of the country put additional people at risk of exposure when floods do occur,[43] especially in low-lying urban areas.[44] In northern regions of the United States, more frequent flooding may also occur with heavy rainfall events in the spring concurrent with warming temperatures, snowmelt, and rain falling on frozen ground or snow.[45] Aging infrastructure such as dams, levees, and wastewater infrastructure are deteriorating in the face of heavy rainfall, leaving communities more vulnerable to the effects of increasing precipitation.[46]

C. Health Implications

The health impacts from inland flooding range from immediate effects (such as drowning, physical injuries, electrocution, and hypothermia) to medium- and long-term outcomes (such as exposure to contaminated water, poor mental health, and intensified chronic conditions).[47]

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[38] Farshid Vahedifard et al., *Compound Hazards Yield Louisiana Flood*, 353 SCI. 1374 (2016), https://www.science.org/doi/10.1126/science.aai8579.
[39] Easterling et al., *Precipitation*, *supra* note 38.
[40] Vahedifard et al., *Compound Hazards*, *supra* note 39.
[41] U.S. ENV'T PROT. AGENCY, CLIMATE CHANGE AND SOCIAL VULNERABILITY IN THE UNITED STATES, EPA 430-R-21-003 (Sept. 2021), https://www.epa.gov/cira/social-vulnerability-report.
[42] Cameron Wobus et al., *Climate Change Impacts on Flood Risk and Asset Damages Within Mapped 100-Year Floodplains of the Continuous United States*, 17 NAT. HAZARDS EARTH SYS. SCI. 2199 (2017), https://doi.org/10.5194/nhess-17-2199-2017.
[43] Vahedifard et al., *Compound Hazards*, *supra* note 39.
[44] GERALD E. GALLOWAY ET AL., UNIV. OF MARYLAND & TEXAS A&M UNIV., THE GROWING THREAT OF URBAN FLOODING: A NATIONAL CHALLENGE (2018), https://cdr.umd.edu/urban-flooding-report.
[45] Wobus et al., *Climate Change*, *supra* note 43.
[46] David Reidmiller et al., *Report-in-Brief*, U.S. GLOBAL CHANGE RSCH. PROGRAM, FOURTH NATIONAL CLIMATE ASSESSMENT VOL. II: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES (2018), https://nca2018.globalchange.gov/downloads/NCA4_Report-in-Brief.pdf.
[47] Weiwei Du et al., *Health Impacts of Floods*, 25 PREHOSPITAL & DISASTER MED. 265 (2010), https://doi.org/10.1017/S1049023X00008141.

During the 20th century, floods claimed more lives in the United States than any other natural disaster.[48] Between 1980 and 2020, inland flooding was responsible for over 600 deaths in the United States, with most mortality following flash flood events[49] and associated with vehicles.[50] Injuries related to floods include those incurred while evacuating or due to unstable structures during the flood or afterwards while repairing and clearing debris. Electrical injuries, burns from disrupted gas infrastructure, and hypothermia can also occur during a flood. Floodwaters can become contaminated with sewage and industrial chemicals, leading to waterborne disease transmission and exposure to hazardous materials.

Mental health outcomes that result from floods include post-traumatic stress disorder, anxiety, depression, overall psychological distress, and substance abuse. In general, higher levels of exposure to loss, damages, threat, and harm during a flood result in more severe mental health impacts.[51] Floods can cause short- or long-term disruption of health services in a region, especially impacting the health of patients with acute flood-related injuries and those who require access to treatment, medication, and other medical services related to a chronic condition.

Displacement of communities and loss of property, crops, and other assets related to livelihood following floods can also impact overall well-being, especially financial security and mental health. From 1980 to 2020, an average of $3.7 billion of damages resulted each year from inland flooding.[52] While floods occurring in larger urban areas can impact more people due to population size, smaller urban communities can be more severely impacted due to a lack of resources to address extreme rainfall events and because damages may not amount to the level of losses required to receive federal assistance.[53]

[48] Charles A. Perry, U.S. Geological Survey, *Significant Floods in the United States During the 20th Century—USGS Measures a Century of Floods* (Mar. 2000), https://doi.org/10.3133/fs02400.
[49] Du et al., *Health Impacts*, *supra* note 48.
[50] NOAA, NAT'L CTRS. FOR ENV'T INFO., *U.S. Billion-Dollar Weather and Climate Disasters, 1980-Present*, https://doi.org/10.25921/STKW-7W73.
[51] Ana Fernandez et al., *Flooding and Mental Health: A Systematic Mapping Review*, 10 PLOS ONE 1 (2015), https://doi.org/10.1371/journal.pone.0119929.
[52] NOAA, *supra* note 51.
[53] GALLOWAY ET AL., THE GROWING THREAT OF URBAN FLOODING, *supra* note 45.

