No. 18-36082

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

KELSEY CASCADIA ROSE JULIANA, et al.,
Plaintiffs-Appellees,

v.

UNITED STATES OF AMERICA, et al.,
Defendants-Appellants.

ON APPEAL FROM THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF OREGON (NO. 6:15-CV-01517-AA)

BRIEF OF *AMICI CURIAE* PUBLIC HEALTH EXPERTS, PUBLIC HEALTH ORGANIZATIONS, AND DOCTORS IN SUPPORT OF PLAINTIFFS-APPELLEES SEEKING AFFIRMANCE

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CORPORATE DISCLOSURE STATEMENT

Pursuant to Federal Rules of Appellate Procedure 26.1 and 29(a)(4)(A), organizational *amici* state that they do not have any parent companies and no publicly-held company has a 10% or greater ownership interest in any of them.

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INTERESTS OF THE *AMICI CURIAE*[1]

Amici are leading experts in public health and medicine as well as public health organizations representing thousands of health professionals. Through their research and/or clinical work, the *amici* observe and document the harmful impacts of greenhouse gas (GHG) emissions on people born in the United States since 1995—the Plaintiffs' generation, the "Juliana Generation." This generation is suffering—and will continue to suffer as they age—harms different from those of prior generations. *Amici* feel a special responsibility to safeguard the Juliana Generation's health now.

Amici study and/or clinically treat the effects of heat, drought, severe storms, and air pollution on the mental and physical health of children and adolescents. *Amici* believe that prompt reductions in GHG emissions in the United States can mitigate these adverse health impacts and relieve the unprecedented adverse health impacts facing the Juliana Generation.

Amicus Samantha Ahdoot is Assistant Professor of Pediatrics at Virginia Commonwealth University School of Medicine, Inova Campus. She provided expert consultation on the effects of climate change on children's health to the

[1] Pursuant to Federal Rule of Appellate Procedure Rule 29(a)(2), *amici* state that all parties have consented to the filing of this brief. Pursuant to Federal Rule of Appellate Procedure 29(A)(4)(e), *amici* certify that no person or entity, other than *amici* or its counsel, made a monetary contribution to the preparation or submission of this brief or authored this brief in whole or in part.

President's Task Force on Children's Environmental Health in 2014. She co-authored the 2015 American Academy of Pediatrics (AAP) report on the effects of climate change on children's health.

Amicus Eric Chivian is the Founder and Director Emeritus of the Center for Health and the Global Environment at Harvard Medical School (HMS). He is the co-founder of International Physicians for the Prevention of Nuclear War, which won the Nobel Peace Prize in 1985.

Amicus Sir Andrew Haines is Professor of Environmental Change and Public Health at the London School of Hygiene & Tropical Medicine and was its Director for almost a decade. He focuses his research, and has chaired an international commission, on the health impacts of environmental change and the policies needed to address these changes. He has been on the UN Intergovernmental Panel on Climate Change for the second, third, and fifth assessments.

Amicus Kim Knowlton is Assistant Professor of Environmental Health Sciences at Columbia University Mailman School of Public Health (CUMSPH), researching the health impacts of climate change and estimating their costs. She was the co-convening lead author on the human health chapter of the Third U.S. National Climate Assessment.

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Amici include the following organizations: American Academy of Allergy, Asthma and Immunology; American Academy of Pediatrics; American Association of Community Psychiatrists; American Heart Association; American Lung Association; American Pediatric Society; American Thoracic Society; Infectious Diseases Society of America; International Society for Children's Health and the Environment; Medical Society Consortium on Climate and Health; National Association of County and City Health Officials; National Environmental Health Association; National Medical Association; and Society for Academic Emergency Medicine.

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INTRODUCTION AND SUMMARY OF ARGUMENT

The generation of today's youth (the "Juliana Generation"), represented by the Plaintiffs, was born into a world made hazardous to their health and well-being by greenhouse gases (GHGs) emitted by human activities. There is scientific consensus that GHG emissions are causing major physical, chemical, and ecological changes to the planet, manifesting as extreme weather events, including heat waves and heavy precipitation, as well as droughts. The medical community widely considers the health effects of human-induced climate change, GHG emissions, and the other air pollutants that are emitted when fossil fuels are combusted to be significant public health threats, representing an "unacceptably high level of risk for the current and future health" of the U.S. population.[2]

Children are especially vulnerable to climate-related health effects because of their developing bodies; higher exposure to air, food, and water per unit body weight; unique behavior patterns; and dependence on caregivers.[3] GHG emissions

[2] Nick Watts et al., *The 2018 Report of the Lancet Countdown on Health and Climate Change: Shaping the Health of Nations for Centuries to Come*, 392 Lancet 2479, 2479 (2018).

[3] Samantha Ahdoot & Susan E. Pacheco, *Global Climate Change and Children's Health*, 136 Pediatrics e1468, e1470 (2015)

cause harmful physical and psychological impacts via extreme weather events, increased heat stress, decreased air quality, altered disease patterns and increased climate-sensitive infections, and food, water and nutrient insecurity in vulnerable regions of the United States.[4] Children and others are already feeling these effects, which will continue to worsen over the course of the Juliana Generation's lifetimes. Cumulatively, these health impacts will cost the United States trillions of dollars per year by the end of the century.[5] These current and future adverse public health impacts and costs can be significantly mitigated if the federal government acts promptly to reduce GHG emissions. For these reasons, *amici* request that the Court grant Plaintiffs' request for a remand to the district court for trial.

