Appendix G
Public Health

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Introduction and Background

Climate change is considered one of the greatest global public health threats of the twenty-first century;[1] but taking action to address climate change presents one of the most significant opportunities to improve public health outcomes.[2] Actions by California and other jurisdictions working together to transition away from fossil fuels to clean energy and technology and actions to improve land management will lead to a much healthier future. Many actions to reduce greenhouse gas (GHG) emissions and address climate change, also have health co-benefits that can improve the health and well-being of populations across the state. Pursuing climate friendly strategies through a deliberate implementation process can create healthy, equitable and resilient communities where all people can thrive. This qualitative analysis supplements the quantitative analysis of public health impacts in Chapter 3, Appendix H (AB 32 GHG Inventory Sector Modeling) and Appendix C (AB 197 Measure Analysis) to demonstrate the many ways that climate action and health improvements go hand in hand providing substantial and long-lasting benefits.

Overview of the Human Health Impacts of Climate Change

Climate Change leads to a wide range of serious human health threats, including hotter temperatures, worsened air quality, rising sea levels, drought, wildfires and smoke, and other climate effects. The changes underway are affecting natural landscapes and processes, disrupting food and water resources, changing agricultural productivity, weakening infrastructure, and resulting in other climate-related effects, which lead to higher levels of physical, mental, and environmental stress on communities.[3, 4] The impact on California is significant. California's population is the most diverse in the continental U.S. (*CDPH Portrait of Promise, 2015.*) This population diversity leads to diversity in health conditions, and health disparities between different populations. California is also one of the most geographically and ecologically diverse regions in the world, with landscapes ranging from chaparral and grasslands to sandy beaches and rugged coastal areas to redwood rainforests and dense interior forests to snow-covered alpine mountains to dry desert valleys. Each of these regions experiences a unique combination of impacts from climate change.

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[1] Romanello, M., McGushin, A., Napoli, C. D., Drummond, P., Hughes, N., Jamart, L., Kennard, H., Lampard, P., Rodriguez, B. S., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Cai, W., Campbell-Lendrum, D., Capstick, S., Chambers, J., Chu, L., Ciampi, L., Dalin, C., & Dasandi, N. (2021). The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. The Lancet, (389):1619-62. *https://doi.org/10.1016/S0140-6736(21)01787-6.*

[2] Watts N, Adger WN, Agnolucci P, et al. 2015. Health and climate change: policy responses to protect public health. Lancet: 386, 1861-1914.

[3] American Public Health Association. 2019. Addressing the Impacts of Climate Change on Mental Health and Well-Being. Policy No: 20196. Available at: *https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2020/01/13/addressing-the-impacts-of-climate-change-on-mental-health-and-well-being.*

[4] Dodgen D, Donato D, Kelly N, La Greca A, Morganstein J, Reser J, Ruzek J, Schweitzer S, Shimamoto MM, Thigpen Tart K, and Ursano R. 2016. Chapter 8: Mental Health and Well-Being. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, 217-246. *http://dx.doi.org/10.7930/J0TX3C9H.*

From record temperatures to increasingly intense wildfires[5] to rising sea levels and increasingly acidic seas[6] to less reliable snowpack,[7] climate change poses an immediate and escalating threat to California's environment, public health, and economic vitality.

The health impacts of the climate crisis are already being felt by Californians, with negative health effects projected to only worsen in the coming years,[8, 9] particularly if swift actions are not taken to drastically reduce greenhouse gas emissions. As the climate changes, California's wildfires are getting worse with increased fire risks, higher frequency of occurrence, larger burn areas, and a longer fire season. Extreme droughts related to climate change have already started hurting agricultural productivity, decreasing our water reserves, and exacerbating fugitive dust emissions that contribute to pollution and higher risk of Valley Fever. Temperature changes can also increase the risk of severe weather events, such as heat waves and intense storms. A wide range of impacts on ecosystems and on human health and well-being are associated with increased temperatures.[10]

According to CalFire, since 1932, the top 8 largest wildfires in California have occurred in the past five years (2017-2022) with 151 deaths caused directly by wildfires during that period.[11] Researchers estimate that wildfire smoke during August and September 2020 may have led to as many as 3,000 excess deaths among elderly Californians. Increasing frequency and intensity of wildfires is already having a measurable effect on air quality.[12] At least 95 percent of Californians suffered unhealthy levels of particle pollution due to wildfires in 2020. Wildfires also damage crops and soil, harm livestock, and create a high-risk environment for agricultural workers. Climate impacts threaten economic security, and this can impact human health and increase stress on individuals and communities.

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[5] N.S. Diffenbaugh, A.G. Konings, C.B. Field, (2021). Atmospheric variability contributes to increasing wildfire weather but not as much as global warming. Proceedings of the National Academy of Sciences Nov 2021, 118 (46) e2117876118; DOI: 10.1073/pnas.2117876118. https://www.pnas.org/content/118/46/e2117876118

[6] E.B. Osborne, et al., Decadal Variability in Twentieth-century Ocean Acidification in the California Current Ecosystem, 13 NAT. GEOSCI. 43–49 (2020), https://doi.org/10.1038/s41561-019-0499-z.

[7] P.W. Mote, et al., Dramatic Declines in Snowpack in the Western US, 1 NATURE PARTNER JS. CLIM. ATMOS. SCI. (2018), https://doi.org/10.1038/s41612-018-0012-1.

[8] McCall J. 2018. Climate change and health: understanding how global warming could impact public health in California. California Senate Office of Research. Available at: https://sor.senate.ca.gov/sites/sor.senate.ca.gov/files/Public%20Health%20Climate%20Change%20LINKS_4%201126.pdf

[9] United States Global Change Research Program (USGCRP). 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

[10] Office of Environmental Health Hazard Assessment, Indicators of Climate Change, oehha.ca.gov/climate-change/document/indicators-climate-change-california.

[11] California Department of Forestry and Fire Protection (CAL FIRE). "Stats and Events." Cal Fire Department of Forestry and Fire Protection, https://www.fire.ca.gov/stats-events/

[12] Liu X, Huey LG, Yokelson RJ, Selimovic V, Simpson IJ, Müller M, Jimenez JL, Campuzano-Jost P, Beyersdorf AJ, Blake DR, Butterfield Z. (2017). Airborne measurements of western US wildfire emissions: Comparison with prescribed burning and air quality implications. Journal of Geophysical Research: Atmospheres, 122(11), 6108-6129.

Climate change exacerbates other air pollution problems throughout California. Increasing temperatures generally cause increases in ozone concentrations in California's polluted regions.[13] At one point, California came under siege from record-breaking heat waves and smoke from more than 7,000 fires burning simultaneously.[14] Intense heat waves and widespread wildfire smoke caused Southern California to experience worse air pollution readings and the highest number of health-damaging bad air-days since the mid-1990s. In 2020, there were 157 bad-air days for ozone pollution across the vast, coast-to-mountains basin spanning Los Angeles, Orange, Riverside, and San Bernardino Counties—the most days above the federal health standard since 1997. A recent study suggests that smoke from wildfires like these could become one of the deadliest climate impacts within decades.[15, 16] Continued climate change will further amplify the number of days with extreme fire weather by the end of the century (absent any additional actions).[17] In addition, particulate matter exposure is a heightened problem during droughts, which climate change is also anticipated to exacerbate in California as changes in weather patterns block rainfall from reaching the State.[18, 19] Worse air quality leads to increased risk for a wide range of chronic illnesses including respiratory infections like bronchitis and pneumonia, which will result in greater health costs to the State.[20, 21, 22]

Despite successes in increasing agricultural yields in the state, the effect of extreme droughts has already started hurting agricultural productivity, decreasing the State's water reserves and exacerbating fugitive dust emissions. Californians can expect more extreme droughts to continue into the end of the 21st century, with decreased precipitation frequency from fewer non-atmospheric river storms and long-term declines in groundwater, which cannot frequently recover from subsequent wet weather conditions. If greenhouse gas emissions continue to rise, California's

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[13] American Lung Association, State of the Air 2022, State of the Air | American Lung Association
[14] Thomas Fuller & Christopher Flavelle, "A Climate Reckoning in Fire-Stricken California," N.Y. TIMES, Sept. 18, 2020, https://www.nytimes.com/2020/09/10/us/climate-change-california-wildfires.html.
[15] Tony Barboza, "Wildfire smoke now causes up to half the fine-particle pollution in Western U.S., study finds," L.A. TIMES, Jan. 13, 2021, https://www.latimes.com/california/story/2021-01-13/wildfire-smoke-fine-particle-pollution-western-us-study (new study blames climate change for worsening air quality and health risks in both urban and rural communities in recent years).
[16] Burke M, Driscoll A, Heft-Neal S, Xue J, Burney J, Wara M. The changing risk and burden of wildfire in the United States. Proc Natl Acad Sci U S A. 2021 Jan 12;118(2):e2011048118. doi: 10.1073/pnas.2011048118. PMID: 33431571; PMCID: PMC7812759.
[17] Michael Goss, Daniel L Swain, John T Abatzoglou, Ali Sarhadi, et al., Climate Change is Increasing the Risk of Extreme Autumn Wildfire Conditions Across California, ENVT'L RES. LETTERS (2020), DOI: 10.1088/1748-9326/ab83a7.
[18] A.P. Williams, Richard Seager, John T. Abatzoglou, Benjamin I. Cook, Jason E. Smerdon, Edward R. Cook, Contribution of Anthropogenic Warming to California Drought During 2012-2014, 42 GEOPHYS. RES. LETT. 6819–28 (2015), http://doi.org/10.10022015GL064924.
[19] I. Cvijanovic, B.D. Santer, C. Bonfils, C. et al., Future Loss of Arctic Sea-ice Cover Could Drive a Substantial Decrease in California's Rainfall, 8 NAT. COMMUN. 1947 (2017), https://doi.org/10.1038/s41467-017-01907-4.
[20] John A. Romley, Andrew Hackbarth & Dana P. Goldman, Cost and Health Consequences of Air Pollution in California, Santa Monica, CA, RAND Corp. (2010), https://www.rand.org/pubs/research_briefs/RB9501.html.
[21] M. Wang, C.P. Aaron, J. Madrigiano, et al., Association Between Long-term Exposure to Ambient Air Pollution and Change in Quantitatively Assessed Emphysema and Lung Function, 322(6) J. AM. MED. ASSOC.
546-56 (2019), doi:10.1001/jama.2019.10255.
[22] A. Inserro, Air Pollution Linked to Lung Infections, Especially in Young Children, AM. J. MANAGED CARE (May 6, 2018), https://www.ajmc.com/newsroom/air-pollution-linked-to-lung-infections-especiallyin-young-children.

agricultural industry will be increasingly harder hit, with both decreasing revenues and increasing food prices for residents.

While the direct medical and physical health impacts from a climate-related extreme weather event is often noticeable, the psychological impacts can develop and persist well after the event. People with mental health challenges are more likely to be harmed in extreme weather events and are more likely to have their mental health impacted for extended periods. Estimates range from about 20-65 percent of survivors of extreme weather events having mental health issue following the event.[23]

This appendix has only summarized a small subset of the large range of human health impacts occurring now and expected in the future from climate change. Direct health impacts from climate change include increased heat related illnesses (i.e., heat exhaustion and heat stroke) and injuries and deaths from extreme weather events or disasters (i.e., severe storms, flooding, wildfires). Indirect impacts include more air pollution-related exacerbations of cardiovascular and respiratory diseases (smog, wildfires), increased vector-borne diseases due to changes in the distribution and geographic range of disease-carrying species (e.g., mosquitoes and ticks); negative nutritional consequences related to decreases in agricultural food yields; stress and mental trauma due to extreme weather-related catastrophes as well as anxiety, depression, and other mental health impacts associated with unemployment and income loss (e.g., prolonged drought or temperature shifts affecting jobs and industries dependent on natural resources and/or environmental conditions), and residential displacement and home loss (e.g., sea level rise impacting coastal communities). Climate-related health impacts are not distributed equally across all communities and populations. Climate vulnerable communities are at higher risk and are likely to experience greater compounded health impacts of climate change and individuals facing the greatest health risks include low-income populations, the very young and the very old, Black, Indigenous and communities of color, those suffering from chronic illness and those who have been marginalized or discriminated against based on gender, race/ethnicity, or sexual orientation.[24] CARB developed a "Climate Vulnerability Metric (CVM)" to quantify and map climate impact on human welfare in California communities, taking into account community vulnerability, and provide this information at the census tract level. The CVM is discussed in Appendix K (Climate Vulnerability Metric).

Carbon pollution from fossil fuel combustion is the biggest contributor to climate change in California, and the state's progress forward is tied to a rapid transition away

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[23] American Public Health Association. 2019. Addressing the Impacts of Climate Change on Mental Health and Well-Being. Policy No: 20196. Available at: *https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2020/01/13/addressing-the-impacts-of-climate-change-on-mental-health-and-well-being*

[24] United States Global Change Research Program (USGCRP). 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

from fossil fuel dependency and toward clean energy and technology. Combustion sources emitting greenhouse gases also emit criteria pollution including ozone and particle pollution, toxic contaminants and short-lived climate pollutants including black carbon, all linked to serious health effects. In addition, higher temperatures from climate change can amplify the production of some of these pollutants, creating a cycle of worsening effects. Dramatic reductions in fossil fuel combustion by 2045 will have substantial health benefits. This Scoping Plan focuses on the contrast between a California that is still dependent on a fossil fuel-based economy and a California that is transitioning to a carbon-neutral, clean energy future. This Scoping Plan health analysis will demonstrate the broad range of potential benefits associated with a shift away from fossil fuel combustion while providing information to help achieve the goal of equitable distribution of benefits across the state.

Health Analysis Components

This Scoping Plan (SP) qualitative health analysis evaluates the benefits of a dramatic reduction in fossil fuels by 2045 combined with healthier ecosystem management and compares health outcomes for a "no action" scenario (Reference) to a "take action" decarbonization scenario to determine the types of possible benefits and directionality of benefits. This Scoping Plan also includes a quantitative analysis of a subset of health endpoints (or outcomes) from reductions in air pollution in Chapter 3, Appendix H (AB 32 GHG Inventory Sector Modeling) and Appendix C (AB 197 Measure Analysis). This analysis looks at a broad range of additional impacts particularly as it relates to community resiliency.

This analysis provides best estimates or descriptions of statewide actions and trends that can be linked to decarbonization for the focus-areas listed below. While generally qualitative, the analysis does provide quantitative estimates where possible. This analysis identifies potential co-benefits, provides directional effects, and includes quantitative analysis information where possible. While the analysis is focused on health outcomes state-wide, it also includes discussion of potential inequities experienced at a community-level and areas for further action to achieve success in health improvements and equitable solutions. If available, the analysis uses specific emissions data or other indicators of changes expected by 2045, including from the Scoping Plan scenarios, to assess potential benefits.

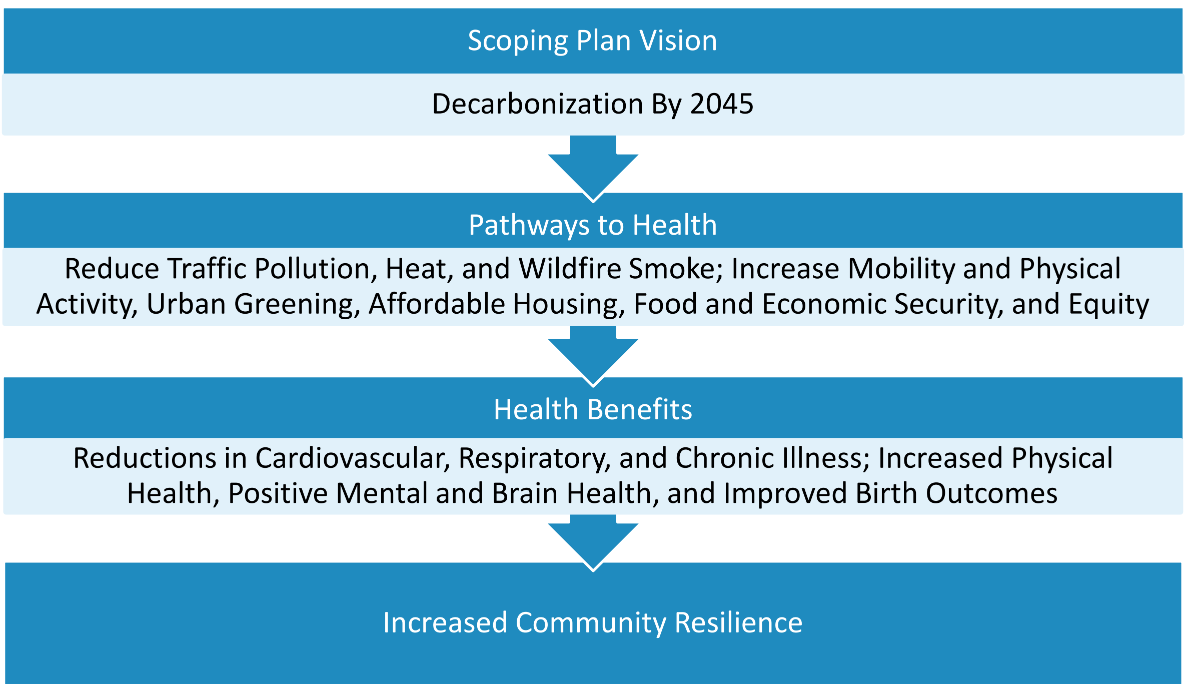
Key areas of focus in this qualitative analysis include:

- Heat impacts
- Wildfires and Smoke Impacts
- Children's health and development
- Economic security
- Food security
- Mobility and physical activity

- Affordable Housing
- Urban Greening

For each focus area, this analysis covers the scientific evidence and compares expected health effects between “no action” and “take action.” The analysis includes the directional or quantitative health benefits, the strength of these benefits where possible, and how the benefits contribute to community health and climate resilience. The analysis also discusses strategies for achieving further success to promote health improvements and equitable solutions. Figure G-1 shows the co-benefit areas covered in the Scoping Plan and the path to health improvements and increased community resilience.