Box 5: Case Study—2019 Floods

In the spring of 2019, a historic flood impacted large areas of the Midwest. The flood resulted in $10.9 billion in economic loss, affecting 14 million people, the displacement of hundreds of people, loss of millions of acres of farmland and livestock, and damaged infrastructure.[54]

Tribal nations were heavily impacted by the floods. Pine Ridge Reservation in South Dakota is one of the poorest areas of the country with unemployment rates resting at 75%.[55] The reservation has a long history of government distrust and neglect. It is the site of the Wounded Knee Massacre and Keystone Pipeline Protests. Compared to Nebraska and other flood-ridden areas of the Midwest, the reservation was slow to receive assistance from the federal and state government.[56] When assistance came, it paled in comparison to the need. Pine Ridge lacks infrastructure, transportation, emergency services, funding, and power that is needed to respond successfully to a disaster. Many families were only able to be reached by horseback.

Little has been done to improve government trust with the Tribe. Just weeks after the flooding, while the reservation still struggled to access basic needs and federal assistance, the federal government advanced a permit for the same pipeline that tribes in South Dakota had fought against. The pipeline threatened to further increase the environmental injustices faced by the reservation.

VII. Tropical Cyclones

A. History and Background

Tropical cyclones (TCs) are a common natural hazard along the Gulf of Mexico and the Atlantic Coast of the United States. A hurricane is a cyclone that has reached specific windspeeds of at least 74 miles per hour (mph).[57] The degree of damage of TCs varies widely depending on where the cyclone makes landfall and is closely tied to the social vulnerabilities of the impacted areas.

For example, 2017 saw three major hurricanes reach U.S. shores: Harvey in Texas, Irma in Florida, and Maria in Puerto Rico. All were category 4 hurricanes at landfall. Puerto Rico received a fraction of the assistance and is still dealing with the aftermath, while Texas began receiving assistance in advance of the hurricane. Puerto Rico experienced a wider impact due to structural inequities (less and slower federal government assistance), individual vulnerability (high rates of informal housing and poverty), social vulnerability (limited financial resources of the territory), and infrastructural and geographic challenges (outdated power grids, transportation barriers).[58] Climate change is predicted to increase the frequency and intensity of hurricanes in the Atlantic Basin thereby increasing the potential of hurricanes to increase social, health, and economic inequities if efforts are not taken to address the factors that create the fabric for unequal impact of TCs in the first place.[59]

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[54] *The 2019 Floods in the Central U.S.*, LANCET COUNTDOWN (last visited Feb. 3, 2023), https://www.lancetcountdownus.org/2020-case-study-2/.
[55] Michael Sainato, *"We're in Constant Crisis": Cyclone-Hit Reservation Forced to Recover on Its Own*, GUARDIAN (May 10, 2019), https://www.theguardian.com/us-news/2019/may/10/south-dakota-pine-ridge-reservation-cyclone-aid-recovery-on-own.
[56] Mitch Smith, *"A State of Emergency": Native Americans Stranded for Days by Flooding*, N.Y. TIMES (Mar. 24, 2019), https://www.nytimes.com/2019/03/24/us/midwest-flooding-pine-ridge.html.
[57] INSURANCE INFO. INST., *Facts + Statistics: Hurricanes* (last visited Feb. 3, 2023), https://www.iii.org/fact-statistic/facts-statistics-hurricanes.
[58] Charley E. Willison et al., *Quantifying Inequities in US Federal Response to Hurricane Disaster in Texas and Florida Compared With Puerto Rico*, 4 BMJ GLOBAL HEALTH 1 (2019), http://dx.doi.org/10.1136/.
[59] Adam H. Sobel et al., *Human Influence on Tropical Cyclone Intensity*, 353 SCI. 242 (2016), https://doi.org/10.1126/science.aaf6574.

