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Re: Request for Comment on the Proposed Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks; Docket Nos. EPA-HQ-OAR-2018-0283 & FRL-9981-74-OAR; RIN 2127-AL76 & 2060-AU09

The Environmental Law Clinic at the University of California, Berkeley (UC Berkeley) submits the following comments on the Proposed Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks. The Clinic, a teaching law office at the UC Berkeley School of Law, engages in environmental legal and policy advocacy in the public interest. Recognizing that our rapidly changing climate poses a grave threat to both the public and the environment, the Clinic is committed to protecting laws, regulations, and policies that aim to scale back greenhouse gas (GHG) emissions. The Clinic's work to combat climate change is informed, in part, by the work of our colleagues at UC Berkeley, one of the world's leading academic institutions and home to many eminent scientists and researchers who have devoted their careers to studying climate change.

The Environmental Protection Agency (EPA) issued this Notice announcing its plan to rescind the existing vehicle GHG emission standards for cars manufactured through model year 2025, and instead freeze the standards at the 2020 levels for cars manufactured through model year 2026. Additionally, EPA is proposing to withdraw California's Clean Air Act (CAA) preemption waiver. The Clinic supports maintaining both the current federal vehicle GHG emissions standards, i.e., the standards promulgated in 2012, and California's waiver. Not only would weakening the federal standards undermine the purpose of the CAA to "protect . . . the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population,"[1] but it would expose California, which is already grappling with compelling and extraordinary conditions induced by climate change, to further unnecessary harm. Additionally, by repealing California's preemption waiver, EPA would undermine the state's efforts to limit the onset of those climate-induced conditions. To demonstrate how important both the existing federal vehicle GHG emissions standards and the CAA preemption waiver are to California, this comment letter explains many of the significant ways in which climate change affects this state and its citizens.

[1] 42 U.S.C. § 7401(b)(1).

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Introduction

Climate change has already dramatically impacted California's ecosystems, industries, and residents, and unless GHG emissions are reined in, the harm to this state over the next century will be tremendous. Climate change will increase drought, flooding, sea-level rise, wildfire activity, agricultural disruption, and disease outbreak. Controlling GHG emissions today can temper the extent and pace of these changes. Transportation is a major source of these emissions, accounting for fourteen percent of GHG emissions worldwide[2] and thirty-nine percent of GHG emissions in California.[3] Therefore, cutting back emissions from this sector is essential to tackling climate change and mitigating climate-related harms in California.

The proposed SAFE Vehicles Rule threatens to exacerbate these harms by relaxing the current federal GHG emissions standards for vehicles manufactured through model year 2025. Even more concerning is the proposed rule's plan to withdraw California's CAA preemption waiver. This unprecedented and unlawful move would disrupt California's vehicle emissions program, which has been operating under this waiver for more than five years. Losing the waiver would increase California's vulnerability to the effects of climate change, although EPA contends that the state does not need its own GHG emissions standards to meet any "compelling and extraordinary conditions," citing CAA section 209(b)(1)(B).[4]

Preliminarily, withdrawing California's waiver on this basis would not be in accordance with law and would exceed the limits of EPA's narrow authority under section 209(b).[5] A determination on "compelling and extraordinary conditions" is a basis for an initial waiver *denial* but not one for *withdrawal* of a waiver, five years after EPA issued it.[6] Section 209(b) does not grant EPA any residual authority over a preemption waiver. Indeed, the legislative history and structure of section 209(b) are clear that EPA's discretion with respect to California's waiver is "sharply restricted," and Congress structured the provision to strongly favor California's maintaining its own vehicle emissions standards.[7]

Regardless, if there is any doubt that California is facing "compelling and extraordinary conditions" induced by GHG-driven climate change, this letter, based in significant part on nearly a dozen interviews with climate researchers at UC Berkeley and affiliated institutions,[8] sets forth many of the significant ways in which climate change has affected and will continue to affect this state and its citizens. These researchers described their findings and predictions, reflecting current scientific understanding and some of the most sophisticated climate analyses.

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[2] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 44 (2014).
[3] *California Greenhouse Gas Emission Inventory – 2017 Edition*, CAL. AIR RES. BD., https://www.arb.ca.gov/cc/inventory/data/data.htm (last visited Oct. 29, 2017).
[4] 42 U.S.C. § 7543(b)(1)(B).
[5] 5 U.S.C. § 706(2)(A),(C); *see Motor & Equip. Mfrs. Ass'n, Inc. v. EPA*, 627 F.2d 1095, 1121-22 (D.C. Cir. 1979) (explaining that since Congress wanted to grant California the "broadest possible discretion" in setting its emissions standards, it set a presumption that the standards satisfy the waiver requirements, placing "the burden of proving otherwise" on those who challenge the waiver).
[6] *See* 42 U.S.C. § 7543(b)(1)(B).
[7] *See Motor & Equip. Mfrs. Ass'n, Inc. v. EPA*, 627 F.2d 1095, 1121 (D.C. Cir. 1979).
[8] *See* Appendix A.

Although this letter does not provide a comprehensive overview of all the climate-change impacts facing California, it reveals California's vast exposure to harm if EPA shirks its CAA duties by relaxing the current federal vehicle GHG emissions standards and withdrawing California's CAA preemption waiver.

Part I of this letter provides a foundation for understanding the extraordinary and compelling ways in which climate change affects California by describing direct, physical changes to the state's environment. The remaining sections examine the ways in which those physical changes will, in turn, affect the state's infrastructure, its key industries, and the health of its citizens. Part II describes effects on California's water management and energy infrastructure. Part III examines industry effects by discussing anticipated changes to one of the state's most important and lucrative sectors: agriculture. Finally, Part V discusses some of the anticipated human health effects of climate change facing Californians. In sum, this letter previews the significant ways in which California will change if GHG emissions rates remain unchecked and demonstrates why both the existing federal vehicle GHG emissions standards and the California waiver are critical for this state and its citizens.

I. Physical Effects of Climate Change in California

Over the course of the twenty-first century, California's atmosphere and physical environment will change dramatically due to climate change. The state will be hotter, with increases in average annual temperatures, daily temperature highs, and heatwaves. Precipitation patterns in California will also fundamentally change. There will be less snowfall, and during California's rainy season, storms will be fewer and significantly more intense. Ultimately, these shifts threaten to devastate California's water supply. These hotter and drier conditions will not only change the physical environment and atmosphere, but their compounded effects disrupt other natural systems in California like wildfires, which are likely to intensify and become more frequent in the coming century. Finally, as a coastal state with approximately 1,000 miles of shoreline, the threat of sea-level rise further enhances California's vulnerability to climate change. This Part describes, in detail, the physical changes to California's environment that are driven by climate change.

A. High Temperatures and Heat

Increasing GHG levels in the atmosphere will increase average annual temperatures and extreme heat events in California. This state is especially vulnerable to warming: temperature increases over the past century were most pronounced in California and other western states, outpacing the rest of the country by a factor of two.[9] This warming was intensified by GHG emissions produced by human activity, known as anthropogenic emissions.[10] Already, average

[9] Gerald A. Meehl, et al. *Mechanisms Contributing to the Warming Hole and the Consequent U.S. East-West Differential of Heat Extremes*, 25 J. CLIMATE 6394, 6394-95 (2012).

[10] Thomas R. Knutson, et al., *Multimodal Assessment of Regional Surface Temperature Trends: CMIP3 and CMIP5 Twentieth Century Simulations*, 26 J. Climate 8709 (2013); Russell S. Vose, et al., *Temperature changes in the United States*, 1 CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT 185, 186-88, 192-98 (2017) (attributing temperature increases to human activity).

annual temperatures in California are projected to increase by roughly 3.6 °F by the 2060s.[11] Summers, particularly, will be significantly warmer, especially in inland areas of the state, where there is no temperature moderation by the ocean.[12] Additionally, unchecked GHG emissions threaten California with extreme heat events. In the decades from 1950 to present, California already experienced an increase in the occurrence of extreme heat days and more frequent, sustained, and intense heatwaves.[13] These trends will only continue in the decades ahead.[14]

Climate change threatens to make these heat events in California even longer, more frequent, and more severe, breaking record after record in quick succession.[15] The extent and magnitude of these anticipated increases in annual temperatures and extreme heat scale with the quantity of GHG emissions released into the atmosphere today.[16] Climate mitigation strategies like vehicle GHG emissions standards are thus essential to managing these heat and temperature-related harms facing California.

B. Hydrological Effects

California's water resources are extremely vulnerable to devastation due to hydrological changes induced by climate change. The most notable of these expected changes are increased likelihood of powerful, flood-inducing storms, loss of major storm events essential to maintaining the state's water supply, and reduction of snowpack, an important natural water storage system. This Subpart examines each of these effects in detail, thereby explaining another element of California's extreme vulnerability to climate change.

i. Precipitation Shifts

Climate change brings to California more intense storms, more dramatic precipitation variation, and a heightened risk of drought. One of the most powerful ways in which precipitation in California will change is through an uptick in "a particularly dangerous subset of flood-generating storms": those caused by atmospheric rivers.[17] Atmospheric rivers are narrow bands of extremely concentrated, moist air, akin to "rivers in the sky,"[18] that transport water

[11] David W. Pierce et al., *Probabilistic Estimates of Future Changes in California Temperature and Precipitation Using Statistical and Dynamical Downscaling*, 40 CLIMATE DYNAMICS 839, 844 (2012).
[12] David W. Pierce et al., *Probabilistic Estimates of Future Changes in California Temperature and Precipitation Using Statistical and Dynamical Downscaling*, 40 CLIMATE DYNAMICS 839, 844, 854 (2012).
[13] Sarah E. Perkins, et al., *Increasing Frequency, Intensity, and Duration of Observed Global Heatwaves and Warm Spells*, 39 Geophys. Res. Letters 1, 2-3 (2012).
[14] Norman L. Miller et al., *Climate, Extreme Heat, and Electricity Demand in California*. 47 J. APPLIED METEOROLOGY & CLIMATOLOGY 1834, 1835, 1842 (2008).
[15] Scott. C. Sheridan, et al., *Future Heat Vulnerability in California, Part I: Projecting Future Weather Types and Heat Events*, 115 CLIMATE CHANGE 291, 306 (2012); Katharine Hayhoe, et al., *Emissions Pathways, Climate Change and Impacts on California*, 101 PROC. NAT'L ACAD. SCI. 12422, 12427 (2004).
[16] *See* Katharine Hayhoe, et al., *Emissions Pathways, Climate Change and Impacts on California*, 101 PROC. NAT'L ACAD. SCI. 12422, 12424 (2004).
[17] Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514, 515 (2011).
[18] *See* Alexandra Witze, *California Study Targets Rivers in the Sky*, 517 Nature 424, 424 (2015).

vapor from the tropics to the poles.[19] When atmospheric rivers from the tropics near Hawaii travel northeastward and eventually reach California, they can cause downpours of rain or heavy snowstorms.[20] In fact, atmospheric rivers are responsible for most of the major floods in California history.[21] Although atmospheric river storms are important for ensuring that California is not in drought,[22] climate change will intensify these storms in the state because warmer temperatures will transfer even more ocean water into atmospheric rivers.[23] And as larger atmospheric river storms will become more frequent, California will experience increased flooding.[24]

Additionally, climate change will intensify the cycling of warm and dry years in California, dictated by the El Niño and La Niña weather patterns.[25] El Niño and La Niña are cyclical oceanic climate patterns that largely determine precipitation variation in California: El Niño years are rainy, while La Niña years are drier.[26] Climate change will likely lead to drier La Niña years and more intense precipitation in El Niño years.[27]

The climate-change-induced increase in precipitation intensity does not mean that California will benefit from an abundance of water; precipitation frequency will also drop,

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[19] Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514, 515 (2011).

[20] Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514, 515 (2011).

[21] Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514, 515 (2011).

[22] Phone Interview with Michael F. Wehner, Senior Staff Scientist, Lawrence Berkeley National Laboratory (Nov. 8, 2017) (The opinions of Dr. Michael F. Wehner are his alone and in no way represent the views of the U.S. Department of Energy, the University of California, or the Lawrence Berkeley National Laboratory).

[23] Robert J. Allen & Rainer Luptowitz, *El Niño-Like Teleconnection Increases California Precipitation in Response to Warming*, NATURE COMMUNICATIONS (July 2017), at 7, 11. While the rate at which atmospheric rivers will transport precipitation from the tropics to California remains unclear, models show a trend of increased precipitation brought on by a warming climate. *See id.* at 11. In addition, rising temperatures increase the capacity of the atmosphere to hold water vapor and these heightened levels of saturation of water vapor result in more intense downpours. *See* David R. Easterling et al., *Precipitation Change*, *in* U.S. GLOBAL CHANGE RES. PROGRAM, 1 CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT 210 (2017). California will likely experience a rate of saturation of at least six percent more water vapor in the atmosphere per 1^{o} C (1.8^{o} F) of warming. *See id.*; Phone Interview with Michael F. Wehner, Senior Staff Scientist, Lawrence Berkeley National Laboratory (Nov. 8, 2017) (The opinions of Dr. Michael F. Wehner are his alone and in no way represent the views of the U.S. Department of Energy, the University of California, or the Lawrence Berkeley National Laboratory).

[24] Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514, 515, 521 (2011).

