Nos. 20-1530, 20-1531, 20-1778, 20-1780

IN THE

Supreme Court of the United States

WEST VIRGINIA, ET AL.,
Petitioners,

v.

ENVIRONMENTAL PROTECTION AGENCY, ET AL.,
Respondents.

ON WRIT OF CERTIORARI TO THE
UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

BRIEF OF CLIMATE SCIENTISTS MICHAEL OPPENHEIMER, NOAH DIFFENBAUGH, CHRISTOPHER FIELD, STEPHEN PACALA, DANIEL SCHRAG, AND SUSAN SOLOMON AS AMICI CURIAE IN SUPPORT OF RESPONDENTS

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ADDITIONAL CAPTIONS LISTED ON INSIDE COVER

THE NORTH AMERICAN COAL CORPORATION,
Petitioner,

v.

ENVIRONMENTAL PROTECTION AGENCY, ET AL.,
Respondents.

WESTMORELAND MINING HOLDINGS LLC,
Petitioner,

v.

ENVIRONMENTAL PROTECTION AGENCY, ET AL.,
Respondents.

NORTH DAKOTA,
Petitioner,

v.

ENVIRONMENTAL PROTECTION AGENCY, ET AL.,
Respondents.

TABLE OF CONTENTS

Page

TABLE OF AUTHORITIES iii

INTEREST OF AMICI CURIAE 1

SUMMARY OF ARGUMENT 4

ARGUMENT 7

I. IT IS UNEQUIVOCAL THAT HUMAN ACTIVITY IS THE CAUSE OF UNPRECEDENTED GLOBAL WARMING 7

A. The Greenhouse Effect Controls The Earth's Temperature, Which Has Been Rising At An Unprecedented Rate 7

B. The Only Convincing Explanation For The Rapid Rise In Global Temperature Is That Human Activity Has Altered The Makeup Of The Earth's Atmosphere 10

II. CLIMATE CHANGE ALREADY AFFECTS EVERY AMERICAN AND—WITHOUT ACTION—ITS IMPACT ON DAILY LIFE IS EXPECTED TO GROW IN DRAMATIC AND NOT FULLY PREDICTABLE WAYS 15

1. Climate Change Has Already Had Notable Effects Across The Country 15

2. Absent Action, More Severe Consequences Are Expected 26

III. THE UNITED STATES STILL HAS THE OPPORTUNITY TO HELP MITIGATE THE EFFECTS OF CLIMATE CHANGE 32

TABLE OF CONTENTS—Continued

Page

CONCLUSION 33

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INTEREST OF AMICI CURIAE

Amici curiae are individual climate scientists who have dedicated their careers to studying changes to the Earth's climate that have been caused by human activities and the broader effects of those changes.[1]

Amicus Michael Oppenheimer is the Albert G. Milbank Professor of Geosciences and International Affairs at Princeton University.[2] He is a long-time participant in the Intergovernmental Panel on Climate Change ("IPCC"), which won the Nobel Peace Prize in 2007. He served most recently as a coordinating lead author on IPCC's *Special Report on the Ocean and Cryosphere in a Changing Climate* (2019), and serves as a Review Editor of its Sixth Assessment Report. He has authored over 200 articles published in academic journals and co-authored two books, *Dead Heat: The Race against the Greenhouse Effect*, and *Discerning Experts: The Practices of Scientific Assessment for Environmental Policy*. He is a Heinz Award winner and a Fellow of the American Association for the Advancement of Science.

Amicus Noah S. Diffenbaugh is the Kara J Foundation Professor and Kimmelman Family Senior Fellow at Stanford University. He has served as a lead author for the IPCC. He is also an elected Fellow of the

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[1] No counsel for a party authored this brief in whole or in part, and no entity or person other than amici curiae and their counsel made a monetary contribution intended to fund the preparation or submission of this brief. Counsel for all parties have consented to the filing of this brief.

[2] Professor Oppenheimer and his colleagues are appearing in their individual capacities. University affiliations are listed for identification purposes only.

American Geophysical Union, which has bestowed upon him the James R. Holton Award and the William Kaula Award. He has been recognized as a Kavli Fellow by the U.S. National Academy of Sciences.

Amicus Christopher B. Field is the Melvin and Joan Lane Professor for Interdisciplinary Environmental Studies at Stanford University and the Perry L. McCarty Director of the Stanford Woods Institute for the Environment. He co-chaired IPCC's Working Group II from 2008 to 2015, where he led the effort to draft materials on climate change impacts and adaption. He is a member of the U.S. National Academy of Sciences and the American Academy of Arts and Sciences, and a fellow of the American Association for the Advancement of Science, the American Geophysical Union, and the Ecological Society of America. He has received the Max Planck Research Award, and the Roger Revelle Medal.

Amicus Stephen W. Pacala is the Frederick D. Petrie Professor in Ecology and Evolutionary Biology at Princeton University. He has chaired three expert committees for the National Academies of Sciences, Engineering and Medicine related to renewable energy, carbon emissions and mitigation, and the transition to a net-zero carbon economy. He has received numerous honors, including the Weldon Memorial Prize from Oxford University; the Presidential Award from the American Society of Naturalists; an appointment as a Lifetime Fellow of the Ecological Society of America; and the Robert H. MacArthur Award from the Ecological Society of America. He has been elected as a member of the National Academy of Sciences, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences.

Amicus Daniel P. Schrag is the Sturgis Hooper Professor of Geology and Professor of Environmental Science and Engineering at Harvard University and the Director of the Harvard University Center for the Environment. He is the author or co-author of over 180 journal articles, including research on new technological approaches to mitigating future climate change. He was the recipient of the James B. Macelwane Medal from the American Geophysical Union and was named a MacArthur Foundation Fellow in 2000. He has been elected as a member of the American Academy of Arts and Sciences and the American Association for the Advancement of Science.

Amicus Susan Solomon is the Lee and Geraldine Martin Professor of Environmental Studies at Massachusetts Institute of Technology. She is particularly well known for having pioneered the theory explaining why the ozone hole occurs in Antarctica and obtaining some of the first chemical measurements that helped to establish the chlorofluorocarbons as its cause. She has authored several influential scientific papers in climate science, including one on the irreversibility of the climate change problem. Among her many awards, she has received the National Medal of Science (the highest scientific honor in the US), as well as the Grande Medaille (the highest award of the French Academy of Sciences). She is a member of the National Academy of Sciences, the French Academy of Sciences, the Royal Society, the Pontifical Academy of Sciences, and the Acadameia Europaea. She also co-led IPCC's Working Group I. Time magazine named Professor Solomon as one of the 100 most influential people in the world in 2008.