B. Incidence

Since 1878, an average of six to seven TCs have formed every year in the North Atlantic Ocean.[60] However, there has also been a considerable upward trend of North Atlantic hurricane activity since the 1970s.[61] Meteorological data clearly show that the intensity of cyclones has increased considerably in the last 20 years. Since warmer waters directly fuel more powerful tropical storms, climate change will impact the frequency and severity of TCs by increasing sea surface temperatures. Climate models predict that as climate change produces stronger storms (i.e., category 4 and 5 hurricanes), there will be increased concurrent rainfall and resulting flooding.[62] While there is still some disagreement among models about the extent to which cyclones will get stronger in a warmer world, a growing body of evidence indicates that climate change will exacerbate the magnitude of cyclones and their resulting health impacts throughout the southeastern United States.[63]

C. Health Implications

When a coastal community experiences a tropical cyclone, both direct and indirect health impacts ensue, with implications in the short and long term. Depending on the size and intensity of the hurricane, community members may endure substantial physical injury, trauma, or mortality. These direct health impacts are typically exacerbated by the altered or destroyed physical landscape and infrastructure following a hurricane.[64] Access to timely healthcare may

Box 6: Case Study—Hurricane Harvey

Hurricane Harvey was the catalyst for a natural-technological (na-tech) disaster when the hurricane led 42 petrochemical facilities to release toxic chemicals along the Gulf Coast. Na-tech disasters, the most well-known being Fukushima, can lead to mass exposure to toxic materials and long-term health consequences. Over 5.5 million pounds of emissions were reported during and after Hurricane Harvey, many of which are known to cause respiratory issues and cancer. Recent research found that the chemical releases were concentrated in neighborhoods that had more Latinx residents, residents with disabilities, children, and moderate to high levels of poverty. Toxic chemical exposure after Hurricane Harvey impacted already vulnerable communities more than privileged groups highlighting the importance of compound exposures and compound vulnerabilities.

In addition, higher exposure rates in neighborhoods with higher proportions of children may lead to more significant long-term outcomes as children have more severe consequences from toxic chemical exposures. Facilities can schedule shutdowns in advance of storms to reduce the risk of accidental releases. However, without consequences to their action, there is little incentive for facilities to enforce stricter policies and protect the health of vulnerable communities. For more, see Aaron B. Flores et al., *Petrochemical Releases Disproportionately Affected Socially Vulnerable Populations Along the Texas Gulf Coast After Hurricane Harvey*, 42 POPULATION & ENV'T 279 (2021), https://doi.org/10.1007/s11111-020-00362-6.

[60] U.S. ENV'T PROT. AGENCY, *Climate Change Indicators: Tropical Cyclone Activity* (last updated Aug. 1, 2022), https://www.epa.gov/climate-indicators/climate-change-indicators-tropical-cyclone-activity.
[61] James P. Kossin et al., *Extreme Storms*, Chapter 9, *in* U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP), CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT VOL. I (2017), http://doi.org/10.7930/J07S7KXX.
[62] Kevin J.E. Walsh et al., *Tropical Cyclones and Climate Change*, 7 WIRES CLIMATE CHANGE 65 (2016), https://doi.org/10.1002/wcc.371.
[63] Sobel et al., *Human Influence*, *supra* note 60.
[64] Samantha L. Waddell et al., *Perspectives on the Health Effects of Hurricanes: A Review and Challenges*, 18 INT'L J. ENV'T RSCH. & PUB. HEALTH 1 (2021), https://doi.org/10.3390/ijerph18052756.

be severely impeded. Adequate delivery of care and treatment of both acute and chronic illnesses are profoundly reduced in areas ravaged by hurricanes. For instance, three major hospitals that were damaged and surrounded by floodwaters had to close for several months, with devastating and deadly impacts on both in- and out-patient care.[65]

Additionally, the release of toxic and hazardous substances into the environment increases dramatically, particularly in manufacturing settings and regions that experience flooding.[66] The high likelihood of post-hurricane flooding also results in greater contamination of drinking water and increased incidence of waterborne and vector-borne diseases, including Zika virus (Hurricane Maria, PR), viral gastroenteritis (Hurricane Sandy, NY), and fecal coliform bacterial infection (Hurricane Katrina, LA).[67]

Finally, in the aftermath of a tropical cyclone, individuals may suffer various manifestations of mental illness. Reported cases of stress, anxiety, PTSD, and depression are elevated among those who experienced a hurricane, and there is a significant increase in psychiatric emergency department visits.[68] While the most severe mental health symptoms are reported in the few months immediately following the hurricane, data from Hurricane Katrina survivors indicate that some individuals may still suffer from poor mental health, including post-traumatic stress symptoms, more than a decade after the disaster.[69] Unfortunately, these deleterious health effects following a TC are not shared equally throughout affected areas, and preexisting health disparities among vulnerable communities tend to be exacerbated.