ARGUMENT

I. GHG EMISSIONS ARE CAUSING ECOLOGICAL CHANGES AND EXTREME WEATHER EVENTS THAT THREATEN CHILDREN'S HEALTH IN THE UNITED STATES

There is scientific consensus that GHGs emitted by human activities are causing major physical, chemical, and ecological changes to the planet (climate change) including rising global temperatures, which are already manifesting as extreme weather events. The federal government recently issued its Fourth

[4] *Id.* at e1468.

[5] U.S. Global Change Research Program, *Fourth National Climate Assessment* 1358 (2018) [hereinafter NCA].

National Climate Assessment recognizing and detailing the serious effects that climate change is projected to have on public health.[6] GHG emissions pose a threat to the health of all people, but will have especially significant impacts on children's health.[7] The Juliana Generation faces an increasing burden of heat exposure, extreme weather events, infectious disease, less food, and less nutritious food that costs more.

A. Rising Temperatures and Increased Heat Exposure Threaten Children's Health

Global average temperature increased by about 1.8°F from 1901 to 2016 and the scientific evidence indicates that human activities, especially emissions of GHGs, are the dominant cause.[8] Exposure to extreme heat is the leading cause of weather-related deaths in the United States.[9] Heat exposure in the United States is increasing as hot days become more frequent and extreme heat waves become more prolonged. Cities face particularly hot temperatures due to the urban heat

[6] *Id.* at 512–71.

[7] *See* Andy Haines & Kristie Ebi, *The Imperative for Climate Action to Protect Health*, 380 New Eng. J. Med. 263, 267 fig.3 (2019); *see also* Ahdoot & Pacheco, *supra* note 3; Rebecca Pass Philipsborn & Kevin Chan, *Climate Change and Global Child Health*, 141 Pediatrics, June 2018; Ying Zhang et al., *Climate Change and Disability-Adjusted Life Years*, 70 J. Envtl. Health 32, 33 (2007) (estimating children will bear 88% of the burden of disease due to climate change).

[8] NCA, *supra* note 5, at 73 (2018).

[9] Ahdoot & Pacheco, *supra* note 3, at e1471.

island effect, in which dark surfaces and reduced vegetation lead to warmer air in cities than in rural areas.[10] In Boston, for example, the number of days with temperatures above 90°F will increase from an annual average of eleven days in the late twentieth century to ninety days by 2070 under a high-emissions, business-as-usual scenario.[11] In San Francisco, such days will increase from ten currently to about fifty in 2050 and over 100 in 2100.[12]

Children are particularly susceptible to the effects of extreme heat.[13] For instance, the 2006 heat wave in California generated 16,166 excess visits to emergency departments over 2.5 weeks; children's incidence of visits to emergency departments exceeded that of adults.[14] Infant mortality increases 25% on extremely hot days, with the first seven days of life representing a period of

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[10] Hashem Akbari, Lawrence Berkeley Nat'l Lab., *Energy Saving Potentials and Air Quality Benefits of Urban Heat Island Mitigation* 1–2 (2005).

[11] City of Boston, *Climate Projection Consensus* (2016), https://www.boston.gov/sites/default/files/03_climate_ready_boston_digital_climateprojectionconsensus.pdf.

[12] S.F. Dep't Pub. Health, *San Francisco Climate and Health Profile* 9 (Nov. 2014), https://sfclimatehealth.org/wp-content/uploads/2018/12/SFDPH_ClimateHealthProfile_FinalDraft.pdf.

[13] Philipsborn & Chan, *supra* note 7, at 2.

[14] Kim Knowlton, *The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits*, 117 Envt'l Health Persp. 61, 63, 63 tbl.1 (2009).

critical vulnerability.[15] Heat illness is a leading cause of death and illness in high school athletes; nearly 10,000 episodes occur annually.[16] Emergency room visits for exertional heat-related injuries increased 134% between 1997 and 2006 in the United States.[17]

GHG emissions also exacerbate allergies. Allergies are the sixth-leading cause of chronic illness in the United States, costing more than $18 billion annually.[18] 8.4% of U.S. children suffer from allergic rhinitis (hay fever), a syndrome of sneezing, stuffy nose, runny nose, watery eyes, and itching of the nose, eyes, or roof of the mouth triggered by airborne pollen.[19] Many asthma attacks in children are also allergy-associated. When exposed to warmer temperatures and higher levels of carbon dioxide, plants grow more vigorously and produce more pollen than they otherwise would.[20] The ragweed pollen season in

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[15] Xavier Basagaña et al., *Heat Waves and Cause-Specific Mortality at All Ages*, 22 Epidemiology 765, 765 (2011).

[16] J. Gilchrist et al., *Heat Illness Among High School Athletes—United States, 2005–2009*, 59 Morbidity & Mortality Wkly. Rep. 1009, 1009 (2010).

[17] Nicolas G. Nelson et al., *Exertional Heat-Related Injuries Treated in Emergency Departments in the U.S., 1997–2006*, 40 Am. J. Preventative Med. 54, 56 (2011).

[18] *Allergy Facts*, Am. C. Allergy, Asthma, & Immunology (Jan. 9, 2018), https://acaai.org/news/facts-statistics/allergies.