[25] Xingying Huang & Paul A. Ullrich, *Changing Character of Twenty-First-Century Precipitation over the Western U.S. in the Variable-Resolution CESM*, 30 J. CLIMATE 7555, 7572 (2017). Scientists refer to the phenomenon of climate shifting between El Niño and La Niña phases as the El Niño Southern Oscillation (ENSO). *See id.*; Kevin E. Trenberth, *The Definition of El Niño*, 78 BULLETIN AM. METEOROLOGICAL SOC'Y 2771, 2772 (1997). For simplicity, this comment refers to ENSO by its El Niño/La Niña phases.

[26] Xingying Huang & Paul A. Ullrich, *Changing Character of Twenty-First-Century Precipitation over the Western U.S. in the Variable-Resolution CESM*, 30 J. CLIMATE 7555, 7572 (2017); Kevin E. Trenberth, *The Definition of El Niño*, 78 BULLETIN AM. METEOROLOGICAL SOC'Y 2771, 2772 (1997).

[27] *See* Xingying Huang & Paul A. Ullrich, *Changing Character of Twenty-First-Century Precipitation over the Western U.S. in the Variable-Resolution CESM*, 30 J. CLIMATE 7555, 7569–71 (2017).

thereby increasing drought risk.[28] For example, in Southern California, dramatic drops in precipitation frequency will outweigh gains in storm intensity, causing a substantial loss of rain overall.[29] Along the northern coast and in the Sierra Nevada, where most of the state's precipitation occurs,[30] declines in precipitation frequency are significant because only a small number of winter storms dictate the state's water supply; loss of a single storm event could mean drought for the whole state.[31]

These anticipated precipitation losses and extremely hot temperatures in California, both attributable to anthropogenic GHG emissions, have raised the likelihood that the state will experience devastating droughts.[32] A large number of climate models agree, with near certainty, that over the next few decades any dry period in California will also be extremely warm.[33] Although the precipitation loss is the direct cause of drought, hot temperatures accelerate evaporation of what ground water remains; this exacerbates the intensity and impact of drought and heat waves.[34] Climate change has likely increased the probability that very hot and very dry conditions will persist for consecutive years, meaning extended droughts that will jeopardize human health, the economy, and natural systems in California.[35] Maintaining the existing federal vehicle GHG emissions standards and retaining California's preemption waiver can help diminish the scale of such severe droughts.

ii. Snowpack Loss

Climate change will also compromise California's snowpack, one of the state's crucial water storage resources, by both diminishing snow accumulation and disrupting melting patterns.[36] Snowpack accumulates in winter, when about eighty percent of California's

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[28] David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879, 5891 (2013).
[29] David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879, 5893, 5895 (2013).
[30] David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879, 5891-92 (2013).
[31] *See* Michael D. Dettinger, *Historical and Future Relations Between Large Storms and Droughts in California*, 14 S.F. WATERSHED & ESTUARY SCI., July 2016, at 2, 18–19; David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879, 5893 (2013).
[32] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015); *see* Toan Trinh et al., *Assessment of 21st Century Drought Conditions at Shasta Dam Based on Dynamically Projected Water Supply Conditions by a Regional Climate Model Coupled with a Physically-based Hydrology Model*, 586 SCI. TOTAL ENV'T 197, 204 (2017).
[33] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3931 (2015).
[34] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3931 (2015).
[35] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015); *see also* Amir AghaKouchak et al., *Global Warming and Changes in Risk of Concurrent Climate Extremes: Insights from the 2014 California Drought*, 41 GEOPHYS. RES. LETT. 8847, 8851 (2014).
[36] *See* Soumaya Belmecheri et al., *Multi-Century Evaluation of Sierra Nevada Snowpack*, NATURE CLIMATE CHANGE, Jan. 2016, at 2; Yixin Mao et al., *Is Climate Change Implicated in the 2013–2014 California Drought? A Hydrologic Perspective*, 42 GEOPHYSICAL RES. LETTERS 2805, 2805 (2015); David W. Pierce et al., *Attribution of Declining Western U.S. Snowpack to Human Effects*, 21 J. CLIMATE 6425, 6441 (2008).

precipitation occurs, and supplies the state with water as it melts in the warmer spring and summer months.[37] Snowmelt from the Sierra Nevada mountains provides surface water for municipal and agricultural use throughout California, supplying thirty percent of the state's water supply.[38]

Climate change will likely cause annual precipitation to fall more as rain than snow, particularly in the lower catchments, reducing snowpack volume by as much as thirty percent between 2000 and 2039.[39] Diminished snowpack will strain California's water supply because there will be less runoff from snowmelt.[40] This loss of runoff will be especially consequential in summer months, which will already be drier due to climate-change-related loss of spring precipitation.[41]

Rising temperatures also melt snowpack earlier in the year, decreasing spring and summer stream flows and diminishing California's overall water supply.[42] In 2015, a year with record high winter temperatures, the amount of water contained in California's snowpack fell to levels below any point in the past five hundred years.[43] Moreover, increasingly warmer rainfall from atmospheric rivers could accelerate the melting of the snowpack.[44]

The loss of snowpack from climate change poses a major threat to California's water security and ecological integrity. Reduced snowpack runoff decreases surface soil moisture[45] and surface-water availability.[46] It also reduces groundwater recharge in the Central Valley.[47] This

[37] Soumaya Belmecheri et al., *Multi-century evaluation of Sierra Nevada snowpack*, NATURE CLIMATE CHANGE, Jan. 2016, at 2.
[38] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015); Yixin Mao et al., *Is Climate Change Implicated in the 2013–2014 California Drought? A Hydrologic Perspective*, 42 GEOPHYSICAL RES. LETTERS 2805, 2805 (2015).
[39] Moetasim Ashfaq et al., *Near-term Acceleration of Hydroclimatic Change in the Western U.S.*, 118 J. GEOPHYSICAL RES. 10676, 10689 (2013).
[40] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015).
[41] David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879, 5895 (2013).
[42] Amir AghaKouchak et al., *Comment: Recognize Anthropogenic Drought*, 524 NATURE 409, 410–11 (2015); Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015).
[43] Soumaya Belmecheri et al., *Multi-century Evaluation of Sierra Nevada Snowpack*, NATURE CLIMATE CHANGE, Jan. 2016, at 2. Snow water equivalent on April 1, 2015 was at only five percent of its historical average. *Id.*
[44] Phone Interview with Michael F. Wehner, Senior Staff Scientist, Lawrence Berkeley National Laboratory (Nov. 8, 2017) (The opinions of Dr. Michael F. Wehner are his alone and in no way represent the views of the U.S. Department of Energy, the University of California, or the Lawrence Berkeley National Laboratory).
[45] *See* Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015).
[46] Richard Seager et al., *Projections of Declining Surface-Water Availability for the Southwestern United States*, 3 NATURE CLIMATE CHANGE 482, 485 (2012).
[47] Thomas Meixner et al., *Implications of Projected Climate Change for Groundwater Recharge in the Western United States*, 534 J. HYDROLOGY 124, 133 (2016). Reductions in groundwater recharge are projected to be greater in the Central Valley because, in Northern California, irrigators use more surface water than groundwater. *Id.* at 135. The Death Valley Regional Flow System, shared between California and Nevada, is also anticipated to experience losses in groundwater recharge, but the Meixner et al. synthesis report did not provide exact percentages. *Id.* at 133.

diminished water availability places additional pressure on the competing water demands of the agriculture sector, a growing human population, and riparian ecosystems.[48]

In sum, diminishing snowpack and loss of precipitation will have profound consequences for California, touching every industry, ecosystem, and resident. The magnitude of the anticipated water supply losses demonstrates the urgency of mitigating these impacts by scaling back GHG emissions as soon as possible. California's fragile water supply is one reason, among many, that maintaining the existing vehicle GHG emissions standards is important to this state.

C. Wildfire

The rising temperatures and precipitation shifts described in the two preceding sections will also disrupt other natural systems in California such as wildfire. The effects of climate change on wildfires in California will be significant.

California's record-breaking 2017 fire season illustrates the high stakes and magnitude of risk associated with wildfires in this state. In October 2017, a series of massive wildfires raged through eight Northern California counties, including Napa and Sonoma, killing forty-three people and ruthlessly razing entire neighborhoods.[49] The fires damaged at least ten thousand homes[50] and twenty-seven vineyards[51] and displaced up to eight thousand people.[52] An early estimate of insured losses from the fires was more than $3 billion.[53]

A few months later, in December 2017, a massive wildfire tore through Ventura and Santa Barbara counties in Southern California.[54] This was the largest fire on record in the state.[55] Two people died and the fire destroyed 1,000 buildings, including at least 750 homes.[56] This fire

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[48] Richard Seager et al., *Projections of Declining Surface-Water Availability for the Southwestern United States*, 3 NATURE CLIMATE CHANGE 482, 486 (2012).

[49] Sarah Ravani, *Wine Country Fires Destroyed 8,889 Structures*, S.F. GATE (Nov. 2, 2017), http://www.sfgate.com/bayarea/article/Wine-Country-fires-destroyed-8-889-structures-12328007.php; Peter Fimrite & Kurtis Alexander, *17-Year-Old Dies of Burns, Becomes 43rd Victim of California Wildfires*, S.F. GATE (Oct. 30, 2017), http://www.sfgate.com/bayarea/article/17-year-old-dies-of-burns-becomes-43rd-victim-of-12317178.php; *see* Anjali Singhvi & Derek Watkins, *Satellite Images Show 1,800 Buildings Destroyed by Fire in Santa Rosa*, N.Y. TIMES (Oct. 12, 2017), https://www.nytimes.com/interactive/2017/10/12/us/santa-rosa-california-fires-damage.html; Tiffany Hsu, *In California Wine Country, Wildfires Take a Toll on Vintages and Tourism*, N.Y. TIMES (Oct. 10, 2017), https://www.nytimes.com/2017/10/10/business/wineries-california-wildfire.html.

[50] *Insured Losses from October Wildfires Top $3 Billion Statewide*, CAL. DEP'T INS., https://www.insurance.ca.gov/0400-news/0100-press-releases/2017/release118-17.cfm (last visited Nov. 26, 2017).

[51] Paul Hodgins, *27 Wineries Damaged or Destroyed by Recent Fires*, ORANGE CTY. REG. (Oct. 23, 2017), http://www.ocregister.com/2017/10/23/list-of-wineries-damaged-or-destroyed-by-recent-fires/.

[52] Lizzie Johnson, *Big Wine Country Fire Question: Where Are All the Displaced Going to Live?* S.F. CHRONICLE (Oct. 25, 2017), http://www.sfchronicle.com/bayarea/article/Big-Wine-Country-fire-question-Where-are-all-the-12303601.php.

[53] *Insured Losses from October Wildfires Top $3 Billion Statewide*, CAL. DEP'T INS., https://www.insurance.ca.gov/0400-news/0100-press-releases/2017/release118-17.cfm (last visited Nov. 26, 2017)

[54] Michael Livingston & Javier Panzar, *Thomas Fire Becomes Largest Wildfire on Record in California*, L.A. TIMES (Dec. 22, 2017), http://www.latimes.com/local/lanow/la-me-thomas-fire-size-20171222-20171222-htmlstory.html.

[55] California Dep't of Forestry & Fire Protection, *Top 20 Largest California Wildfires* (Dec. 22, 2017), http://fire.ca.gov/communications/downloads/fact_sheets/top20_acres.pdf.

[56] Michael Livingston & Javier Panzar, *Thomas Fire Becomes Largest Wildfire on Record in California*, L.A. TIMES (Dec. 22, 2017), http://www.latimes.com/local/lanow/la-me-thomas-fire-size-20171222-20171222-htmlstory.html;

also damaged hundreds of thousands of acres of agricultural land in Ventura and Santa Barbara counties, the biggest lemon- and avocado-producing area in the United States.[57] California's 2017 fire season was likely the most destructive in the state's history.

Data gaps preclude attribution of the 2017 California wildfires to climate change,[58] but climate change is increasing the risk that wildfires as devastating as these will afflict California now and in the future.[59] As of August 1, 2018—the early weeks of the fire season—there were already 17 large wildfires raging in the state, including the seventh most destructive fire in California history.[60] Although wildfires are endemic to California and important to ensuring forest health,[61] the hotter and drier conditions attributable to anthropogenic forcing of climate change is amplifying wildfire activity in California.[62] Increasing heat and loss of precipitation dries out plant matter and vegetation, and this enhances both the availability and flammability of wildfire fuel.[63]

Additionally, climate change expands the window of wildfire season in California, which typically runs from summertime to early fall, a hot and dry time in the state. As climate change brings hot and dry weather to historically cooler spring months, plant matter will dry out earlier in the year and become susceptible to burning.[64] Increasing variability in precipitation increases the probability of delays in the onset of California's rainy season, which historically began in October,[65] and this can extend wildfire risks into late-autumn and even winter months.[66] In Northern California, for example, the end of wildfire season is dependent on the occurrence of the first large rainstorm, which may come later in some years due to climate change.[67]

Associated Press, *All Significant California Wildfire Evacuation Orders Lifted*, N.Y. TIMES (Dec. 21, 2017), https://www.nytimes.com/aponline/2017/12/21/us/ap-us-california-wildfires.html.

[57] Miriam Jordan, *More Victims of the California Wildfires: Avocados and Lemons*, N.Y. TIMES (Dec. 13, 2017), https://www.nytimes.com/2017/12/13/us/california-fires-avocados.html.

[58] California fire records do not closely track fire trends on a geographic scale as small as a few counties. Phone Interview with Anthony L. Westerling, Associate Professor, University of California, Merced (Nov. 2, 2017).