Figure G-1: Scoping Plan outcome and the path to health improvements



It is important to note that in the future CARB may be able to quantify health impacts for some health endpoints that are currently analyzed as qualitative benefits pending results from ongoing research contracts. The Scoping Plan does include quantification and monetization of a subset of air pollution health benefits in other analysis within the document. And while that analysis does quantify and monetize more air pollution health endpoints than in previous Scoping Plans, there are many additional health impacts that should be considered, both air pollution and broader impacts, that are strongly associated with decarbonization by 2045. This appendix provides a broader health analysis, including impacts that cannot currently be monetized. CARB is also researching important additional health endpoints related to air pollution exposure that could be monetized in the future including neurodevelopmental and metabolic impacts (e.g. diabetes) as well as birth outcomes. As more health endpoints are monetized, CARB will be able to provide more comprehensive estimates of benefits. Therefore, the likely impacts of inaction are underestimated in the quantitative analysis provided in other parts of the Scoping Plan.

Community Resilience and Health

Health leaders such as the World Health Organization have established that a public health approach to climate change must involve a broad-based response that addresses the root causes of health inequities and climate threats simultaneously, which requires working across multiple sectors to improve core health systems and address societal factors that increase health risks. It is important to help communities to reduce environmental hazards and address social determinants of health to become more resilient in the face of climate threats. Work on building community resilience involves interagency coordination across state and local agencies that are involved in different aspects of health policy, and that work is reflected in many statewide efforts including the Scoping Plan, the California Natural Resources Agency (CNRA) *California Climate Adaptation Strategy*, the California Department of Public Health (CDPH) *Climate Change and Health Equity Section* (including its *CalBRACE project*), the CNRA *Extreme Heat Action Plan*, the Office of Planning and Research (OPR) *Integrated Climate Adaptation and Resiliency Program* and other efforts. Building resilience to climate risks is an important part of a public health response to climate change.

A strong body of scientific literature supports the importance of building community resilience against adverse climate effects. The IPCC has made this a major theme of its reports on climate change and climate adaptation, including its working group reports for the Fifth and Sixth Assessment reports. Reducing chronic illness and health disparities and improving health systems to protect against illness are critical factors in increasing community resilience to climate events as stated in the IPCC Working Group II's contribution to the Sixth Assessment report, Climate Change 2022: Impacts, Adaptation and Vulnerability Report.[25] Scoping Plan outcomes that reduce chronic illness and improve health outcomes will directly contribute to community resilience. As discussed in the analysis of health co-benefit areas, a range of benefits that affect environmental and social determinants of health are expected to accompany Scoping Plan outcomes.

This health analysis emphasizes community resilience as a key public health goal, which includes the ability of a community to reduce harm and maintain an acceptable

[25] IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

quality of life in the face of climate-induced stresses. Climate resilience is not simply about having the ability to “bounce-back” after climate disasters, but to "bounce forward” to more equitable and healthier living conditions despite climate disruptions.[26] In California, some communities have had challenges in maintaining quality of life in response to environmental stress – this lack of resilience has been occurring across the state and tackling this complex problem is urgent and critical. Increasing and fostering the capacity of communities and people to face, adapt, recover, and learn from disruptions brought by a changing climate will help to build more resilient communities.[27] While community resilience takes on different forms depending on specific community circumstances, it is important to emphasize that the purpose of building community resilience is to change the conditions and systems that lead to disproportionate harm in communities rather than to build capacity to absorb more harm.

Social and Environmental Determinants of Health Equity

Communities across the state do not experience pollution sources and effects equally. Vulnerable communities experience significantly higher rates of pollution and adverse health conditions than others. As shown in Figure G-2, the most impacted areas in California with the highest combined pollution burden according to CalEnviroScreen closely match areas with larger percentages of non-White population. Recent findings show that Black Californians have 19 percent higher PM2.5 exposure from vehicle emissions than the state average, and the census tracts with the highest PM2.5 pollution burden from vehicle emissions have a high proportion of people of color.[28] Air pollutant emissions from mobile sources have disproportionate impacts on low-income communities and communities of color as well as vulnerable individuals.[29] Diesel-fueled vehicles traveling on California’s freeways and major roads expose nearby residents to pollution that is linked to lung cancer, premature death, hospitalizations and emergency department visits for chronic heart and lung disease.[30, 31] Chronic exposure to traffic and freight emissions results in significant and disproportionate health harm. Environmental exposures are one component of a broader set of community factors discussed in this section that can threaten health and the combination of all these factors can compound health effects.

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[26] Pathways to Resilience: Transforming Cities in a Changing Climate. 2015. Movement Strategy Center. https://movementstrategy.org/wp-content/uploads/2021/10/Pathways-to-Resilience-Transforming-Cities-in-a-Changing-Climate.pdf

[27] California Natural Resources Agency. Safeguarding California Plan: 2018 Update-California’s Climate Adaptation Strategy. 2018

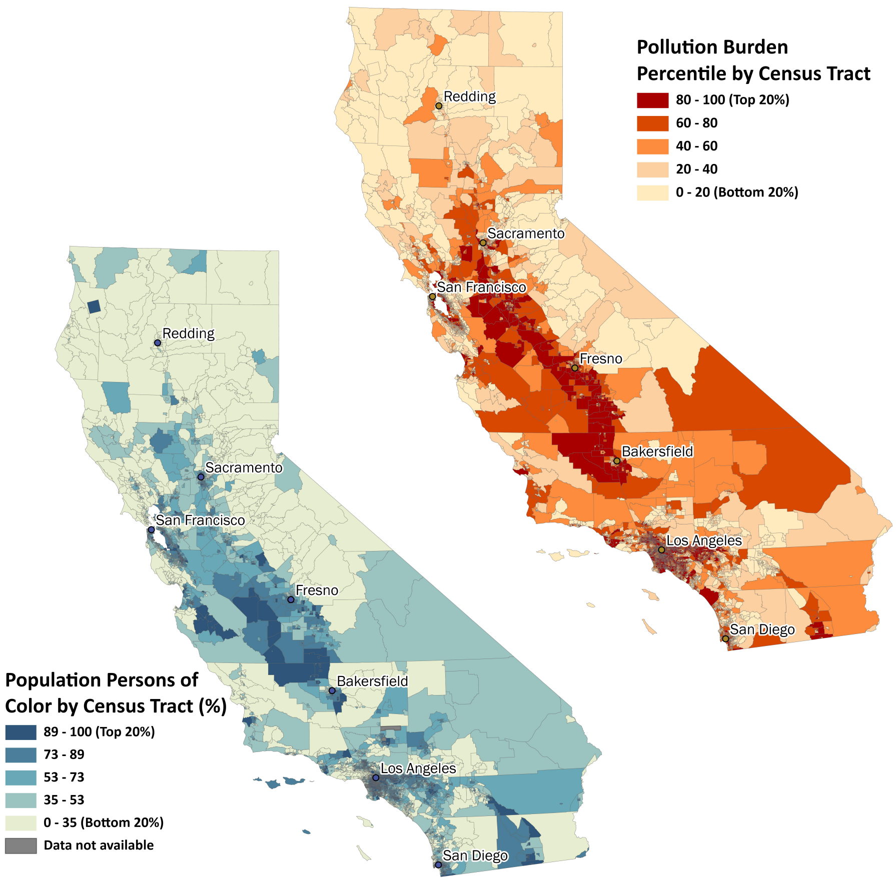
[28] Reichmuth. 2019. Inequitable exposure to air pollution from vehicles in California. Available: https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019.

[29] CARB. 2017b. California's 2017 climate change scoping plan. Available: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

[30] CARB. 2020a. Overview: Diesel exhaust & health. Available: https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health

[31] Kagawa J. 2002. Health effects of diesel exhaust emissions--a mixture of air pollutants of worldwide concern. Toxicology 181-182:349-353.

Figure G-2: California impacted communities and pollution burden by census tract



Source: California Environmental Protection Agency (Cal/EPA) and the Office of Environmental Health Hazard Assessment (OEHHA), California Communities Environmental Health Screening Tool, Version 3.0 (CalEnviroScreen 3.0), 2017. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Social Determinants of Health Equity

The physical and mental health, well-being, and resilience of individuals and communities is shaped, to a great extent, by the social, economic, and environmental circumstances in which people live, work, play, and learn. According to the World

Health Organization, these same circumstances—or social determinants of health—are "mostly responsible for health inequities: the unfair and avoidable differences in health status seen within and between countries." These determinants include the social and economic circumstances in which people grow up and live as adults, the educational opportunities they have, and the environmental quality and built environment in which they live and work. In fact, a strong body of evidence demonstrates that more than 50 percent of long-term health outcomes are determined to be the result of social determinants affecting an individual.[32] Race/ethnicity and socioeconomic status, for example, have been found to amplify impacts from long- and short-term environmental exposures for several health outcomes, such as mortality and birth outcomes.[33, 34, 35, 36] Social factors combine in vulnerable communities to create levels of toxic chronic stress and limit opportunities for healthy food and healthy lifestyles. Social factors can also cause health disparity through psychosocial pathways such as discrimination and social exclusion.[37] While the importance of social determinants is well known, measuring the specific and cumulative impacts of social determinants is challenging. Figure G-3 shows the higher percentage of people of color in the most pollution impacted neighborhoods in California.

Many social determinants are rooted in systemic racism experienced by communities of color that has permeated society in the United States and within California throughout our history. Certain communities continue to experience environmental and health inequities from elevated levels of pollution and environmental hazards, along with impacts of climate change. Communities near ports, rail yards, warehouses, and freeways are often low-income and communities of color, and they experience a higher concentration of air pollution than other areas due to emissions from mobile sources such as cars, trucks, locomotives, and ships. Many of the same communities also experience pollution impacts from large industrial and energy facilities. Proximity to smaller sources like chrome platers and metal recycling facilities likewise contribute to localized air toxics impacts in many communities across the state.

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[32] California Department of Public Health (CDPH). 2015. The Portrait of Promise: The California Statewide Plan to Promote Health and Mental Health Equity. A Report to the Legislature and the People of California by the Office of Health Equity. Sacramento, CA: California Department of Public Health, Office of Health Equity.

[33] O'Neill MS , Jerrett M , Kawachi I , Levy JI , Cohen AJ , Gouveia N , et al. Health, wealth, and air pollution: advancing theory and methods . Environ Health Perspect . 2003 ; 111 (16): 1861 – 70 .

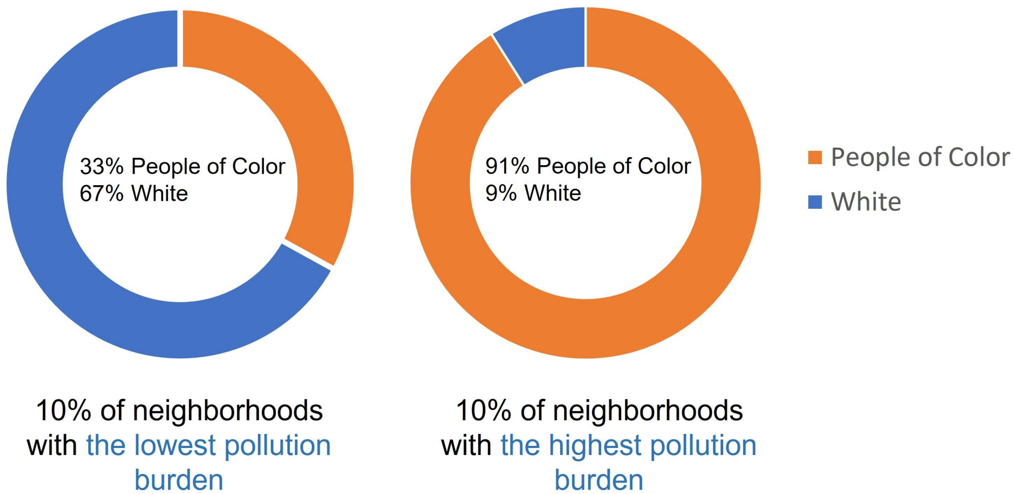
[34] Ponce NA , Hoggatt KJ , Wilhelm M , Ritz B . Preterm birth: the interaction of traffic-related air pollution with economic hardship in Los Angeles neighborhoods . Am J Epidemiol . 2005 ; 162 (2): 140 – 8 .

[35] Morello-Frosch R , Jesdale B , Sadd J , Pastor M . Ambient air pollution exposure and full-term birth weight in California. Environ Health . 2010 ; 9 : 44 .

[36] Finkelstein MM , Jerrett M , DeLuca P , Finkelstein N , Verma DK , Chapman K , et al. Relation between income, air pollution, and mortality: a cohort study . CMAJ . 2003 ; 169 (5): 397 – 402 .

[37] Clougherty J , Kubzansky L . A framework for examining social stress and susceptibility in air pollution and respiratory health. Environ Health Perspect . 2009 ; 117 (9): 1351 – 8.

Figure G-3: Least and most impacted neighborhoods from CalEnviroScreen[1]



[1] Represents the top and bottom decile scoring CalEnviroScreen census tracts for pollution burden
Source: This chart is modified from Figure 2. Race in the Least and Most Impacted Census Tracts of CalEnviroScreen 4.0 in the Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Analysis of Race/Ethnicity and CalEnviroScreen 4.0 Scores. 2021

An overwhelming scientific consensus demonstrates that cumulative adverse childhood experiences or ACEs in children, particularly during critical and sensitive developmental periods, is a root cause for harmful and expensive health challenges. ACEs are strongly associated with nine of the 10 leading causes of death in the United States, including heart disease, cancer, chronic lower respiratory disease, strokes, and earlier mortality. Children that live in low-income communities are subject to increased levels of stress and tend to have more adverse childhood experiences. Children that have 4 or more ACEs are more likely to develop asthma and Latino children with 4 or more ACEs are at increased risk of asthma compared to other children without these experiences. The California Office of Surgeon General's report, "*Roadmap for Resilience: The California Surgeon General's Report on Adverse Childhood Experiences, Toxic Stress and Health*" provides updated information on ACEs and the associated mortality and morbidity effects.[38, 39]

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[38] Bhushan D, Kotz K, McCall J, Wirtz S, Gilgoff R, Dube SR, Powers C, Olson-Morgan J, Galeste M, Patterson K, Harris L, Mills A, Bethell C, Burke Harris N, Office of the California Surgeon General. *Roadmap for Resilience: The California Surgeon General's Report on Adverse Childhood Experiences, Toxic Stress, and Health.* Office of the California Surgeon General, 2020. DOI: *10.48019/PEAM8812.*
[39] Office of the California Surgeon General. Adverse Childhood Experiences (ACEs) and Toxic Stress. https://osg.ca.gov/aces-toxic-stress-2/

Environmental Determinants of Health Equity

Communities with large percentages of Black, Indigenous, and other people of color, and other socially vulnerable groups are disproportionately located near pollution sources, such as traffic and freight facilities, industrial facilities, hazardous waste sites, etc.[40, 41, 42, 43] Research shows large disparities in exposure to pollution between White and non-white populations in California, and large disparities in exposure to pollution between low-income and higher-income communities. The research also shows Black and Latino populations experience significantly greater air pollution impacts than White populations in California. While mobile sources account for over 30 percent of total PM2.5 on average, for example, greater percentages were found in racial and ethnic sub-groups.[44] Figure G-4 compares the contributions of several top PM2.5 sources to average PM2.5 exposure concentrations by race and in disadvantaged communities as defined by CalEnviroScreen.[45] This figure shows that mobile sources are the largest source of pollution exposure disparity for Black populations and residents of disadvantaged communities, as defined by CalEnviroScreen, when compared to the average population in California. Specifically, mobile sources accounted for 45 percent of exposure disparity for the Black population, and 37 percent of exposure disparity for people in disadvantaged communities.

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[40] Mohai P , Lanz PM , Morenoff J , House JS , Mero RP . Racial and socioeconomic disparities in residential proximity to polluting industrial facilities: evidence from the Americans' Changing Lives Study . Am J Public Health . 2009 ; 99 (Suppl 3): S649 – 56.

[41] Mohai P , Saha R . Racial inequality in the distribution of hazardous waste: a national-level reassessment . Soc Probl . 2007 ; 54 (3): 343 – 70.

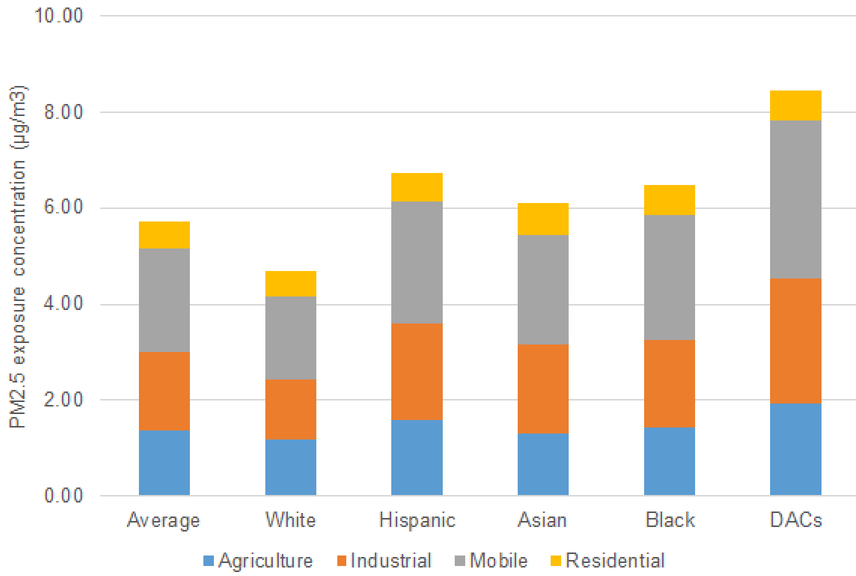
[42] Morello-Frosch R , Pastor M , Porras C , Sadd J . Environmental justice and regional inequality in southern California: implications for future research . Environ Health Perspect . 2002 ; 110 (Suppl 2): 149 – 54.