D. Inequitable Recovery

Inequities in hurricane response and recovery have been well documented and researched. Challenges with recovery span multiple categories. First, the ability of individuals to recover is influenced by socioeconomic status, housing type, damages and injuries incurred, occupation, and education and literacy rates.[70] People who rent homes face barriers toward accessing federal assistance, filing insurance claims, and receiving temporary housing.[71] Federal assistance for home owners is based on housing appraisal values, which means that low-income home owners, who are

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[65] *Id.*

[66] Perri Zeitz Ruckart et al., *Hazardous Substances Releases Associated With Hurricane Katrina and Rita in Industrial Settings, Louisiana and Texas*, 159 J. HAZARDOUS MATERIALS 53 (2008), https://doi.org/10.1016/j.jhazmat.2007.07.124.

[67] Stephen Y. Liang & Nicole Messenger, *Infectious Diseases After Hydrologic Disasters*, 36 EMERGENCY MED. CLINICS N. AM. 835 (2018), https://doi.org/10.1016/j.emc.2018.07.002.

[68] Fangtao Tony He et al., *Temporal and Spatial Patterns in Utilization of Mental Health Services During and After Hurricane Sandy: Emergency Department and Inpatient Hospitalizations in New York City*, 10 DISASTER MED. & PUB. HEALTH PREPAREDNESS 512 (2016), https://doi.org/10.1017/dmp.2016.89.

[69] Ethan J. Raker et al., *Twelve Years Later: The Long-Term Mental Health Consequences of Hurricane Katrina*, 242 SOC. SCI. & MED. 1 (2019), https://doi.org/10.1016/j.socscimed.2019.112610.

[70] Taylor Gauthier, *The Devastating Effects of Climate Change on US Housing Security*, ASPEN INSTITUTE (Apr. 9, 2021), https://www.aspeninstitute.org/blog-posts/the-devastating-effects-of-climate-change-on-us-housing-security/; Jee Young Lee & Shannon Van Zandt, *Housing Tenure and Social Vulnerability to Disasters: A Review of the Evidence*, 34 J. PLANNING LIT. 156 (2019), https://doi.org/10.1177/0885412218812080; Kimberly Thomas et al., *Explaining Differential Vulnerability to Climate Change: A Social Science Review*, 10 WIRES CLIMATE CHANGE e565 (2019), https://doi.org/10.1002/wcc.565.

[71] Lee & Van Zandt, *supra* note 71.

often people of color, receive less money, often slower, than wealthy home owners.[72] For example, in a demographic breakdown of Hurricane Katrina impacts, African Americans, renters, those in poverty, and those who were unemployed in New Orleans experienced heavier damage and were affected at rates higher than those at regional and national levels (Figure 8).[73] This inequitable distribution was the result of historical redlining practices that in turn impacted individuals' ability quickly and completely to recover from the disaster.

Historical housing policies such as redlining have pushed low-income communities and communities of color into a cycle of being more likely to live in areas of environmental hazards, such as hurricanes and flooding, while being less able to access home and flood insurance and disaster assistance due to the low appraisal value of their homes, further exacerbating inequities.[74]

Displacement is a common outcome of hurricanes as residents are evacuated before and after landfall. The impacts and duration of temporary relocation, however, has been found to vary by income and socioeconomic status. For example, after Hurricane Katrina, low-income, majority Black neighborhoods that were hardest hit by flooding were reopened to residents nine months after the hurricane hit, compared to one month for unflooded neighborhoods.[75] Only half of New Orleans's Black residents had returned to the city four months after the hurricane compared to 71% of non-Black residents.[76] Similar patterns were found for residents with and without a college degree.[77] Lower return rates in low-income communities impact social cohesion of the neighborhoods and break apart social safety nets. These communities in New Orleans experienced worse crime rates, and a reduction in employment opportunities, access to community services, and infrastructure compared to undamaged areas of the city.