[59] Benjamin P. Bryant & Anthony L. Westerling, *Scenarios for Future Wildfire Risk in California: Links between Changing Demography, Land Use, Climate, and Wildfire*, 25 ENVIRONMETRICS 468 (2014).

[60] Julia Jacobs, *The Carr Fire, the 7th Most Destructive in California History, Rages On*, N.Y. TIMES (July 31, 2018), https://www.nytimes.com/2018/07/31/us/carr-fires-california-explained.html.

[61] Gregg Garfin et al., *Southwest*, *in* U.S. GLOBAL CHANGE RES. PROGRAM, NATIONAL CLIMATE ASSESSMENT 468 (2014).

[62] *See, e.g.*, John. T. Abatzoglou & A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western U.S. Forests*, 113 PROC. NAT'L ACAD. SCI. 11770, 11773 (2016) (finding that anthropogenic contributions to climate change doubled fuel flammability in western U.S. forests over the past fifty years).

[63] Michael F. Wehner et al., *Droughts, Floods, and Wildfires*, *in* U.S. GLOBAL CHANGE RES. PROGRAM, 1 CLIMATE SPECIAL SCIENCE REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT 243 (2017); Jeremy S. Littel et al., *A Review of the Relationships between Drought and Forest Fire in the United States*, 22 GLOBAL CHANGE BIOLOGY 2353, 2354 (2016).

[64] Zachary L. Steel et al., *The Fire Frequency-severity Relationship and the Legacy of Fire Suppression in California Forests*, 6 ECOSPHERE 1, 2, 18 (2015).

[65] Phone Interview with Anthony L. Westerling, Associate Professor, University of California, Merced (Nov. 2, 2017); Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds*, 119 J. GEOPHYSICAL RES. 432, 442 (2014).

[66] Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds*, 119 J. GEOPHYSICAL RES.: BIOGEOSCIENCES 432, 448 (2014).

[67] Phone Interview with Anthony L. Westerling, Associate Professor, University of California, Merced (Nov. 2, 2017); Phone Interview with Michael F. Wehner, Senior Staff Scientist, Lawrence Berkeley National Laboratory

This expansion of the wildfire window into late fall also increases the likelihood that wildfires will occur when dry and powerful coastal winds blow through the state.[68] These dry winds are seasonal, arising each fall, and they increase the potential for rapidly spreading, unmanageable wildfires.[69] This problem may become more serious in the coming century, because these seasonal winds are likely to get hotter, drier, and more powerful due to climate change.[70]

Additionally, the hotter temperatures and drier conditions that climate change will bring to California over the next century may increase the typical burn areas of wildfires.[71] By 2085, burn areas in forested mountain zones in Northern California will be more than double those observed in the late twentieth century.[72] Statewide, average annual burned area may increase by anywhere between twelve to seventy-four percent by 2085, depending on the intensity of continued GHG emissions and human habitation patterns.[73]

Although the forest management practice of aggressive fire suppression has also intensified California wildfires by causing increased buildup of flammable plant matter in California's forests,[74] many areas in the state face increasing wildfire susceptibility primarily due to changes in climate, not forest management. For example, forests along California's northern coast and those in high-altitude mountain regions contain ample potential wildfire fuel but have remained relatively fire resistant because of high moisture levels.[75] Such forests generally require some combination of drought, high winds, and high temperatures for wildfires to ignite and spread.[76] As climate change increases the likelihood and co-occurrence of these conditions, it will increase the probability of destructive wildfire activity in these historically cool, moist ecosystems.[77]

(Nov. 8, 2017) (The opinions of Dr. Michael F. Wehner are his alone and in no way represent the views of the U.S. Department of Energy, the University of California, or the Lawrence Berkeley National Laboratory).

[68] Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds,* 119 J. GEOPHYSICAL RES. 432, 448 (2014).

[69] Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds*, 119 J. GEOPHYSICAL RES.: BIOGEOSCIENCES 432, 448 (2014).

[70] Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds*, 119 J. GEOPHYSICAL RES. 432, 448 (2014).

[71] Anthony L. Westerling et al., *Climate Change and Growth Scenarios for California Wildfire*, 109 CLIMATIC CHANGE S445, S459 (2011)

[72] Anthony L. Westerling et al., *Climate Change and Growth Scenarios for California Wildfire*, 109 CLIMATIC CHANGE S445, S457 (2011); *see also* Donald McKenzie & Jeremy S. Littell, *Climate Change and the Eco-Hydrology of Fire: Will Area Burned Increase in a Warming Western USA?*, 27 ECOLOGICAL APPLICATIONS 26, 30 (2017).

[73] Anthony L. Westerling et al., *Climate Change and Growth Scenarios for California Wildfire*, 109 CLIMATIC CHANGE S445, S457 (2011).

[74] Zachary L. Steel et al., *The Fire Frequency-Severity Relationship and the Legacy of Fire Suppression in California Forests,* 6 ECOSPHERE 1, 3–4 (2015).

[75] Zachary L. Steel et al., *The Fire Frequency-Severity Relationship and the Legacy of Fire Suppression in California Forests s*, 6 ECOSPHERE 1, 2 (2015).

[76] Zachary L. Steel et al., *The Fire Frequency-Severity Relationship and the Legacy of Fire Suppression in California Forests*, 6 ECOSPHERE 1, 2 (2015).

[77] Alisa Keyser & Anthony L. Westerling, *Climate Drives Inter-Annual Variability in Probability of High Severity Fire Occurrence in the Western United States*, 12 ENVTL. RES. LETTERS 1, 6–7 (2017); *see also* Michael F. Wehner

Climate change in California is increasing the intensity of fire, expanding the seasonal window of wildfire-risk, making fires larger and more difficult to contain, and raising wildfire risk in historically fire-resistant regions of the state. Because human contributions to climate change are a significant driver of these changes,[78] cutting GHG emissions rates can help ensure that wildfire regimes in California maintain their historical characteristics, making them more predictable and manageable. Thus, upholding California's CAA waiver and retaining the existing federal vehicle GHG emissions standards can help limit wildfire-related destruction and devastation in twenty-first century California.

D. Sea-Level Rise

Over the next century, climate change will cause significant sea-level rise.[79] The extent of damage this will cause in California, a state abutting the ocean, depends on GHG emissions rates today.[80]

California has approximately one thousand miles of coastline,[81] and there are two major urban centers, many fragile ecosystems, and hundreds of thousands of homes situated along the coast. These are all highly vulnerable to flooding and erosion due to climate change. Under the worst-case emissions scenario, by year 2100, rising sea level would submerge land inhabited by approximately 900,000 Californians.[82] But even under a more moderate emissions scenario, sea-level rise threatens to inundate the coastal homes of over 200,000 Californians.[83] Already, rising sea level has accelerated erosion along the coast, increasing the vulnerability of California's major metropolitan areas, including San Francisco and Los Angeles, to coastal flooding and

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et al., *Droughts, Floods, and Wildfires*, *in* U.S. GLOBAL CHANGE RES. PROGRAM, 1 CLIMATE SPECIAL SCIENCE REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT, 242 (2017).

[78] *See, e.g.*, John. T. Abatzoglou & A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western U.S. Forests*, 113 PROC. NAT'L ACAD. SCI. 11770, 11773 (2016) (finding that anthropogenic contributions to climate change doubled fuel flammability in western U.S. forests over the past fifty years).

[79] *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 1142 (2013).

[80] *See* William V. Sweet, et al., U.S. Global Change Research Program, *Sea Level Rise*, 1 CLIMATE SCIENCE SPECIAL REPORT: FOURTH NATIONAL CLIMATE ASSESSMENT, 333, 333 (2017) ("Human-caused climate change has made a substantial contribution to [sea-level rise] since 1900 (*high confidence*), contributing to a rate of rise that is greater than during an preceding century in at least 2,800 years (*medium confidence*).").

[81] Daniel Cayan, *Climate Change Projections of Sea-Level Extremes Along the California Coast*, 87 CLIMATE CHANGE S57, S58 (2008).

[82] *See* Benjamin Strauss & Scott Kulp, CLIMATE CENTRAL, *Extreme Sea Level Rise and the Stakes for America*, http://www.climatecentral.org/news/extreme-sea-level-rise-stakes-for-america-21387 (last visited Nov. 28, 2017); *Surging Seas Risk Finder—California, USA*, CLIMATE CENTRAL, https://riskfinder.climatecentral.org/state/california.us (last visited Nov. 28, 2017); *see also* BEN STRAUSS ET AL., CLIMATE CENTRAL, CALIFORNIA, OREGON, WASHINGTON AND THE SURGING SEA: A VULNERABILITY ASSESSMENT WITH PROJECTIONS FOR SEA LEVEL RISE AND COASTAL FLOOD RISK 7 (2014).

[83] *See* Mathew E. Hauer et al., *Millions Projected to be at Risk from Sea-level Rise in the Continental United States*, 6 NATURE CLIMATE CHANGE 691, 692 (2016).

storm surges.[84] This flooding will most seriously impact low-income communities of color in the San Francisco Bay Area and in Monterey, Orange, and Ventura Counties.[85]

Not only does sea-level rise threaten coastal infrastructure with flooding and erosion, but it compromises the structural integrity of the built environment in dramatic ways. As seawater pushes onto land, the denser saltwater displaces fresh groundwater, pushing both the groundwater table and the soil upwards.[86] The resultant upward pressure from saltwater displacement of groundwater and soil has significant force and can compromise the structural integrity of buildings, pushing them up out of the ground; this is already happening in Alameda County in California.[87] Additionally, when rising sea-level pushes groundwater up, it moistens soil such that the soil behaves more like a liquid than a solid during earthquakes.[88] This heightens the risk of building collapse during earthquakes, which is a grave concern for two of California's major urban and economic centers that are coastal and in earthquake risk zones: Los Angeles and the Bay Area in California.[89]

There is a direct and close connection between California's vulnerability to sea-level rise and GHG emissions. Indeed, there is "current scientific consensus . . . that anthropogenically forced climate change is warming the planet and contributing to sea-level rise."[90] This highlights importance of the California waiver and maintaining the existing federal vehicle GHG emissions standards: scaling back these emissions today promises to reduce climate-related threats to California's major urban and economic centers, its fragile coastal ecosystems, and the homes and communities on its shores.

II. Infrastructure Effects

Escalating temperatures, rising sea levels, and increasingly intense storm events endanger many aspects of California's built environment, including its transportation networks, military bases, electric grid, and waste- and water-management infrastructure.[91] This Part focuses on impacts to two segments that directly address and manage the consequences of climate change:

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[84] Bryan J. Boruff et al., *Erosion Hazard Vulnerability of US Coastal Counties*, 21 J. COASTAL RES. 932, 937, 939 (2005); *see also* Katie K. Arkema et al., *Coastal Habitats Shield People and Property from Sea-level Rise and Storms*, 3 NATURE CLIMATE CHANGE 913, 915 (2013).
[85] HEATHER COOLEY ET AL., PAC. INST., SOCIAL VULNERABILITY TO CLIMATE CHANGE IN CALIFORNIA 39–40 (Sept. 28, 2012). Generally, the San Francisco Bay Area has more communities vulnerable to flooding because valuable properties in that region tend to sit at higher elevations; in the Los Angeles area, the more expensive properties are usually along the coast.
[86] Beatriz Azevedo de Almeida & Ali Mostafavi, *Resilience of Infrastructure Systems to Sea-Level Rise in Coastal Areas: Impacts, Adaptation Measures, and Implementation Challenges*, 8 SUSTAINABILITY 1115, 1120, 1122 (2016).
[87] Interview with Kristina Hill, Associate Professor of Landscape Architecture & Environmental Planning and Urban Design, U.C. Berkeley, Berkeley, CA (Oct. 5, 2017).
[88] Kazuya Yasuhara et al., *Influence of Global Warming on Coastal Infrastructural Instability*, 2 SUSTAINABILITY SCI. 13, 21 (2007).
[89] *See* California Dep't of Conservation, *California Seismic Hazard Map*, http://maps.conservation.ca.gov/cgs/informationwarehouse/ (last visited Dec. 8, 2017).
[90] William W. Sweet & Joseph Park, *From the Extreme to the Mean: Acceleration and Tipping Points of Coastal Inundation from Sea Level Rise*, 2 EARTH'S FUTURE 579, 579 (2014).
[91] *See generally*, Beatriz Azevedo de Almeida & Ali Mostafavi, *Resilience of Infrastructure Systems to Sea-Level Rise in Coastal Areas: Impacts, Adaptation Measures, and Implementation Challenges*, 8 SUSTAINABILITY 1115, 1120 (2016).

California's water-management and energy infrastructure. The state's water infrastructure—its levees and dams specifically—are the systems that control flooding and store and distribute water. Sea-level rise, drought, and torrential storms will dramatically intensify the demands on these structures. Meanwhile, the extreme heat and rising annual temperatures associated with climate change will strain California's power grid by substantially increasing power demand while reducing the efficiency of grid infrastructure.

This Part demonstrates how climate change will not only compromise segments of this state's built environment, but it will also frustrate the effectiveness of some systems that help Californians manage and cope with consequences of climate change. These anticipated effects ultimately reveal how both California's own vehicle emissions regulations and the current federal vehicle GHG emissions standards can help ensure that the state can address the environmental changes already set in motion by the anthropogenic climate-forcing of the last century. Conversely, relaxing the federal vehicle standards by freezing them at the 2020 levels and simultaneously rescinding California's waiver, will intensify climate-related stressors so as to push the systems that manage them, like California's levees, dams, and power grid, to the point of likely failure or collapse.