[43] Gunier RB , Hertz A , von Behren J , Reynolds P . Traffic density in California: socioeconomic and ethnic differences among potentially exposed children . J Expo Anal Environ Epidemiol . 2003 ; 13 (3): 240 – 6.

[44] Apte et al (2019). A Method to Prioritize Sources for Reducing High PM2.5 Exposures in Environmental Justice Communities in California. CARB Research Contract Number 17RD006

[45] CARB. 2020 Mobile Source Strategy. 2021. https://ww2.arb.ca.gov/sites/default/files/2021-09/Proposed_2020_Mobile_Source_Strategy.pdf

Figure G-4: Top sources of PM2.5 and their contribution to exposures by race



Source: Apte et al (2019). A Method to Prioritize Sources for Reducing High PM2.5 Exposures in Environmental Justice Communities in California. CARB Research Contract Number 17RD006

Exposure disparities result in health disparities. Communities located near major roadways are at increased risk of asthma attacks and other respiratory and cardiac effects; these are often low-income communities and communities of color. Studies consistently show that mobile source pollution exposure near major roadways contributes to and exacerbates asthma, impairs lung function, and increases cardiovascular mortality.[46] The exposure to mixtures of gaseous and particulate pollutants in mobile sources (including PM, NOx, and benzene) is associated with higher rates of heart attacks, strokes, lung cancer, autism, and dementia.[47] Individuals living in communities located near ports and freight hubs are also subject to higher cancer risks than surrounding communities.[48] People living in areas near freight and other significant sources are at risk of exposure to high quantities of diesel emission fumes.[49, 50] A significant body of research has documented these disproportionate health harms.

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[46] U.S. Environmental Protection Agency website. How Mobile Source Pollution Effects Your Health https://www.epa.gov/mobile-source-pollution/how-mobile-source-pollution-affects-your-health
[47] USC Environmental Health Centers. (2018). Living Near Busy Roads or Traffic Pollution. https://envhealthcenters.usc.edu/wp-content/uploads/2016/10/living-near-bus_19696172.pdf
[48] South Coast AQMD (2015). Multiple Air Toxics Exposure Study in the South Coast Air Basin
[49] Garshick E, Laden F, Hart JE, Davis ME, Eisen EA, Smith TJ. Lung cancer and elemental carbon exposure in trucking industry workers. Environ Health Perspect. 2012 Sep;120(9):1301-6. doi: 10.1289/ehp.1204989. Epub 2012 Jun 1. PMID: 22739103; PMCID: PMC3440130.
[50] Pronk A, Coble J, Stewart PA. Occupational exposure to diesel engine exhaust: a literature review. J Expo Sci Environ Epidemiol. 2009 Jul;19(5):443-57. doi: 10.1038/jes.2009.21. Epub 2009 Mar 11. PMID: 19277070; PMCID: PMC3073453.

Environmental hazards found in communities can also include exposures to toxic substances and emissions as well as occupational exposures. Low-income communities and communities of color are often located close to sources of toxic pollution including chrome platers, metal recycling facilities, oil and gas operations, agricultural burning, railyards, facilities transporting, managing or disposing of hazardous waste, areas impacted by pesticides, among other sources. Some populations may be at increased risk of exposure both at work and home. Exposures to contaminants from these sources can increase risk of harm independently or cumulatively, although few studies exist to accurately measure cumulative effects of combined chemical exposures.

Occupational exposures can include diesel particulates and other sources. The use of diesel-powered on- and off-road equipment can be a major source of exposure to toxic diesel exhaust for workers in occupations including agriculture, construction, energy extraction, mining, rail, shipping, transport/logistics, tunneling, vehicle repair, and warehousing. Prolonged exposure to diesel emissions over many years is associated with an increase in workers' risk of cardiovascular, cardiopulmonary and respiratory disease, and lung cancer.[51, 52, 53, 54, 55] Low-income workers also may be placed at higher risks of occupational exposures in working with chemicals such as agricultural pesticides.

Children are more susceptible to environmental pollutants for many reasons, including the ongoing development of their nervous, immune, digestive, and other bodily systems. Moreover, children eat more food, drink more fluids, and breathe more air relative to their body weight, as compared to adults.[56] Exposure to high levels of air pollutants, including indoor air pollutants, increases the risk of premature death, respiratory infections, heart disease, and asthma.[57] Children living in low-income neighborhoods near industrial operations, rail yards, and heavily travelled freeways and streets in urban areas are at especially high risk of chronic respiratory conditions. Results from CARB's groundbreaking, long-term children's health study in Southern California demonstrated that particle pollution may significantly reduce lung function

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[51] HEI. (1995). Diesel Exhaust: A Critical Analysis of Emissions, Exposure and Health Effects. A Special Report of the Institute's Diesel Working Group. Health Effects Institute

[52] Garshick E, Laden F, Hart JE, et al. Lung cancer and vehicle exhaust in trucking industry workers. Environ Health Perspect. 2008;116(10):1327-1332. doi:10.1289/ehp.11293

[53] NIOSH. NIOSH current intelligence bulletin: 50-carcinogenic effects of exposure to diesel exhaust, August 1988. 1988.

[54] Mauderly, J. L. (1992). Diesel Exhaust, Chapter 5, Environmental Toxicants: Human Exposures and Their Health Effects

[55] Wade JF 3rd, Newman LS. Diesel asthma. Reactive airways disease following overexposure to locomotive exhaust. J Occup Med. 1993 Feb;35(2):149-54. PMID: 8433186.

[56] Blaisdell RJ. Air Toxics Hot Spots Program Risk Assessment Guidelines. Technical Support Document for Exposure Assessment and Stochastic Analysis. Oakland, CA: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment; August 2012.

[57] Woodruff TJ, Axelrad DA, Kyle AD, Nweke O, Miller GG. America's Children and the Environment: Measures of Contaminants, Body Burdens, and Illness. 2nd ed. Washington, DC: United States Environmental Protection Agency; February 2003.

growth in children,[58, 59, 60] and indicates these effects are likely permanent.[61] Additionally, increased exposure to vehicular traffic pollution was associated with adverse childhood health impacts, including slower lung development[62] increased symptoms and medication use in asthmatic children,[63, 64] and increases in the development of asthma in children.[65] In California, children with asthma living in low-income households miss more than twice as many days of school due to the severity of symptoms as children living in higher income households.[66] A review of hundreds of studies also found substantial agreement in findings that children in homes with gas appliances experience higher rates of asthma symptoms.

The timing of exposure to chemicals or other insults is critical in determining the consequences to children's health.[67] Because of differing windows of susceptibility, the same exposure during different periods of children's development can have very different consequences.[68] For example, due to the complexity and speed of development during the prenatal period, organ system development is particularly susceptible to adverse effects resulting from environmental exposures. Children's lungs continue to grow and develop into the late teens and early adulthood, putting children at greater risk from air pollution exposures.[69]

For older adults, increased vulnerability to environmental pollutants is linked to immune, respiratory, and cardiovascular systems weakened by aging.[70] Pre-existing health conditions interact with environmental pollutants to enhance risks of adverse

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[58] Peters JM, Avol E, Gauderman WJ, Linn WS, Navidi W, London SJ, Margolis H, Rappaport E, Vora H, Gong H Jr, Thomas DC. A study of twelve Southern California communities with differing levels and types of air pollution. II. Effects on pulmonary function. Am J Respir Crit Care Med. 1999 Mar;159(3):768-75. doi: 10.1164/ajrccm.159.3.9804144.
[59] Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. Am J Respir Crit Care Med. 2001 Dec 1;164(11):2067-72. doi: 10.1164/ajrccm.164.11.2102005.
[60] Gauderman WJ, Gilliland GF, Vora H, Avol E, Stram D, McConnell R, Thomas D, Lurmann F, Margolis HG, Rappaport EB, Berhane K, Peters JM. Association between air pollution and lung function growth in southern California children: results from a second cohort. Am J Respir Crit Care Med. 2002 Jul 1;166(1):76-84. doi: 10.1164/rccm.2111021
[61] Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, Margolis H, Bates D, Peters J. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med. 2004 Sep 9;351(11):1057-67. doi: 10.1056/NEJMoa040610.
[62] Gauderman WJ, Vora H, McConnell R, Berhane K, Gilliland F, Thomas D, Lurmann F, Avol E, Kunzli N, Jerrett M, Peters J. Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. Lancet. 2007 Feb 17;369(9561):571-7. doi: 10.1016/S0140-6736(07)60037-3.
[63] Gauderman WJ, Avol E, Lurmann F, Kuenzli N, Gilliland F, Peters J, McConnell R. Childhood asthma and exposure to traffic and nitrogen dioxide. Epidemiology. 2005 Nov;16(6):737-43. doi: 10.1097/01.ede.0000181308.51440.75.
[64] McConnell R, Berhane K, Yao L, Jerrett M, Lurmann F, Gilliland F, Künzli N, Gauderman J, Avol E, Thomas D, Peters J. Traffic, susceptibility, and childhood asthma. Environ Health Perspect. 2006 May;114(5):766-72. doi: 10.1289/ehp.8594
[65] McConnell R, Islam T, Shankardass K, Jerrett M, Lurmann F, Gilliland F, Gauderman J, Avol E, Künzli N, Yao L, Peters J, Berhane K. Childhood incident asthma and traffic-related air pollution at home and school. Environ Health Perspect. 2010 Jul;118(7):1021-6. doi: 10.1289/ehp.0901232.
[66] Wolstein J, Meng YY and Babey SH. Income Disparitiesin Asthma Burden and Care in California. Los Angeles, CA: UCLA Center for Health Policy Research, 2010.
[67] WHO. Summary of principles for evaluating health risks in children associated with exposure to chemicals. 2011. WHO Document Production Services, Geneva, Switzerland. https://www.who.int/ceh/health_risk_children.pdf
[68] U.S. EPA. Children Are Not Little Adults! 2021. https://www.epa.gov/children/children-are-not-little-adults
[69] American Lung Association. Children and Air Pollution. 2020. https://www.lung.org/clean-air/outdoors/who-is-at-risk/children-and-air-pollution
[70] Sandström T, Frew AJ, Svartengren M , Viegi G . The need for a focus on air pollution research in the elderly. Eur Respir J Suppl. 2003; 40 : 92s – 5s.

health outcomes.[71, 72] The recent COVID-19 pandemic has highlighted the heightened vulnerability of older adults as well as communities of color to respiratory disease as hospital admissions and mortality data linked to COVID-19 cases for these groups have been higher than other groups. Research has also underscored the important link between COVID-19 mortality and morbidity and air pollution, demonstrating significantly higher mortality and morbidity for COVID-19 in areas with elevated PM 2.5 pollution.

Cumulative Impacts in Communities

The social and environmental determinants referred to in this section are components of a broader set of social, economic, and environmental factors that can amplify health conditions and the combination of all these factors can compound the health effects of individual exposures. This broader set of community factors can be referred to as "cumulative impacts." In addition, specific populations are more sensitive to pollution and face greater susceptibility. This includes young children, older adults, and individuals with existing health conditions.

CARB has been working over the past decade to better understand and map cumulative impacts in California, in coordination with OEHHA, and to identify communities that are experiencing the highest levels of socio-economic and pollution related vulnerability. CARB research, for example, evaluated environmental, health, social vulnerability factors and supported the development of *CalEnviroScreen* (CES), a statewide cumulative impacts mapping tool by California Environmental Protection Agency (CalEPA) and the California Office of Health Hazard Assessment (OEHHA). There are a number of tools that assess community and climate vulnerability that can assist in identifying vulnerable communities. An overview of community vulnerability tools and their indicators can also be found in a resource guide, *Defining Vulnerable Communities in the Context of Climate Adaptation*, on the Integrated Climate Adaptation and Resiliency Program website. These tools can be used in the implementation phase of greenhouse gas reduction measures to provide important information about factors in communities that can amplify health effects and to inform planning for actions and investments.

CES is a GIS-based mapping tool that provides information on cumulative pollution burdens and vulnerabilities on a statewide basis. CES scores and integrates 21 different indicators of a community's vulnerability from pollution burden and population impacts. Built on analysis of environmental, public health, and socioeconomic data on conditions in California's 8,000 census tracts, it maps impacts from individual indicators or cumulative impacts. Categories of indicators include

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[71] Zanobetti A , Schwartz J . Are diabetics more susceptible to the health effects of airborne particles? Am J Respir Crit Care Med. 2001 ; 164 (5): 831 – 3 .

[72] Zanobetti A , Schwartz J , Gold D . Are there sensitive subgroups for the effects of airborne particles? Environ Health Perspect. 2000; 108 (9): 841 – 5.

environmental (exposures to pollutants and adverse environmental conditions), population (prevalence of certain health conditions), and socioeconomic factors. CES cumulative rankings by census tract provide a snapshot of disparities in California. CES rankings, for example, show the communities ranked in the highest percentiles are largely in the San Joaquin Valley and South Coast regions. A supplemental analysis of CES shows a direct, persistent relationship between exposure to environmental burdens and socio-economic and health vulnerabilities affecting communities of color. CES has also been recently used in health research on effects in highly impacted communities.

The *Healthy Places Index* (HPI) is another statewide tool that uses a set of vulnerability indicators to provide a cumulative picture of factors influencing health disparities. The HPI uses 25 indicators from eight categories that affect life expectancy including, economic, education, transportation, social neighborhood, healthcare access, housing and clean environment. Similar to CES, HPI also provides and ranks scores by census tract. HPI data and maps help identify neighborhoods that can benefit from policy action and funding opportunities. HPI has already been utilized by more than 100 government agencies, health care institutions, community groups and other sectors for a variety of different purposes, including transportation planning, climate vulnerability analysis, philanthropic grantmaking, and hospital community health needs assessments. CES, HPI and other current and emerging tools can help inform implementation of the Scoping Plan.

Climate Vulnerabilities

Climate change serves as a risk multiplier, further increasing the risk of negative health outcomes for those already experiencing health inequities. Often the communities that are most impacted by social and environmental conditions are those on the front lines of climate change. A report from the California Climate Change Center warned that the impacts of climate change will likely create especially heavy burdens on low-income and many other vulnerable populations.[73] Authors of the publication, The Climate Gap: Inequalities in How Climate Change Hurts Americans and How to Close the Gap, state that "without proactive policies to address these equity concerns, climate change will likely reinforce and amplify current as well as future socioeconomic disparities, leaving low-income, minority, and politically marginalized groups with fewer economic opportunities and more environmental and health burdens".[74] The communities that are on the front lines for experiencing the worst impacts of climate change and the communities that are already experiencing multiple social and

[73] Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association.
[74] Morello Frosch R, Pastor M, Sadd J, Shonkoff S. (2009). The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. https://dornsife.usc.edu/eri/the-climate-gap-inequalities-how-climate-change-hurts-america/

environmental stressors and suffering from inequities are almost always the same communities.

In the U.S. Environmental Protection Agency's "Climate Change and Social Vulnerability in the US, A Focus on Six Impacts",[75] investigators analyzed risks of six primary climate change impacts disproportionately impacting communities across income, educational attainment, race/ethnicity, and age groups. Four socially vulnerable populations were identified as having a higher likelihood of experiencing the greatest impacts of a changing climate (according to the projected 2°C of global warming or 50 cm of global sea level rise) and they were: low-income communities, racial and ethnic subgroup populations, people with less educational attainment, and people age 65 and older. Disproportionate impacts were projected for climate events including air quality, extreme temperature, coastal flooding, and other impacts leading to increased risk of health and other adverse outcomes. The EPA study projected significant health impacts for low-income communities, certain racial and ethnic sub-groups, and those with lower educational attainment. For example, racial/ethnic subgroup and low-income populations are respectively projected to experience a 14 percent and 20 percent greater risk of childhood asthma than others in the Southwest region.

U.S. EPA's identified vulnerable communities for climate events overlap with groups discussed earlier in this section that experience health inequities due to environmental and social conditions in communities as well as individual vulnerability due to age. Following are brief descriptions of the groups highlighted in EPA's analysis as they relate to climate impacts:

Low-income communities - Communities with higher poverty rates have been seen to have higher exposure to environmental pollution, including ambient PM2.5 and O3 concentrations. Elevated mortality associated with heat effects has been observed in poor neighborhoods, particularly for individuals who cannot afford health insurance. In addition to adverse health outcomes attributed to high temperature, low-income populations would have greater economic impact from lost labor hours related to extreme weather events. Also, flooding is more likely to cause severe damage in poor-quality and old dwellings that are affordable to low-income populations.

Communities of Color - Communities with a majority of racial or ethnic sub-group populations have been found to be more polluted and linked to worse health outcomes. Black and Hispanic sub-groups have shown greater heat attributed-health impacts. Prolonged travel hours due to climate-driven events or disasters, such as flooding, can hinder accessibility and/or opportunity to employment and/or social engagement (i.e. isolation) among low income communities and communities of color. Recovering from damage (such as lost property) brought by climate change is more

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[75] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003.

challenging for low-income communities and communities of color, particularly according to economic impacts.

Education level - Educational attainment has been related to neighborhood air pollution concentrations in studies and is included as an indicator of cumulative impacts in CalEnviroScreen.