[19] *Id.*

[20] Yong Zhang et al., *Allergenic Pollen Season Variations in the Past Two Decades Under Changing Climate in the United States*, 21 Global Change Biology 1581 (2015); Lewis H. Ziska & Paul J. Beggs, *Anthropogenic Climate Change and*

North America has grown thirteen to twenty-seven days longer since 1995 because of higher temperatures and greater carbon dioxide levels.[21]

Emerging evidence also demonstrates a link between hotter temperatures and (1) mental health impairments in children,[22] (2) antibiotic resistance among bacteria that cause human infection;[23] and (3) adverse pregnancy outcomes and congenital heart defects.[24]

B. Extreme Weather Events Pose Direct and Indirect Threats to Children's Health

Extreme weather events in the United States, including heat waves, droughts, wildfires, and floods, have steadily increased since 1980 and are

Allergen Exposure: The Role of Plant Biology, 129 J. Allergy & Clinical Immunology 27 (2012).

[21] Lewis Ziska et al., *Recent Warming by Latitude Associated with Increased Length of Ragweed Pollen Season in Central North America*, 108 Proc. Nat'l Acad. Sci. 4248, 4248 (2011).

[22] Nick Obradovich et al., *Empirical Evidence of Mental Health Risks Posed by Climate Change*, 115 Proc. Nat'l Acad. Sci. 10,953 (2018); Jose Guillermo Cedeño Laurent et al., *Reduced Cognitive Function During a Heat Wave Among Residents of Non-Air-Conditioned Buildings: An Observational Study of Young Adults in the Summer of 2016*, 15 PLOS Medicine e1002605 (July 10, 2018).

[23] Derek R. MacFadden, *Antibiotic Resistance Increases with Local Temperature*, 8 Nature Climate Change 510 (2018).

[24] Wangjian Zhang et al., *Projected Changes in Maternal Heat Exposure During Early Pregnancy and the Associated Congenital Heart Defect Burden in the United States*, 8 J. Am. Heart Ass'n, Feb. 5, 2019, at 5–6, 10.

projected to become even more frequent.[25] These events cause destruction, injuries, infectious diseases, and death.[26] In 2012, Hurricane Sandy caused 234 deaths, $50 billion in property damage, the destruction of 375,000 housing units in New York and New Jersey, the loss of power for 8.5 million people, and the evacuation of 1,000 hospital patients.[27] In 2017, Hurricane Maria disrupted medical services to 31% of households in Puerto Rico, displaced 10,600 people, and resulted in an estimated 5,740 excess deaths.[28] Sixteen extreme weather events in 2017 caused an estimated $313 billion in damages that significantly undermine physical and mental health, particularly for those who are not insured.[29]

A series of expert reports published by the American Meteorological Society since 2012 has identified many such extreme weather events that have been made more likely because of GHG emissions. The reports for 2016 and 2017 identified for the first time several extreme weather events that could not have happened

[25] NCA, *supra* note 5, at 97.

[26] *Id.*

[27] John Manuel, *The Long Road to Recovery: Environmental Health Impacts of Hurricane Sandy*, 121 Envtl. Health Persp. A153, A153–54 (2013).

[28] Renee N. Salas et al., *2018 Lancet Countdown on Health and Climate Change: Brief for the United States of America* 13 (2018); Nishant Kishore et al., *Mortality in Puerto Rico After Hurricane Maria*, 379 New Eng. J. Med. 162, 166 (2018).

[29] Salas et al., *supra* note 28, at 10.

without human-induced climate change, including the Northern Great Plains drought and a marine heat wave off Alaska.[30]

GHG emissions are linked to longer, more intense, and geographically broader droughts now than occurred in the twentieth century, especially in the western United States.[31] Droughts have depleted groundwater supplies in the United States, including the High Plains and Dakota Aquifers, jeopardizing access to drinking water for some communities.[32] Droughts impair human health by increasing wildfires and dust storms, exacerbating particulate matter air pollution, increasing the risk of certain infectious diseases,[33] and increasing food insecurity.

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[30] *Explaining Extreme Events of 2017 from a Climate Perspective*, 100 Bull. Am. Meteorological Soc'y, Supp. Jan. 2019, at S1; *Explaining Extreme Events of 2016 from a Climate Perspective*, 99 Bull. Am. Meteorological Soc'y, Supp. Jan. 2018, at Sii.

[31] U.S. Global Change Research Program, *The Impacts of Climate Change on Human Health in the United States* [hereinafter *Impacts on Health*] 102 tbl.1 (2016); NCA, *supra* note 5, at 155; Noah S. Diffenbaugh et al., *Anthropogenic Warming has Increased Drought Risk in California*, 112 Proc. Nat'l Acad. Sci. 3931 (2015).

[32] NCA, *supra* note 5, at 148.

[33] *Id.* at 154; *Impacts on Health*, *supra* note 31, at 108, 110. Warmer, more stagnant waters provide favorable conditions for certain key pathogens and insects that carry disease. Jesse E. Bell et al., *Changes in Extreme Events and the Potential Impacts on Human Health*, 68 J. Air & Waste Mgmt. Ass'n 265, 274 (2017).

The 2011–2012 drought cost the United States $33 billion and significantly disrupted agriculture resulting in higher food prices.[34]

GHG emissions have increased the likelihood of wildfires in the United States. The 2017 and 2018 California wildfires were among the most destructive ever recorded in the state.[35] In addition to the stress, direct trauma, and deaths associated with wildfires, wildfire smoke increases air-pollution levels by as much as a factor of ten and is associated with respiratory disease. Children exposed to wildfires suffer substantial eye symptoms, as well as upper and lower respiratory symptoms.[36] The 2003 wildfires in southern California resulted in a 25% higher rate of asthma-related hospitalizations in five- to nineteen-year olds during the fire

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[34] NCA, *supra* note 5, at 150; Neil S. Grigg, *The 2011–2012 Drought in the United States: New Lessons from a Record Event*, 30 Int'l J. Water Res. Development 183, 190 (2014).