A. Water-Management Infrastructure

Climate change threatens serious strains on California's water infrastructure. Storm tracks will shift northward, meaning that rain will no longer fall in the historical water basins around which California's water management systems are constructed[92]. Additionally, sea-level rise and extreme weather pose serious threats to California's levees and dams. Levees, the earthen embankments that protect land from flooding and help store water, may dry out and lose structural integrity in drought years or erode in floods from rising seas.[93] Meanwhile, climate change creates huge challenges for the state's dam management. California dams have dual purposes: water storage and flood management.[94] Climate change pits these purposes against each other, and dam operators must choose to either maximize water storage in case of drought or reserve empty space in dams to prevent flooding during powerful storm events.[95] When a heavy stormy winter follows close on the heels of drought or a hot and dry summer—a combination that is increasingly likely due to climate change—the consequences are disastrous for California dams.

i. Flooding Risk, Erosion, and California's Levee System

[92] Phone Interview with Michael F. Wehner, Senior Staff Scientist, Lawrence Berkeley National Laboratory (Nov. 8, 2017) (The opinions of Dr. Michael F. Wehner are his alone and in no way represent the views of the U.S. Department of Energy, the University of California, or the Lawrence Berkeley National Laboratory).

[93] *See* Farshid Vahedifard et al., *Drought Threatens California's Levees*, 349 SCIENCE 799, 799 (2015); Benjamin A. Brooks & Deepak Manjunath, UNIV. HAWAII, TWENTY-FIRST CENTURY LEVEE OVERTOPPING PROJECTIONS FROM INSAR-DERIVED SUBSIDENCE RATES IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA: 2006– 2010, at 8, 12 (2012); *see also* CLIMATE CENTRAL, *Surging Seas Risk Finder—California, USA*, https://riskfinder.climatecentral.org/state/california.us (last visited Nov. 27, 2017).

[94] Michael D. Dettinger, *Historical and Future Relations Between Large Storms and Droughts in California*, 14 S.F. WATERSHED & ESTUARY SCI., July 2016, at 2.

[95] Michael D. Dettinger, *Historical and Future Relations Between Large Storms and Droughts in California*, 14 S.F. WATERSHED & ESTUARY SCI., July 2016, at 2.

Climate change threatens California's aging levees, which stretch over 13,000 miles, with heightened risk of erosion or flooding beyond levee capacity.[96] Sea-level rise and future precipitation patterns in California will produce bigger and more frequent floods, overwhelming the state's network of levees. In the Sacramento-San Joaquin Delta, for example, unchecked GHG emissions rates will put fifty percent of the levees in the Sacramento-San Joaquin Delta at risk of failure by 2035, with ninety percent failing by 2065.[97]

The failure of any segment of these thousands of miles of levees has serious consequences for drinking and agricultural water supplies throughout the state of California. Levees in and around the San Francisco Bay Area, for example, help maintain the boundary between saltwater and freshwater further inland, protecting a major source of California's drinking water from mixing with seawater.[98]Additionally, levees facilitate transport of much of California's water from northern California, where seventy-five percent of the state's precipitation occurs, to southern California, with its key agricultural and population centers that constitute seventy-five percent of the state's water demand.[99]

In sum, sea-level rise and heightened storm-intensity dramatically increase the risk of levee-failure in California. Curbing climate change can reduce this risk, and therefore maintaining California's waiver and the existing federal GHG emissions standards can help some of California's crucial levees avoid collapse.

ii. Drought, Extreme Precipitation, and California's Dams

Drought and storm intensification due to climate change pose a serious threat to California's 1,500 dams and spillways.[100] When longer and more strenuous droughts finally give way to rainy seasons with torrential and unrelenting downpours, the sudden influx of water can inundate dams, heightening risk of dam collapse and flooding.[101] During periods of drought, water users pressure dam operators to maximize water storage.[102] But if operators favor water storage and fill dams to close to capacity, dams will be unable to accommodate increasingly

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[96] *See* Farshid Vahedifard et al., *Drought Threatens California's Levees*, 349 SCIENCE 799, 799 (2015); Farshid Vahedifard et al., *Can Protracted Drought Undermine the Structural Integrity of California's Earthen Levees?* 142 J. GEOTECHNICAL AND GEOENVIRONMENTAL ENG. 02516001-1, 02516001-2, 02516001-5 (2016).
[97] Benjamin A. Brooks & Deepak Manjunath, UNIV. HAWAII, TWENTY-FIRST CENTURY LEVEE OVERTOPPING PROJECTIONS FROM INSAR-DERIVED SUBSIDENCE RATES IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA: 2006– 2010, at 8, 12 (2012).
[98] Benjamin A. Brooks & Deepak Manjunath, UNIV. HAWAII, TWENTY-FIRST CENTURY LEVEE OVERTOPPING PROJECTIONS FROM INSAR-DERIVED SUBSIDENCE RATES IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA: 2006– 2010, at i, 1 (2012).
[99] Ellen Hanak et al., PUB. POLICY INST. CAL., MANAGING CALIFORNIA'S WATER: FROM CONFLICT TO RECONCILIATION 3 (2011).
[100] CAL. DEP'T OF WATER RES., DAMS WITHIN JURISDICTION OF THE STATE OF CALIFORNIA 1—101 (2017), http://www.water.ca.gov/damsafety/docs/Dams%20by%20Dam%20Name_Sept%202017.pdf.
[101] Brianna R. Pagán et al., *Extreme Hydrological Changes in the Southwestern U.S. Drive Reductions in Water Supply to Southern California by Mid Century*, 11 ENVTL. RES. LETTERS, Sept. 21, 2016, at 1, 7–9.
[102] Justin Gillis, *California Wants to Store Water for Farmers, but Struggles Over How to Do It*, N.Y. TIMES (Dec. 21, 2015), https://www.nytimes.com/2015/12/22/science/california-wants-to-store-water-for-farmers-but-struggles-over-how-to-do-it.html.

intense winter storms. Thus, shifts in precipitation patterns due to climate change presents dam operators with a difficult and delicate choice during hot, dry summers: either release water to maintain a flood buffer and thereby waste vital water supplies or risk disastrous flooding in winter.[103]

The near-failure of the Oroville Dam, the tallest dam in North America, in 2017 serves as a warning of pressures on dams in the coming years due to climate-change related drought and storm intensification.[104] The Oroville Dam in Northern California contributes to the State Water Project, which supplies water for 750,000 acres of irrigated agricultural land in the state.[105] In 2017, Northern California was experiencing an extremely wet winter that came immediately after a record-setting, three-year drought.[106] Because these winter storms were warm, precipitation was falling as rain that ran off and filled area reservoirs to the brim, rather than snow, which would have accumulated in the snowpack.[107] Given the then-recent drought, Oroville Dam managers had no idea how much winter precipitation to expect, and they had opted to store rainfall at the beginning of the rainy season.[108] Then, the unanticipated and unrelenting winter rain eventually overwhelmed the Oroville Dam's reservoir and spillways.[109] This left a large hole in the main spillway of the dam and eroded the emergency spillway.[110] The threat of the dam's failure prompted the evacuation of 190,000 people.[111]

The near-failure of the Oroville Dam highlights both how climate change will challenge California's dam operators in the coming decades and how inadequate California's dams may be to deal with those challenges. Many of California's aging dams are not designed to accommodate future extreme precipitation events,[112] exacerbating the risk of similar dam-failure events throughout the state.[113] In addition, climate change projections suggest that increased sediment and debris from wildfires and droughts may obstruct flow from California's dams.[114] California's systemic dam problems may have severe human consequences; 678 dams in the state are anticipated to cause fatalities if they fail.[115]

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[103] Brianna R. Pagán et al., *Extreme Hydrological Changes in the Southwestern U.S. Drive Reductions in Water Supply to Southern California by Mid Century*, IOP SCIENCE ENVTL. RES. LETTERS, Sept. 21, 2016, at 1, 7–9.
[104] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017); Adrian A. Harpold, et al., *Defining Snow Drought and Why it Matters*, Earth & Space Science News (Feb. 28, 2017), https://eos.org/opinions/defining-snow-drought-and-why-it-matters.
[105] CAL. DEP'T OF WATER RES., *California State Water Project Overview*, http://www.water.ca.gov/swp/ (last visited Nov. 9, 2017).
[106] *See* Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017);
[107] Adrian A. Harpold, et al., *Defining Snow Drought and Why it Matters*, Earth & Space Science News (Feb. 28, 2017), https://eos.org/opinions/defining-snow-drought-and-why-it-matters.
[108] Adrian A. Harpold, et al., *Defining Snow Drought and Why it Matters*, Earth & Space Science News (Feb. 28, 2017), https://eos.org/opinions/defining-snow-drought-and-why-it-matters.
[109] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017).
[110] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017).
[111] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017).
[112] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139-40 (2017).
[113] *See* Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017).
[114] Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139, 1139 (2017).
[115] AM. SOC'Y OF CIV. ENG'RS, 2017 INFRASTRUCTURE REPORT CARD: DAMS 1 (2017); AM. SOC'Y OF CIVIL ENG'RS, *2017 Infrastructure Report Card: Infrastructure in California*, https://www.infrastructurereportcard.org/state-item/california/ (last visited Nov. 18, 2017).

The extreme weather conditions that raise the risk of dam-failure, drought, and heavy rainstorms are fueled by climate change. Scaling back GHG emissions rates can reduce these risks in the coming century and help protect California's water resources and save communities from the devastating consequences of dam failure.

B. Energy Infrastructure

Climate change will also place significant strains on California's energy infrastructure. Warmer temperatures throughout the year and an increase in the frequency of extreme heat events will increase energy demand in California as use of air conditioning becomes more frequent and sustained.[116] Average household energy consumption will increase by up to fifty-five percent by the end of the century.[117] California must meet this increased demand by producing more energy, importing electricity, or strictly conserving energy.[118]

While climate change will increase demand for electricity beyond what California's existing infrastructure can supply, it will also diminish the efficiency and generation capacity of the state's existing power infrastructure. Warming temperatures will reduce the efficiency of electricity-producing plants and transmission wires.[119] Gas turbines currently produce half of California's electricity[120] and will become less efficient as temperatures rise in California. The warmer the air used in the gas combustion process, the lower the efficiency of gas-fired turbines.[121] Thus, by the end of the century, California's gas-fired plants may lose between 1.1 and 4.6 percent of their generating capacity on hot days, when peak electricity demand coincides with high temperatures.[122]

Warmer ambient temperatures also impact electric transmission wires. Warmer air has less capacity to cool current-bearing wires, which forces electric grid managers to reduce the current flowing through the wires to maintain safe wire temperatures.[123] By the end of the century, climate-change-induced heatwaves may require reducing transmission current by up to

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[116] Norman L. Miller et al., *Climate, Extreme Heat, and Electricity Demand in California*. 47 J. APPLIED METEOROLOGY & CLIMATOLOGY 1834, 1835, 1842 (2008).
[117] Maximillian Auffhammer & Anin Aroonruengsawat, *Simulating the Impacts of Climate Change, Prices and Population on California's Residential Electricity Consumption*, 109 CLIMATE CHANGE 191, S205 (2011).
[118] Norman L. Miller et al., *Climate, Extreme Heat, and Electricity Demand in California*. 47 J. APPLIED METEOROLOGY & CLIMATOLOGY 1834, 1842 (2008).
[119] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 506, 507 (2013).
[120] CAL. ENERGY COMM'N, *Total System Electric Generation*, http://www.energy.ca.gov/almanac/electricity_data/total_system_power.html (last accessed Nov. 19, 2017).
[121] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 503 (2013).
[122] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL.CHANGE 499, 506 (2013).
[123] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 504 (2013).

seven percent.[124] In addition, transformers, which regulate the voltage of electricity so that it can travel through the transmission system, lose capacity as ambient air temperatures rise.[125] Transformers that heat up too much can fail catastrophically and cause localized blackouts.[126] End-of-century heatwave conditions in California may reduce the capacity of transformers by 1.0 to 3.6 percent.[127]

Furthermore, rising sea levels may flood energy generating and fuel transport infrastructure positioned along the California coast. Sea-level rise threatens to inundate numerous natural gas pipelines and associated infrastructure on or near California's coastlines.[128] Approximately 400 miles of natural gas transmission lines, as well as associated storage infrastructure, are vulnerable to sea-level rise,[129] as are twenty-five power plants along the California coast.[130]

In sum, climate change threatens to take a significant toll on California's power grid. The combination of increased demand for air conditioning, reduced gas turbine efficiency, loss of transmission and transformer efficiency, and compromised coastal power infrastructure suggest that parts of California's grid may require up to 31.2 percent more capacity just to maintain the baseline of current service during conditions expected to prevail during hot days at the end of the century.[131] Limiting GHG emissions, through both upholding California's waiver and retaining the current federal vehicle GHG emissions standards, is critical to minimizing this capacity deficit and reducing future strain on California's electricity grid.