The question presented in this case is of great importance to amici because it has the potential to curtail

the United States' ability to combat climate change at the federal level at a critical time. It is extremely likely that humanity's greenhouse gas emissions have already fundamentally altered the Earth's atmosphere, raising global surface temperature levels by about 2 degrees Fahrenheit since the late 19th century. While Americans have already felt, and will continue to feel, the impacts of climate change, regulatory action by EPA can still mitigate future danger—assuming EPA retains broad authority to act.

SUMMARY OF ARGUMENT

A decade ago, this Court recognized that EPA had found "'compelling' evidence" that humanity's greenhouse gas (e.g., carbon dioxide) emissions have changed the Earth's climate. *See American Elec. Power Co.* v. *Connecticut*, 564 U.S. 410, 417 (2011). At the time, the "dangers of greenhouse gas emissions" were projected to include "heat-related deaths; coastal inundation and erosion"; "more frequent and intense hurricanes, floods, and other 'extreme weather events'"; and "drought due to reductions in mountain snowpack and shifting precipitation patterns." *Id.*

The perilous future identified in *American Electric* has begun to emerge. Since that ruling, the scientific community has only grown more certain that humanity's actions have rapidly increased the Earth's temperature. It is now "unequivocal that human influence has warmed the atmosphere, ocean, and land." Intergovernmental Panel on Climate Change, *Sixth Assessment Report*, Headline Statements at 1 (Aug. 2021) ("*IPCC Sixth Assessment*").[3] And there is "[e]xtensive

[3] *Available* at tinyurl.com/5n878suk.

evidence[] … that human activities, especially emissions of greenhouse gases, are the dominant cause" of global warming since the 1950s. *See* U.S. Global Change Research Program, *Climate Science Special Report: Fourth National Climate Assessment, Volume I* at 10 (2017) ("*Fourth National Climate Assessment, Vol. I*").[4] Global surface temperature has already risen about 2 degrees Fahrenheit when compared to the late 19th century.[5] It is not too late to limit further warming and if greenhouse gas emissions can be significantly reduced, additional warming may amount to less than 2 degrees (i.e., a total warming of less than 4 degrees since the late 19th century). In the absence of sustained efforts to reduce greenhouse gas emissions, however, the total increase in temperature could surpass 10 degrees—leading to physical and ecological impacts that would be irreversible for thousands of years, if ever.

To put those numbers into perspective, the current 2 degree increase in temperature already has had notable effects across the country. Summer heatwaves and other periods of unusually warm weather have become more frequent and more intense, leading to balmy Decembers on the Atlantic Seaboard and temperatures in the Pacific Northwest during the summer of 2021 that were hot enough to melt power cables and buckle roads. Climate change has increased total rainfall and extreme flooding from storms like Hurricane Harvey, causing losses of human life and destroying billions of dollars of property in Texas and Louisiana. And rising

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[4] *Available* at tinyurl.com/yc5kb6bt.

[5] Unless otherwise stated, all references to temperature are measured in Fahrenheit.

temperatures have set the stage for a prolonged drought in the American west, increasing devastation from wildfires in environments as different as Montana forestland and the suburbs of Boulder, Colorado.

If the world remains on a path of high and rising greenhouse gas emissions, and the global temperature increases by 10 degrees or more, the impact on the American way of life is expected to be far worse. Absent large expenditures on measures to defend the coast, children born this year could see portions of coastal cities like New Orleans, Miami, and Annapolis disappear under a rising ocean. Such large increases in temperature, and accompanying increases in frequency or intensity of extreme weather events and drought could also have severe impacts on the United States' food security, economy, and national defense. These impacts would continue or accelerate already existing trends, but a dramatic increase in temperature raises the possibility of black swan events that have severe consequences but are difficult to predict—for example, destabilization of parts of the Antarctic or Greenland ice sheets leading to rates of sea level rise several times current estimates.

These projections are not a counsel of despair. It is still possible to mitigate the human and economic costs of climate change—as particularly relevant here, if greenhouse gas emissions from existing power plants and other sources can be reduced. But such mitigation will require significant coordination at the federal level. And this Court has recognized that EPA is the nation's "primary regulator of greenhouse gas emissions," the entity with "the scientific, economic, and technological resources [necessary to] cop[e] with issues of this order." *American Elec. Power*, 564 U.S. at 428. Because the D.C. Circuit's ruling below recognizes EPA's

obligation to develop the rules necessary to reduce greenhouse emissions, we respectfully submit that the decision should be affirmed.

ARGUMENT

I. IT IS UNEQUIVOCAL THAT HUMAN ACTIVITY IS THE CAUSE OF UNPRECEDENTED GLOBAL WARMING

A. The Greenhouse Effect Controls The Earth's Temperature, Which Has Been Rising At An Unprecedented Rate

The basic physics of the greenhouse effect are well-established. The Earth's atmosphere contains not just nitrogen and the oxygen we breathe, but also greenhouse gases like water vapor, carbon dioxide, methane, and nitrous oxide. *Fourth National Climate Assessment, Vol. I* at 74-80. As this Court has summarized, "greenhouse gases are so named because they 'trap … heat that would otherwise escape from the [Earth's] atmosphere.'" *American Elec. Power Co., Inc.* v. *Connecticut*, 564 U.S. 410, 416 (2011). The resulting "'greenhouse effect … helps keep the Earth warm enough for life.'" *Id.*

Indeed, much of the difference in surface temperature between the Earth, Venus (whose surface is hot enough to melt lead), and icy Mars can be explained by their respective greenhouse gas levels. *See Climate Change, Part I: H. Comm. Hearing Before the Subcomm. on Environment* at 3 (Apr. 9, 2019) (Testimony of Dr. Michael Oppenheimer) ("Oppenheimer 2019 Testimony").[6] Without greenhouse gases, for example, the Earth's average surface temperature would sink as low

[6] *Available at* tinyurl.com/2rxv2pfh.

as 0 degrees. NASA Earth Observatory, *Effects of Changing the Carbon Cycle* (June 16, 2011).[7]

It is similarly well-established that the Earth is warming at an unprecedented rate. *See IPCC Sixth Assessment*, Summary for Policymakers at 8[8]; *see also Fourth National Climate Assessment, Vol. I* at 10 ("This period is now the warmest in the history of modern civilization."). It can be stated with high confidence that the Earth's surface temperature has risen more quickly since 1970 than it has in any other 50-year period since the days of Julius Caesar. *Id.* As a result, "the six warmest years on record have all occurred since 2012," including 2021. *See* National Oceanic & Atmospheric Admin., *U.S. saw its 4th-warmest year on record, fueled by a record-warm December* (Jan. 10, 2022).[9] For Maine and New Hampshire, 2021 was "their second warmest year on record" and one of the five warmest for 19 other "states across the Northeast, Great Lakes, Plains, and West." *Id.*