Age 65 and older - Older adults are more likely to experience adverse health outcomes from climate change, including respiratory and cardiovascular diseases, induced, or exacerbated by air pollution, particularly for those with underlying medical conditions. Heat is another stressor that can exacerbate underlying medical conditions, such as cardiac diseases, and thus older adults are more susceptible to heat exposure. Limited access to health care and lack of ability to relocate associated with climate-driven extreme weather events can make individuals with less mobility, such as older adults and individuals with disabilities, more vulnerable than they already are.

Several climate vulnerability tools have been developed or are under development to better understand and map areas at higher risk of climate impacts. These tools, together with those discussed under cumulative impacts, can assist in the implementation phase of greenhouse gas reduction measures or help inform climate investments. The California Department of Public Health's (CDPH) Climate Change and Health Vulnerability Indicators (CCHVIs) for California, for example, has assisted with state and local climate adaptation and mitigation efforts. It provides information on 21 different indicators in three categories: environmental exposures, population sensitivity and adaptive capacity (see examples in Figure G-5). Using this tool, agencies can compare the county values with the state average and/or explore more detailed information maps on every indicator by census tracts. The majority of indicators for Los Angeles County, for example, are higher than the state averages (i.e., more vulnerable to climate and health risks) particularly for the indicators of limited English proficiency or linguistically isolated (more than twice the state average). Moreover, vulnerability based on various combinations of exposure and sensitivity indicators can be visualized and compared across counties.

Figure G-5: Examples of climate change and health vulnerability indicators

Climate Change and Health Vulnerability Indicators from CCHVIs Tool		
% Household with English Speaker	% Impervious Surface	% People without Health Insurance
Ozone and PM 2.5 Concentrations	Extreme Heat Days – Midcentury/End of Century	% Households without Tree Canopy
% Under-resourced People	% People Over Age 65	Violent Crimes/1,000 People
% Under Age 5	% Households Without Air Conditioning	% Without College Education
% People with Disability	% Outdoor Workers	% People in Sea Level Rise Risk Areas

Source: The California Department of Public Health's (CDPH) Climate Change and Health Vulnerability Indicators (CCHVIs) for California

CARB developed a new climate vulnerability tool that will estimate differential impacts of climate change on a statewide basis at a census tract level. The CVM integrates indicators of climate change vulnerability to map cumulative impacts, including heat island risk, projected changes in temperature, and additional measures of social isolation and lack of mobility. More information on this tool is available in Chapter 3 and Appendix K (Climate Vulnerability Metric).[76]

Conclusions

Climate change is posing serious health risks to Californians that multiply the effects of existing social and environmental inequities and increase vulnerability for children and seniors. Many environmental, social, individual, economic and other factors affect health in California and contribute to elevated health risks from climate change impacts. This section summarizes a substantial and growing body of health research documenting these different factors. A broader discussion of health inequities is available in "An Update on the *Portrait of Promise:* Demographic Report on Health

[76] See presentation from March 15, 2022 CARB Scoping Plan workshop: Unequal Climate Impacts in the State of California: Developing a Climate Vulnerability Metric

and Mental Health Equity in California"[77], which presents background and evidence for the root causes and consequences of health inequities in California. This report illustrates how a broad range of socioeconomic forces, including income security, education and child development, housing, transportation, health care access, environmental quality, and other factors shape the health of entire communities, especially vulnerable communities, resulting in preventable health inequities for specific populations. This section of the appendix clearly demonstrates the impact existing social, environmental, and other factors have on health outcomes and health disparities across communities, and the need for strong action to reduce these health threats.

The next section of the analysis focuses on eight health co-benefit areas related to social and environmental conditions in communities where Scoping Plan outcomes can benefit health and discusses the following for each one: current trends, health impacts and disparities related to the topic, key health metrics, a description of "no action" (Reference) and a "take action" Scoping Plan scenario, health benefits analyzed including directional health benefits as well as quantitative information on benefits where available, and areas for further action, including the types of mitigation actions that can help promote health equity and reduce or eliminate health disparities. As discussed throughout the analysis, pursuing state efforts to assist climate vulnerable communities is a top priority to meet state goals for improved health everywhere in California and will serve to maximize the benefits of Scoping Plan outcomes.

Analysis of Health Co-Benefit Areas

Heat Impacts

Background and Health Impacts

Globally, increasing concentrations of greenhouse gases in the atmosphere are causing a continuing increase of the planet's average temperature over time. California temperatures have risen since records began in 1895, with the rate of increase accelerating since the 1980s.[78] Data released in fall of 2020 by NOAA's National Centers for Environmental Information shows that September 2020 officially ranks as California's hottest September since record-keeping began in 1880.[79] California's latest Climate Assessment projects that heat waves will be more intense,

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[77] An Update on the Portrait of Promise: Demographic Report on Health and Mental Health Equity in California. A Report to the Legislature and the People of California by the Office of Health Equity. Sacramento, CA: California Department of Public Health, Office of Health Equity; February 2020. https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/OHE%20Demographic%20Report%20Approved%20by%20CHHS%20Feb%202020%20Final%202.26.20.pdf

[78] Office of Environmental Health Hazard Assessment, California Environmental Protection Agency (2018). Indicators of Climate Change in California. *https://oehha.ca.gov/media/downloads/climate-change/report/2018caindicatorsreportmay2018.pdf.*

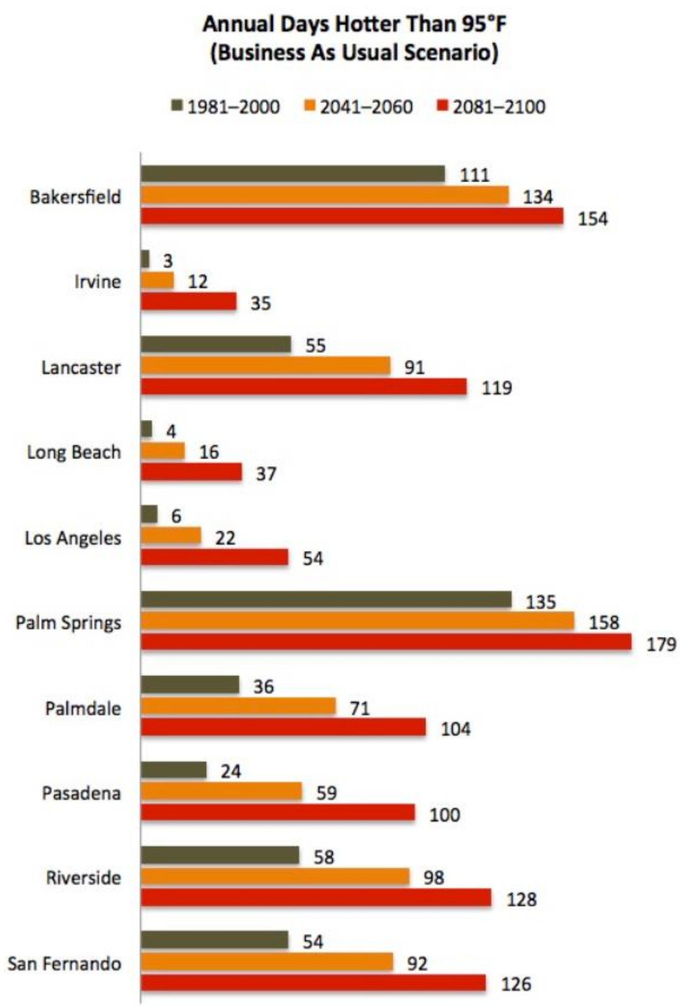
[79] NOAA, Earth just had its hottest September on record (Oct. 14, 2020), https://www.noaa.gov/news/earth-just-had-its-hottest-september-on-record. https://www.noaa.gov/news/summer-2021-neck-and-neck-with-dust-bowl-summer-for-hottest-on-record.

longer, and more frequent in years ahead. For more than three weeks in 2020, back-to-back heat waves settled over the Southwest, claiming dozens of lives, and leaving tens of millions of people sweltering in triple-digit temperatures. California's 2021 heat wave broke records across the state, with Sacramento topping out at 109 degrees and the Coachella Valley having its hottest year ever with temperatures reaching 123 degrees.[80] That event caused emergency room visits to soar to 10 times their normal number during extreme heat days, including when it reached 121°F in Los Angeles County.

Heat waves have a particularly high impact in Southern California, where they have become more frequent, intense, and longer-lasting over the past five decades. Recently Hulley et al., published a study showing how heatwaves became more frequent, intense, and longer-lasting in Southern California from 1950 to 2020.[81] The results indicate that inland urban heatwaves are rapidly increasing in frequency, duration, and intensity with a greater tendency toward more humid nighttime events—a trend likely to accelerate through the 21st century and linked to human-induced climate change. Heatwaves have a high probability of increasing by 42% in frequency and by 26% in duration during severe drought conditions. By 2050, Los Angeles is predicted to experience an average of 22 extreme heat days annually — up from six days in the period from 1980 to 2000. Figure G-6[82] below shows the average number of days per year exceeding 95°F in the baseline period (1981-2000) and the two future periods under a business-as-usual scenario in southern California.

[80] Anne C. Mulkern, California Presents Plan to Prevent Extreme Heat Deaths, E&E News on January 13, 2022 *https://www.scientificamerican.com/article/california-presents-plan-to-prevent-extreme-heat-deaths/*
[81] Hulley, G. C., Dousset, B., & Kahn, B. H. 2020: Rising trends in heatwave metrics across Southern California. Earth's Future, 8, e2020EF001480. *https://doi.org/10.1029/2020EF001480*
[82] *http://research.atmos.ucla.edu/csrl/LA_project_summary.html*

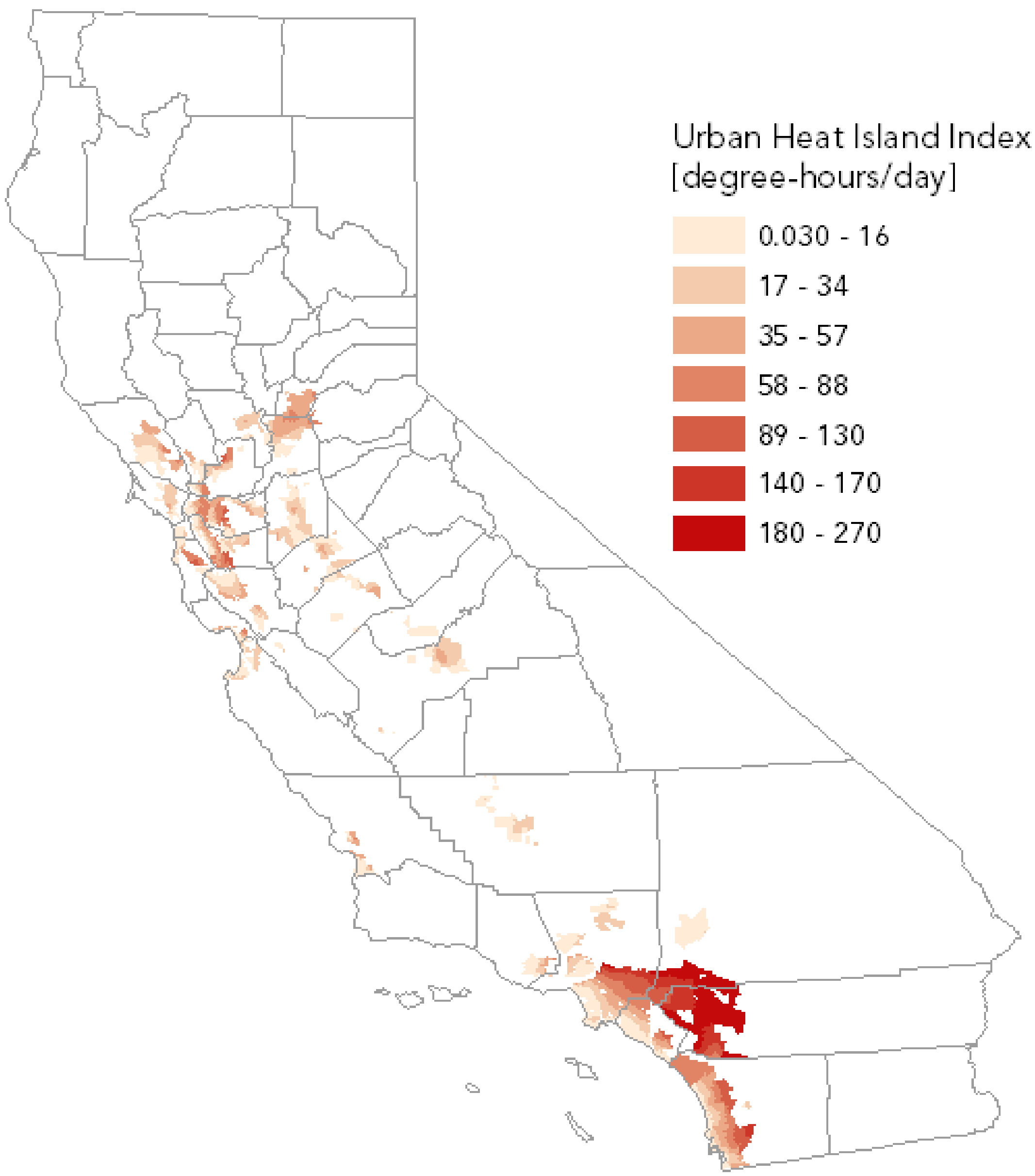
Figure G-6: Annual days hotter than 95 degrees Fahrenheit



Source: The Climate Change in the Los Angeles Region Project

This rising heat is further exacerbated by the urban heat island (UHI) effect, increasing summer temperatures in cities, suburbs, and towns. The urban heat island effect describes the higher day and night temperatures experienced in urban and suburban areas in comparison to their surrounding rural areas. This temperature gap results from solar heat trapped and absorbed by the built environment – roads, pavements, buildings, and roofs. The UHI effect also exacerbates air pollution like ozone formation and increases GHG emissions as a result of greater reliance on air conditioning. The UHI effect offers a useful metric for quantifying locally generated heat, and thus also a potential target for the cooling possible in urbanized or developed locations. In California, urban heat island mitigation measures have been selected based on input from the counties, cities, and communities. Figure G-7 shows a map of California with the darker colored areas measuring higher on the UHI index.

Figure G-7: Urban heat island index map of California



Source: CalEPA Urban Heat Island Interactive Maps *https://calepa.ca.gov/urban-heat-island-interactive-maps-2/*

Hotter temperatures and heatwaves linked to climate change are increasing illnesses and deaths with impacts that vary by age, gender, urbanization, and socioeconomic factors. These health impacts are projected to increase even with adaptation efforts. In California, weather patterns already demonstrate the effects of climate change, and scientists expected that effects will worsen in the coming decades, particularly if actions are not taken to mitigate greenhouse gas emissions.

Hotter temperatures not only lead to heat related illness, but they can also lead to increased air pollution related illness and elevated health effects from the combined health risks. Heat can affect air quality in California by increasing the formation of ground-level ozone and other pollutants. The combination of exposures to extreme heat and air pollution episodes leads to increased health burdens on communities. Two recent studies demonstrate these serious combined effects. A study on climate change and ozone pollution by Zhu et al., indicates that in the absence of emissions controls, climate change will worsen ozone air quality throughout the state, increasing exceedances of ambient air quality standards.[83] If planned reductions in emissions are implemented, ozone air quality throughout the less urban areas of the state may be improved in the year 2035, but regions such as the South Coast Air Basin and the San Francisco Bay Area will likely continue to experience high ozone concentrations throughout the summer season. Recent research also demonstrates co-occurrences of both PM 2.5 and ozone with heat and wildfires. A study by Kalashnikov et al., indicates that the frequency, spatial extent, and temporal persistence of extreme PM2.5/ozone co-occurrences have increased significantly between 2001 and 2020, increasing annual population exposure to multiple harmful air pollutants by ~25 million person-days/year.[84] The results also suggest an increasing potential for these co-occurring air pollution episodes. These increases are undercutting progress toward meeting federal Clean Air Act goals.

A rise in ambient temperature has been shown to be associated with increases in mortality and morbidity.[85] Specifically, high heat events have revealed increased risk of hospitalization for various diagnoses including cardiovascular disease, acute renal failure, dehydration, heat illness and respiratory disease.[86, 87] As the severity, frequency and duration of extreme heat events continue to increase due to climate change, the

[83] Zhu, Shupeng, Jeremy R Horne, Michael Mac Kinnon, G S Samuelsen, and Donald Dabdub. 2019. "Comprehensively Assessing the Drivers of Future Air Quality in California." Environment International 125: 386–98. *https://doi.org/10.1016/j.envint.2019.02.007*

[84] Kalashnikov Dmitri A.; Schnell Jordan L.; Abatzoglou John T.; Swain Daniel L.; Singh Deepti. 2022. Increasing co-occurrence of fine particulate matter and ground-level ozone extremes in the western United States. Science Advances 8(1):eabi9386. *https://www.science.org/doi/pdf/10.1126/sciadv.abi9386*

[85] Benmarhnia, T., Deguen, S., Kaufman, J.S., Smargiassi, A., 2015. Vulnerability to heat related mortality: a systematic review, meta-analysis, and meta-regression analysis. Epidemiology 26 (6), 781–793.

[86] Guirguis, K., Basu, R., Al-Delaimy,W.K., Benmarhnia, T., Clemesha, R.E., Corcos, I., Guzman-Morales, J., Hailey, B., Small, I., Tardy, A., 2018. Heat, disparities, and health outcomes in San Diego County's diverse climate zones. Geo Health 2 (7), 212–223.