[72] Gauthier, *supra* note 71.
[73] REILLY MORSE, HEALTH POLICY INST., ENVIRONMENTAL JUSTICE THROUGH THE EYE OF HURRICANE KATRINA (2008).
[74] Gauthier, *supra* note 71.
[75] Elizabeth Fussell et al., *Race, Socioeconomic Status, and Return Migration to New Orleans After Hurricane Katrina*, 31 POPULATION & ENV'T 20 (2010), https://doi.org/10.1007%2Fs11111-009-0092-2.
[76] *Id.*
[77] *Id.*

Federal response and emergency management also leads to inequities. Certain communities are often left out of disaster planning and adaptation action is not taken to reduce vulnerabilities. For example, infrastructure limitations were well-known among government officials in New Orleans before Hurricane Katrina. The issue was not addressed, and hurricane damage was not avoided. Similarly, neighborhoods in low-lying areas are often not appropriately protected and non-adaptative water management techniques can contribute to increased flood damage.[78] For example, flood walls are commonly built in areas that are at risk of coastal flooding. However, once the walls are breached, flooding is uncontrolled leaving homes more vulnerable to flood damage. This can lead to increased damage costs as the homes are not relocated and are less likely to be covered by insurance.

The Federal Emergency Management Agency (FEMA) is responsible for distributing federal

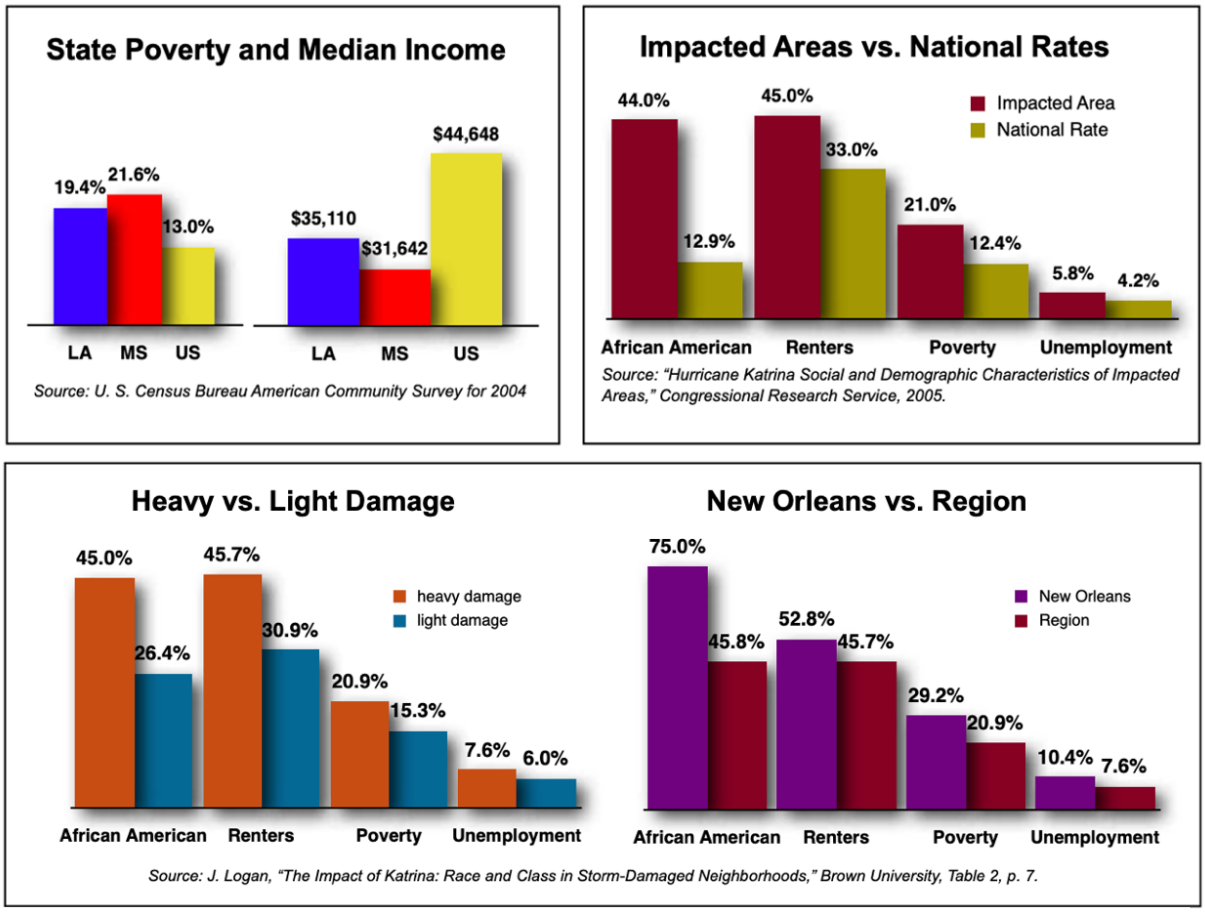

Figure 8. Regional, racial, and sociodemographic breakdown of Hurricane Katrina impacts. Source: REILLY MORSE, HEALTH POLICY INST., ENVIRONMENTAL JUSTICE THROUGH THE EYE OF HURRICANE KATRINA (2008).