[35] Dale Kasler, *Worst Wildfire Year Since When? More California Acres Have Burned in 2018 than the Past Decade*, Sacramento Bee (Nov. 16, 2018), https://www.sacbee.com/latest-news/article221788220.html. Eighty-five people died in last year's Camp Fire, the deadliest wildfire in California's history; losses reached $16.5 billon. Alejandra Reyes-Velarde, *California's Camp Fire was the Costliest Global Disaster Last Year, Insurance Report Shows*, L.A. Times (Jan. 11, 2019), https://www.latimes.com/local/lanow/la-me-ln-camp-fire-insured-losses-20190111-story.html; *Death Toll in Massive California Wildfire Revised Down by One*, Reuters (Feb. 7, 2019), https://www.reuters.com/article/us-california-wildfire/death-toll-in-massive-california-wildfire-revised-down-by-one-idUSKCN1PX08I.

[36] Nino Künzli et al., *Health Effects of the 2003 Southern California Wildfires on Children*, 174 Am. J. Respiratory & Critical Care Med. 1221, 1224 (2006).

and a 56% higher rate after the fires.[37] The 2011 Pains Bay wildfire in eastern North Carolina caused elevated levels of air pollution and higher emergency room visits for respiratory diseases in children under age eighteen.[38] Emerging evidence suggests an association between exposure to wildfire smoke and heart attacks, strokes, and death from all causes.[39]

The impact of extreme weather events on children's mental health is also significant. Children's biological and cognitive development occurs in the context of family, school, neighborhoods, and communities: extreme weather events cause harm to children through devastation of their social context. During and after a weather-related disaster, children experience family loss or separation; school interruption; scarcities of food, water and shelter; and public service outages. The consequences include acute emotional shock and trauma, but also—because early child development is crucial for subsequent physical and mental health—marked

[37] R.J. Delfino, *The Relationship of Respiratory and Cardiovascular Hospital Admissions to the Southern California Wildfires of 2003*, 66 Occupational Envtl. Med. 189, 192 (2009).

[38] Melissa A. Tinling, *Repeating Cardiopulmonary Health Effects in Rural North Carolina Population During a Second Large Peat Wildfire*, 15 Envtl. Health 12 (2016).

[39] Wayne E. Cascio, *Wildland Fire Smoke and Human Health*, 624 Sci. Total Env't 586, 586 (2018).

deleterious effects on later development.[40] More than 200,000 children were evacuated and relocated during Hurricane Katrina;[41] these children have experienced long-lasting and profound mental health impacts. Displaced students experienced a variety of problems related to school attendance, academic performance, behavior, and mental health.[42] Post-traumatic stress disorder was identified in 50% of preschool-age children and 71% of sixth- and seventh-graders following Hurricane Katrina.[43] Many serious emotional disturbances persisted for

[40] Daniel Martinez Garcia & Mary C. Sheehan, *Extreme Weather-Driven Disasters and Children's Health*, 46 Int'l J. Health Services 79 (2016).

[41] Kristie L. Ebi & Jerome A. Paulson, *Climate Change and Child Health in the United States*, 40 Current Prob. Pediatric & Adolescent Health Care 2, 8 (2010).

[42] *See* Alice Fothergill & Lori Peek, *Children of Katrina* (2015).

[43] Lauren Hensley & R. Enrique Varela, *PTSD Symptoms and Somatic Complaints Following Hurricane Katrina: The Roles of Trait Anxiety and Anxiety Sensitivity*, 37 J. Clinical Child & Adolescent Psych. 542, 546 tbl.2 (2008); Michael S. Scheeringa & Charles H. Zeanah, *Reconsideration of Harm's Way: Onsets and Comorbidity Patterns of Disorders in Preschool Children and Their Caregivers Following Hurricane Katrina*, 37 J. Clinical Child & Adolescent Psych. 508 (2008).

years after the storm.[44] Similar long-lasting mental health effects were observed in children following Hurricane Floyd in North Carolina in 1999.[45]

Extreme weather events also affect children's health indirectly through disaster-related healthcare system failures. Disruption of the medical supply chain is an important indirect effect of extreme weather events because it compromises vaccination programs and the availability of medications. In 2017, Hurricane Maria interrupted the production of essential drugs and intravenous fluid manufactured in Puerto Rico, resulting in nationwide shortages.[46]

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[44] Katie A. McLaughlin et al., *Serious Emotional Disturbance Among Youths Exposed to Hurricane Katrina 2 Years Postdisaster*, 48 J. Am. Acad. Child & Adolescent Psychiatry 1069, 1070, 1072 (2009) (defining serious emotional disturbance as "a diagnosable mental disorder that results in significant impairment or decreased role functioning in family, school, or community activities"); Katie A. McLaughlin et al., *Trends in Serious Emotional Disturbance Among Youths Exposed to Hurricane Katrina*, 49 J. Am. Acad. Child & Adolescent Psychiatry 990 (2010).

[45] Carmen V. Russoniello et al., *Childhood Post Traumatic Stress Disorder and Efforts to Cope After Hurricane Floyd*, 28 Behavioral Med. 61, 64 fig.1 (2002).