We can state with high confidence that as temperatures have risen, the concentrations in the Earth's atmosphere of the greenhouse gases (carbon dioxide, methane, and nitrous oxide) have also increased and now are higher than they have been in hundreds of thousands of years. *IPCC Sixth Assessment*, Summary for Policymakers at 8. Carbon dioxide alone makes up a higher percentage of the atmosphere than it has in millions of years. *Id.* As the National Oceanic and Atmospheric Administration charts below demonstrate, the

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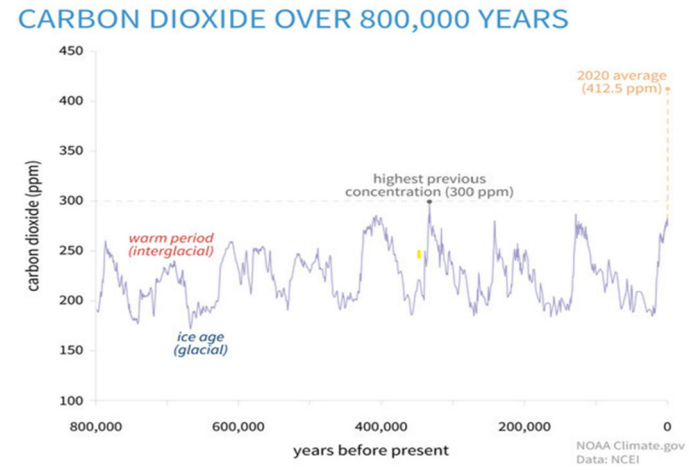
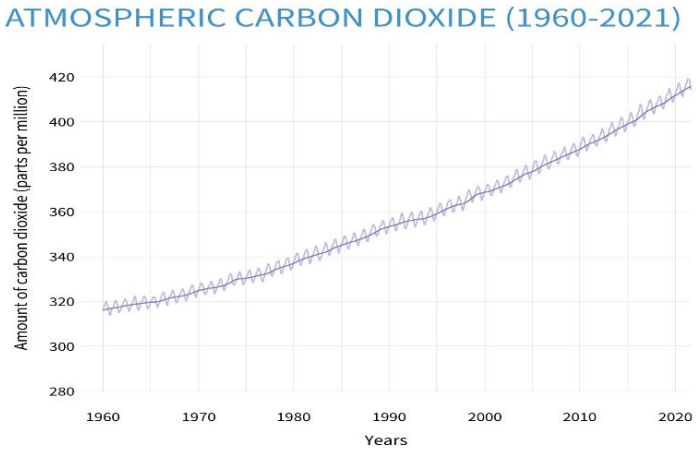
[7] *Available at* https://tinyurl.com/yckmw4a5.

[8] *Available at* https://tinyurl.com/y45v8mjj.

[9] https://tinyurl.com/2p8tt93x.

concentration of carbon dioxide in the atmosphere has skyrocketed in the last sixty years—as is apparent by comparison with the prior 800,000 years.[10]





[10] Both charts can be found at tinyurl.com/3rr7xmeu (visited Jan. 24, 2022). The charts' reference to "parts per million" or "ppm" refers to how many parts of carbon dioxide are in one million parts of air. For example, if carbon dioxide is measured at 416 ppm, there are 416 particles of carbon dioxide for every million particles of air.

B. The Only Convincing Explanation For The Rapid Rise In Global Temperature Is That Human Activity Has Altered The Makeup Of The Earth's Atmosphere

The observation of both a rapidly heating Earth and the skyrocketing levels of carbon dioxide in the modern era is not coincidental. Rather, the evidence is now "unequivocal that human influence has warmed the atmosphere, ocean, and land" and that "[w]idespread and rapid changes in the atmosphere, ocean, … and biosphere have occurred." *IPCC Sixth Assessment*, Summary for Policymakers at 4. Indeed, "[g]reenhouse gas emissions from human activities are the only factors that can account for the observed warming over the last century; there are no credible alternative human or natural explanations." U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* at 39-40 (2018) ("*Fourth National Climate Assessment, Vol. II*")[11]; *see also, e.g.*, Mann et al., *Record Temperature Streak Bears Anthropogenic Footprint*, 44 Geophys. Res. Lett. 7936, 7936 (2017) ("th[e] sequence of record-breaking temperatures [between 2014-2016] had a negligible (<.003%) likelihood of occurrence in the absence of … warming" caused by human activity).

Specifically, the average surface temperatures both globally and in the United States have increased by about 2 degrees since the late 19th century, with the majority of that increase occurring in the last 35 years. *See* Lindsey & Dahlman, *Climate Change: Global*

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[11] *Available at* https://tinyurl.com/ymhr5dcb.

Temperature (updated Aug. 12, 2021);[12] EPA, *Climate Change Indicators: U.S. and Global Temperature* (figs. 1-2) (updated Apr. 2021);[13] *Fourth National Climate Assessment, Vol. I* at 14. With "significant reductions in the emissions of greenhouse gases," it may be possible to limit that rise to less than 4 degrees. *Fourth National Climate Assessment, Vol. I* at 35. Without such reductions, the average global temperature increase could reach anywhere from 4 to 10 degrees by late in this century, depending on actual emissions. *IPCC Sixth Assessment*, Summary for Policymakers at 14.

Another demonstration of the connection between the rise in greenhouse gas concentrations in the atmosphere and global warming is a set of new observations from robotic thermometers (called "floats") across the world's oceans that are measuring heat absorption by the ocean at a global scale with unprecedented precision. *See* Destin, National Oceanic & Atmospheric Admin., *The Argo Revolution* (updated July 9, 2021).[14] These floats show that the deep ocean is slowly warming across the globe, and such warming is a predictable consequence of rising atmospheric greenhouse gas levels. Johnson & Lyman, *Warming trends increasingly dominate global ocean*, 10 Nature Climate Change 757, 757, 760 (2020); Lyman et al., *Robust warming of the global upper ocean*, 465 Nature 334, 334, 336 (2010); IPCC, *Special Report on the Ocean and Cryosphere in a Changing Climate*, Summary for Policymakers at 7, 9 (2019) ("*IPCC Ocean and Cryosphere*").[15] Indeed, such

[12] https://tinyurl.com/2xw9nfzn.