III. Agriculture

Climate change also threatens substantial harm to California's economic productivity, and one of its most essential industries, agriculture, stands to suffer significant losses. In 2016, California's farms and ranches received $45.3 billion for goods produced.[132] Not only is California agriculture important for this state's economy, but it provides food to a large portion of the United States and exports crops internationally.[133] California currently produces one-third

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[124] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 507 (2013).
[125] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 504 (2013).
[126] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 504 (2013); *see also* Ben Poston & Dakota Smith, *Massive Valley Blackout Again Puts Spotlight on L.A.'s Failing Infrastructure*, L.A. TIMES (Jul. 10, 2017), http://www.latimes.com/local/lanow/la-me-power-outage-cause-20170710-story.html.
[127] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 507 (2013).
[128] JOHN D. RADKE ET AL., UNIV. CAL., BERKELEY, ASSESSMENT OF CALIFORNIA'S NATURAL GAS PIPELINE VULNERABILITY TO CLIMATE CHANGE 2 (2017).
[129] CAL. ENERGY COMM'N, 2015 INTEGRATED ENERGY POLICY REPORT 245 (2015).
[130] JAYANT A. SATHAYE ET AL., LAWRENCE BERKELEY NAT'L LAB., ESTIMATING RISK TO CALIFORNIA ENERGY INFRASTRUCTURE FROM PROJECTED CLIMATE CHANGE 47 (2012).
[131] Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499, 509 (2013).
[132] *California Agricultural Production Statistics*, CAL. DEP'T OF FOOD & AGRIC., https://www.cdfa.ca.gov/statistics/ (last visited Nov. 19, 2017).
[133] CAL. DEP'T OF FOOD & AGRIC., CALIFORNIA AGRICULTURAL STATISTICS REVIEW 2015–2016, at 1–18 (2016).

of the United States' vegetables and two-thirds of the country's fruits and nuts.[134] In 2013, California growers were responsible for seventy-one percent of head lettuce production in the United States.[135] California is also virtually the United States' sole producer of pistachios, which brought $1.65 billion in revenue to the state in 2014.[136]

Thus, the numerous climate-change-related threats to this key California industry—pests and disease, rising temperatures and water scarcity, and diminishing nutritional value of crops—have national and global significance. This Part examines a few of these threats to California agriculture.

A. Pests & Disease

Climate change will exacerbate existing pest problems in California and bring outbreaks of new pests to the state, compromising agricultural yield. Because growers are likely to take advantage of a warmer climate in California by planting crops earlier, insect pests will get an earlier start feeding; this might mean that crops must contend with "additional generations" of insect pests during a growing season.[137] A warmer climate in California will also increase the range of some insect pests, and with the loss of spring frosts that normally keep insect populations in check, the duration and intensity of insect outbreaks will increase. [138] Finally, warmer temperatures means that new insect pests that historically could not survive in California due cooler temperatures will now thrive and spread.[139]

The control measures necessary to address the increased prevalence and diversity of pests in California will astronomically increase costs for growers and producers, and chemical pest control strategies threaten the health of the state's citizens. The surge of pests will increase dependence on pesticides to protect crop yields, raising production costs.[140] Additionally, heavier pesticide use means greater human exposures to these chemicals, which threaten serious health conditions such as cancer, neurological and respiratory disease, and birth defects.[141]

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[134] CAL. DEP'T OF FOOD & AGRIC., CALIFORNIA AGRICULTURAL STATISTICS REVIEW 2015–2016,.at 57 (2016)
[135] AGRIC. MKTG. RES. CTR., *Lettuce*, https://www.agmrc.org/commodities-products/vegetables/lettuce/ (last visited Nov. 9, 2017).
[136] Itai Trilnick et al., *Micro-Climate Engineering for Climate Change Adaptation in Agriculture*, AM. ECON. ASS'N 1, 2 (2017).
[137] John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 76 (2009).
[138] John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 76 (2009).
[139] Nikos T. Papadopoulos et al., *From Trickle to Flood: The Large-Scale, Cryptic Invasion of California by Tropical Fruit Flies*, PROC. ROYAL SOC'Y B 1, 1-2 (2013); Eike Luedeling et al., *Climate Change Effects on Walnut Pests in California*, 17 GLOBAL CHANGE BIOLOGY 228, 234–35 (2011).
[140] John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 75 (2009)
[141] Maxwell J. Richardson et al., *Environmental Health Tracking Improves Pesticide Use Data to Enable Research and Inform Public Health Actions in California*, 23 J. PUB. HEALTH MGMT. PRAC. S97, S97 (2017).

Among the many sectors in California agriculture that face substantial harm from pest-borne diseases is the wine industry, worth more than $30 billion annually.[142] A close examination of how climate change will affect one of the many pests that afflicts wine grapes can illustrate the nature and scale of the pest problems threatening California agriculture. Small flying insects called glassy-winged sharpshooters can transmit a bacterium to grapevines that causes a disorder called Pierce's disease.[143] In the late 1990s, the glassy-winged sharpshooter spread from the southeastern United States and eastern Mexico into southern California vineyards, causing Pierce's disease epidemics that wiped out entire vineyards, especially in the Central Valley and Temecula Valley.[144]

Climate change threatens to further expand the glassy-winged sharpshooter's range northwards into California's central coast and Sonoma and Napa valley vineyards, where the insects could not survive through the historically cooler winter temperatures. Rising temperatures will allow the glassy-winged sharpshooter to thrive in northern California, bringing Pierce's disease with it.[145] The costs of managing the spread of this pest will be astronomical. Today, controlling the glassy-winged sharpshooter already costs California $104.4 million per year,[146] and federal, state, and local government entities spend an additional $48.3 million in pest control and monitoring efforts associated with the spread of Pierce's disease.[147]

B. Agricultural Niches and Nutritional Value

Pest problems are not the only way in which climate change threatens California agriculture. This Subpart discusses how the physical changes of warmer temperatures, less precipitation, and higher carbon dioxide concentrations will affect California crops, with a focus on loss of agricultural niches and decline in nutritional content of produce.

In the absence of strong GHG emission controls, climate change threatens California's agricultural niches: the matching of state's distinct—and in some cases unique—microclimates to crops that are ideal for those conditions.[148] Rising temperatures and water scarcity will impair crop yield in these niches, developed through decades of grower effort, by changing and possibly destroying California's microclimates.[149] For example, warmer winters impair blooming of

[142] WINE INSTITUTE, *2016 California Wine Sales in U.S. Hit New Record: 238 Million Cases with Retail Value of $34.1 Billion* (May 1, 2017), http://www.wineinstitute.org/resources/pressroom/05012017. The industry is also a major driver of tourism for the state.
[143] *See* Kabir P. Tumblr et al., *Pierce's Disease Costs California $104 Million Per Year*, 68 CAL. AGRIC. 20, 20–21 (2014).
[144] *See* Kabir P. Tumblr et al., *Pierce's Disease Costs California $104 Million Per Year*, 68 CAL. AGRIC. 20, 23 (2014).
[145] *See* Andrew P. Gutierrez et al., *Geographic Distribution and Relative Abundance of the Invasive Glassy-Winged Sharpshooter: Effects of Temperature and Egg Parasitoids* 40 ENVTL. ENTOMOLOGY 755, 761–65 (2011).
[146] *See* Kabir P. Tumblr et al., *Pierce's Disease Costs California $104 Million Per Year*, 68 CAL. AGRIC. 20, 20 (2014).
[147] *See* Kabir P. Tumblr et al., *Pierce's Disease Costs California $104 Million Per Year*, 68 CAL. AGRIC. 20, 20 (2014).
[148] Interview with David Zilberman, Professor, University of California, Berkeley, Department of Agricultural and Resource Economics (Oct. 6, 2017).
[149] Interview with David Zilberman, Professor, University of California, Berkeley, Department of Agricultural and Resource Economics (Oct. 6, 2017).

certain fruit and nut plants, like pistachios, and severely diminish production yields.[150] Adapting crops to these environmental changes will be challenging and expensive.[151]Additionally, warmer temperatures throughout the year adversely impact crops accelerating soil and leaf moisture loss, also compromising yields.[152]

Although there is hypothetically potential for climate change to benefit crop yields by increasing atmospheric carbon dioxide concentrations, this benefit is undercut by loss of nutritional value and increased pest feeding.[153] Plants grown under higher atmospheric concentrations of carbon dioxide do grow more, increasing yields.[154] But when certain grains and legumes are grown under these conditions, they also have lower concentrations of nutrients like zinc, iron, and protein.[155] A related problem is that insect pests actually feed more aggressively on crops grown under elevated carbon dioxide concentrations to obtain the nutrients they need.[156] These factors offset anticipated gains in crop yield.

The loss of crop nutritional value, along with disruption of agricultural niches and exacerbation of pest problems, are serious and significant effects on California agriculture, but are only a few of the innumerable ways in which climate change will affect the sector. Because California farms are important food sources for the rest of this country and even other countries around the globe, minimizing the anticipated climate-change-related threats to California crops is vital for all. Thus, GHG emissions rates must be scaled back in the interest of global food security. Weakening the existing federal vehicle GHG emissions standards by holding them at the 2020 levels and withdrawing California's waiver will frustrate this goal.

IV. Human Health Effects

Climate change has exacerbated Californians' existing health problems and introduced new risks. This Part first explores how the warming temperatures and extreme heat associated with climate change will affect current public health issues in California, such those arising from poor air quality. Next, this Part examines the rise of newer risks facilitated by climate change,

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[150] *See, e.g.*, Itai Trilnick et al., *Micro-Climate Engineering for Climate Change Adaptation in Agriculture*, AM. ECON. ASS'N 1–2, 4 (2017) (discussing how warmer winters interfere with the blooming of pistachios, an industry that produced $1.65 billion in 2014 in California as only the state's ninth leading agricultural product).
[151] *See* Itai Trilnick et al., *Micro-Climate Engineering for Climate Change Adaptation in Agriculture*, AM. ECON. ASS'N 1, 4 (2017).
[152] Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931, 3934 (2015). Evapotranspiration, the scientific term for this phenomenon, refers to the combined effect of evaporation directly out of the soil and transpiration from plants that draw water out of the soil and then lose the water as vapor through their leaves. *Id.* Agricultural drought results when excessive evapotranspiration leads to soil moisture deficits failing to meet the requirements for growing crops. *See* AM. METEOROLOGICAL SOC'Y, *Drought*, https://www.ametsoc.org/ams/index.cfm/about-ams/ams-statements/statements-of-the-ams-in-force/drought/ (last visited Nov. 28, 2017).
[153] *See* Samuel S. Myers et al., *Increasing CO_2 Threatens Human Nutrition*, 510 NATURE 139, 139 (2014); John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 74 (2009).
[154] John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 74 (2009).
[155] Samuel S. Myers et al., *Increasing CO_2 Threatens Human Nutrition*, 510 NATURE 139, 139 (2014).
[156] John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73, 74 (2009).

such as toxic algal blooms and mosquito-borne diseases like West Nile. Addressing these public health threats demands combatting the driver of these conditions: anthropogenic GHG emissions. Indeed, retaining the existing vehicle GHG standards can help prevent future disease outbreaks and save lives.

A. Air Quality Impacts

Rising temperatures from climate change in California exacerbate the health impacts of small particulate matter ($PM_{2.5}$) and ozone, which already cause major problems in many parts of the state.[157] $PM_{2.5}$ exposure is linked to incidence of pre-term birth delivery,[158] heart attacks, and several forms of lung disease.[159] Climate change will raise the likelihood of human exposure to high $PM_{2.5}$ concentrations because it will increase the frequency and duration of periods of air stagnation.[160] Air stagnation correlates strongly with elevated $PM_{2.5}$ concentrations.[161]

Climate change will also increase health effects associated with ground-level ozone in California. High ground-level ozone concentrations contribute to adverse birth outcomes,[162] acute respiratory illnesses,[163] and lung cancer and cardiopulmonary mortality.[164] Warmer temperatures in California, brought by climate change, will increase formation of ground-level ozone.[165] The increase in air stagnation associated with climate change will also lead to higher ground-level ozone concentrations.[166] Southern California, specifically, will experience some of the most drastic increases of ground-level ozone pollution in the country.[167]

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[157] Seventeen counties in California do not meet federal ozone air quality standards, and four do not meet $PM_{2.5}$ standards; EPA, *8-Hour Ozone (2008) Designated Area/State Information*, https://www3.epa.gov/airquality/greenbook/hbtc.html (last visited Nov. 28, 2017); EPA, *PM-2.5 (2012) Designated Area/State Information*, https://www3.epa.gov/airquality/greenbook/kbtc.html. (last visited Nov. 28, 2017).
[158] Rupa Basu et al., *Association between $PM_{2.5}$ and $PM_{2.5}$ Constituents and Preterm Delivery in California, 2000–2006*, 31 PEDIATRIC PERINATAL EPIDEMIOLOGY 424, 429-431 (2017).
[159] Brian J. Malig et al. *A Time-Stratified Case-Crossover Study of Ambient Ozone Exposure and Emergency Department Visits for Specific Respiratory Diagnoses in California (2005–2008)*, 124 ENVTL. HEALTH PERSP. 745, 745 (2016).
[160] Daniel E. Horton et al., *Occurrence and Persistence of Future Atmospheric Stagnation Events*, 4 NATURE CLIMATE CHANGE 698, 700 (2014).
[161] Daniel E. Horton et al., *Occurrence and Persistence of Future Atmospheric Stagnation Events*, 4 NATURE CLIMATE CHANGE 698, 700 (2014).
[162] Rochelle Green et al., *Association of Stillbirth with Ambient Air Pollution in a California Cohort Study*, 181 AM. J. EPIDEMIOLOGY 874, 881 (2015).
[163] Neal Fann et al., *Ch. 3: Air Quality Impacts, in* U.S. GLOBAL CHANGE RES. PROGRAM, IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH IN THE UNITED STATES: A SCIENTIFIC ASSESSMENT 76 (2016).
[164] Bart Ostro et al., *Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study*, 118 ENVTL. HEALTH PERSP. 363, 366 (2010); *see also* C. Arden Pope et al., *Lung Cancer, Cardiopulmonary Mortality and Long-Term Exposure to Fine Particulate Air Pollution*, 287 J. AM. MED. ASS'N 1132, 1137 (2002); *see also* Vivian C. Pun et al., *Long-Term $PM_{2.5}$ Exposure and Respiratory, Cancer, and Cardiovascular Mortality in Older US Adults*, 186 AM. J. EPIDEMIOLOGY 961, 961 (2017).
[165] Neal Fann et al., *Ch. 3: Air Quality Impacts, in* U.S. GLOBAL CHANGE RES. PROGRAM, IMPACTS OF CLIMATE CHANGE ON HUMAN HEALTH IN THE UNITED STATES: A SCIENTIFIC ASSESSMENT 69, 76 (2016).
[166] Daniel E. Horton et al., *Occurrence and Persistence of Future Atmospheric Stagnation Events*, 4 NATURE CLIMATE CHANGE 698, 700 (2014).
[167] Fernando Garcia-Menendez et al., *U.S Air Quality and Health Benefits from Avoided Climate Change Under Greenhouse Gas Mitigation*, 49 ENVTL. SCI. & TECH. 7580, 7582-83 (2015).