[87] Malig, B., Wu, X.,Guiguis, K., Gershunov, A., Basu, R. Associations between ambient temperature and hepatobiliary and renal hospitalizations in California, 1999 to 2009. Environ Res 177:https://doi.org/10.1016/j.envres.2019.108566

impact of heat on morbidity and mortality will be exacerbated.[88, 89] Extreme heat conditions are often defined as weather that is substantially hotter than average for a specific time and place. These events are characterized by stagnant warm air and consecutive nights with above average temperatures, and they are considered a public health problem that will be exacerbated by global warming, urbanization, and an aging population. One framework for identifying heat waves considers measures of daily minimum and maximum temperature, the excess heat factor, and the continuation of extreme heat conditions for three days in a row.[90] Based on Fischer and Schär the National Weather Service (NWS) uses climate-focused thresholds and defines a heat wave as two consecutive days where the daytime high and nighttime low temperatures exceed a certain threshold, which is usually between 80 and 105° F.[91] Mitigating heat health impacts of extreme heat requires an understanding of heat conditions, including the distribution of temperatures across the state, that will negatively affect the local populations.

Extreme heat events pose significant risks to individuals and can be especially dangerous for children and infants, seniors, and people in frail health, particularly those taking certain medications. Heat can exacerbate underlying medical conditions, such as cardiac diseases, in older adults. Research by Bekkar et al. conducted an inclusive review on birth outcomes that involved a comprehensive literature review of 57 studies and found strong associations with heat exposure.[92] The majority of the studies showed a significant association of air pollutant and heat exposure with birth outcomes in all geographic regions of the U.S. An increase in risk of preterm birth with $PM_{2.5}$ or ozone exposure was found in almost 80% of the studies and low birth weight was found in over 85%. Nine of the ten studies looking at pregnancy outcomes found a significant association between exposure to heat during pregnancy and adverse birth outcomes. The subpopulations at highest risk were persons with asthma and communities of color.

Recent studies show an association between increased heat and adverse birth outcomes.[93, 94, 95] These studies identified a range of increased risk of preterm birth

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[88] Sheridan, S.C., Allen,M.J., 2018. Temporal trends in human vulnerability to excessive heat. Environ. Res. Lett. 13 (4).

[89] Guo, Y., Gasparrini, A., Li, S., Sera, F., Vicedo-Cabrera, A.M., Coelho, MdSZS, Saldiva, P.H.N., Lavigne, E., Tawatsupa, B., Punnasiri, K., 2018. Quantifying excess deaths related to heatwaves under climate change scenarios: a multicountry time series modelling study. PLoS Med. 15 (7).

[90] Nairn, J., Fawcett, R., 2013. Defining heatwaves: heatwaves defined as a heat impact event servicing all community and business sectors in Australia. CAWCR Technical report No 060. The Centre for Australian Weather and Climate Research A partnership between the Bureau of Meteorology and CSIRO

[91] Fischer, E.M., Schär, C., 2010. Consistent geographical patterns of changes in high-impact European heatwaves. Nat. Geosci. 3 (6), 398–403.

[92] Bekkar B, Pacheco S, Basu R, DeNicola N. Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. JAMA Netw Open. 2020;3(6):e208243. doi:10.1001/jamanetworkopen.2020.8243.

[93] Avalos LA, Chen H, Li D-K, Basu R. The impact of high apparent temperature on spontaneous preterm delivery: a case-crossover study. Environ Health. 2017;16(1):5. doi:10.1186/s12940-017-0209-5.

[94] Basu R, Chen H, Li D-K, Avalos LA. 2016: The impact of maternal factors on the association between temperature and preterm delivery. Environ Res.;154:109-114. doi:10.1016/j.envres.2016.12.017

[95] Basu R, Malig B, Ostro B. 2010: High ambient temperature and the risk of preterm delivery. Am J Epidemiol. 172(10):1108-1117. doi:10.1093/aje/kwq170.

from 8.6 percent to 21 percent. Three of the studies examining large numbers of preterm births in California noted an increased risk of preterm birth for each 5.6 °C increase in temperature, as did another study covering 12 clinical sites across the US for 2.8 °C increase.[96] The findings suggest that exacerbation of air pollution and heat exposure related to climate change may be significantly associated with risk to pregnancy outcomes in the U.S.

California researchers including those from The Office of Environmental Health Hazard Assessment found an association of race/ethnicity and heat exposure with an increased risk of preterm birth with higher risk found among Black, Asian, and young mothers.[97, 98] In a case-crossover analysis in California, Basu et al., found an increased risk for still birth of 10.4% per 5.6 °C increase in mean ambient temperature (cumulative average of lags, 2-6 days).[99] A nationwide study by Ha et al., reported an increase in still birth of 6% per 1.0 °C in the week before delivery during the warm season; in both studies the authors accommodated for an estimated 1 week from exposure to fetal loss.[100] Both studies noted higher risks for younger or older mothers and communities of color.

Short-term exposure to extreme heat event and criteria air pollutants also increased the risk of adverse birth outcomes, particularly with extreme heat events experiences during the last week of gestation resulting in premature delivery.[101] Researchers examine relationships between heat and emergency room visits and hospitalizations for various outcomes, including cardiovascular and respiratory diseases as well as mental health outcomes in California.

An increasing number of studies are considering mental health-associated outcomes related to heat and air pollution. Children, whose brains are still developing, could be especially vulnerable. One study on mental health showed an association between temperature and mental health among children aged 6-18 years for overall mental health disorders.[102]

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[96] Ha S, Liu D, Zhu Y, Kim SS, Sherman S, Mendola P. 2017: Ambient temperature and early delivery of singleton pregnancies. Environ Health Perspect. 125(3):453-459. doi:10.1289/EHP97.
[97] Basu R, Chen H, Li D-K, Avalos LA. 2016: The impact of maternal factors on the association between temperature and preterm delivery. Environ Res.;154:109-114. doi:10.1016/j.envres.2016.12.017.
[98] Basu R, Malig B, Ostro B. 2010: High ambient temperature and the risk of preterm delivery. Am J Epidemiol. 172(10):1108-1117. doi:10.1093/aje/kwq170.
[99] Basu R, Sarovar V, Malig BJ. 2016: Association between high ambient temperature and risk of stillbirth in California. Am J Epidemiol. 2016;183(10):894-901. doi:10.1093/aje/kwv295
[100] Ha S, Liu D, Zhu Y, et al. 2017: Ambient temperature and stillbirth: a multi-center retrospective cohort study. Environ Health Perspect. 2017;125(6):067011. doi:10.1289/EHP945
[101] Ilango, Sindana, et al. 2020:"Extreme heat episodes and risk of preterm birth in California, 2005–2013." Environment international 137 (2020): 105541.
[102] Basu, Rupa, et al., 2018: Examining the association between apparent temperature and mental health-related emergency room visits in California." American journal of epidemiology 187.4: 726-735.

Scoping Plan No Action Scenario

Extreme heat threatens public health and safety; economic prosperity; and communities and natural systems. It also poses profoundly disproportionate consequences for the most vulnerable among us. There is a consensus that the intensity, frequency, and duration of heatwaves are projected to worsen under enhanced global warming scenarios.[103, 104, 105, 106] Extreme heat is building in the western United States, with forecasts of record-breaking temperatures in the states of California and Nevada. As the climate changes in California, one of the more serious threats to the public health of Californians will stem primarily from the higher frequency of extreme conditions, principally more frequent, more intense, and longer heat waves. In California, climate change under a scenario of 4°C temperature increase could also double fire frequency in some areas. Similarly, heat waves can increase the risk of mortality associated with air pollution.

If the state and other jurisdictions take no action to reduce or minimize expected impacts from future climate change, the health effects of these disruptions would include many adverse health outcomes related to extreme heat and other weather events including increased respiratory and cardiovascular disease, injuries, and premature deaths. Health impacts from heat will be exacerbated by increased pollution levels and potential increases in wildfires also associated with heat. Smog forms faster in warmer weather, creating a serious health hazard for everyone, especially for infants, children, and the elderly. Cutting back on fossil fuels and switching to cleaner energy will help limit the dangerous effects of climate change and protect our health.

If global greenhouse gas emissions continue at current rates, the state is likely to experience further warming by more than 2 degrees F more by 2040, more than 4 degrees F by 2070, and by more than 6 degrees F by 2100.[107] Cal-Adapt projects that urban and rural population centers throughout California will experience an average of 40 to 53 extreme heat days by 2050 and an average of 40 to 99 days by 2099.[108] This compares to a historical average of four per year. This rise in temperature could translate to roughly 2,100 to 4,300 deaths in 2025, and 6,700 to 11,300 deaths in

[103] Perkins, S. E. & Alexander, L. V., 2013: On the measurement of heat waves. J. Clim. 26, 4500–4517.

[104] Perkins, S. E., Alexander, L. V. & Nairn, J. R. 2012: Increasing frequency, intensity and duration of observed global heatwaves and warm spells. Geophys. Res. Lett. 39, L20714.

[105] Russo, S., Dosio, A., Graversen, R.G., et al. 2014: Magnitude of extreme heat waves in present climate and their projection in a warming world. J. Geophys. Res.: Atmospheres 119, 12–500.

[106] Habeeb, D., Vargo, J. & Stone, B. 2015: Rising heat wave trends in large US cities. Nat. Hazards 76, 1651–1665.

[107] Pierce, D. W., J. F. Kalansky, and D. R. Cayan. 2018. Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CNRA-CEC-2018-006.

[108] Cal-Adapt is a web portal developed in response to a key recommendation of the 2009 California Climate Adaptation Strategy. Cal-Adapt provides access to climate change data and scenarios, climate impact research, and visualization tools that can be useful for local decision-makers. For more information on Cal-Adapt, see: http://cal-adapt.org .

2050.[109] As discussed in Appendix K (Climate Vulnerability Metric) the CVM indicates that communities in California will experience highly unequal impacts resulting from climate change. The CVM provides information about the relative climate vulnerability of communities at the census-tract level.

Without the Scoping Plan actions, emissions from cooling are expected to double by 2030 and triple by 2100, driven by heat waves, population growth and urbanization. Business-as-usual cooling generates a cycle: as the world gets hotter, increased demand for cooling drives up levels of greenhouse gas emissions that, in turn, drive up temperatures and make access to cooling even more critical, all while endangering human safety and livelihoods.

The recent IPCC Sixth Working Group reports include high CO_2 emissions pathways without climate change mitigation and states that crossing the 2°C global warming level (Paris agreement) in the mid-term period (2041–2060) is very likely to occur under the very high GHG emissions scenario. Under higher global warming levels, all regions are projected to experience further increases in hot climatic impact-drivers and scientists expect extreme heat thresholds relevant to health will be exceeded more frequently. The impacts of climate change are significantly affecting public health and the health of the environment. The challenges posed by climate change are accelerating and affecting life in unprecedented ways.

Scoping Plan Take Action Scenario

Achieving carbon neutrality by 2045 will reduce heat effects in several critical ways. Taking the actions outlined in the Scoping Plan will dramatically reduce fossil fuel combustion in California in every sector of the economy, resulting in dramatic reductions in heat-trapping greenhouse gases and heat-forcing pollutants. However, California actions taken in concert with global emission reductions will achieve the greatest benefits. Scoping Plan actions will provide combined benefits of reduction of heat and air pollution together as well as reducing wildfire smoke emissions that can occur during similar periods of time. Similar actions by other jurisdictions nationally and internationally could result in reduced average temperatures and associated health benefits. Specific actions that result from the Scoping Plan may mitigate heat impacts and urban heat island effects such as those discussed more in the section on urban greening.

Health Indicators

Based on the literature review included above Table G-1 includes key studies showing associations between heat and the following health outcomes: mortality,

[109] Ostro, B., Rauch, S., & Green, S. (2011). Quantifying the health impacts of future changes in temperature in California. Environmental Research, 111(8), 1258–1264. https://doi.org/10.1016/j.envres.2011.08.013

hospitalizations and emergency room visits for chronic illness and adverse birth outcomes.

Table G-1: Health co-benefit area - Reduced heat impacts*

Qualitative or Quantitative	Heath Outcome	Direction of Effect	Reference
Findings were used for qualitative analysis	↓Mortality	Strong benefit with reduced heat	Xu, Z., FitzGerald, G., Guo, Y., Jalaludin, B., Tong, S., 2016. Impact of heatwave on mortality under different heatwave definitions: a systematic review and meta-analysis. Environ. Int. 89, 193–203.
	↓Hospitalizations for: Cardiovascular Respiratory Mental health	Strong benefit with reduced heat	Guirguis, K., Basu, R., Al-Delaimy,W.K., Benmarhnia, T., Clemesha, R.E., Corcos, I., Guzman-Morales, J., et. al. 2018. Heat, disparities, and health outcomes in San Diego County's diverse climate zones. Geo Health 2 (7), 212–223.
	↓Increased Emergency Room Visits for: Cardiovascular Respiratory Mental Health Intestinal Infections	Strong benefit with reduced heat	Basu R., Pearson D., Malig B., Broadwin R., Green R. 2012. The effect of high ambient temperature on emergency room visits. Epidemiology. 23:813–820.

	↓Adverse birth outcomes: preterm birth low birth weight and still birth	Strong benefit with reduced heat	Avalos LA, Chen H, Li D-K, Basu R. 2017. The impact of high apparent temperature on spontaneous preterm delivery: a case-crossover study. Environ Health. 16(1):5. Basu R, Chen H, Li D-K, Avalos LA. 2016. The impact of maternal factors on the association between temperature and preterm delivery. Environ Res. 154:109-114. Ha S, Liu D, Zhu Y, Kim SS, Sherman S, Mendola P. 2017. Ambient temperature and early delivery of singleton pregnancies. *Environ* Health Perspect. 125(3):453-459.

*Studies were picked to demonstrate health metrics based on their value in representing strong health evidence for the association between each co-benefit area and health outcomes. In most cases the studies included are representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

Scoping Plan actions are critical to not only reduce heat forcing pollutants but also to mitigate the effects of extreme heat and reduce resulting disabilities and deaths due to heat increases expected in the near term. The Scoping Plan Natural and Working Lands (NWL) actions are projected to expand urban greening and vegetative cover (as discussed in the urban greening section of this analysis) and tree canopy and urban greening can reduce heat island effects. There may be other programs that result through implementation that address sustainable cooling and building materials that could mitigate heat or reduce heat-related risks. Studies have shown that actions to reduce urban heat islands (UHI) reduce heat-related mortality, indicating that UHI mitigation strategies could save up to 22 lives in Los Angeles and an even larger reduction is predicted in hospital admissions.[110]

Decarbonization of energy supply and end use in all sectors in the Scoping Plan will result in improved air quality including reduction of black carbon emissions.[111, 112, 113]

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[110] Vanos, J., L. Kalkstein, D. Sailor, K. Shickman, and S. Sheridan, 2014: Assessing the Health Impacts of Urban Heat Island Reduction Strategies in the Cities of Baltimore, Los Angeles, and New York. Global Cool Cities Alliance, Washington, DC, 38pp. DO - 10.13140/2.1.1474.1127

[111] Lelieveld J, Klingmüller K, Pozzer A, Burnett RT, Haines A, Ramanathan V. 2019: Effects of fossil fuel and total anthropogenic emission removal on public health and climate. Proceedings of the National Academy of Sciences, 201819989, doi:10.1073/pnas.1819989116.

[112] Shindell, D. and C.J. Smith, 2019: Climate and air-quality benefits of a realistic phase-out of fossil fuels. Nature, 573(7774), 408–411, doi: 10.1038/s41586-019-1554-z.

[113] Stechow, C, Minx JC, Riahi K, et al., 2016: 2°C and SDGs: United they stand, divided they fall? Environmental Research Letters, 11,34 34022, doi:10.1088/1748-9326/11/3/034022.

Dramatic reductions in criteria air pollutants will bring wide ranging health benefits outlined in other parts of this qualitative analysis as well as in the AB 197 analysis in Appendix C (AB 197 Measure Analysis) and the quantitative scenario analysis in Chapter 3 (Economic and Health Evaluations) and modeling results in Appendix H (AB 32 GHG Inventory Sector Modeling). In addition, regional studies,[114, 115] where significant CO_2 reductions were assumed for 2030 and 2050, show consistent reduction of $PM_{2.5}$ and ozone concentrations resulting in important health benefits. For example, for a 2°C compatible pathway, Vandyck et al., estimated 5 percent and 15 percent reduction in premature mortality due to PM2.5 in 2030 and 2050, respectively, compared to reference scenarios.[116] The health indicators in Table G-1 above for Health Metrics can demonstrate the directional benefits of the actions in the Scoping Plan to reduce health impacts from heat.

Areas for Further Action

While the Scoping Plan offers important win-win climate and health solutions that reduce heat effects and address the urgent climate change challenges facing humanity, there are areas to be considered for further action to achieve success. A key issue to address is the equitable distribution of heat mitigation efforts in climate vulnerable communities. Existing research studies highlight current impacts on health from a range of climate-related hazards and the potential health vulnerabilities to climate change for specific regions, communities, and populations in California. Some physiological conditions can make people more vulnerable to extreme heat. In general, those who live alone, older adults, infants and children, pregnant women, and people with chronic illnesses are especially sensitive to heat exposure and those who work outdoors can have greater exposures.

Additional social and economic factors can put people at a disadvantage in a warming world, especially when combined with physical risks and existing health inequities. Actions that provide heat mitigation for vulnerable or highly impacted groups can help promote health equity. Extreme heat and heat exposure disproportionately impacts the following groups:[117]

- Low-income families are more likely to live in poorly ventilated or poorly insulated apartments or mobile homes, lack access to air conditioners, or are unable to afford the costs of cooling.

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[114] Shindell, D.T., Y. Lee, and G. Faluvegi, 2016: Climate and health impacts of US emissions reductions consistent with 2ºC. Nature Climate Change, **6**, 503.

[115] Chen, K, Fiore, AM, Chen R, Jiang L, et al., 2018: Future ozone-related acute excess mortality under climate and population 1 change scenarios in China: A modeling study. PLOS Medicine, 15(7), e1002598.

[116] Vandyck, T., Keramidas, K., Kitous, et al., 2018: Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges. Nature Communications, **9(1)**, 4939, doi:10.1038/s41467-018-06885-9.