[13] *Available at* https://tinyurl.com/4jtcknad.

[14] https://tinyurl.com/2x7d85d3.

[15] *Available* at https://tinyurl.com/mswryzap.

sustained warming of the deep ocean cannot be explained by any process other than the rise of greenhouse gases.

As one of us has summarized, "the broad outlines of [this] problem bearing high risk for humans and society" have been clear for over thirty years, "even if many important details remained to be fleshed out." Oppenheimer 2019 Testimony at 3. By the late 1980s, it was known that (1) "atmospheric carbon dioxide … was increasing and the only plausible explanation was fossil fuel combustion along with a lesser contribution from deforestation," (2) "climate models projected a significant warming due to the increasing greenhouse effect," and (3) "it was … understood that the warming could bring Earth to temperatures not experienced in several million years by the end of the 21st century." *Id.* at 5. These findings led the United Nations—and later the United States, under the leadership of President George H.W. Bush—to create organizations dedicated to the study of climate change. *Id.* at 5-6 (discussing the founding of the Intergovernmental Panel on Climate Change); *see also* U.S. Global Change Research Program, *Legal Mandate*.[16]

Since its inception, the IPCC has released six full assessments of the basic science of climate change, the most recent of which is cited throughout this brief. Each report has provided increasingly strong evidence that human activity is responsible for the changes in the global climate:

- The Second Assessment, published in 1996, concluded that "The balance of evidence suggests a discernable human influence on global climate."

[16] tinyurl.com/2s3akhrx (visited Jan. 24, 2022).

Oppenheimer 2019 Testimony at 6 (quoting IPCC, *Second Assessment: Climate Change 1995* (1996) at 22[17]).

- The Third Assessment, published in 2001, found that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." *Id.* (quoting IPCC, *Third Assessment*: *Climate Change 2001* at 5 (first published 2001)[18]).
- The Fourth Assessment, published in 2007, "strengthened this finding further: 'Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in [human] greenhouse gas concentrations.'" *Id.* (quoting IPCC, *Fourth Assessment: Climate Change 2007*, Summary for Policymakers at 5 (first published 2007)[19]).
- The Fifth Assessment, published in 2013, stated that "'[i]t is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by [humanity's] increase in greenhouse gas concentrations and other' human activity." *Id.* (quoting IPCC, *Fifth Assessment: Climate Change 2014*, Summary for Policymakers at 5 (first published 2013)[20]).

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[17] *Available at* https://tinyurl.com/yckv5mtb.

[18] *Available at* https://tinyurl.com/32su34ku.

[19] *Available at* https://tinyurl.com/2p8dn2ze.

[20] *Available at* https://tinyurl.com/2p8djehj.

- And, as noted, the Sixth Assessment—published in August 2021—concluded that the evidence "unequivocal[ly]" shows that human activity has led to climate change. *See supra* p. 4.

The U.S. Global Change Research Program's reports—which are jointly authored by thirteen federal agencies pursuant to the Global Change Research Act of 1990—have followed a similar trajectory as the IPCC's.

- The first National Assessment, published in 2000, acknowledged that "[h]umans are asserting a major and growing influence on some of the key factors that govern climate" and that "[t]he intensity and pattern of temperature changes within the atmosphere implicates human activities as a cause." *See* U.S. Global Change Research Program, *Climate Change Impacts On The United States*, Report Overview at 12-13.[21]
- The second National Assessment, published in 2009, stated that "[t]he global warming observed over the past 50 years is due *primarily* to human-induced emissions of heat-trapping gases." *See* U.S. Global Change Research Program, *Climate Change Impacts in the United States* at 9 (emphasis added).[22]
- The third National Assessment, published in 2014, found that "observations *unequivocally* show that … the warming of the past 50 years is primarily due to human-induced emissions of heat-trapping gases." U.S. Global Change

[21] *Available at* https://tinyurl.com/5e3z3tka.

[22] *Available at* https://tinyurl.com/2e7dc9d2.

Research Program, *Climate Change Impact in the United States* at 5 (emphasis added).[23]

- And, as noted, the fourth National Assessment, first published in 2017, noted that there is "no convincing alternative explanation" for the global increase in temperature beyond human activity. *Fourth National Climate Assessment, Vol. I* at 10; *supra* pp. 4-5.

In sum, after decades of study, both the global and American scientific communities have arrived at the same, unequivocal conclusion: Human activity—in particular, the emission of greenhouse gases—has increased the Earth's temperature. *See, e.g., Fourth National Climate Assessment, Vol. II* at 36 ("[T]he evidence of human-caused climate change is overwhelming and continues to strengthen.").

II. CLIMATE CHANGE ALREADY AFFECTS EVERY AMERICAN AND—WITHOUT ACTION—ITS IMPACT ON DAILY LIFE IS EXPECTED TO GROW IN DRAMATIC AND NOT FULLY PREDICTABLE WAYS

1. Climate Change Has Already Had Notable Effects Across The Country

There is "a direct connection" between the 2 degree global temperature rise that has already taken place and "the resulting changes that affect Americans' lives, communities, and livelihoods, now, and in the future." *Fourth National Climate Assessment, Vol. II* at 36; *see also id.* at 55 (changes caused by warming "increasingly threaten the health and well-being of the American people"). Between 2015 and April 2018 alone, for

[23] *Available at* https://tinyurl.com/3mj4m7ef.

example, "the United States … experienced 44 billion-dollar weather and climate disasters …, incurring costs of nearly $400 billion." *Id.* at 66-68. Indeed, warmer temperatures in the United States have already been associated with a number of interrelated long-term climate trends, short-term weather events, and resulting impacts, such as (1) extreme heat and heatwaves, (2) rising sea levels, and accompanying coastal flooding, (3) increases in the frequency and intensity of storms producing heavy precipitation, including hurricanes and typhoons, (4) more intense and longer droughts, (5) wildfires, and (6) habitat degradation increasing risk of local extinctions and biodiversity loss.

a. Extreme Heat and Heatwaves: Temperatures across the United States have "increased rapidly" since the 1970s and in recent years, "twice as many high-temperature records have been set as low-temperature records." *Fourth National Climate Assessment, Vol. I* at 186, 190-192; *see also supra* p. 8. Heatwaves (i.e., "6-day periods with a maximum temperature above the 90th percentile") have similarly increased in most places in the country. *Fourth National Climate Assessment, Vol. I* at 191. By the federal government's estimate, the frequency has increased from 2 heatwaves per year in the 1960s to 6 per year in the 2010s. *See* EPA, *Climate Change Indicators: Heat Waves* (updated Apr. 2021).[24] This is no coincidence, as historical warming has made the hottest days of the year both more likely and hotter between 1961 and 2010. Diffenbaugh et al., *Quantifying the influence of global warming on unprecedented extreme climate events*, 114 Proceedings Nat'l Academy Sci. U.S.A. ("PNAS") 4881,

[24] *Available at* https://tinyurl.com/ye23jv82.