assistance to declared disasters. Hurricane Harvey and Irma, both of which impacted the U.S. mainland, received more federal funding, personnel, and equipment quicker, compared to Hurricane Maria in Puerto Rico.[79] The response did not correlate to storm severity or population need, both of which would favor increased assistance to Puerto Rico over Texas and Florida.[80] The federal

[78] Lee & Van Zandt, *supra* note 71.
[79] Willison et al., *supra* note 59.
[80] Willison et al., *supra* note 59.

response between these hurricanes has been heavily critiqued as an example of structural racism and its impacts for increasing health inequities in already marginalized locations.

Similar patterns have been found on media attention to different disasters and fundraising campaigns. For example, individual and corporate donations to relief efforts raised more than $200 million after Harvey and Irma, compared to $8.1 million after Maria.[81]

VIII. Vulnerable and Susceptible Communities

As defined in Box 1 and described above, vulnerability is the increased probability of exposure to a hazard, while susceptibility reflects increased response following exposure to a hazard. Vulnerable and susceptible communities may be at comparatively higher risk of exposure, lack the capacity to cope, recover, and adapt to climate stressors, or both. A primary consideration of climate justice is that many of the communities at highest risk of harm due to climate hazards contribute the least to the carbon emissions responsible for climate change.

A. Low-Income and Substandard Housing

Low-income individuals and those living in low-quality housing are at higher risk for several climate change-related exposures—especially wildfires, floods, hurricanes, and extreme heat—and can lack access to the resources needed to recover following an extreme event. In the case of wildfires, low-income residents are at increased risk to structure fires because they are more likely to live in substandard housing units. A case study of a California community found a relationship between lower income and higher home ignitability, and survey respondents identified cost constraints as the primary barrier to wildfire mitigation efforts.[82] Another study noted that renters have fewer options for takings steps to reduce their home's ignitability because they have limited control over landscaping and the installation of fire-resistant building materials, two important factors that influence fire behavior and structural survival.[83] Communities that live in coastal areas and low-lying floodplains and those in informal housing, both of which are commonly tied to low incomes, are likely to sustain larger impacts from hurricanes. Low-income communities also face increased difficulties evacuating before, during, or after a flood or hurricane thereby increasing their susceptibility to negative impacts.[84]

The burden of extreme heat similarly falls disproportionately on low-income individuals as those with limited access to adaptive measures such as A/C and people experiencing homelessness often have the highest exposure to heat. Low-income communities in urban areas more commonly live in areas with less vegetation and tree cover, leading to temperatures up to 4.0˚C hotter than higher-

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[81] Eric Levenson, *3 Storms, 3 Responses: Comparing Harvey, Irma, and Maria*, CNN (Sept. 27, 2017), https://www.cnn.com/2017/09/26/us/response-harvey-irma-maria/index.html.
[82] Timothy W. Collins, *Households, Forests, and Fire Hazard Vulnerability in the American West: A Case Study of a California Community*, 6 GLOBAL ENV'T CHANGE PART B: ENV'T HAZARDS 23 (2005), https://doi.org/10.1016/j.hazards.2004.12.003.
[83] Matthew S. Carroll et al., *Fire as a Galvanizing and Fragmenting Influence on Communities: The Case of the Rodeo-Chediski Fire*, 18 SOC'Y & NAT. RES. 301 (2005), https://doi.org/10.1080/08941920590915224.
[84] Katharine Hayhoe, *Our Changing Climate*, Chapter 2, *in* U.S. GLOBAL CHANGE RSCH. PROGRAM, FOURTH NATIONAL CLIMATE ASSESSMENT VOL. II: IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES (2018), https://nca2018.globalchange.gov/chapter/2/.

income areas.[85] These communities can also face difficulties in receiving and responding to extreme weather alerts and being included in disaster programming and response.[86]