Climate change will exacerbate existing air quality problems in the state, increasing burdens on the Californians who already bear the brunt of health impacts of dirty air: children,[168] elderly people,[169] low-income communities, and people of color.[170] Thus, limiting GHG emissions today is especially critical for Californians who are already grappling with the health effects of poor air quality.

B. Heat-Related Illness

Increasing temperatures in California attributable to climate change will likely amplify the incidence and severity of a range of heat-related illnesses and will cause greater mortality linked to heat exposure. Deaths and hospitalizations related to heat-exposure are already a major health problem in California — during California's 2006 heat wave, at least 140 people died from heat exposure[171] —and these will be compounded by climate change. Exposure to higher temperatures alone correlates with increased risk of cardiovascular disease,[172] as well as pre-term delivery.[173] Rising temperatures have also extended the allergen season across the United States.[174] In addition, exposure to air pollution combines with exposure to allergens to enhance the risk of hospitalization from asthma.[175] Under a high-emissions and high-warming scenario, mortality due to a warming climate could rise up to seventeen-fold in California, amounting to between 4,684 to 8,757 deaths per year.[176]

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[168] Michael Jerrett et al., *Traffic-Related Air Pollution and Asthma Onset in Children: A Prospective Cohort Study with Individual Exposure Measurement*, 116 ENVTL. HEALTH PERSP. 1433, 1433 (2008); Michael Jerrett et al., *Traffic-related air pollution and obesity formation in children: a longitudinal, multilevel analysis*, 13 ENVTL. HEALTH 1, 5-7 (2014).

[169] *See* Antonella Zanobetti et al., *Summer Temperature Variability and Long-Term Survival among Elderly People with Chronic Disease*, 109 PROC. NAT'L ACAD. SCI. 6608, 6608, 6611 (2012).

[170] Manuel Pastor et al., *The Air is Always Cleaner on the Other Side: Race, Space, and Ambient Air Toxics Exposures in California*, 27 J. URB. AFFAIRS 127, 143 (2005); *see also* Douglas Houston et al., *Disparities in Exposure to Automobile and Truck Traffic and Vehicle Emissions Near the Los Angeles-Long Beach Port Complex*, 104 AM. J. PUB. HEALTH 156, 162 (2014); *see also* Nancy Tian et al., *Evaluating Socioeconomic and Racial Differences in Traffic-Related Metrics in the United States Using a GIS Approach*, 23 J. EXPOSURE SCI. & ENVTL. EPIDEMIOLOGY 215, 215 (2013).

[171] Paul English et al., CAL. DEP'T PUB. HEALTH, HEAT-RELATED ILLNESS AND MORTALITY INFORMATION FOR THE PUBLIC HEALTH NETWORK IN CALIFORNIA 1, 22 (2007); *see also* Toki Sherbakov et al. *Ambient Temperature and Added Heat Wave Effects on Hospitalizations in California from 1999 to 2009*, 160 ENVTL. RES. 83, 86-87 (2018); Kristen Guirguis et al., *The Impact of Recent Heat Waves on Human Health in California*, 53 J. APPLIED METEOROLOGY & CLIMATOLOGY 16-17 (2014).

[172] Rupa Basu et al., *Estimating the Associations of Apparent Temperature and Inflammatory, Hemostatic, and Lipid Markers in a Cohort of Midlife Women*, 152 ENVTL. RES. 322, 325 (2017).

[173] Lyndsay A. Avalos et al., *The Impact of High Apparent Temperature on Spontaneous Preterm Delivery: A Case-Crossover Study*, 16 ENVTL. HEALTH 1, 11-13 (2017).

[174] 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, 4249 (2011); Yong Zhang et al., *Allergenic Pollen Season Variations in the Past Two Decades under Changing Climate in the United States*, 21 GLOBAL CLIMATIC CHANGE 1581, 1586-87 (2015).

[175] Sabit Cakmak et al., *Does Air Pollution Increase the Effect of Aeroallergens on Hospitalization for Asthma?*, 129 J. ALLERGY & CLINICAL IMMUNOLOGY 228, 229-30 (2012).

[176] Scott C. Sheridan et al., *Future heat vulnerability in California, Part II: projecting future heat-related mortality*, 115 CLIMATIC CHANGE 311, 324 (2012),

California's coastal populations have heightened vulnerability to the extreme heat events anticipated to increase with climate change for two reasons. First, populations along California's temperate northern coast are not adapted to dealing with heat.[177] Second, residents of California's coastal cities—particularly low-income residents and people of color—suffer from the "urban heat island" effect.[178] This occurs when dark city surfaces such as asphalt absorb sunlight, and in the absence of urban tree-cover or grass, can add 1ºF to 6ºF to ambient temperatures during the day, and up to an additional 22ºF at night.[179]

Additionally, in California's inland agricultural regions, changes in temperature patterns will significantly affect outdoor workers. Here, too, there are racially disparate impacts, with disproportionate impacts on low-income Californians of color.[180] Of California's 450,000 agricultural workers, an estimated two-thirds are Latino.[181] Greater heat exposure and heat strain in recent years has already led to a higher incidence of acute kidney injury among agricultural workers in California's Central Valley.[182]

Thus, maintaining the federal GHG emissions standards and maintaining California's CAA preemption waiver can help spare the state's population from asthma, cardiovascular disease, and even heat-related death.

C. Toxic Algal Blooms

Climate change may also enhance the risk of food-borne health risks in California, such as those associated with harmful algal blooms. Harmful algal blooms are overgrowths of a specific marine microorganism that produces a human neurotoxin.[183] This neurotoxin travels up the marine food chain and accumulates in animals ingested by humans, such as Dungeness crabs.[184] Consuming seafood containing this algal neurotoxin can be fatal.[185]

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177 HEATHER COOLEY ET AL., PAC. INST., SOCIAL VULNERABILITY TO CLIMATE CHANGE IN CALIFORNIA 4 (2012).
178 Seth B. Shonkoff, et al. *The Climate Gap: Environmental Health and Equity Implications of Climate Change and Mitigation Policies in California—a Review of the Literature*, 109 CLIMATE CHANGE S485, S487 (2011).
179 CAL. ENVTL. PROTECTION AGENCY, *Understanding the Urban Heat Island Index*, https://calepa.ca.gov/climate/urban-heat-island-index-for-california/understanding-the-urban-heat-island-index/ (last visited Nov. 27, 2017).
180 *See* Sally Moyce et al., *Heat Strain, Volume Depletion and Kidney Function in California Agricultural Workers*, 74 OCCUPATIONAL & ENVTL. MED. 402, 406 (2017); Seth B. Shonkoff, et al. *The Climate Gap: Environmental Health and Equity Implications of Climate Change and Mitigation Policies in California—a Review of the Literature*, 109 CLIMATE CHANGE S485, S487 (2011).
181 Maria Stoecklin-Marois et al., *Heat-related Illness Knowledge and Practices among California Hired Farm Workers in the MICASA Study*, 51 INDUS. HEALTH 47, 48 (2013).
182 Sally Moyce et al., *Heat Strain, Volume Depletion and Kidney Function in California Agricultural Workers,* 74 OCCUPATIONAL & ENVTL. MED. 402, 406 (2017).
183 Ryan M. McCabe et al., A*n Unprecedented Coastwide Toxic Algal Bloom Linked to Anomalous Ocean Conditions*, 43 GEOPHYSICAL RES. LETTERS 10366, 10366 (2016).
184 Ryan M. McCabe et al., A*n Unprecedented Coastwide Toxic Algal Bloom Linked to Anomalous Ocean Conditions*, 43 GEOPHYSICAL RES. LETTERS 10366, 10366 (2016).
185 Daniel Lasoff, & Binh Ly, CAL. POISON CONTROL SYS., UNIV. OF CAL., S.F., *Amnesic Shellfish Poisoning*, https://calpoison.org/news/amnesic-shellfish-poisoning (last visited Nov. 27, 2017).

A harmful algal bloom that arose recently off the Pacific Coast demonstrated how climate change can amplify this health risk. From 2015 to 2016, a large algal bloom—the largest ever recorded—developed between southern California and southern Alaska.[186] The conditions that gave rise to this unprecedented bloom are associated with climate change: anomalously warm ocean temperatures and spring storms.[187] Ocean temperatures historically limited the geographic range of harmful algal blooms, but climate change is causing ocean warming and facilitating expansion of these blooms into new locations.[188] Climate change also stimulates algal bloom development via nutrient run-off during intense precipitation events.[189]

Thus, climate change increases the likelihood that California's coast will continue to see massive harmful algal blooms, and the consequences for this state are serious. The 2015 bloom forced widespread closure of California's commercial and recreational fisheries to prevent poisoning outbreaks, and these closures cost at least $30 million.[190] This is yet another example of how the effects of climate change on a single system in California—in this case, coastal algal blooms—can have dire and sweeping consequences reaching not just California's ecosystems, but its economy and the health of its citizens. This event is a preview of what may be in store for California in the coming decades if GHG emissions rates are not curtailed through strategies like its own vehicle emissions program and the maintaining current federal vehicle emissions standards, which ramp up through 2025.

D. Mosquito-Borne Diseases

Higher temperatures and increased incidence of drought and floods in California will likely increase human exposure to a range of disease vectors like mosquitoes. The prevalence of West Nile virus-bearing mosquitos in California, for example, has already increased in recent years[191] due to conditions attributable to climate change.[192] West Nile virus causes a range of severe human health symptoms like meningitis, and it can be fatal.[193] California has reported the highest number of West Nile infections of any state,[194] and treating West Nile virus outbreaks is

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[186] Ryan M. McCabe et al., A*n Unprecedented Coastwide Toxic Algal Bloom Linked to Anomalous Ocean Conditions*, 43 GEOPHYSICAL RES. LETTERS 10366, 10366-67 (2016).
[187] Ryan M. McCabe et al., A*n Unprecedented Coastwide Toxic Algal Bloom Linked to Anomalous Ocean Conditions*, 43 GEOPHYSICAL RES. LETTERS 10366, 10366-67, 10369 (2016).
[188] Christopher J. Gobler et al., *Ocean Warming Since 1982 Has Expanded the Niche of Toxic Algal Blooms in the North Atlantic and North Pacific Oceans,* 114 PROC. NAT'L ACAD. SCI. 4975, 4979 (2017).
[189] Eva Sinha et al., *Eutrophication Will Increase During the 21st Century as a Result of Precipitation Changes*, 357 SCIENCE 405, 406-07 (2017).
[190] CALIFORNIA OCEAN SCIENCE TRUST, FRAMING THE SCIENCE: HARMFUL ALGAL BLOOMS AND CALIFORNIA FISHERIES 7 (2016).
[191] Tina Feiszli et al. *Surveillance for Mosquito-borne Encephalitis Virus Activity in California, 2014*, 83 PROC. PAPERS MOSQUITO VECTOR CONTROL ASSOC. CAL. 98, 100 (2015).
[192] Cory W. Morin & Andrew C. Comrie, *Regional and Seasonal Response of a West Nile Virus Vector to Climate Change*, 110 PROC. NAT'L ACAD. SCI. 15620, 15622 (2013).
[193] Edward B. Hayes et al. *Virology, Pathology, and Clinical Manifestations of West Nile Virus Disease*, 11 EMERGING INFECTIOUS DISEASES 1174, 1175 (2005).
[194] *Final Cumulative Maps & Data*, CTRS. FOR DISEASE CONTROL, https://www.cdc.gov/westnile/statsmaps/cumMapsData.html (last visited Nov. 28, 2017).

costly: in 2005, Sacramento County spent approximately $3 million treating a small outbreak of West Nile.[195]

Climate change increases the risk of West Nile virus outbreaks through warmer temperatures and drought conditions. Warmer temperatures lengthen the season in which mosquitos can transmit West Nile virus, and increase the speed of virus reproduction.[196] In addition, drought can fuel the spread of West Nile virus, because it both increases mosquito abundance and the transmission of the virus between mosquitoes.[197] Indeed, in the midst of California's severe drought between 2012 and 2015, the number of annual cases of West Nile virus doubled.[198]

Some communities in California are especially vulnerable to mosquito-borne diseases like West Nile virus in the face of warming temperatures. For example, in many low-income and rural communities in California that do not have access to potable water,[199] some may resort storing rainwater in open containers; this creates mosquito breeding grounds.[200] And in the Central Valley, the combination of drought and the presence of open irrigation channels may expose predominantly Latino farm workers to mosquitoes that carry West Nile virus.[201]

The increased likelihood of a West Nile outbreak in California is but a single example of the public health crises facing California as it gets hotter and drier due to climate change. Warmer temperatures will also favor the spread of other mosquito-borne diseases, including Zika, dengue, and yellow fever.[202] Furthermore, mosquito-borne disease, along with the other risks examined in this letter—asthma, respiratory disease, heat-related fatalities, and neurotoxins in food—are just a small sample of the human health burdens facing Californians if climate change is left unchecked. Thus, maintaining California's waiver along with the existing federal

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[195] Loren M. Barber et al., *Economic Cost Analysis of West Nile Virus Outbreak, Sacramento County, California, USA, 2005*, 16 EMERGING INFECTIOUS DISEASES 480, 480, 483 (2010).