4882 (2017).[25] To take one recent example, an early study suggests that last summer's heatwave in the Pacific Northwest—where temperatures rose 40 degrees above average, hot enough to melt power cables and make asphalt buckle—was "virtually impossible without human-induced climate change." *See* Philip et al., *Rapid attribution analysis of the extraordinary heatwave on the Pacific Coast of the US and Canada June 2021*, World Weather Attribution (July 7, 2021);[26] *see also* Januta, *Pacific Northwest heat wave 'virtually impossible' without climate change-research*, Reuters (July 8, 2021);[27] *see also* Fischels, *PHOTOS: The Record-Breaking Heat Wave That's Scorching The Pacific Northwest*, NPR (June 29, 2021).[28]

The increasing temperature is especially troubling because "[e]xtreme heat is the leading cause of climate-related death in the" United States. *See Climate Change Science: Hearing Before the H. Comm. on Science, Space, and Technology* at 14 (Mar. 12, 2021) (Testimony of Dr. Michael Oppenheimer) ("Oppenheimer 2021 Testimony").[29] In particular, "[h]igh temperatures in the summer are linked directly to an increased risk of illness and death, particularly among older adults, pregnant women, and children." *Fourth National Climate Assessment, Vol. II* at 55. From 1991 to 2018, 37% of heat-related summer deaths worldwide were attributable to human-caused climate change. Vicedo-

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[25] *Available at* https://tinyurl.com/n3dd85ak.

[26] *Available at* https://tinyurl.com/y29dnrvp.

[27] https://tinyurl.com/dbpec3cj.

[28] https://tinyurl.com/3pncwwxt.

[29] *Available at* https://tinyurl.com/3b5jftfj.

Cabrera et al., *The burden of heat-related mortality attributable to recent human-induced climate change*, 11 Nature Climate Change 492, 492 (2021); *see also* Schwartz, *More Than a Third of Heat Deaths Are Tied to Climate Change, Study Says*, N.Y. Times (May 31, 2021).[30]

b. Sea Levels And Flooding: It can be stated with high confidence that global sea levels have risen faster since 1900 than over any prior century in 3000 years. *See IPCC Sixth Assessment*, Summary for Policymakers at 8. Rising sea levels are directly linked to climate change. Most of the heat trapped by greenhouse gases has been absorbed by the oceans, which have reacted to this heat as most liquids do—by expanding and taking up greater volume. *Id.* at 11; Oppenheimer 2021 Testimony at 5-6. At the same time, the ice sheets located around the Earth's poles and mountain glaciers alike have begun to melt at an increasing rate—that meltwater eventually ends up in the ocean. *See IPCC Sixth Assessment*, Summary for Policymakers at 11; Oppenheimer 2021 Testimony at 5-6.

Ocean levels rose 2.5 times faster between 2006-2015 (about 14 inches per century) than they did between 1901 and 1990 (about 6 inches per century). *IPCC Ocean and Cryosphere*, Summary for Policymakers at 10; Oppenheimer 2021 Testimony at 6. Rising sea levels have increased coastal flooding at high tide as much as "5- to 10-fold" over the norm in the 1960s in cities like Miami, Wilmington, North Carolina, and Charleston, South Carolina. *Fourth National Climate Assessment, Vol. II* at 99, 757. Similarly, areas of Norfolk, Virginia are now 4 times more likely to flood than

[30] https://tinyurl.com/yck4pjvm.

they were in the 1960s. *Id.* at 758. And between 1932 and 2016, Louisiana lost 2006 *square miles* of land due in part to high rates of sea level rise. *Id.* at 775. That is the equivalent of one football field-sized piece of land disappearing every 34 to 100 minutes. *Id.*

c. Storms and Hurricanes: Heavy rain and snow storms across most of the United States "have increased in both intensity and frequency since 1901." *Fourth National Climate Assessment, Vol. II* at 152. This result is consistent with higher temperatures leading to "higher levels of water vapor in the atmosphere, which in turn lead to more frequent and intense precipitation extremes." *Id.* at 88. Storm-caused flooding inflicts billions of dollars in damage annually in the United States, and research suggests that intensifying storms have been responsible for about a third of those costs in recent years. Davenport & Diffenbaugh et al., *Contribution of historical precipitation change to US flood damages*, 118 PNAS 1, 3 (2021).[31] For example, the exceptionally heavy precipitation and flooding events that occurred in the mid-Atlantic states including Pennsylvania, New Jersey, Maryland, and Washington, D.C. in 2018 were made 1.1 to 2.3 times more likely by human-caused climate change. Winter et al., *Anthropogenic Impacts on the Exceptional Precipitation of 2018 in the Mid-Atlantic United States*, 101 Bull. Am. Meteorological Soc'y 5, 5 (2020).[32]

Notably, the increase in intense rainstorms has combined with sea level rise to make hurricane season in the Atlantic Ocean more dangerous. *Fourth National Climate Assessment, Vol. I* at 27. While climate

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[31] *Available at* https://tinyurl.com/25d3szt5.

[32] *Available at* https://tinyurl.com/2exx26wk.

change may not necessarily increase the total number of hurricanes, hurricanes' precipitation totals are expected to rise. Unusually high precipitation totals have been observed and directly linked to climate change in some recent hurricanes. For example, one study estimated that as much as 38% of the total rainfall from Hurricane Harvey—a storm that made landfall in Texas and Louisiana in 2017—was caused by "human-induced climate change"; another study estimated that human activity made "the event itself three times more likely." *Fourth National Climate Assessment, Vol. II* at 95. And higher sea levels in combination with storm surge have further increased the risk of coastal flooding. Trenberth et al., *Hurricane Harvey Links to Ocean Heat Content and Climate Change Adaption*, 6 Earth's Future 730, 741-742 (2018) (using Hurricane Harvey to demonstrate how human-induced climate change causes higher sea temperature, intensifies storms, and increases flooding rains);[33] Lin et al., *Hurricane Sandy's flood frequency increasing from year 1800 to 2100*, 113 PNAS 12071, 12071-12073 (2016) (the frequency of Hurricane Sandy-like extreme flood events has increased significantly over the past two centuries due to the compound effects of sea level rise and storm surge).[34]

The results were catastrophic. The 2017 Atlantic hurricane season, for example, caused more than 250 deaths and $250 billion in damage. *Fourth National Climate Assessment, Vol. II* at 66. Hurricane Harvey's rainfall in Houston was about 30 inches and higher amounts fell at some locations nearby, with its total

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[33] *Available at* https://tinyurl.com/bdxn2vee.