[117] Abby Roller, Equity in Resilience: Addressing the unequal health impacts of extreme heat, September 2021. *https://www.c2es.org/2021/09/equity-in-resilience-addressing-the-unequal-health-impacts-of-extreme-heat/*

- Outdoor workers—as well as indoor workers in facilities without air conditioning—are subject to hot and humid conditions that increase their risk of heat-related illness and workplace injury, particularly in workplaces such as commercial kitchens and warehouses. Those in rural communities may lack resources and access to care.
- People experiencing homelessness often lack adequate shelter, access to cooling, and clean drinking water to minimize heat stress.
- Indigenous and Black populations have the two highest rates of heat-related death in the United States. Other communities of color may lack resources to cope with increased heat.
- People without air conditioning - A significant number of Californians reside in coastal counties where they are least acclimated to extreme heat and many lack air conditioning, therefore these residents are more vulnerable to heat and experience disproportionate effects from heat waves.

Lack of resources, along with inadequate housing, infrastructure, and health services in many indigenous communities results in less ability to manage growing heat. Recent research from the University of California San Diego confirms previous findings of micro-heat islands in low-income communities of color. The researchers found that in 76% of the counties they studied, lower income people experienced higher temperatures than those with higher incomes. When looking at neighborhoods by race, 71% of counties showed that people of color lived in neighborhoods with higher temperatures compared with White people.[118] Ensuring equitable distribution of heat exposure mitigation efforts is a key consideration. Tools like the CVM, discussed in Appendix K (Climate Vulnerability Metric), can help identify communities most at risk from climate impacts, including impacts from heat exposure, which can support targeted mitigation efforts.

Another key area of focus is increasing sustainable cooling as part of California's renewable energy future. Efficient, affordable, and sustainable cooling can help alleviate poverty, reduce food loss, improve health, manage energy demand, and combat climate change.

[118] Jennifer Burney, Poor and Minority Communities Suffer More from Extreme Heat in U.S. Cities. August 2021. *https://ucsdnews.ucsd.edu/media-resources/spotlight?spotlight=8025*

Wildfires and Smoke Impacts

Background and Health Impacts

Restoring climate resilient and fire adapted forests, rangelands, and grasslands is critical in terms of fighting climate change.[119] Wildland vegetation play an important role in removing carbon dioxide (CO_2) from the atmosphere and storing carbon. However, vegetation can also release CO_2 back into the atmosphere when the vegetation dies or is burned by fires. Climate can influence wildfires in different ways.[120] Temperature impacts the length of the fire and growing seasons, which alters the time in which fires can burn and the amount of available fuels. Annual variability in precipitation and droughts (as well as the dynamic feedback between them) impact the production and moisture of the fuels, which affect the amount of fuel and its combustibility. California's natural and working lands (NWL), cover more than 90 percent of California and include rangeland, forests, woodlands, grasslands, wetlands urban green space, and other lands. They provide biodiversity, health and ecosystem benefits including their ability to sequester carbon from the atmosphere.[121]

Throughout California, vegetative ecosystems evolve with changes in climate; and as a result, fire behavior, the use of fire by people, and the emissions associated with burning also change in response to those vegetation and climate changes. Hence, protecting and managing California's forests and maintaining their health are key practices for maximizing GHG benefits and minimizing climate change impacts.[122]

California's wildfires are getting worse with increased fire risks, higher frequency of occurrence, larger burn areas, and a longer fire season. Tracking with rising temperatures, California's 2020 fire season was record-breaking, not only in the total amount of acres burned but also in wildfire size that destroyed over 10,000 structures and cost over $12 billion in damages. In U.S. EPA's *Environmental Justice Screening and Mapping Tool*, California and its adjacent states have a large portion of areas identified as "very high" or "high" wildfire risk (i.e. "*the relative potential for wildfire that may be difficult to control*") (See Figure G-8).

The emissions associated with the combustion of live and dead vegetation by wildfires and prescribed fires are a function of the amount of fuel consumed and the efficiency of the combustion.[123] CARB staff used GIS-based data on wildfire perimeters,

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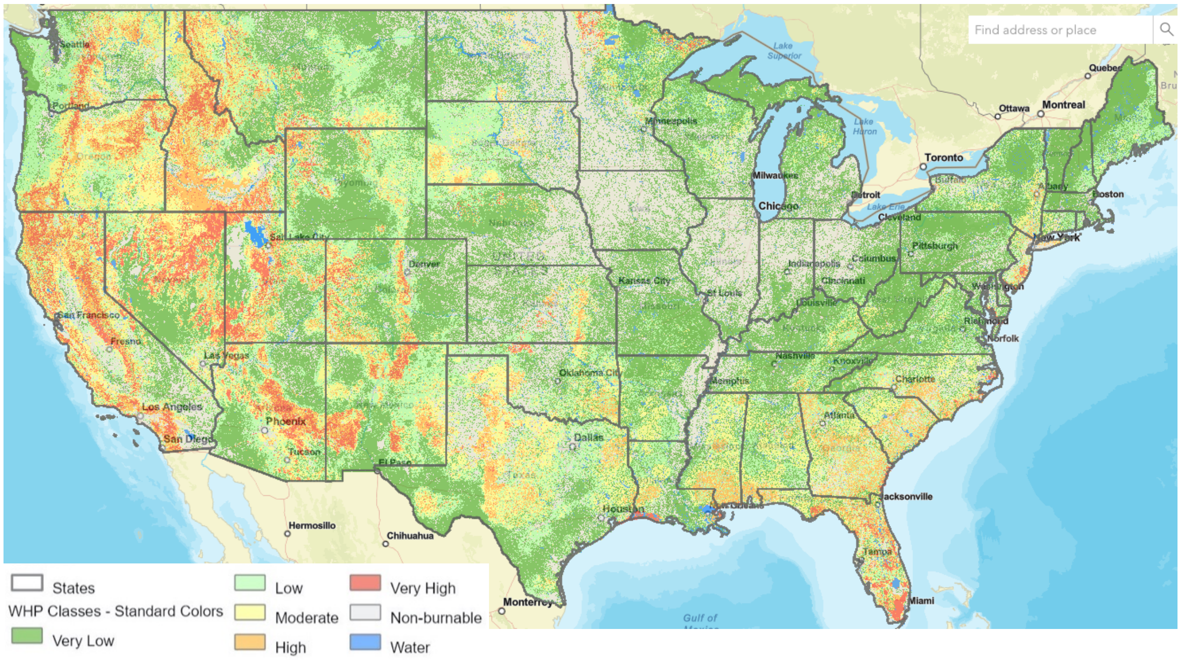
[119] Cal FIRE. CAL FIRE's Climate and Energy Program. 2022. https://www.fire.ca.gov/programs/resource-management/climate-change-and-energy/
[120] CARB. Public Comment Draft California's Historical Fire Activity before Modern Fire Suppression. 2021. https://ww2.arb.ca.gov/sites/default/files/classic/cc/SB901_Draft_Historical_Fire_Report.pdf
[121] CARB. California 2030 Natural and Working Lands Climate Change Implementation Plan. 2019. https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf
[122] CARB. California 2030 Natural and Working Lands Climate Change Implementation Plan. 2019. https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf
[123] CARB, Greenhouse Gas Emissions of Contemporary Wildfire, Prescribed Fire, and Forest Management Activities. 2020. Access from *https://ww3.arb.ca.gov/cc/inventory/pubs/ca_ghg_wildfire_forestmanagement.pdf*

vegetation fuels and fuel moisture, and burn severity, as inputs to a fire emission model to estimate emissions from all fires in California. In 2020, more than 4 million acres were burned by wildfires (See Figure G-9) 106.7 million metric tons of CO_2 (vs. 14 MMT CO_2 for 2000-2019 annual average (See Figure G-10) 1,394 thousand short tons of PM10 and 1,181 thousand short tons of PM2.5 emissions (the highest emissions since 2000).[124, 125]

[124] CARB, Greenhouse Gas Emissions of Contemporary Wildfire, Prescribed Fire, and Forest Management Activities. 2020. Access from *https://ww3.arb.ca.gov/cc/inventory/pubs/ca_ghg_wildfire_forestmanagement.pdf*

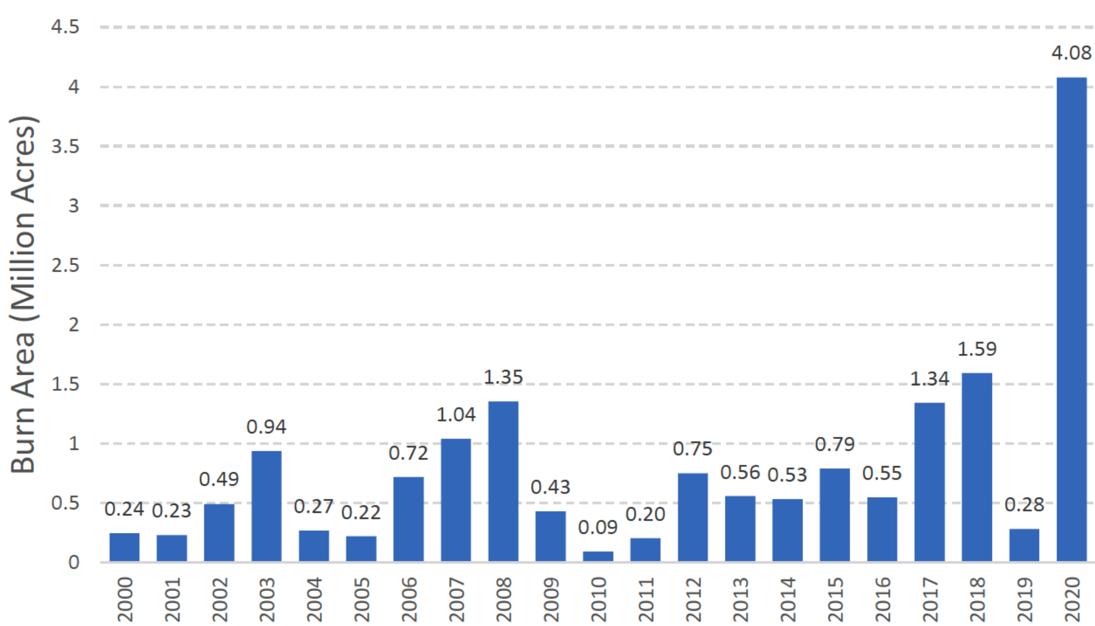
[125] CARB, Wildfire Emissions & Burned Area Estimates 2000–2020. 2020. Access from *https://ww2.arb.ca.gov/sites/default/files/2021-07/Wildfire%20Emission%20Estimates%20for%202020%20_Final.pdf*

Figure G-8: The nationwide distribution of wildfire hazard potential



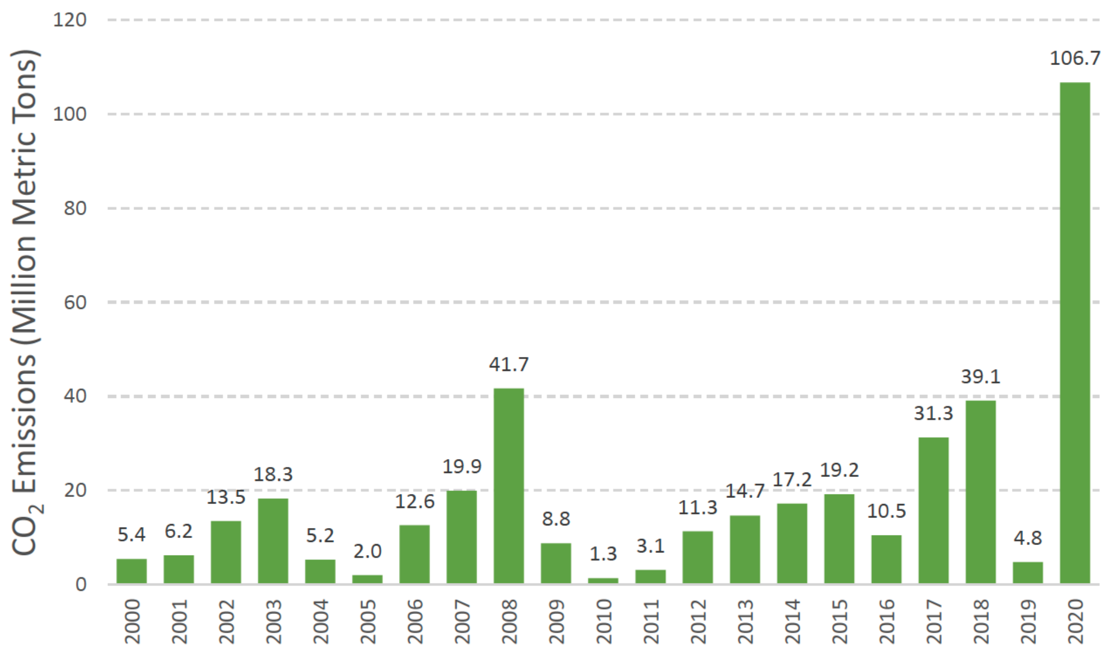
Source: The results were obtained from the "U.S. EPA's Environmental Justice Screening and Mapping Tool" (https://ejscreen.epa.gov/mapper/).

Figure G-9: Acreage of burned wildland vegetation area



Source: CARB, Wildfire Emissions & Burned Area Estimates 2000–2020

Figure G-10: Estimates of wildfire CO_2 emissions



Source: CARB, Wildfire Emissions & Burned Area Estimates 2000–2020. 2020

Many factors affect health impacts from wildfire smoke, including stage of life (children and the elderly) and existing health conditions such as cardiovascular or respiratory disease as well as social factors including race/ethnicity. Many studies document the human health effects from exposure to wildfire, showing wildfire smoke is associated with increased risk of respiratory and cardiovascular diseases. Children, seniors, and those with underlying chronic diseases are at the highest risk for health impacts.[126] People of color have long suffered from a lack of resources and support due to a history of structural racism and this lack of resources results in greater exposures to ambient smoke. Insufficient health care resources and poor housing that lacks filtration and insulation as well as jobs that require outdoor work will result in greater exposures during wildfire smoke events. This lack of resources directly impacts the ability of certain groups such as the unhoused to avoid high-smoke environments or implement mitigation strategies such as improved filtration or the use of portable air cleaners.

During peak fire periods, studies have found significant increases in respiratory outcomes. One study found emergency department visits for respiratory conditions increased by 34 percent and visits for asthma by 112 percent in vulnerable

[126] Liu JC, Pereira G, Uhl SA, Bravo MA, Bell ML. A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke. Environ Res. 2015 Jan;136:120-32. doi: 10.1016/j.envres.2014.10.015. Epub 2014 Nov 20. PMID: 25460628; PMCID: PMC4262561.

populations. Young children had bigger increases in visits during the peak fire period than older age groups - children aged 0–4 had a 136 percent increase in emergency department visits for asthma, and very young children aged 0–1 experienced a 243 percent increase. Emergency department visits for asthma went up 73 percent on days following an air quality day designated as "unhealthy for sensitive groups" (AQI: Orange, 101-150), compared to the AQI level "good".[127] An increase in pediatric respiratory emergency room visits during the Santa Ana Wind-driven Lilac Fire was observed in San Diego County. Younger children (aged 0 to 5 years) were particularly affected.[128] At all levels of socio-economic status, asthma exacerbations were elevated. However, one study showed the highest effects observed in the ZIP codes with the lowest median income.[129]

For hospitalizations, the most robust PM2.5 relationships are positive associations with respiratory and chronic lower respiratory disease.[130] Increases in respiratory hospitalizations ranging from 1.3 to up to 10 percent with a 10 µg/m3 increase in wildfire-specific PM2.5, compared to 0.67 to 1.3 percent associated with non-wildfire PM2.5.[131] The highest excess respiratory hospitalizations are concentrated in areas downwind of wildfires. The excess hospitalizations tend to follow the distribution of smoke plumes across space and time (i.e., driven by wind patterns).[132] PM2.5 was associated with respiratory ED visits and hospitalizations for exacerbations of asthma and COPD during a wildfire period even when adjusted for ozone.[133] Wildfire-related PM2.5 led to increased respiratory hospital admissions for asthma, acute bronchitis, COPD and pneumonia. The strongest wildfire-related PM2.5 associations are for asthma, especially among people ages 65–99 years and ages 0–4 years followed by ages 20–64 years.