[196] Cory W. Morin & Andrew C. Comrie, *Regional and Seasonal Response of a West Nile Virus Vector to Climate Change*, 110 PROC. NAT'L ACAD. SCI. 15620, 15622 (2013).

[197] Cory W. Morin & Andrew C. Comrie, *Regional and Seasonal Response of a West Nile Virus Vector to Climate Change*, 110 PROC. NAT'L ACAD. SCI. 15620, 15622 (2013); Marilyn Ruiz, et al., *Local Impact of Temperature and Precipitation on West Nile Virus Infection in* Culex *Species Mosquitoes in Northeast Illinois, USA*, 3 PARASITES & VECTORS 1, 2 (2010).

[198] *Final Cumulative Maps & Data*, CTRS. FOR DISEASE CONTROL, https://www.cdc.gov/westnile/statsmaps/cumMapsData.html (last visited Nov. 28, 2017); *see also* Tina Feiszli et al. *Surveillance for Mosquito-borne Encephalitis Virus Activity in California, 2014*, 83 PROC. PAPERS MOSQUITO VECTOR CONTROL ASSOC. CAL. 98, 104 (2015).

[199] Juliet Christian-Smith et al., ASSESSING WATER AFFORDABILITY— A PILOT STUDY IN TWO REGIONS OF CALIFORNIA 10–15 (2013); *see also* Eli Moore & Eyal Matalon, THE HUMAN COSTS OF NITRATE-CONTAMINATED DRINKING WATER IN THE SAN JOAQUIN VALLEY 9–10 (2011).

[200] Mary M. Ramos et al. *Epidemic Dengue and Dengue Hemorrhagic Fever at the Texas–Mexico Border: Results of a Household-based Seroepidemiologic Survey, December 2005*, 78 AM. J. TROPICAL HYGIENE 364, 366 (2008).

[201] *See* John P. DeGroote et al., *Landscape, Demographic and Climatic Associations with Human West Nile Virus Occurrence Regionally in 2012 in the United States of America*, 9 GEOSPATIAL HEALTH 153, 160, 165 (2014); *see also* Ryan J. Harrigan et al., *A Continental Risk Assessment of West Nile Virus under Climate Change*, 20 GLOBAL CHANGE BIOLOGY 2417, 2423 (2014).

[202] *See* Micah B. Hahn et al., *Updated Reported Distribution of* Aedes (Stegomyia) aegypti *and* Aedes (Stegomyia) albopictus (Diptera: Culicidae) *in the United States, 1995–2016*, 54 J. Med. Entomology 1420, 1420, 1423 (2016); Oliver J. Brady et al., *Global Temperature Constraints on* Aedes aegypti *and* Ae. albopictus *Persistence and Competence for Dengue Transmission*, 7 PARASITE VECTORS 1, 8–10 (2014).

vehicle GHG emissions standards will not merely help protect this state's environmental and economic resources—it will save lives.

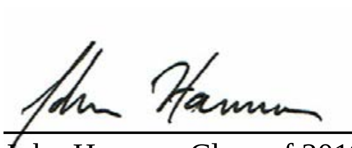
Conclusion

As this letter reveals, climate change poses sweeping threats to California and its citizens: rising temperatures, intensifying rainstorms, diminishing water supply, surging seas, raging wildfires, dwindling crops, and growing epidemics. The "compelling and extraordinary conditions" described here are but a subset of the many significant ways in which climate change affects this state; there are numerous other serious impacts, such as harm to wildlife resources that make California a biodiversity "hotspot,"[203] and the adverse sociological effects of hotter weather, manifest in declines in worker productivity and increases in interpersonal violence.[204] Nevertheless, the effects described here offer a brief and terrifying glimpse of California in the twenty-first century—a California drastically transformed by climate change.

Fortunately, that picture of California's future is not yet complete, and there is still time to paint a different one, shaped by more modest temperature increases, sea-level rise, and shifts in precipitation patterns. Realizing this alternative vision could save entire ecosystems, millions of lives, and billions of dollars, but it requires immediate action to cut back GHG emissions. California itself has already declared, by statute, its state-level commitment to limiting GHG emissions to avert some of the devastating consequences of climate change.[205] And the state has made aggressive and sustained efforts to cut GHG emissions rates within its borders.

Meaningfully deterring the onset of extreme heat, drought, flooding, wildfire, and disease in California will require efforts to limit vehicle GHG emissions from every level of government. EPA should therefore maintain the existing federal vehicle GHG emissions standards and back away from its attempt to unlawfully withdraw California's waiver. After all, it is EPA's critical statutory responsibility to protect our country's air quality and "promote the public health and welfare and the productive capacity of its population."[206]

Sincerely,



8/30/2018

John Hannon, Class of 2019 — Date

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[203] Elisa Barbour & Lara M. Kueppers, *Conservation and Management of Ecological Systems in a Changing California*, 111 CLIMATE CHANGE 135, 136 (2012)
[204] Solomon Hsiang, et al. *Estimating Economic Damages from Climate Change in the United States*, 356 SCIENCE 1362, 1364 (2017).
[205] *See* CAL. HEALTH & SAFETY CODE § 38501 (2017) (original version at § 42823 and § 42018.5 (2002)).
[206] *See* 42 U.S.C. § 7401(b)(1).

William Mumby, Class of 2018 — **8/28/18** Date

Sophia TonNu, Class of 2019 — **8/30/18** Date

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Appendix A

The authors of this Comment Letter spoke with the following researchers at UC Berkeley and affiliated institutions:

- Prof. Ronald Cohen – *UC Berkeley, College of Chemistry*
- Prof. Kristina Hill – *UC Berkeley, College of Environmental Design*
- Daniella Hirschfeld – *UC Berkeley, College of Environmental Design*
- Prof. Solomon Hsiang – *UC Berkeley, Goldman School of Public Policy*
- Prof. Norman Miller – *UC Berkeley, Department of Geography*
- Prof. Justin Remais – *UC Berkeley, School of Public Health*
- Prof. Scott Stephens – *UC Berkeley, Department of Environmental Science, Policy, and Management*
- Dr. Michael Wehner – *Lawrence Berkeley National Laboratory, Computational Research Division*
- Prof. Leroy Westerling – *UC Merced / Sierra Nevada Research Institute*
- Dr. Adam Zeilinger – *UC Berkeley, Department of Environmental Science, Policy, and Management*

Appendix B

The references cited in this letter and listed below are also submitted by mail, on DVD for agency consideration.

References Cited

- John. T. Abatzoglou & A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western U.S. Forests*, 113 PROC. NAT'L ACAD. SCI. 11770 (2016).
- Amir AghaKouchak et al., *Comment: Recognize Anthropogenic Drought*, 524 NATURE 409, 410–11 (2015).
- Amir AghaKouchak et al., *Global Warming and Changes in Risk of Concurrent Climate Extremes: Insights from the 2014 California Drought*, 41 GEOPHYS. RES. LETT. 8847 (2014).
- Robert J. Allen & Rainer Luptowitz, *El Niño-Like Teleconnection Increases California Precipitation in Response to Warming*, NATURE COMMUNICATIONS (July 2017).
- Katie K. Arkema et al., *Coastal Habitats Shield People and Property from Sea-level Rise and Storms*, 3 NATURE CLIMATE CHANGE 913 (2013).
- Moetasim Ashfaq et al., *Near-term Acceleration of Hydroclimatic Change in the Western U.S.*, 118 J. GEOPHYSICAL RES. 10676 (2013).
- Maximillian Auffhammer & Anin Aroonruengsawat, *Simulating the Impacts of Climate Change, Prices and Population on California's Residential Electricity Consumption,* 109 CLIMATE CHANGE 191 (2011).
- Lyndsay A. Avalos et al., *The Impact of High Apparent Temperature on Spontaneous Preterm Delivery: A Case-Crossover Study*, 16 ENVTL. HEALTH 1 (2017).
- Beatriz Azevedo de Almeida & Ali Mostafavi, *Resilience of Infrastructure Systems to Sea-Level Rise in Coastal Areas: Impacts, Adaptation Measures, and Implementation Challenges*, 8 SUSTAINABILITY 1115 (2016).
- Loren M. Barber et al., *Economic Cost Analysis of West Nile Virus Outbreak, Sacramento County, California, USA, 2005*, 16 EMERGING INFECTIOUS DISEASES 480 (2010).
- Elisa Barbour & Lara M. Kueppers, *Conservation and Management of Ecological Systems in a Changing California*, 111 CLIMATE CHANGE 135 (2012).
- Rupa Basu et al., *Association between $PM_{2.5}$ and $PM_{2.5}$ Constituents and Preterm Delivery in California, 2000–2006,* 31 PEDIATRIC PERINATAL EPIDEMIOLOGY 424 (2017).

- Rupa Basu et al., *Estimating the Associations of Apparent Temperature and Inflammatory, Hemostatic, and Lipid Markers in a Cohort of Midlife Women*, 152 ENVTL. RES. 322 (2017).
- Soumaya Belmecheri et al., *Multi-century Evaluation of Sierra Nevada Snowpack*, NATURE CLIMATE CHANGE, Jan. 2016.
- Bryan J. Boruff et al., *Erosion Hazard Vulnerability of US Coastal Counties*, 21 J. COASTAL RES. 932 (2005).
- Oliver J. Brady et al., *Global Temperature Constraints on* Aedes aegypti *and* Ae. albopictus *Persistence and Competence for Dengue Transmission*, 7 PARASITE VECTORS 1 (2014)
- Benjamin A. Brooks & Deepak Manjunath, TWENTY-FIRST CENTURY LEVEE OVERTOPPING PROJECTIONS FROM INSAR-DERIVED SUBSIDENCE RATES IN THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA: 2006– 2010 (2012).
- Benjamin P. Bryant & Anthony L. Westerling, *Scenarios for Future Wildfire Risk in California: Links between Changing Demography, Land Use, Climate, and Wildfire*, 25 ENVIRONMETRICS 468 (2014).
- Sabit Cakmak et al., *Does Air Pollution Increase the Effect of Aeroallergens on Hospitalization for Asthma?* 129 J. ALLERGY & CLINICAL IMMUNOLOGY 228 (2012).
- Cal. Dep't of Food & Agric., CALIFORNIA AGRICULTURAL STATISTICS REVIEW 2015–2016 (2016).
- California Dep't of Forestry & Fire Protection, *Top 20 Largest California Wildfires* (Dec. 22, 2017).
- Cal. Energy Comm'n, 2015 INTEGRATED ENERGY POLICY REPORT 245 (2015).
- CALIFORNIA OCEAN SCIENCE TRUST, FRAMING THE SCIENCE: HARMFUL ALGAL BLOOMS AND CALIFORNIA FISHERIES 7 (2016).
- Daniel Cayan, *Climate Change Projections of Sea-Level Extremes Along the California Coast*, 87 CLIMATE CHANGE S57 (2008).
- Juliet Christian-Smith et al., Pacific Institute, ASSESSING WATER AFFORDABILITY: A PILOT STUDY IN TWO REGIONS OF CALIFORNIA (2013).
- Heather Cooley et al., Pac. Inst., SOCIAL VULNERABILITY TO CLIMATE CHANGE IN CALIFORNIA (Sept. 28, 2012).
- John P. DeGroote et al., *Landscape, Demographic and Climatic Associations with Human West Nile Virus Occurrence Regionally in 2012 in the United States of America*, 9 GEOSPATIAL HEALTH 153 (2014).
- Michael Dettinger, *Historical and Future Relations Between Large Storms and Droughts in California*, 14 S.F. WATERSHED & ESTUARY SCI., July 2016.