[34] *Available at* https://tinyurl.com/29kvz2c7.

rainfall "likely exceed[ing] that of any known historical storm in the continental United States." *Id.* at 66, 95-96. It killed 68 people and inflicted $125 billion in damage, National Oceanic & Atmospheric Admin., *Service Assessment: August-September 2017 Hurricane Harvey* iv (June 2018);[35] it also "knocked out power to 300,000 customers in Texas," including hospitals and water treatment facilities, *Fourth National Climate Assessment, Vol. II* at 643.

d. Droughts: Rising global temperatures can "play a critical role in increasing the rate of drought onset, overall drought intensity, and drought impact through altered water availability and demand," *Fourth National Climate Assessment, Vol. II* at 399; and it can be said with medium confidence that "human-induced climate change" has made droughts worse by increasing the rate at which water evaporates into the atmosphere, *IPCC Sixth Assessment*, Summary for Policymakers at 8; *see also id.* at 24 (as temperatures increase in the future, "the level of confidence in and the magnitude of the change in droughts … increase").

Drought conditions in recent years have caused billions of dollars in damage in the western half of the United States. *Fourth National Climate Assessment, Vol. II* at 67. For example, the Northern Great Plains region—which encompasses states like Idaho and North Dakota—endured a severe drought in 2017 that damaged wheat crops and forced ranchers to sell off their cattle because they were unable to feed them. *Id.* Even today, Lake Powell—the nation's second-largest reservoir, which supplies drinking water to 40 million people in states like Utah and Arizona—is at just 27%

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[35] *Available at* https://tinyurl.com/nhaa5eha.

of capacity. *See* Maffly, *Feds tighten Colorado River flow at Glen Canyon Dam as ever-shrinking Lake Powell nears critical level*, Salt Lake Tribune (Jan. 7, 2022);[36] Meiners, *Scientists see silver lining in fed's latest efforts to avoid 'dead pool' at Lake Powell*, St. George Spectrum & Daily News (updated Jan. 12, 2022).[37]

e. Wildfires: Climate change can also play a role in wildfires, as higher temperatures dry out vegetation and make forests more likely to burn. *Fourth National Climate Assessment, Vol. I* at 243. Extreme wildfires are increasing in the western United States and human-caused warming has contributed to at least two-thirds of that increase. Zhuang et al., *Quantifying contributions of natural variability and anthropogenic forcings on increased fire weather risk over the western United States*, 118 PNAS 1, 7 (2021);[38] *see also* Diffenbaugh & Field, et al., *Atmospheric variability contributes to increasing wildfire weather but not as much as global warming*, 118 PNAS 1, 1 (2021) (Commentary).[39]

Specifically, "[h]uman-caused climate change is estimated to have doubled the area of forest burned in the western United States from 1984 to 2015." *Fourth National Climate Assessment, Vol. II* at 521. During the summer of 2015 alone, "over 10.1 million acres—an area larger than the entire state of Maryland—burned across the United States." *Id.* at 67-68. The scope of the wildfires in that year was unprecedented since

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[36] https://tinyurl.com/3pry3nmr.

[37] https://tinyurl.com/3c5eck93.

[38] *Available at* https://tinyurl.com/yc4marbz.

[39] *Available at* https://tinyurl.com/46nrucfp.

recordkeeping began in 1960, burning over 5 million acres in Alaska and 1 million in Montana. *Id.* In both 2017 and 2020, more than 10 million acres across the United States were burned each year. Congressional Res. Serv., *Wildfire Statistics* (updated Oct. 4, 2021).[40]

As a more recent example, just last month, the suburbs of Boulder County, Colorado were hit by the most destructive wildfire in state history—one that damaged or destroyed roughly 1,000 homes, *see* NASA Earth Observatory, *Colorado Faces Winter Urban Firestorm* (Dec. 30, 2021).[41] The six months prior to the fire were the warmest on record in the region, which was experiencing extremely dry conditions. Swain, *The Deadly Dynamics of Colorado's Marshall Fire*, Outside (Jan. 11, 2022).[42] Although climate change did not start the fire, in the words of one local researcher, it "led to a perfectly built stack of fuels in the fireplace, ready and waiting to be burned." Freedman, *Climate scientists grapple with wildfire disaster in their backyard*, Axios (Jan. 3, 2022);[43] *see also* Chuck, *How climate change primed Colorado for a rare December wildfire*, NBC News (updated Jan. 2, 2022).[44]

f. Loss of Biodiversity: Increases in temperature affect not just the land and seas, but the creatures that inhabit them. A hotter world "aid[s] the spread of invasive species" to new locations, while forcing other species to "shift[] their ranges … and [make] changes in

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[40] *Available at* https://tinyurl.com/2p857kth.

[41] https://tinyurl.com/a5xe5bpr.

[42] https://tinyurl.com/pe3wsjjw.

[43] https://tinyurl.com/2p8zbyux.

[44] https://tinyurl.com/4n9rfjfs.

the timing of important biological events." *Fourth National Climate Assessment, Vol. II* at 53. For example, tree-killing bark beetles have been able to dramatically expand their ranges in both the eastern and western United States. *Id.* at 250, 649, 1115. And in the Mississippi River Basin—the home of over 300 fish species, as well as waterfowl, turkey, moose, and alligator—more frequent hot days and milder winters have begun to disrupt the wildlife's mating and migration patterns. *See* National Wildlife Federation, *A Hunter's & Angler's Guide to Climate Change: Challenges, Opportunities & Solutions* 8-9 (Oct. 2021).[45]

In some cases, climate change has thinned species' populations and contributed to local extinction. *See* Wiens, *Climate-Related Local Extinctions are Already Widespread Among Plant and Animal Species*, 14 PLOS Biology 1, 1 (2016) ("[C]limate-related local extinctions have already occurred in … 47% of the 976 species surveyed" and "will presumably become much more prevalent as global warming increases");[46] Panetta et al., *Climate Warming Drives Local Extinction: Evidence from Observation and Experimentation*, 4 Sci. Adv. 1, 1 (2018) (finding that "local warming is driving local extinction").[47] The Midwest, for instance, may soon lose iconic trees like the paper birch and the black ash. *Fourth National Climate Assessment, Vol. II* at 873, 886.