[46] Katie Thomas, *U.S. Hospitals Wrestle With Shortages of Drug Supplies Made in Puerto Rico*, N.Y. Times (Oct. 23, 2017), https://www.nytimes.com/2017/10/23/health/puerto-rico-hurricane-maria-drug-shortage.html; *Statement by FDA Commissioner Scott Gottlieb, M.D., Updating on Puerto Rico Related Medical Product Shortages*, U.S. Food & Drug Admin. (Nov. 30, 2017), https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm587290.htm.

C. GHG Emissions Are Altering and Increasing the Burden of Infectious Disease

Vector-borne infections in the United States are principally transmitted by mosquitoes or ticks. Rising temperatures and increased precipitation affect the biology and behavior of mosquitoes and ticks, leading to expanded and altered geographic distributions, prolonged transmission seasons, and the emergence of new human pathogens. Annual reports of vector-borne diseases in the United States tripled from 2004 to 2016, and the areas reporting diseases expanded.[47]

Lyme disease, the most common tick-borne disease in the United States,[48] can lead to arthritis and diseases of the heart, eyes, and skin.[49] Children between the ages of five and nine years have the highest incidence of Lyme disease in the United States.[50] Cases of Lyme disease have increased steadily since 1991.[51] Warmer winter and spring temperatures, resulting from GHG emissions, are

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[47] Ronald Rosenberg et al., *Vital Signs: Trends in Reported Vectorborne Disease Cases—United States and Territories, 2004–2016*, 67 Mortality & Morbidity Weekly Rep. 496, 497 (2018).

[48] Aaron S. Bernstein & Samuel S. Myers, *Climate Change and Children's Health*, 23 Current Opinion Pediatrics 221, 222 (2011).

[49] Amy L. Ross Russell et al., *Lyme Disease: Diagnosis and Management*, 18 Prac. Neurology 455, 457 (2018).

[50] Bernstein & Myers, *supra* note 48, at 222.

[51] Data are available for each year in CDC annual reports. *See Notifiable Infectious Diseases and Conditions Data Tables*, Ctrs. Disease Control & Prevention, https://wwwn.cdc.gov/nndss/infectious-tables.html (last visited Feb. 28, 2019).

projected to lead to an earlier annual onset of Lyme disease cases in the eastern United States and to a more prolonged season.[52] The geographic distribution of the ticks that transmit Lyme disease is expected to expand to higher latitudes and elevations in the United States.[53] The spread of ticks to new geographic areas will expose unprepared populations to the risk of new diseases, posing challenges for diagnosis and public health preparedness.

GHG emissions are altering the ecology, geographic range, and number of disease-carrying mosquitoes in the United States. The United States is expected to experience a large climate-driven increase in the percentage of people exposed to the mosquito *Aedes aegypti* over the twenty-first century.[54] This mosquito transmits viruses—including dengue and Zika—that cause human disease. Zika virus causes fever, headache and rash; infection during pregnancy can cause birth defects, including serious brain defects and stillbirth. The United States experienced a large outbreak of Zika virus disease in 2015–2016, with local

[52] Sean M. Moore et al., *Meteorological Influences on the Seasonality of Lyme Disease in the United States*, 90 Am. J. Tropical Med. & Hygiene 486 (2014).

[53] John S. Brownstein et al., *Effect of Climate Change on Lyme Disease Risk in North America*, 2 EcoHealth 38, 38 (2005); Rosenberg et al., *supra* note 47, at 497.

[54] Salas et al., *supra* note 28, at 15.

transmission in Florida, Texas, and Puerto Rico.[55] These regions subsequently experienced a 21% increase in birth defects strongly linked to Zika virus in the last half of 2016.[56]

Changes in temperature and precipitation due to GHG emissions are affecting the spread of infections related to soil and water exposure. Coccidioidomycosis, also known as "valley fever," is an infection caused by a fungus found in the soil that flourishes in hot, dry areas, including Arizona and California.[57] Valley fever is contracted by inhaling spores.[58] Symptoms include rash, cough, and fever, but when infection spreads from the lungs it can cause severe symptoms and occasionally death.[59] More than 8,000 cases of valley fever occurred in California in 2018, an increase of more than 40% since 2016.[60] Heavy

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[55] Augustina Delaney et al., *Population-Based Surveillance of Birth Defects Potentially Related to Zika Virus Infection—15 States and U.S. Territories, 2016*, 67 Morbidity & Mortality Wkly. Rep. 91, 92 n.** (2018).

[56] *Id.* at 92.

[57] *Valley Fever (Coccidioidomycosis)*, Ctrs. Disease Control & Prevention (Jan. 2, 2019), https://www.cdc.gov/fungal/diseases/coccidioidomycosis/index.html.

[58] *Id.*

[59] *Symptoms of Valley Fever (Coccidioidomycosis)*, Ctrs. Disease Control & Prevention (Jan. 2, 2019), https://www.cdc.gov/fungal/diseases/coccidioidomycosis/symptoms.html.

[60] *Coccidioidomycosis in California Provisional Monthly Report*, Cal. Dep't Pub. Health 3 (Jan. 31, 2019),

rainfall followed by drought and increasing temperatures are important factors in this increase. Cases have also been newly observed in Washington State.[61]

Vibrio is a family of bacteria that cause bloodstream infections, diarrhea, and skin infections,[62] with an estimated 80,000 illnesses and 100 deaths in the United States each year.[63] Warmer sea temperatures due to GHG emissions have been associated with an observed 7% annual increase in Vibrio infections in the United States from 1999 to 2014.[64] Vibrio infections are likely to increase further as sea temperatures continue to warm.