Wildfire smoke exposure is associated with increased rates of emergency department visits for numerous cardiovascular disease outcomes, including ischemic heart disease,

[127] Hutchinson JA, Vargo J, Milet M, French NHF, Billmire M, et al. (2018) The San Diego 2007 wildfires and Medi-Cal emergency department presentations, inpatient hospitalizations, and outpatient visits: An observational study of smoke exposure periods and a bidirectional case-crossover analysis. PLOS Medicine 15(7): e1002601. https://doi.org/10.1371/journal.pmed.1002601
[128] Leibel S, Nguyen M, Brick W, Parker J, Ilango S, Aguilera R, Gershunov A, Benmarhnia T. Increase in Pediatric Respiratory Visits Associated with Santa Ana Wind-Driven Wildfire Smoke and PM2.5 Levels in San Diego County. Ann Am Thorac Soc. 2020 Mar;17(3):313-320. doi: 10.1513/AnnalsATS.201902-150OC. PMID: 31860802
[129] Reid CE, Jerrett M, Tager IB, Petersen ML, Mann JK, Balmes JR. Differential respiratory health effects from the 2008 northern California wildfires: A spatiotemporal approach. Environ Res. 2016 Oct;150:227-235. doi: 10.1016/j.envres.2016.06.012. Epub 2016 Jun 15. PMID: 27318255.
[130] Malig BJ, Fairley D, Pearson D, Wu X, Ebisu K, Basu R. Examining fine particulate matter and cause-specific morbidity during the 2017 North San Francisco Bay wildfires. Sci Total Environ. 2021 Sep 15;787:147507. doi: 10.1016/j.scitotenv.2021.147507. Epub 2021 May 4. PMID: 35142610.
[131] Aguilera, R., Corringham, T., Gershunov, A. et al. Wildfire smoke impacts respiratory health more than fine particles from other sources: observational evidence from Southern California. Nat Commun 12, 1493 (2021). https://doi.org/10.1038/s41467-021-21708
[132] Aguilera, R., Hansen, K., Gershunov, A., Ilango, S. D., Sheridan, P., & Benmarhnia, T. (2020). Respiratory hospitalizations and wildfire smoke: a spatiotemporal analysis of an extreme firestorm in San Diego County, California. Environmental epidemiology (Philadelphia, Pa.), 4(5), e114. https://doi.org/10.1097/EE9.0000000000000114
[133] Reid CE, Considine EM, Watson GL, Telesca D, Pfister GG, Jerrett M. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. Environ Int. 2019 Aug;129:291-298.

dysrhythmia, heart failure, pulmonary embolism, and stroke for all adults. The observed risk is greatest among adults aged>65 years.[134]

The associations between wildfire smoke and mortality are clear in recent studies. A review article by Reid et al.[135] reports the growing evidence on the linkage between exposure to wildfire smoke and all-cause mortality. A California study identified 133 excess cardiorespiratory-related deaths (predominantly among the elderly) caused by wildfire-smoke exposure from a major Southern California wildfire event (including 14 wildfires occurred from October 21st to November 4th, 2003 with total 750,043 acres burned). The mean estimated total mortality-related cost associated with the 2003 southern California wildfire event is approximately one billion U.S. dollars (2008 U.S. dollars).[136]

Wildfire can also result in the burning of structures and the release of toxic compounds. In the 2018 Camp Fire, the deadliest wildfire in California history, at least 85 people died as the catastrophic wildfire burned through Butte County, destroying nearly 19,000 buildings and most of the town of Paradise. CARB's analysis shows that during the Camp Fire, elevated levels of lead and zinc were detected.[137] While the elevated levels of lead detected in Chico during the Camp Fire only lasted for about a day, these numbers are still concerning, since lead is considered a toxic air contaminant and any increased exposure can be harmful. Lead exposure has been linked to high blood pressure, reproductive effects, and cancer in adults.[138] Infants and young children are especially sensitive to low levels of lead that are known to cause behavioral changes and learning deficits.[139] Although there are few studies examining the effects of exposure to smoke from structural burning, studies of urban firefighters can be examples of the types of effects that may be seen. Most studies have found an increase in the risks of cancer in urban firefighters[140] including an increased risk of mortality from cancers.[141] In a study of U.S. firefighters, investigators reported an excess of lung, digestive, and urinary cancers, and a rare cancer of the lung -

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[134] Wettstein ZS, Hoshiko S, Fahimi J, Harrison RJ, Cascio WE, Rappold AG. Cardiovascular and Cerebrovascular Emergency Department Visits Associated With Wildfire Smoke Exposure in California in 2015. J Am Heart Assoc. 2018 Apr 11;7(8):e007492.

[135] Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. Critical Review of Health Impacts of Wildfire Smoke Exposure. Environ Health Perspect. 2016 Sep;124(9):1334-43. doi: 10.1289/ehp.1409277. Epub 2016 Apr 15. PMID: 27082891; PMCID: PMC5010409.

[136] Ikuho Kochi, Patricia A. Champ, John B. Loomis, Geoffrey H. Donovan. Valuing mortality impacts of smoke exposure from major southern California wildfires. Journal of Forest Economics. 2012. 18: 61-75.

[137] CARB. Camp Fire Air Quality Data Analysis. 2021. https://ww2.arb.ca.gov/sites/default/files/2021-07/Camp_Fire_report_July2021.pdf

[138] ATSDR. Toxicological Profile for Lead. 2020. Agency for Toxic Substances and Disease Registry, the Public Health Service, or the U.S. Department of Health and Human Services.

[139] ATSDR. Toxicological Profile for Lead. 2020. Agency for Toxic Substances and Disease Registry, the Public Health Service, or the U.S. Department of Health and Human Services.

[140] Soteriades ES, Kim J, Christophi CA, Kales SN. Cancer Incidence and Mortality in Firefighters: A State-of-the-Art Review and Meta-Analysis. Asian Pac J Cancer Prev. 2019 Nov 1;20(11):3221-3231. doi: 10.31557/APJCP.2019.20.11.3221. PMID: 31759344; PMCID: PMC7063017.

[141] Pinkerton L, Bertke SJ, Yiin J, et al, Mortality in a cohort of US firefighters from San Francisco, Chicago and Philadelphia: an update. Occupational and Environmental Medicine 2020;77:84-93

mesothelioma (associated with asbestos exposure).[142] Recently, investigators reported excess leukemia and excess chronic obstructive pulmonary disease (COPD)-related deaths associated with the amount of time spent at fires.[143] Few studies have found noncancer effects in the health of urban firefighters and the results were inconsistent.[144] It is always important to remember that firefighters will receive a higher exposure to the smoke from urban fires as an occupational hazard than the surrounding neighborhoods.

Scoping Plan No Action Scenario

Wildfires in California have been increasing in size, severity, and destructive capacity over the last two decades and the emissions from smoke emitted from these fires have also been increasing. Wildfire smoke emissions are already causing serious and widespread harm to public health costing billions of dollars per year as discussed above. Without natural and working lands management strategies outlined in the Scoping Plan, levels of wildfire smoke exposure, ecological degradation, deforestation, and a wide range of adverse public health and safety outcomes will be higher than if we implemented statewide fuels reduction treatments.

Scoping Plan Take Action Scenario

Scoping Plan scenarios that include increasing management of natural and working lands will result in improved ecosystem health and significant reductions in wildfires and associated smoke risks. Given the current estimations of quantified wildfire health effects and expected increases in smoke exposures without further action, the analysis below finds that land management actions will achieve important public health benefits in reduced illness and deaths. Several types of implementation practices will lower the potential for damaging fires by increasing ecosystem health, reducing biological fuel load, and restoring a heterogeneous landscape, including, but not limited to, harvesting, thinning and prescribed burning.

Health Indicators

The health analysis for wildfire smoke uses research done in support of the Natural Working Lands Health Scenario Tool[145] and health effect estimates derived from epidemiological literature on wildfire smoke health effects to quantitatively assess human health impacts from NWL management scenarios. This tool is currently under

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[142] Daniels RD, Kubale TL, Yiin JH, Dahm MM, Hales TR, Baris D, Zahm SH, Beaumont JJ, Waters KM, Pinkerton LE. Mortality and cancer incidence in a pooled cohort of US firefighters from San Francisco, Chicago and Philadelphia (1950-2009). Occup Environ Med. 2014 Jun;71(6):388-97. doi: 10.1136/oemed-2013-101662. Epub 2013 Oct 14. PMID: 24142974; PMCID: PMC4499779.
[143] Pinkerton L, Bertke SJ, Yiin J, Dahm M, Kubale T, Hales T, Purdue M, Beaumont JJ, Daniels R. Mortality in a cohort of US firefighters from San Francisco, Chicago and Philadelphia: an update. Occup Environ Med. 2020 Feb;77(2):84-93. doi: 10.1136/oemed-2019-105962. Epub 2020 Jan 2. PMID: 31896615.
[144] Crawford JO, Graveling RA. Non-cancer occupational health risks in firefighters. Occup Med (Lond). 2012 Oct;62(7):485-95. doi: 10.1093/occmed/kqs116. PMID: 23034787.
[145] BETA VERSION 1.0 is available in https://dgonzales98.users.earthengine.app/view/nwlhealth-scenario-tool-uiv11rc

development in a CARB research contract with UCLA. Under this contract, investigators reviewed and compiled health outcome information from numerous studies to provide estimates of wildfire-related mortality and hospitalizations for chronic illnesses based specifically on exposure to fine particulate matter from wildfire smoke. The UCLA investigators used the results from these health studies to estimate the statewide health impact of wildfire smoke exposure in California. Using wildfire smoke-specific emissions information and health effect estimates generated for past wildfires, CARB staff has estimated future health outcomes associated with wildfires resulting from the Scoping Plan scenario compared to the Reference scenario. The health outcomes and epidemiological studies estimated for this analysis using the NWL tool are shown in Table G-2.

Table G-2: Health co-benefit area - Reduced wildfire smoke*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for quantitative analysis	↓ All-Cause Mortality	Strong benefit with reduced wildfire smoke	Doubleday, A., Schulte, J., Sheppard, L., Kadlec, M., Dhammapala, R., Fox, J. and Busch Isaksen, T., 2020. Mortality associated with wildfire smoke exposure in Washington state, 2006–2017: a case-crossover study. *Environmental health*, 19(1), pp.1-10.
	↓ Hospital Admissions – Asthma	Strong benefit with reduced wildfire smoke	Delfino, R.J., Brummel, S., Wu, J., Stern, H., Ostro, B., Lipsett, M., Winer, A., Street, D.H., Zhang, L., Tjoa, T. and Gillen, D.L., 2009. The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003.*Occupational and environmental medicine*, *66*(3), pp.189-197. Reid, C.E., Considine, E.M., Watson, G.L., Telesca, D., Pfister, G.G. and Jerrett, M., 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. *Environment international*, *129*, pp.291-298.
	↓ Hospital Admissions - COPD (without Asthma)	Strong benefit with reduced wildfire smoke	Delfino, R.J., Brummel, S., Wu, J., Stern, H., Ostro, B., Lipsett, M., Winer, A., Street, D.H., Zhang, L., Tjoa, T. and Gillen, D.L., 2009. The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003.

			Occupational and environmental medicine, *66*(3), pp.189-197. Reid, C.E., Considine, E.M., Watson, G.L., Telesca, D., Pfister, G.G. and Jerrett, M., 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. *Environment international*, *129*, pp.291-298.
	↓ Hospital Admissions - All Respiratory Outcomes	Strong benefit with reduced wildfire smoke	Delfino, R.J., Brummel, S., Wu, J., Stern, H., Ostro, B., Lipsett, M., Winer, A., Street, D.H., Zhang, L., Tjoa, T. and Gillen, D.L., 2009. The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003. *Occupational and environmental medicine*, *66*(3), pp.189-197. Reid, C.E., Considine, E.M., Watson, G.L., Telesca, D., Pfister, G.G. and Jerrett, M., 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. *Environment international*, *129*, pp.291-298. Aguilera, R., Corringham, T., Gershunov, A. and Benmarhnia, T., 2021. Wildfire smoke impacts respiratory health more than fine particles from other sources: Observational evidence from Southern California. *Nature communications*, 12(1), pp.1-8.
	↓ Emergency Room Visits – Asthma	Strong benefit with reduced wildfire smoke	Hutchinson, J.A., Vargo, J., Milet, M., French, N.H., Billmire, M., Johnson, J. and Hoshiko, S., 2018. The San Diego 2007 wildfires and Medi-Cal emergency department presentations, inpatient hospitalizations, and outpatient visits: An observational study of smoke exposure periods and a bidirectional case-crossover analysis. *PLoS medicine*, 15(7), p.e1002601. Reid, C.E., Considine, E.M., Watson, G.L., Telesca, D., Pfister, G.G. and Jerrett, M., 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. *Environment international*, 129, pp.291-298.

	↓ Emergency Room Visits - All Respiratory Outcomes	Strong benefit with reduced wildfire smoke	Hutchinson, J.A., Vargo, J., Milet, M., French, N.H., Billmire, M., Johnson, J. and Hoshiko, S., 2018. The San Diego 2007 wildfires and Medi-Cal emergency department presentations, inpatient hospitalizations, and outpatient visits: An observational study of smoke exposure periods and a bidirectional case-crossover analysis. *PLoS medicine*, 15(7), p.e1002601. Reid, C.E., Considine, E.M., Watson, G.L., Telesca, D., Pfister, G.G. and Jerrett, M., 2019. Associations between respiratory health and ozone and fine particulate matter during a wildfire event. *Environment international*, 129, pp.291-298.
	↓ Emergency Room Visits All Cardiac Outcomes	Strong benefit with reduced wildfire smoke	Malig, B.J., Fairley, D., Pearson, D., Wu, X., Ebisu, K. and Basu, R., 2021. Examining fine particulate matter and cause-specific morbidity during the 2017 North San Francisco Bay wildfires. *Science of The Total Environment*, 787, p.147507.

*The studies shown here are included in the quantitative analysis of wildfire smoke effects and are representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

Researchers estimated the statewide health outcomes including reduction in mortality and hospitalizations for respiratory and cardiovascular illnesses associated with wildfire-specific PM2.5 exposure estimated for the years 2008 – 2018 (See Table G-3). To estimate these health outcomes, researchers used the EPA Environmental Benefits Mapping and Analysis Program (*BenMAP-CE*), modeling results for historical wildfire PM 2.5 concentrations, and health endpoint concentration response functions for mortality, hospitalizations and emergency room visits derived from studies listed in Table G-2. These quantified estimates of mortality and morbidity demonstrate the significant impacts experienced in the past decade and the tremendous potential for health benefits from reducing wildfire smoke in the future.

Table G-3: Statewide wildfire-specific PM2.5 concentrations and health outcomes

Year	PM2.5 (µg/m3)	Estimated Health Outcomes* (counts)						
		All-Cause Mortality	Hospitalizations, Asthma	Hospitalizations, COPD	Hospitalizations, All Respiratory Outcomes	Emergency Room Visits, Asthma	Emergency Room Visits, All Respiratory Outcomes	Emergency Room Visits, All Cardiac Outcomes
2008	2.44	8,787	327	376	1,107	4,221	9,269	3,203
2009	0.56	2,023	102	94	295	1,004	2,177	764
2010	0.29	1,083	57	50	159	523	1,155	410
2011	0.36	1,373	72	63	194	677	1,452	512
2012	0.38	1,560	76	74	221	730	1,590	580
2013	0.76	2,890	117	136	429	1,462	3,063	1,153
2014	0.47	1,856	128	89	351	775	2,031	705
2015	0.72	2,946	199	141	275	1,021	3,226	1,131
2016	1.03	3,804	277	187	757	1,510	4,122	1,479
2017	2.85	11,266	647	458	1,876	3,753	10,266	3,844
2018	2.70	10,958	736	542	2,161	4,299	11,644	4,342

*Health outcomes were calculated using Random Effects Pooled Estimates; These are modelled estimates with accompanying uncertainty in precision.

CARB staff estimated that the management actions included in the Scoping Plan would provide major health benefits in reduced cases of hospitalizations for chronic illness and early death due to wildfire smoke exposure and this translates to significant benefits in reduced health costs (See Table G-4). The estimates provided here are average annual estimates from 2025 to 2045 for Scoping Plan implementation compared to the reference scenario. The health analysis uses the average annual statewide values of the health outcomes based on the studies outlined in the chart in the Health Metrics section and the cost using projected exposure to wildfire-specific PM2.5 from 2025 to 2045 (Table G-3). Comparing with the reference scenario, implementation of the Scoping Plan results in an approximately 10% decrease in wildfire emissions. Note that these reductions in illness and death cannot be directly compared to benefits from reducing fossil fuel combustion, but they provide a helpful estimate of the scale of public health benefits that sustainable NWL climate action can provide.

Table G-4: Projected average annual health endpoint counts and economic costs (USD) in dollars from 2025-2045 associated with Californian wildfire emissions of Scoping Plan Scenario relative to the Reference Scenario

Health Endpoints	Scoping Plan Scenario*
Hospitalizations, Asthma	-22
Hospitalizations, Asthma Cost	-350,389
Hospitalizations, COPD	-20
Hospitalizations, COPD Cost	-432,713
Hospitalizations, All Respiratory Outcomes	-63
Hospitalizations, All Respiratory Outcomes Cost	-1,777,280
Emergency Room Visits, Asthma	-155
Emergency Room Visits, Asthma Cost	-74,920
Emergency Room Visits, All Respiratory Outcomes	-419
Emergency Room Visits, All Respiratory Outcomes Cost	-341,454
Emergency Room Visits, All Cardiac Outcomes	-157
Emergency Room Visits, All Cardiac Outcomes Cost	-159,148
All-Cause Mortality	-395
All-Cause Mortality Cost	-3,080,045,406
Total Cost	-3,083,181,310

* Negative values mean a decrease relative to the reference scenario. COPD=Chronic obstructive pulmonary disease Cost in dollars.

Areas for Further Action:

During the recent decades, human activities and development have been expanded toward wildland areas. Increasing population shifts and housing development have been observed in the wildland-urban interface (WUI), the zone of transition between unoccupied land and human development.[146] WUI is considered to have higher wildfire risks because of the built environment's proximity to forests.[147] California has the greatest number of homes in the WUI in the United States.[148] As of 2010, about one third of all homes in California (more than 4 million housing units and 10 million

[146] U.S. Fire Administration. What is the WUI? 2021. https://www.usfa.fema.gov/wui/what-is-the-wui.html
[147] Stewart S.I., Radeloff V.C., Hammer R.B., Hawbaker T.J. Defining the Wildland—Urban Interface. J. For. 2007;105:201–207.
[148] U.S. Fire Administration. What is the WUI? 2021. https://www.usfa.fema.gov/wui/what-is-the-wui.html

people) are located within the WUI.[149,150] As noted in Appendix I (NWL Modeling) CARB determined that only 48% of WUI properties are compliant with existing defensible space regulations to protect against wildfires. Actions that strengthen protections for populations living in the WUI can help reduce wildfire impacts and smoke exposures.