- Michael Dettinger, *Climate Change, Atmospheric Rivers, and Floods in California–A Multimodel Analysis of Storm Frequency and Magnitude Changes*, 47 J. AM. WATER RESOURCES ASS'N 514 (2011).
- Noah S. Diffenbaugh et al., *Anthropogenic Warming Has Increased Drought Risk in California*, 112 PROC. NAT'L ACAD. SCI. 3931 (2015).
- Paul English et al., Cal. Dep't Pub. Health, HEAT-RELATED ILLNESS AND MORTALITY INFORMATION FOR THE PUBLIC HEALTH NETWORK IN CALIFORNIA 1 (2007).
- Neal Fann et al., *The Geographic Distribution and Economic Value of Climate Change-Related Ozone Health Impacts in the United States in 2030*, 65 J. AIR & WASTE MGMT. 570 (2015).
- Tina Feiszli et al. *Surveillance for Mosquito-borne Encephalitis Virus Activity in California, 2014*, 83 PROC. PAPERS MOSQUITO VECTOR CONTROL ASSOC. CAL. 98 (2015).
- Fernando Garcia-Menendez et al., *U.S Air Quality and Health Benefits from Avoided Climate Change Under Greenhouse Gas Mitigation*, 49 ENVTL. SCI. & TECH. 7580 (2015).
- Christopher J. Gobler et al., *Ocean Warming Since 1982 Has Expanded the Niche of Toxic Algal Blooms in the North Atlantic and North Pacific Oceans*, 114 PROC. NAT'L ACAD. SCI. 4975 (2017).
- Rochelle Green et al., *Association of Stillbirth with Ambient Air Pollution in a California Cohort Study*, 181 AM. J. EPIDEMIOLOGY 874 (2015).
- Kristen Guirguis et al., *The Impact of Recent Heat Waves on Human Health in California*, 53 J. APPLIED METEOROLOGY & CLIMATOLOGY 16 (2014).
- Andrew P. Gutierrez et al., *Geographic Distribution and Relative Abundance of the Invasive Glassy-Winged Sharpshooter: Effects of Temperature and Egg Parasitoids* 40 ENVTL. ENTOMOLOGY 755 (2011).
- Micah B. Hahn et al., *Updated Reported Distribution of* Aedes (Stegomyia) aegypti *and* Aedes (Stegomyia) albopictus (Diptera: Culicidae) *in the United States, 1995–2016*, 54 J. MED. ENTOMOLOGY 1420 (2016).
- Ellen Hanak et al., Pub. Policy Inst. Cal., MANAGING CALIFORNIA'S WATER: FROM CONFLICT TO RECONCILIATION (2011).
- Ryan J. Harrigan et al., *A Continental Risk Assessment of West Nile Virus under Climate Change*, 20 GLOBAL CHANGE BIOLOGY 2417 (2014).
- Mathew E. Hauer et al., *Millions Projected to be at Risk from Sea-level Rise in the Continental United States,* 6 NATURE CLIMATE CHANGE 691 (2016).
- Edward B. Hayes et al., *Virology, Pathology, and Clinical Manifestations of West Nile Virus Disease*, 11 EMERGING INFECTIOUS DISEASES 1174 (2005).

- Katharine Hayhoe, et al., *Emissions Pathways, Climate Change and Impacts on California*, 101 PROC. NAT'L ACAD. SCI. 12422 (2004).
- Daniel E. Horton et al., *Occurrence and Persistence of Future Atmospheric Stagnation Events*, 4 NATURE CLIMATE CHANGE 698 (2014).
- Douglas Houston et al., *Disparities in Exposure to Automobile and Truck Traffic and Vehicle Emissions Near the Los Angeles-Long Beach Port Complex*, 104 AM. J. PUB. HEALTH 156 (2014).
- Solomon Hsiang, et al. *Estimating Economic Damages from Climate Change in the United States*, 356 SCIENCE 1362 (2017).
- Xingying Huang & Paul A. Ullrich, *Changing Character of Twenty-First-Century Precipitation over the Western U.S. in the Variable-Resolution CESM*, 30 J. CLIMATE 7555 (2017).
- Michael Jerrett et al., *Traffic-Related Air Pollution and Obesity Formation in Children: A Longitudinal, Multilevel Analysis*, 13 ENVTL. HEALTH 1 (2014).
- Michael Jerrett et al., *Traffic-Related Air Pollution and Asthma Onset in Children: A Prospective Cohort Study with Individual Exposure Measurement*, 116 ENVTL. HEALTH PERSP. 1433 (2008).
- Yufang Jin et al., *Contrasting Controls on Wildland Fires in Southern California During Periods with and without Santa Ana Winds*, 119 J. GEOPHYSICAL RES. 432 (2014).
- Alisa Keyser & Anthony L. Westerling, *Climate Drives Inter-Annual Variability in Probability of High Severity Fire Occurrence in the Western United States*, 12 ENVTL. RES. LETTERS 1 (2017).
- Thomas R. Knutson, et al., *Multimodal Assessment of Regional Surface Temperature Trends: CMIP3 and CMIP5 Twentieth Century Simulations*, 26 J. CLIMATE 8709 (2013).
- Jeremy S. Littell et al., *A Review of the Relationships between Drought and Forest Fire in the United States*, 22 GLOBAL CHANGE BIOLOGY 2353 (2016).
- Eike Luedeling et al., *Climate Change Effects on Walnut Pests in California*, 17 GLOBAL CHANGE BIOLOGY 228 (2011).
- Brian J. Malig et al. *A Time-Stratified Case-Crossover Study of Ambient Ozone Exposure and Emergency Department Visits for Specific Respiratory Diagnoses in California (2005–2008)*, 124 ENVTL. HEALTH PERSP. 745 (2016).
- Yixin Mao et al., *Is Climate Change Implicated in the 2013–2014 California Drought? A Hydrologic Perspective*, 42 GEOPHYSICAL RES. LETTERS 2805 (2015).
- Ryan M. McCabe et al., A*n Unprecedented Coastwide Toxic Algal Bloom Linked to Anomalous Ocean Conditions,* 43 GEOPHYSICAL RES. LETTERS 10366 (2016).

- Donald McKenzie & Jeremy S. Littell, *Climate Change and the Eco-Hydrology of Fire: Will Area Burned Increase in a Warming Western USA?*, 27 ECOLOGICAL APPLICATIONS 26 (2017).
- Gerald A. Meehl, et al. *Mechanisms Contributing to the Warming Hole and the Consequent U.S. East-West Differential of Heat Extremes*, 25 J. CLIMATE 6394 (2012).
- Thomas Meixner et al., *Implications of Projected Climate Change for Groundwater Recharge in the Western United States*, 534 J. HYDROLOGY 124 (2016).
- Norman L. Miller et al., *Climate, Extreme Heat, and Electricity Demand in California*. 47 J. APPLIED METEOROLOGY & CLIMATOLOGY 1834 (2008).
- Eli Moore & Eyal Matalon, Pacific Institute, THE HUMAN COSTS OF NITRATE-CONTAMINATED DRINKING WATER IN THE SAN JOAQUIN VALLEY (2011).
- Cory W. Morin & Andrew C. Comrie, *Regional and Seasonal Response of a West Nile Virus Vector to Climate Change*, 110 PROC. NAT'L ACAD. SCI. 15620 (2013).
- Sally Moyce et al., *Heat Strain, Volume Depletion and Kidney Function in California Agricultural Workers*, 74 OCCUPATIONAL & ENVTL. MED. 402 (2017).
- Samuel S. Myers et al., *Increasing CO_2 Threatens Human Nutrition*, 510 NATURE 139 (2014).
- Bart Ostro et al., *Long-Term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study*, 118 ENVTL. HEALTH PERSP. 363 (2010).
- Brianna R. Pagán et al., *Extreme Hydrological Changes in the Southwestern U.S. Drive Reductions in Water Supply to Southern California by Mid Century*, 11 ENVTL. RES. LETTERS 1, 7–9 (2016).
- Nikos T. Papadopoulos et al., *From Trickle to Flood: The Large-Scale, Cryptic Invasion of California by Tropical Fruit Flies*, PROC. ROYAL SOC'Y B (2013).
- Manuel Pastor et al., *The Air is Always Cleaner on the Other Side: Race, Space, and Ambient Air Toxics Exposures in California*, 27 J. URB. AFFAIRS 127 (2005).
- Sarah E. Perkins, et al., *Increasing Frequency, Intensity, and Duration of Observed Global Heatwaves and Warm Spells*, 39 GEOPHYS. RES. LETTERS 1, 2-3 (2012).
- David W. Pierce et al., *The Key Role of Heavy Precipitation Events in Climate Model Disagreements of Future Annual Precipitation Changes in California*, 26 J. CLIMATE 5879 (2013).
- David W. Pierce et al., *Probabilistic Estimates of Future Changes in California Temperature and Precipitation Using Statistical and Dynamical Downscaling*, 40 CLIMATE DYNAMICS 839 (2012).

- David W. Pierce et al., *Attribution of Declining Western U.S. Snowpack to Human Effects*, 21 J. CLIMATE 6425 (2008).
- C. Arden Pope et al., *Lung Cancer, Cardiopulmonary Mortality and Long-Term Exposure to Fine Particulate Air Pollution*, 287 J. AM. MED. ASS'N 1132 (2002).
- Vivian C. Pun et al., *Long-Term $PM_{2.5}$ Exposure and Respiratory, Cancer, and Cardiovascular Mortality in Older US Adults*, 186 AM. J. EPIDEMIOLOGY 961 (2017).
- John D. Radke et al., ASSESSMENT OF CALIFORNIA'S NATURAL GAS PIPELINE VULNERABILITY TO CLIMATE CHANGE (2017).
- Mary M. Ramos et al. *Epidemic Dengue and Dengue Hemorrhagic Fever at the Texas–Mexico Border: Results of a Household-based Seroepidemiologic Survey, December 2005*, 78 AM. J. TROPICAL HYGIENE 364 (2008).
- Maxwell J. Richardson et al., *Environmental Health Tracking Improves Pesticide Use Data to Enable Research and Inform Public Health Actions in California*, 23 J. PUB. HEALTH MGMT. PRAC. S97 (2017).
- Marilyn Ruiz, et al., *Local Impact of Temperature and Precipitation on West Nile Virus Infection in* Culex *Species Mosquitoes in Northeast Illinois, USA*, 3 PARASITES & VECTORS 1 (2010).
- Jayant A. Sathaye et al., *Estimating Impacts of Warming Temperatures on California's Electricity System*, 23 GLOBAL ENVTL. CHANGE 499 (2013).
- Jayant A. Sathaye et al., ESTIMATING RISK TO CALIFORNIA ENERGY INFRASTRUCTURE FROM PROJECTED CLIMATE CHANGE (2012).
- Richard Seager et al., *Projections of Declining Surface-Water Availability for the Southwestern United States*, 3 NATURE CLIMATE CHANGE 482 (2012).
- Toki Sherbakov et al. *Ambient Temperature and Added Heat Wave Effects on Hospitalizations in California from 1999 to 2009*, 160 ENVTL. RES. 83 (2018).
- Scott. C. Sheridan, et al., *Future Heat Vulnerability in California, Part I: Projecting Future Weather Types and Heat Events*, 115 CLIMATE CHANGE 291 (2012).
- Seth B. Shonkoff, et al. *The Climate Gap: Environmental Health and Equity Implications of Climate Change and Mitigation Policies in California—a Review of the Literature*, 109 CLIMATE CHANGE S485 (2011).
- Raquel A. Silva et al., *Future Global Mortality from Changes in Air Pollution Attributable to Climate Change*, 7 NATURE CLIMATE CHANGE 647 (2017).
- Eva Sinha et al., *Eutrophication Will Increase During the 21st Century as a Result of Precipitation Changes,* 357 SCIENCE 405 (2017).
- Zachary L. Steel et al., *The Fire Frequency-Severity Relationship and the Legacy of Fire Suppression in California Forests*, 6 ECOSPHERE 1 (2015).

- Maria Stoecklin-Marois et al., *Heat-related Illness Knowledge and Practices among California Hired Farm Workers in the MICASA Study*, 51 INDUS. HEALTH 47 (2013).
- William W. Sweet & Joseph Park, *From the Extreme to the Mean: Acceleration and Tipping Points of Coastal Inundation from Sea Level Rise,* 2 EARTH'S FUTURE 579 (2014)
- Nancy Tian et al., *Evaluating Socioeconomic and Racial Differences in Traffic-Related Metrics in the United States Using a GIS Approach*, 23 J. EXPOSURE SCI. & ENVTL. EPIDEMIOLOGY 215 (2013).
- Itai Trilnick et al*., Micro-Climate Engineering for Climate Change Adaptation in Agriculture*, AM. ECON. ASS'N 1 (2017).
- Toan Trinh et al., *Assessment of 21st Century Drought Conditions at Shasta Dam Based on Dynamically Projected Water Supply Conditions by a Regional Climate Model Coupled with a Physically-based Hydrology Model*, 586 SCI. TOTAL ENV'T 197 (2017).
- John T. Trumble & Casey D. Butler, *Climate Change Will Exacerbate California's Insect Pest Problems*, 63 CAL. AGRIC. 73 (2009).
- Kabir P. Tumblr et al., *Pierce's Disease Costs California $104 Million Per Year*, 68 CAL. AGRIC. 20 (2014).
- Farshid Vahedifard et al., *Lessons from the Oroville Dam*, 355 SCIENCE 1139 (2017).
- Farshid Vahedifard et al., *Can Protracted Drought Undermine the Structural Integrity of California's Earthen Levees?* 142 J. GEOTECHNICAL AND GEOENVIRONMENTAL ENG. 02516001-1 (2016).
- Farshid Vahedifard et al., *Drought Threatens California's Levees*, 349 SCIENCE 799 (2015).
- Anthony L. Westerling et al., *Climate Change and Growth Scenarios for California Wildfire*, 109 CLIMATIC CHANGE S445 (2011).
- Alexandra Witze, *California Study Targets Rivers in the Sky*, 517 NATURE 424 (2015).
- Kazuya Yasuhara et al., *Influence of Global Warming on Coastal Infrastructural Instability*, 2 SUSTAINABILITY SCI. 13 (2007).
- Antonella Zanobetti et al., *Summer Temperature Variability and Long-Term Survival among Elderly People with Chronic Disease*, 109 PROC. NAT'L ACAD. SCI. 6608 (2012).
- Yong Zhang et al., *Allergenic Pollen Season Variations in the Past Two Decades under Changing Climate in the United States,* 21 GLOBAL CLIMATIC CHANGE 1581 (2015).

- 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 (2011).