B. Communities of Color and Indigenous Communities

Communities of color frequently experience disproportionate impacts from extreme weather events beyond vulnerabilities related to income or susceptibility tied to underlying health conditions. Individuals' race has consistently predicted the severity of the hurricane aftermath experienced by survivors. Preexisting social injustices are exacerbated when a storm occurs, as evidenced in racial disparities between the level of preparedness leading up to the disaster and in the following recovery efforts.[87] For example, while the initial number of homes flooded during Hurricane Katrina did not substantially differ by race (67% of Black homes vs. 51% of White homes), racial disparities were evident in the recovery process and which households remained flooded a month later (60% of Black homes vs. 24% of White homes).[88] Racial disparities are also prominent in the health impacts felt by vulnerable communities following a hurricane.[89]

With inland flooding, vulnerability is heightened among communities that live in flood zones. A study in Washington State found that Latinx communities were overrepresented in flood zones, while another study found communities with a high proportion of mobile homes or Black or Indigenous residents are more likely to coincide with areas of high flood risk and high social vulnerability.[90] The majority of high-risk and high social vulnerability areas were found in the southern United States compared to other regions.[91]

Drought can disrupt the relationship between Indigenous communities and the surrounding land, threatening livelihoods, traditional uses of flora and fauna, and negatively impacting mental health due to the cultural significance of the natural world.[92] The exacerbation of heat vulnerability in communities of color has been attributed to historical housing policies that led to systematic disinvestment and poor urban planning in areas that remain largely occupied by low-income communities of color. Redlined areas experience land surface temperatures up to 7°C hotter than non-redlined neighborhoods in the same city.[93] According to the Centers for Disease Control and Prevention (CDC), Black, Hispanic, and Indigenous communities more frequently live in housing

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[85] Robert I. McDonald et al., *The Tree Cover and Temperature Disparity in US Urbanized Areas: Quantifying the Association With Income Across 5,723 Communities*, 16 PLOS ONE 1 (2021), https://doi.org/10.1371/journal.pone.0249715.
[86] Hayhoe, *supra* note 85.
[87] Aaron B. Flores et al., *Petrochemical Releases Disproportionately Affected Socially Vulnerable Populations Along the Texas Gulf Coast After Hurricane Harvey*, 42 POPULATION & ENV'T 279 (2021), https://doi.org/10.1007/s11111-020-00362-6.
[88] MORSE, *supra* note 74.
[89] Ivory A. Toldson et al., *Examining the Long-Term Racial Disparities in Health and Economic Conditions Among Hurricane Katrina Survivors: Policy Implications for Gulf Coast Recovery*, 42 J. BLACK STUDIES 360 (2011), https://doi.org/10.1177/0021934710372893.
[90] Mathis L. Messager et al., *Fine-Scale Assessment of Inequities in Inland Flood Vulnerability*, 133 APPLIED GEOGRAPHY 1 (2021), http://dx.doi.org/10.1016/j.apgeog.2021.102492; Eric Tate et al., *Flood Exposure and Social Vulnerability in the United States*, 106 NAT. HAZARDS 435 (2021), https://doi.org/10.1007/s11069-020-04470-2.
[91] Tate et al., *supra* note 91.
[92] Holly Vins et al., *The Mental Health Outcomes of Drought: A Systematic Review and Causal Process Diagram*, 12 INT'L J. ENV'T RSCH. & PUB. HEALTH 13251 (2015), https://doi.org/10.3390/ijerph121013251.
[93] Jeremy S. Hoffman et al., *The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas*, 8 CLIMATE 1 (2020), https://doi.org/10.3390/cli8010012.

with inadequate protection against heat, have more limited access to health care, and face higher baseline rates of respiratory and cardiovascular diseases, illnesses which are often worsened under extreme heat conditions.[94]

C. Urban and Rural Communities

Differences in exposure, infrastructure, support systems, resources, and population density exist between rural and urban environments, resulting in vulnerable communities in both types of areas but for varying reasons. More research on the impacts of flooding has been conducted in urban areas. Urban areas disrupt natural stream flows making the area vulnerable to flooding. High population density also contributes to greater observed damage. However, rural census tracts have more properties at risk of flooding, higher poverty rates, more people over the age of 65, and a higher percentage of the population dependent on flood-at-risk industries (i.e., agriculture) compared to urban areas.[95]

Rural and agricultural communities tend to be more vulnerable to drought than urban areas, especially in places that are highly dependent on irrigation. Loss of livelihood in these communities may particularly impact poor, rural, and immigrant communities.[96] For example, the 2014 drought in California led to a loss of more than 17,000 mostly agricultural jobs in rural communities of the Central Valley.[97] Mental health impacts of drought—such as anxiety, depression, and suicide—may be especially prevalent in rural communities where drought can disrupt individual and community economic productivity and even lead to migration away from a drought-stricken area.[98] People who rely on private wells or small water systems, often also in rural areas, are at risk of losing access to their water supply. Over the summer and fall of 2014, during a period of severe drought in California, 2,455 private wells went dry, affecting over 12,000 people.[99]