The loss of biodiversity is not limited to the land. Oceans are getting warmer, *see supra* pp. 11-12, 18, and

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[45] *Available at* https://tinyurl.com/mrxd98uk.

[46] *Available at* https://tinyurl.com/nhf2cptc.

[47] *Available at* https://tinyurl.com/vc3pjs33.

"[i]t is virtually certain that human-caused [carbon-dioxide] emissions are the main driver" of ocean acidification, *IPCC Sixth Assessment*, Summary for Policymakers at 5. Acidification has caused a marked decrease in carbonate ions—the building blocks of coral and sea shells, *Fourth National Climate Assessment, Vol. II* at 357. The United States' major coral reefs are thus both dying (from the increased water temperatures, among other contributors to decline) and unable to rebuild (due to acidification). *Id.* at 359, 368. If no action is taken to reduce greenhouse gas emissions, the percentage of live coral in Hawaii will decline from 38% in 2010 to 11% in 2050; in southern Florida, live coral will vanish almost entirely. *See* EPA, *Multi-Modal Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment* 171-172 (May 2017).[48] Further north, the shellfish that live in the Gulf of Maine are also vulnerable to warming and ocean acidification, reducing the ability of Mainers to catch or raise shellfish like lobsters, scallops, blue crabs, and oysters. *Fourth National Climate Assessment, Vol. II* at 687. And on the other side of the country, salmon populations have been declining for decades and even facing extinction as a result of a warming climate. Crozier et al., *Climate change threatens Chinook salmon throughout their life cycle*, 4 Comms. Biology 1, 3, 5 (2021).[49]

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[48] *Available at* https://tinyurl.com/2p8fnrw3.

[49] *Available at* https://tinyurl.com/2p92tsm5.

2. Absent Action, More Severe Consequences Are Expected

Under any realistic emissions scenario, global surface temperature will continue to increase until at least 2050. *IPCC Sixth Assessment*, Summary for Policymakers at 14. If greenhouse gas emissions can be significantly reduced, additional warming may be limited to less than 2 degrees, or a total warming of less than 4 degrees since the late 19 century. *Id.* In the absence of sustained efforts to reduce greenhouse-gas emissions, the total increase in temperature could surpass 10 degrees. *Id.*

With "every additional increment[al]" change in temperature, "changes in extremes continue to become larger," meaning "increases in the frequency and intensity of hot extremes, … heavy precipitation, … agricultural and ecological droughts; an increase in the proportion of intense tropical cyclones; and reductions in Arctic sea ice, snow cover and permafrost." *IPCC Sixth Assessment*, Summary for Policymakers at 15. Failing to reduce greenhouse gas emissions will "impose substantial damages on the U.S. economy, human health, and the environment." *Fourth National Climate Assessment*, *Vol. II* at 1347. It will also lead to physical and ecological impacts that would be irreversible for thousands of years—if ever. *IPCC Sixth Assessment*, Summary for Policymakers at 21 (noting that changes to ocean temperature and acidification—as well as to permafrost at the Earth's poles—"are irreversible for centuries to millennia").

Because listing all potential harms that could occur in the next thirty to eighty years as a result of climate change would require hundreds of pages, *see, e.g.*,

Fourth National Climate Assessment, Vol. II at 72-1308, we have included representative examples below.

a. Coastal Cities And Landmarks Flooded: Under even a low emissions scenario, oceans will rise approximately 7-13 inches by midcentury and approximately 11-23 inches in eighty years. Oppenheimer 2021 Testimony at 7; Oppenheimer, et al., *Sea Level Rise and Implications for Low-Lying Islands, Coasts, and Communities* 321, 327, in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*.[50] To put that amount of sea level rise in practical terms, by 2050, water levels during storms and very high tides that were only seen once a century are expected *every year* in places like Savannah, Jacksonville, Miami, and San Diego. Oppenheimer 2021 Testimony at 9. The Northeast also faces flooding, particularly in the historic districts of cities like Annapolis, Maryland and Newport, Rhode Island, as well as portions of Washington D.C. near the tidal basin. *See Fourth National Climate Assessment, Vol. II* at 695-696 (noting that the "historic districts" in coastal cities and towns—like Annapolis and Newport, Rhode Island—*already* "face the threat of rising sea levels"). Without reductions in greenhouse gas emissions, ocean levels would go even higher, as much as approximately 9-16 inches by midcentury and approximately 24-43 inches by 2100. Oppenheimer 2021 Testimony at 7; Oppenheimer, *Sea Level Rise and Implications for Low-Lying Islands, Coasts, and Communities* 327.

b. Food Security At Risk: In numerous parts of the world, "[c]limate change has already affected food security due to warming, changing precipitation patterns,

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[50] *Available at* https://tinyurl.com/473nunx2.

and greater frequency of some extreme events." IPCC, *Climate Change and Land*, Summary for Policymakers at 10 (2020).[51] In the United States, "increases are expected in the incidence of drought and elevated growing-season temperatures," which will decrease the "[a]verage yields of many commodity crops (for example, corn, soybean, [and] rice") and "specialty crops" like fruits and vegetables. *Fourth National Climate Assessment*, *Vol. II* at 399-400; *see also* Gray, *Global Climate Change Impact on Crops Expected Within 10 Years, NASA Study Finds*, NASA (Nov. 2, 2021) (under a high emissions scenario, corn yields are projected to decline 24% by 2030).[52]

The Midwest's agricultural sector will be hit particularly hard and is "projected to be the largest contributing factor to declines in the productivity of U.S. agriculture." *Fourth National Climate Assessment*, *Vol. II* at 875. Indeed, "[p]rojected changes in precipitation, coupled with rising extreme temperatures before mid-century, will reduce Midwest agricultural productivity to levels of the 1980s" (assuming no major technological advances). *Id.* at 873.

c. Heat-Related Health Issues Spread: Rising heat will pose an increasing threat to human health. For example, if no action is taken to reduce greenhouse gas emissions, "almost three-quarters of the world's population" will be exposed to deadly levels of heat and humidity for at least 20 days a year by 2100. Mora et al., *Global risk of deadly heat*, 7 Nature Climate Change 501, 505 (2017).

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[51] *Available at* https://tinyurl.com/2p9deevt.

[52] https://tinyurl.com/285m2rvh.