Extreme weather events can also lead to the spread of food- and water-borne diseases through disruption and contamination of water systems.[65] Drinking water can become contaminated when heavy rainfall causes stormwater to mix with raw

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https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/CocciinCAProvisionalMonthlyReport.pdf.

[61] *Washington State Communicable Disease Report 2017*, Wash. State Dep't Health 26 (Nov. 2018), https://www.doh.wa.gov/Portals/1/Documents/5100/420-004-CDAnnualReport2017.pdf.

[62] Watts et al., *supra* note 2, at 2488.

[63] *Vibrio Species Causing Vibriosis*, Ctrs. Disease Control & Prevention (Sept. 28, 2018), https://www.cdc.gov/vibrio/.

[64] Chloë Logar-Henderson et al., *Effects of Large-Scale Oceanic Phenomena on Non-Cholera Vibriosis Incidence in the United States: Implications for Climate Change*, Lancet (preprint 2018).

[65] K.F. Cann et al., *Extreme Water-Related Weather Events and Waterborne Disease*, 141 Epidemiology & Infection 671 (2013).

sewage in combined sewer systems, which then discharge the mixed water and sewage into rivers, streams, and other water bodies. Heavy rainfall has been linked to childhood gastrointestinal illness in the United States.[66]

D. Rising Temperatures and Extreme Weather Will Increase Food Insecurity and Malnutrition

Climate change reduces both the availability of crops and their nutrient content. Growing children are at special risk of adverse consequences of undernutrition, including poor growth, nutritional deficiencies, and worsened school performance.

Weather extremes and scarcity of water increase crop losses.[67] Crop yields are projected to decline by about 1% per decade at a time when demands for food

[66] Frank C. Curriero et al., *The Association Between Extreme Precipitation and Waterborne Disease Outbreaks in the United States, 1948–1994*, 91 Am. J. Pub. Health 1194, 1197 (2001) (finding a significant link in EPA data between outbreaks of water-borne disease and extreme precipitation events); Patrick Drayna et al., *Association between Rainfall and Pediatric Emergency Department Visits for Acute Gastrointestinal Illness*, 118 Envtl. Health Persp. 1439, 1440–41 (2010); Jonathan A. Patz et al., *Climate Change: Challenges and Opportunities for Global Health*, 312 J. Am. Med. Ass'n 1565, 1569 (2014); Timothy J. Wade et al., *Did a Severe Flood in the Midwest Cause an Increase in the Incidence of Gastrointestinal Symptoms?*, 159 Am. J. Epidemiology 398, 398, 400, 402 (2004) (confirming relationship between flooding and symptoms of gastrointestinal illness).

[67] Bernstein & Myers, *supra* note 48, at 224.

are increasing.[68] Reductions in crop yields result in higher prices that disproportionately affect poor families and their children.

Moreover, increased levels of carbon dioxide in the atmosphere have been directly linked to reductions in nutrients in food. Studies have shown that protein content will decline in wheat, rice, and barley; iron and zinc content will decline in rice, soybeans, wheat, and peas; and vitamin B and micronutrient content will decline in rice and wheat.[69] Declines in several micronutrients in food crops have already been reported; research indicates that elevated carbon dioxide levels likely play a role in these changes.[70]

II. BURNING FOSSIL FUELS CAUSES AND EXACERBATES ALREADY DANGEROUS LOCALIZED AIR POLLUTION

The production and use of fossil fuels not only emit GHGs (including carbon dioxide and methane), but also emit other air pollutants, including particulate matter, polycyclic aromatic hydrocarbons, nitrogen dioxide, mercury, and the

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[68] John R. Porter et al., *Food Security and Food Production Systems*, *in* Climate Change 2014: Impacts, Adaptation, and Vulnerability 485, 505 (Christopher B. Field et al. eds., 2014).

[69] Ahdoot & Pacheco, *supra* note 3, at e1476; Haines & Ebi, *supra* note 7, at 266; Patz et al., *supra* note 66, at 1570.

[70] Roddy Scheer & Doug Moss, *Dirt Poor: Have Fruits and Vegetables Become Less Nutritious?*, Scientific Am., https://www.scientificamerican.com/article/soil-depletion-and-nutrition-loss/ (last visited Feb. 28, 2019).

precursor pollutants to ozone.[71] These pollutants pose neurodevelopmental and respiratory hazards to children's health. Children are particularly vulnerable to air pollution: they breathe proportionally more air because of their higher respiratory rate, they spend more time outdoors exposed to pollution, and their lungs and other organs are still developing.[72] Today's youth and their children will experience worsened effects of air pollutants attributable to continued burning of fossil fuels in the United States.

Ozone is a powerful lung irritant that is formed from methane (a GHG) and chemicals released by the combustion of fossil fuels.[73] Increases in ambient temperature also affect the generation of ozone pollution. Exposure to ozone pollution causes asthma exacerbations[74] and increased emergency room visits and

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[71] Ebi & Paulson, supra note 41, at 9; Frederica P. Perera, *Multiple Threats to Child Health from Fossil Fuel Combustion: Impacts of Air Pollution and Climate Change*, 125 Envtl. Health Persp. 141 (2017); F. Perera et al., *Towards a Fuller Assessment of Benefits to Children's Health of Reducing Air Pollution and Mitigating Climate Change due to Fossil Fuel Combustion*, 172 Envtl. Res. 55 (2019).