Agricultural and other outdoor workers in both urban and rural communities are particularly vulnerable to extreme heat given the level of physical exertion required for their work, often with prolonged exposure to direct sunlight and with poor working conditions that heighten their risk for heat stress.[100]

D. Limited Mobility and Underlying Health Conditions

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[94] Ambarish Vaidyanathan et al., CTRS. FOR DISEASE CONTROL & PREV. *Heat-Related Deaths-United States, 2004-2018*, 69 MORBIDITY & MORTALITY WEEKLY REP. (June 19, 2020), https://www.cdc.gov/mmwr/volumes/69/wr/pdfs/mm6924a1-H.pdf.
[95] Danielle Rhubart & Yue Sun, *The Social Correlates of Flood Risk: Variation Along the US Rural-Urban Continuum*, 43 POPULATION & ENV'T 232 (2021), https://doi.org/10.1007/s11111-021-00388-4.
[96] Amir AghaKouchak et al., *Water and Climate: Recognize Anthropogenic Drought*, 524 NATURE 409 (2015), https://doi.org/10.1038/524409a.
[97] HOWITT ET AL., *supra* note 35.
[98] Vins et al., *supra* note 93.
[99] Tracy Barreau et al., *Physical, Mental, and Financial Impacts From Drought in Two California Counties, 2015*, 107 AM. J. PUB. HEALTH 783 (2017), https://doi.org/10.2105/ajph.2017.303695.
[100] Moussa El Khayat et al., *Impacts of Climate Change and Heat Stress on Farmworkers' Health: A Scoping Review*, 10 FRONTIERS PUB. HEALTH 1 (2022), https://doi.org/10.3389/fpubh.2022.782811.

Elderly individuals, people with limited mobility and/or underlying health conditions, and young children and pregnant people can be especially vulnerable to climate hazards due to challenges with evacuation and physiological susceptibility. As with low-income communities, these groups face a broad spectrum of challenges associated with climate exposures, including in terms of response to extreme weather alerts, evacuation during flooding caused by extreme storms or hurricanes, and difficulty accessing resources to respond in the aftermath of disasters.[101] Some evidence indicates that high-severity drought conditions may increase the risk of mortality among the elderly, especially in areas that have experienced comparatively fewer droughts.[102] In cases of extreme heat, negative health outcomes are most commonly observed in older adults due to their limited ability to rapidly adjust to high temperatures and their heightened rates of chronic conditions compared to younger people. The population above aged 65 is steadily increasing, which is likely to contribute to a drastic increase in heat-related hospitalizations and deaths for this group with increased climate change-related warming.[103]

IX. Conclusions

Throughout this module, we highlighted the systems of injustice that create inequities in climate exposures and impacts in the United States. Low-income communities, communities of color, Indigenous communities, and those with preexisting health conditions are more vulnerable to adverse outcomes of climate hazards, including wildfire, extreme heat, tropical cyclones, and inland flooding, are less likely to be able to recover, and have often contributed much less to greenhouse gas emissions. These impacts have implications for all branches of government, and state and federal policymakers are taking actions in response to this science. For more on the intersection of the science with law, including with environmental rights amendments, the public trust doctrine, environmental justice laws, and climate justice laws, check out the Fundamental Rights module.

Implementing just and intentional adaptation programs will ensure that climate change will not burden some communities more than others and help to address the systems and policies behind these inequities. Climate injustice is becoming a central topic related to the funding and implementing of climate adaptation and mitigation strategies, loss and damage retribution calculations, and climate attribution. More on climate risks, costs, and attribution will be discussed in the Risks and Costs and Drawing the Causal Chain modules.

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[101] Hayhoe, *supra* note 85.

[102] Jesse D. Berman et al., *Drought and the Risk of Hospital Admissions and Mortality in Older Adults in Western USA From 2000 to 2013: A Retrospective Study*, LANCET PLANETARY HEALTH (2017), https://doi.org/10.1016/s2542-5196(17)30002-5.

[103] Antonia Kaltsatou et al., *The Impact of Heat Waves on Mortality Among the Elderly: A Mini Systematic Review*, 4 J. GERIATRIC MED. & GERONTOLOGY 1 (2018), https://doi.org/10.23937/2469-5858/1510053.