In North America, climate change is projected to shift the "geographic range and distribution of disease-carrying insects and pests," meaning that "more people" "could [be] expos[ed] … to ticks that carry Lyme disease and mosquitos that transmit viruses such as West Nile, … dengue, and Zika." *Fourth National Climate Assessment, Vol. II* at 57, 545. Incidences of West Nile in particular "are projected to more than double by 2050[,]" "resulting in $1 billion per year in hospitalization costs and premature deaths under a higher [emissions] scenario." *Id.* at 552. Moreover, "[i]ncreasing water temperatures associated with climate change are projected" to increase the number of "harmful algae and coastal pathogens" in fresh water. *Id.* at 545. In the Great Lakes, for example, "[i]ncreased water temperatures and nutrient inputs contribute to algal blooms, including harmful cyanobacterial algae that are toxic to people, pets and many native species." *Id.* at 895.

d. Damage to National Economy: If greenhouse gas emissions are not reduced, the United States is projected to lose more than two billion labor hours a year by 2090 due to increasing temperatures, "costing an estimated $160 billion in lost wages." *Fourth Climate Assessment, Vol. II* at 50. Other harms wrought by climate change, including to coastal property, air quality, roads, and inland flooding, are expected to lead to over $200 billion in additional damage on an annual basis. *Id.* at 1358. For consumers, energy and water costs may skyrocket—particularly in the southern United States—as the demand for air conditioning increases and the competition for water between individuals, farmers, and power plants continues to grow. *See, e.g., id.* at 777-778.

e. National Security At Risk: Rising temperatures and intensifying storms due to climate change also implicate the United States' national security. The Department of Defense has recognized for well over a decade that "[g]lobal climate change will have wide-ranging implications for U.S. national security interests." *See* U.S. Department of Defense, *The National Security Implications of Climate-Related Risks and a Changing Climate* 2-3 (May 2015);[53] *see also* U.S. Department of Defense, *Climate Risk Analysis* 4 (Oct. 2021) ("Climate change touches most of what th[e] Department does, and this threat will continue to have worsening implications for U.S. national security.").[54] For example, national security is directly "impacted by damage to U.S. military assets such as roads, runways, and waterfront infrastructure from extreme weather and climate-related events." *Fourth National Climate Assessment, Vol. II* at 59. More broadly, "changes in climate increase risks … by affecting factors that can exacerbate conflict and displacement outside of U.S. borders, such as food and water insecurity and commodity price shocks." *Id.* Indeed, "in worst-case scenarios[,] climate-change related impacts could … contribute to mass migration events or political crises, civil unrest, shifts in the regional balance of power, or even state failure." U.S. Department of Defense, *Climate Risk Analysis* at 8.

f. Some of the Most Extreme Outcomes Are Unpredictable: It can be stated with high confidence that the probability of (currently) "low-likelihood, high-impact outcomes increases with higher global warming levels." *IPCC Sixth Assessment*, Summary for Policy-

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[53] *Available at* https://tinyurl.com/2p8ssywm.

[54] *Available at* https://tinyurl.com/yckkh5d5.

makers at 27; *accord Fourth National Climate Assessment, Vol. II* at 66 (similar). For instance, "[h]uman influence has likely increased the chance of" multiple climate-change-related impacts occurring at the same time, like "concurrent heatwaves and droughts," *IPCC Sixth Assessment*, Summary for Policymakers at 9 (emphasis omitted), or "extreme rainfall combined with coastal flooding," *Fourth National Climate Assessment, Vol. II* at 44-45. The "physical and socioeconomic impacts" of such "compound extreme events can be greater than the sum of the parts." *Id.* at 91. In the heatwave/drought example, demand for water would go up as supply goes down; in the extreme rainfall/coastal flooding example, ground that is already water-logged from the rain might absorb far less flood waters than normal.

Higher temperatures—and their accompanying effects—also increase the likelihood of "large-scale shifts in the climate system" (i.e., "tipping points"). *Fourth National Climate Assessment, Vol. II* at 66; *see also IPCC Sixth Assessment*, Summary for Policymakers at 27 ("with higher global warming levels," "[a]brupt responses and tipping points of the climate system … cannot be ruled out"). For example, it can be projected with high confidence that—over the next eighty years—water from increased rainfall and melting ice will weaken the Atlantic ocean currents that move warm water north and cold water south. *IPCC Sixth Assessment*, Summary for Policymakers at 27; *see also Fourth National Climate Assessment, Vol. I* at 418. While it can be said with medium confidence that the currents will not collapse during this century, "[i]f such a collapse were to occur, it would very likely cause abrupt shifts in regional weather patterns and water cycles"—e.g., shifting rain events further south and

away from Europe, *IPCC Sixth Assessment*, Summary for Policymakers at 27 (emphasis omitted)—and could cause sea levels in the northeastern United States to rise as much as 1.6 feet, *Fourth National Climate Assessment, Vol. I* at 418. As another example, warming temperatures in the Arctic could release substantial amounts of carbon dioxide and methane trapped in the permafrost and the ocean floor, "driv[ing] continued warming even if human-caused emissions stopped altogether." *Id.* at 418-419.

III. THE UNITED STATES STILL HAS THE OPPORTUNITY TO HELP MITIGATE THE EFFECTS OF CLIMATE CHANGE

While we cannot avoid all negative effects from climate change, it is not too late to limit the harm. Indeed, "[m]any climate change impacts and associated economic damages in the United States can be substantially reduced over the course of the 21st century" through reducing greenhouse gas emissions. *U.S. Fourth National Assessment, Vol. II* at 1347. Practically speaking, this means that "[d]ecisions made today determine risk exposure for current and future generations" and "the severity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur." *Id.* at 34.

As the nation with the second-highest emissions of carbon dioxide from fossil fuel combustion in the world (and higher than the largest emitter, China, on a per capita basis), Global Carbon Project, *Global Carbon Budget* at 19-20 (Nov. 4, 2021),[55] the policies that the United States sets into place can make a substantial difference in the conditions that future generations will

[55] *Available at* https://tinyurl.com/9zh44cd8.

face. *See IPCC Sixth Assessment*, Summary for Policymakers at 27-29 (noting "with *high* confidence … that there is a near-linear relationship" between carbon dioxide emissions and global warming). Substantially reducing emissions could "avoid[] thousands to tens of thousands of deaths per year from extreme temperatures," and "hundreds to thousands of deaths per year from poor air quality." *Fourth National Assessment, Vol. II* at 1359. And if global warming can be limited to less than a total of 4 degrees, the ultimate economic costs of climate change this century could be less than 1/4 of what they would be under a high emissions scenario. *Fourth National Assessment, Vol. II* at 1360. This Court should exercise caution before unduly limiting EPA's ability to enact rules that help protect the future for today's and tomorrow's children.

CONCLUSION

The judgment of the court of appeals should be affirmed.

Respectfully submitted,

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