[72] Patz et al., *supra* note 66, at 1569; Perera, *supra* note 71, at 144.

[73] Kent E. Pinkerton et al., *An Official American Thoracic Society Workshop Report: Climate Change and Human Health*, 9 Proc. Am. Thoracic Soc'y 3, 4–5 (2012).

[74] Janneane F. Gent et al., *Association of Low-Level Ozone and Fine Particles with Respiratory Symptoms in Children with Asthma*, 290 J. Am. Med. Ass'n 1859, 1862 (2003).

pediatric intensive care unit admissions for asthma.[75] It also increases a child's risk of developing asthma.[76] Asthma is a lung disease that causes wheezing, breathlessness, chest tightness, and nighttime or early morning coughing. It affects 8.3% of American children.[77] Asthma rates have been increasing in the United States since the early 1980s, and it is the top reason for missed school days. In addition to its physical symptoms, childhood asthma causes anxiety and is associated with more severe behavioral problems in children with attention-deficit disorder.[78] Ozone-related mortality in the New York metropolitan region is projected to rise 4.5% over 1990s levels by the 2050s.[79]

A robust and growing body of research documents the dangers of fine particulate matter (PM) in children. Exposure to PM is associated with

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[75] Robert A. Silverman & Kazuhiko Ito, *Age Related Association of Fine Particles and Ozone with Severe Acute Asthma in New York City*, 125 J. Allergy & Clinical Immunology 367 (2010).

[76] *See* Patrick L. Kinney, *Climate Change Air Quality, and Human Health*, 35 Am. J. Preventative Med. 459, 461 (2008).

[77] *Most Recent Asthma Data*, Ctrs. Disease Prevention & Control (May 2018), https://www.cdc.gov/asthma/most_recent_data.htm.

[78] Adrienne P. Borschuk et al., *The Influence of Comorbid Asthma on the Severity of Symptoms in Children with Attention-Deficit Hyperactivity Disorder*, 55 J. Asthma 66 (2017); P.J. Vuillermin et al., *Anxiety is More Common in Children with Asthma*, 95 Archives Disease Childhood 624 (2010).

[79] Kim Knowlton et al., *Assessing Ozone-Related Health Impacts Under a Changing Climate*, 112 Envtl. Health Persp. 1557 (2004).

significantly increased rates of bronchitis and asthma, associated hospital admissions, mortality, and school absenteeism.[80] Children exposed to PM no larger than 2.5 micrometers ($PM_{2.5}$) have decreased lung function growth at age 18.[81] A study of children ages 6–18 in New York City found the rates of intensive care unit admissions and hospitalizations increased 26% and 19%, respectively, when $PM_{2.5}$ concentration increased by 12 $\mu g/m^3$.[82]

Nitrogen dioxide (NO_2), another byproduct of fossil fuel combustion, also poses documented health risks. Exposure to NO_2 during childhood can decrease children's lung function.[83] A study of a cohort of fourth graders, for example, found decreased lung function growth in children exposed to higher levels of NO_2.[84]

Combustion of coal at power plants results in air emissions of mercury, another extremely harmful air pollutant. Coal plants are responsible for 44% of

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[80] Perera, *supra* note 71, at 143.

[81] Edward L. Avol et al., *Respiratory Effects of Relocating to Areas of Differing Air Pollution Levels*, 164 Am. J. Respiratory Critical Care Med. 2067 (2001).

[82] Silverman & Ito, *supra* note 75.

[83] Perera, *supra* note 71, at 143.

[84] W. James Gauderman et al., *Association Between Air Pollution and Lung Function Growth in Southern California Children*, 162 Am. J. Respiratory & Critical Care Med. 1383, 1388 (2000).

U.S. mercury emissions.[85] Mercury is a potent neurotoxin: prenatal exposure can lead to decreased motor and cognitive abilities even at low exposures.[86] As children age, low-level mercury exposures have been linked to higher risks of hypertension, heart disease,[87] and endocrine disturbances.[88]

Changes in temperature, precipitation, and air stagnation patterns lead $PM_{2.5}$ to remain in the air longer, increasing ambient concentrations.[89] Wildfires, in addition to their direct harms, also release $PM_{2.5}$.[90]

III. GHG EMISSIONS IMPOSE SIGNIFICANT COSTS, INCLUDING TO THE U.S. HEALTHCARE SYSTEM

The impacts described above will result in significant economic harm. Under a business-as-usual scenario that results in 2.5–3°C of warming by 2100, the net

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[85] A.C. (Thanos) Bourtsalas & Nickolas J. Themelis, *Major Sources of Mercury Emissions to the Atmosphere: The U.S. Case*, 85 J. Waste Mgmt. 90, 92 fig.2 (2019).

[86] Comm. on the Toxicological Effects of Methylmercury, Nat'l Research Council, *Toxicological Effects of Methylmercury* 4 (2000), https://www.nap.edu/read/9899/.

[87] *Id.*; Henry A. Roman et al., *Evaluation of the Cardiovascular Effects of Methylmercury Exposures: Current Evidence Supports Development of a Dose–Response Function for Regulatory Benefits Analysis*, 119 Envtl. Health Persp. 607, 607 (2011).

[88] Shirlee W. Tan et al., *The Endocrine Effects of Mercury in Humans and Wildlife*, 39 Critical Reviews Toxicology 228, 240 (2009).

[89] Perera, *supra* note 71, at 144.

[90] R.J. Delfino, *supra* note 37, at 192.

present value of heat-related costs in the United States is estimated at between $4.7 trillion and $10.4 trillion, at a 3% discount rate.[91] One analysis projects that U.S. GDP will be 1.0–3.0% lower at the end of the century under a business-as-usual warming scenario.[92] Because this analysis only includes impacts on certain sectors,[93] the actual cost will likely be even higher.

Importantly, the federal government's Fourth National Climate Assessment, issued in November 2018, finds that costs to selected sectors of the U.S. economy will reach $1.1 trillion by 2090.[94] The report concludes that "impacts to human health are likely to have some of the largest effects on the economy."[95] The largest categories of impacts identified in the Assessment include extreme temperature, reduced air quality, and reduced labor productivity from the health impacts of heat.[96]

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[91] Tatyana Deryugina & Solomon Hsiang, Nat'l Bureau Econ. Research, *The Marginal Product of Climate* 40 (2017).

[92] Solomon Hsiang et al., *Estimating Economic Damage from Climate Change in the United States*, 356 Science 1362, 1369 (2017).

[93] NCA, *supra* note 5, at 1360; Hsiang et al., *supra* note 92, at 1365.

[94] NCA, *supra* note 5, at 1358.

[95] *Id.* at 1369.

[96] *Id.* at 1358.

"In some sectors, the value of health damages is estimated to reach hundreds of billions of dollars per year" in a high-emissions scenario.[97] EPA has estimated that costs from impaired water quality alone will reach at least $3.2 billion by 2100, and extreme heat will lead to over 1.8 billion lost labor hours and $170 billion in lost wages.[98]

Infectious diseases can also lead to high health costs, particularly when they spread to unprepared areas. Only 329 people were infected in a 2002 outbreak of West Nile virus in Louisiana, but costs to the health system approached $210 million.[99]

Extreme weather events are already costly, and will become even more so. In 2016, there were fifteen extreme weather events in the United States whose costs exceeded $1 billion.[100] In 2017, there were sixteen extreme weather events costing $313 billion.[101] Flooding events have extremely high per-person costs:

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[97] *Id.* at 1369.

[98] EPA, *Climate Change in the United States: Benefits of Global Action* 28, 31 (2015), https://www.epa.gov/sites/production/files/2015-06/documents/cirareport.pdf.

[99] Kim Knowlton et al., *Six Climate Change–Related Events In The United States Accounted For About $14 Billion In Lost Lives And Health Costs*, 30 Health Affairs 2167, 2172 (2011).

[100] Bell et al., *supra* note 33, at 266–67.

[101] Salas et al., *supra* note 28, at 10.

2009 flooding in North Dakota led to health impacts costing over $145,000 per 1000 people in 2008 dollars.[102]

The magnitude of these impacts, however, can be significantly reduced if the federal government acts promptly to limit GHG emissions. The government's own National Climate Assessment explains that reducing emissions sufficiently to reach a lower emissions scenario rather than a higher one "is projected to reduce the number of premature deaths and lost labor hours from extreme temperatures by 24% and 21% (respectively) by 2050, and 58% and 48% by 2090."[103]

Reducing GHG emissions will produce significant additional health benefits. U.S. measures promoting clean energy and clean transportation could prevent 22,000 and 14,000 premature deaths, respectively, annually after 2030, mostly in the United States.[104] The San Francisco Department of Public Health has concluded that actions to reduce the city's GHG emissions would reduce the urban

[102] Knowlton et al., *supra* note 99, at 2170.

[103] NCA, *supra* note 5, at 1371. The Intergovernmental Panel on Climate Change projects that limiting warming to 1.5˚C—compared with 2˚C—will result in lower heat-related morbidity and mortality, lower ozone-related mortality, decreased risks from vector-borne diseases, and smaller net reductions in crop yields. IPCC, *Global Warming of 1.5˚C: Summary for Policymakers* 11 (2018).

[104] Drew T. Shindell et al., *Climate and Health Impacts of US Emissions Reductions Consistent with 2 °C*, 6 Nature Climate Change 503, 505 (2016).

heat island effect in the city, with the greatest benefits experienced by children and other vulnerable groups.[105]

CONCLUSION

Continued significant GHG emissions will dramatically shape the world in which the Juliana Generation will live, exposing them to grave, new health hazards. Reducing emissions will help alleviate the particular harms they face.

For the foregoing reasons, *amici* respectfully request that the Court grant Plaintiffs' request for a remand to the district court for trial.

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[105] S.F. Dep't Pub. Health, *Assessing the Health Co-Benefits of San Francisco's Climate Action Plan* 21, https://sfclimatehealth.org/wp-content/uploads/2018/12/CAP-130826.pdf (last visited Feb. 27, 2019).

[106] The Emmett Environmental Law & Policy Clinic acknowledges the significant contributions to this brief of Grant Glovin, a Clinic student.

CERTIFICATE OF COMPLIANCE

Pursuant to Federal Rule of Appellate Procedure 29(a)(4)(G), I hereby certify that the foregoing brief complies with the type-volume limitations in Federal Rules of Appellate Procedure 29(a)(5) and 32(a)(7)(b). It was prepared using Microsoft Word 2013 in Times New Roman 14-point font, a proportionally spaced typeface, and contains 6864 words.

/s/ Shaun A. Goho
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I hereby certify that I electronically filed the foregoing brief with the Clerk of the Court for the United States Court of Appeals for the Ninth Circuit by using the appellate CM/EF system on March 1, 2019. I certify that all participants in the case are registered CM/ECF users and that service will be accomplished by the appellate CM/ECF system.

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