While wildfire occurrences and wildfire smoke can be widespread over the entire state, vulnerable communities experience disproportionate impacts. Masri et al.'s study[151] reported that census tracts with predominantly Native American populations, older adults, and low-income populations are more likely to be highly impacted by wildfires based on 2000-2020 statewide data. These highly impacted areas tend to be rural census tracts. Wildfires can cause adverse impacts including direct damage (e.g., loss of lives, injury/illness, property loss, etc.) and indirect influence (e.g., psychological stress from evacuation, air quality impacts, and economic insecurity).[152,153] Hence, considering the existing social and environmental inequities and age-related vulnerability in the abovementioned groups, living in wildfire-impacted areas can exacerbate the conditions affecting their health and result in greater health risks. CARB's work underway, in collaboration with local air districts, on funding future Clean Air Shelters[154] to provide protection from exposure to wildfire smoke focuses on protecting vulnerable populations including vulnerable communities.

Children's Health and Development

Background and Health Impacts

There are a wide range of interconnected environmental, social, biological, and community factors adversely affecting children's health and development as covered earlier in this appendix. This section is focusing on air pollution and near-roadway or traffic pollution as environmental impacts that have a profound effect on children's health. Many communities in California experience disproportionately high levels of air pollution as well as high levels of traffic and freight and these sources harm children's development and predispose them to illnesses throughout their lives. Traffic pollution

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[149] Gabbe C.J., Pierce G., Oxlaj E. Subsidized Households and Wildfire Hazards in California. Environ. Manag. 2020;66:873–883. doi: 10.1007/s00267-020-01340-2.
[150] Radeloff V.C., Helmers D.P., Anu Kramer H., Mockrin M.H., Alexandre P.M., Bar-Massada A., Butsic V., Hawbaker T.J., Martinuzzi S., Syphard A.D., et al. Rapid growth of the US wildland-urban interface raises wildfire risk. Proc. Natl. Acad. Sci. USA. 2018;115:3314–3319. doi: 10.1073/pnas.1718850115.
[151] Masri S, Scaduto E, Jin Y, Wu J. Disproportionate Impacts of Wildfires among Elderly and Low-Income Communities in California from 2000-2020. Int J Environ Res Public Health. 2021;18(8):3921. Published 2021 Apr 8. doi:10.3390/ijerph18083921
[152] McDermott B.M., Lee E.M., Judd M., Gibbon P. Posttraumatic Stress Disorder and General Psychopathology in Children and Adolescents Following a Wildfire Disaster. Can. J. Psychiatry. 2005;50:137–143. doi: 10.1177/070674370505000302.
[153] Reid C.E., Brauer M., Johnston F.H., Jerrett M., Balmes J.R., Elliott C.T. Critical review of health impacts of wildfire smoke exposure. Environ. Health Perspect. 2016;124:1334–1343. doi: 10.1289/ehp.1409277.
[154] CARB. Wildfire Smoke Clean Air Center Grant. *https://ww2.arb.ca.gov/our-work/programs/wildfire-smoke-clean-air-center-grant*

includes the effects of vehicular emissions and the effects of increased noise and congestion that can occur with increased traffic.

Emissions from petroleum fueled vehicles and the gasoline and diesel fuels they run on are responsible for the majority of criteria air pollution in California and produce toxic air contaminants. Children are more sensitive to air pollution effects because their bodies and lungs are still developing, and children are more exposed to air pollution because they take in more air per body weight than adults do. A recent review of the effects of air pollution on children's health and development found evidence for exacerbations of asthma, adverse birth outcomes, abnormal lung and neurodevelopment, pediatric cancer, and risk for obesity and cardiovascular disease.[155] The Health Effects Institute recently released a report that extensively reviews the health impacts from exposure to traffic pollution and found that in addition to the mortality impacts in adults, traffic pollution was strongly associated with asthma onset and acute lower respiratory infections in children. The report also found that birth outcomes were moderately associated with traffic exposures and more research is needed in this area.[156]

Proximity of homes and schools to traffic and increased traffic density increase adverse health outcomes. Non-White children are more likely to live or go to school close to major roadways and experience higher levels of traffic pollution. Studies have shown that a majority of residents in high-traffic areas are non-white[157, 158] and that schools located near busy roads are more likely to be in low-income neighborhoods than those farther away.

The sensitivity of children to air pollution impacts begins in pregnancy before birth. Mothers exposed to higher levels of PM2.5 can deliver lower weight (birth weight less than 5.5lb) infants[159] and have increased risk for preterm (gestational weeks less than 37) birth.[160] Air toxics associated with traffic have been found to increase preterm birth in mothers in Los Angeles County.[161] A recent study funded by CARB examined the impacts of non-combustion traffic sources and found that brake and tire wear are an

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155 Ambient Air Pollution: Health Hazards to Children Heather L. Brumberg, MD, MPH, FAAP, Catherine J. Karr, MD, PhD, FAAP,COUNCIL ON ENVIRONMENTAL HEALTH PEDIATRICS Volume 147, number 6, June 2021:e2021051484

156 HEI Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution. 2022. Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution. Special Report 23. Boston, MA:Health Effects Institute. https://www.healtheffects.org/publication/systematic-review-and-meta-analysis-selected-health-effects-long-term-exposure-traffic

157 Gunier RB, Hertz A, Von Behren J, Reynolds P. Traffic density in California: socioeconomic and ethnic differences among potentially exposed children. J Expo Anal Environ Epidemiol. 2003 May;13(3):240-6. doi: 10.1038/sj.jea.7500276. PMID: 12743618.

158 Tian, N., Xue, J. & Barzyk, T. Evaluating socioeconomic and racial differences in traffic-related metrics in the United States using a GIS approach. J Expo Sci Environ Epidemiol 23, 215–222 (2013). https://doi.org/10.1038/jes.2012.83.

159 Schwarz L, Bruckner T, Ilango SD, Sheridan P, Basu R, Benmarhnia T. A quantile regression approach to examine fine particles, term low birth weight, and racial/ethnic disparities. Environ Epidemiol. 2019 Jul 11;3(4):e060. doi: 10.1097/EE9.0000000000000060.

160 Sheridan P, Ilango S, Bruckner TA, Wang Q, Basu R, Benmarhnia T. Ambient Fine Particulate Matter and Preterm Birth in California: Identification of Critical Exposure Windows. Am J Epidemiol. 2019 Sep 1;188(9):1608-1615. doi: 10.1093/aje/kwz120.

161 Wilhelm, M., Ghosh, J.K., Su, J. et al. Traffic-related air toxics and preterm birth: a population-based case-control study in Los Angeles county, California. Environ Health 10, 89 (2011). https://doi.org/10.1186/1476-069X-10-89

important source of PM-metals and can be associated with adverse health outcomes. There were associations of preterm birth and term low birth weight with metals from brake wear (barium) and tire wear (zinc). Hispanic and African American mothers had higher odds of preterm delivery.[162]

Results from a groundbreaking long-term study of children's health conducted in California, the Children's Health Study, demonstrated that particle pollution can significantly reduce lung function growth in children[163, 164, 165] and that these effects are likely permanent.[166] In addition, those investigators found that traffic pollution can be associated with a number of health impacts including slower lung development,[167] increased symptoms and medication use in asthmatic children,[168, 169] and even increased onset of asthma in children.[170] Children of color and those in low-income communities that are overburdened from higher levels of industrial and traffic pollution are more impacted than other children. Black children are five times more likely to be hospitalized for asthma compared with White children, and Latino children are 2 times more likely to have emergency department visits for asthma than White children.[171] An analysis in the Children's Health Study[172] demonstrated that both regional particulate matter pollution and local near-roadway exposures affect children's health independently, resulting in reduced lung function.

Current studies examining long-term health trends in the Children's Health Study participants have found that the recent reductions of air pollution in the South Coast

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162 Michael Jerrett, PhD, Co-Investigators: Sudipto Banerjee, PhD, Suzanne Paulson PhD, Beate Ritz, MD, PhD, Yifang Zhu, PhD, Final Report for contract 17RD012 Effects of Brake and Tire Wear on Particulate Matter Composition, Reactive Oxygen Species, Placental Development and Birth Outcomes in Los Angeles

163 Peters JM, Avol E, Gauderman WJ, Linn WS, Navidi W, London SJ, Margolis H, Rappaport E, Vora H, Gong H Jr, Thomas DC. A study of twelve Southern California communities with differing levels and types of air pollution. II. Effects on pulmonary function. Am J Respir Crit Care Med. 1999 Mar;159(3):768-75. doi: 10.1164/ajrccm.159.3.9804144.

164 Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. Am J Respir Crit Care Med. 2001 Dec 1;164(11):2067-72. doi: 10.1164/ajrccm.164.11.2102005.

165 Gauderman WJ, Gilliland GF, Vora H, Avol E, Stram D, McConnell R, Thomas D, Lurmann F, Margolis HG, Rappaport EB, Berhane K, Peters JM. Association between air pollution and lung function growth in southern California children: results from a second cohort. Am J Respir Crit Care Med. 2002 Jul 1;166(1):76-84. doi: 10.1164/rccm.2111021.

166 Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, Margolis H, Bates D, Peters J. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med. 2004 Sep 9;351(11):1057-67. doi: 10.1056/NEJMoa040610.

167 Gauderman WJ, Vora H, McConnell R, Berhane K, Gilliland F, Thomas D, Lurmann F, Avol E, Kunzli N, Jerrett M, Peters J. Effect of exposure to traffic on lung development from 10 to 18 years of age: a cohort study. Lancet. 2007 Feb 17;369(9561):571-7. doi: 10.1016/S0140-6736(07)60037-3.

168 Gauderman WJ, Avol E, Lurmann F, Kuenzli N, Gilliland F, Peters J, McConnell R. Childhood asthma and exposure to traffic and nitrogen dioxide. Epidemiology. 2005 Nov;16(6):737-43. doi: 10.1097/01.ede.0000181308.51440.75.

169 McConnell R, Berhane K, Yao L, Jerrett M, Lurmann F, Gilliland F, Künzli N, Gauderman J, Avol E, Thomas D, Peters J. Traffic, susceptibility, and childhood asthma. Environ Health Perspect. 2006 May;114(5):766-72. doi: 10.1289/ehp.8594.

170 McConnell R, Islam T, Shankardass K, Jerrett M, Lurmann F, Gilliland F, Gauderman J, Avol E, Künzli N, Yao L, Peters J, Berhane K. Childhood incident asthma and traffic-related air pollution at home and school. Environ Health Perspect. 2010 Jul;118(7):1021-6. doi: 10.1289/ehp.0901232.

171 California Department of Public Health. Asthma Inequities in California Children. 2021. https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/CPE/CDPH%20Document%20Library/CA_Asthma_Inequities_Children_2021-Infographic.pdfCDPH_OHE_Disparity_Report_Final%20(2).pdf#search=Portrait%20of%20Promise

172 Urman R, McConnell R, Islam T, Avol EL, Lurmann FW, Vora H, Linn WS, Rappaport EB, Gilliland FD, Gauderman WJ. Associations of children's lung function with ambient air pollution: joint effects of regional and near-roadway pollutants. Thorax. 2014 Jun;69(6):540-7. doi: 10.1136/thoraxjnl-2012-203159. Epub 2013 Nov 19. PMID: 24253832; PMCID: PMC4191894.

Air Basin are associated with significantly reduced bronchitic symptoms and clinically significant positive effects on lung-function growth in these children.[173, 174] Decreases in ambient levels of specific traffic-related pollutants in Southern California were significantly associated with lower asthma incidence.[175] These studies help to show how CARB's regulations to reduce transportation pollution emissions can result in health benefits in one of our most sensitive groups, our children. Benefits to children's health will impact not only the life of the child and their future health but also their family as well. When a child is sick, the child can be affected by the loss of school days due to illness. The family is also impacted by the need to provide care for their child, resulting in health care costs, loss work and economic insecurity, as well as increased stress, which can also affect the child's health as well.

Exposure to higher levels of traffic pollution have been associated with slowing of the normal increases in cognitive development in children.[176] Traffic pollution has been linked to cognitive development in children and a recent systematic review found an association between air pollution from traffic and standardized test scores.[177] Children attending schools exposed to less roadway pollution have greater cognition compared to children attending schools exposed to higher pollution levels even after controlling for socioeconomic factors.[178] In addition, low-income asthmatic children in California miss more than twice as many days of school due to the severity of asthma symptoms compared to higher income children[179] and this can affect the children performance in school. CARB is launching a new study on air pollution and cognitive impacts in children to provide more information specific to air pollution and traffic exposures in California.

Scoping Plan No Action Scenario

Mobile sources including cars, trucks, trains, tractors, and a myriad of other on-road and off-road vehicles and equipment are a major source of criteria pollutants and toxic

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[173] Gauderman WJ, Urman R, Avol E, Berhane K, McConnell R, Rappaport E, Chang R, Lurmann F, Gilliland F. Association of improved air quality with lung development in children. N Engl J Med. 2015 Mar 5;372(10):905-13. doi: 10.1056/NEJMoa1414123.

[174] Berhane K, Chang CC, McConnell R, Gauderman WJ, Avol E, Rapapport E, Urman R, Lurmann F, Gilliland F. Association of Changes in Air Quality With Bronchitic Symptoms in Children in California, 1993-2012. JAMA. 2016 Apr 12;315(14):1491-501. doi: 10.1001/jama.2016.3444.

[175] Garcia E, Urman R, Berhane K, McConnell R, Gilliland F. Effects of policy-driven hypothetical air pollutant interventions on childhood asthma incidence in southern California https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6689942/#

[176] Sunyer J, Esnaola M, Alvarez-PedrerolM, et al. Association between traffic-related air pollution in schools and cognitive development in primaryschool children: a prospective cohortstudy.PLoS Med. 2015;12(3):e1001792

[177] Stenson C, Wheeler AJ, Carver A, Donaire-Gonzalez D, Alvarado-Molina M, Nieuwenhuijsen M, et al. The impact of Traffic-Related air pollution on child and adolescent academic Performance: A systematic review. Environment International. 2021 Oct 1;155:106696.

[178] Sunyer J, Esnaola M, Alvarez-Pedrerol M, Forns J, Rivas I, López-Vicente M, et al. Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study. Lanphear BP, editor. PLoS Med. 2015 Mar 3;12(3):e1001792.

[179] Wolstein J, Meng YY, Babey SH. Income Disparities in Asthma Burden and Care in California. Los Angeles, CA: UCLA Center for Health Policy Research; December 2010. In https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Accessible-CDPH_OHE_Disparity_Report_Final%20(2).pdf#search=Portrait%20of%20Promise

air contaminants that directly impact community health and contribute the largest portion of greenhouse gas (GHG) emissions.[180] By 2050 California's population will have increased and about a quarter of the population will be over 65 and the population of California will have become more racially and ethnically diverse.[181] Without the actions planned to decarbonize transportation in the Scoping Plan, this increasingly sensitive population will be exposed to continued high levels of air pollution and near-roadway emissions from traffic. Climate change and increased temperatures will only exacerbate the problem since increased temperatures can increase pollution levels.[182] The numbers of people commuting by single occupant vehicles will also increase without continued focus on reducing VMT, and many options to reduce VMT include increasing sustainable community strategies that provide more mobility options focused on active transportation.

Scoping Plan Take Action Scenario

The reduction of air pollution is a key benefit from the transition away from petroleum fueled vehicles planned in the Scoping Plan. Ozone and fine particulate matter (PM2.5) are damaging criteria pollutants to children's health and mobile sources generate the majority of these pollutants. Since many communities in California are disproportionately impacted by high levels of traffic pollution, the reduction in petroleum fueled vehicles will reduce these additional impacts of living or going to school near highly polluting sources.

The Scoping Plan will achieve an overwhelming transition to zero emission vehicles (ZEVs) and away from fossil fuels. Under the Scoping Plan scenario the state would achieve 100% sales of light duty zero emission vehicles by 2035 and 100% sales of truck zero emission vehicles (MD/HDV) by 2040 along with 30% VMT reductions below 1990 levels by 2045. The dramatic reductions in fossil fuel combustion and reductions in vehicle miles traveled projected in the Scoping Plan will significantly reduce air pollution and the health impacts to children associated with traffic. The Scoping Plan outcomes will reduce pollution from freight, including trucks traffic associated with ports, and warehouses, reduce pollution from cars and buses, and increase mobility options including walking, biking, and transit. Children are also more impacted by heat and can benefit from increased urban greening that will reduce heat island effects, increase comfort for biking and walking and provide green parks for children to benefit from physical activity and social interaction. Increasing forest health will reduce the risk of wildfire and the physical and mental health impacts to children associated

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[180] California Air Resources Board. 2022. California Greenhouse Gas 2000-2020 Emissions Trends and Indicators Report
[181] California Department of Finance, P- 1: State Population Projection in https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/ctp-2050-v3-a11y.pdf
[182] Tang X, Wilson SR, Solomon KR, Shao M, Madronich S. Changes in air quality and tropospheric composition due to depletion of stratospheric ozone and interactions with climate. Photochem Photobiol Sci. 2011 Feb;10(2):280-91. doi: 10.1039/c0pp90039g.

with extreme events such as wildfire. Together with reducing these health burdens, the Scoping Plan outcomes will increase community resilience.

Health Indicators

Analysis of health impacts for reduced traffic pollution includes the health outcomes and supporting research listed below in Table G-5

Table G-5: Health co-benefit area - Reduced traffic pollution*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for quantitative analysis	↓ Respiratory Hospitalization	Strong benefit with reduced traffic pollution	Bell, M. L., Son, J. Y., Peng, R. D., Wang, Y., & Dominici, F. 2015. Ambient PM2.5 and Risk of Hospital Admissions: Do Risks Differ for Men and Women? Epidemiology, 26(4), 575-579.
	↓ Respiratory Emergency Department Visits	Strong benefit with reduced traffic pollution	Krall JR, Mulholland JA, Russell AG, Balachandran S, Winquist A, Tolbert PE, Waller LA, Sarnat SE. 2017. Associations between Source-Specific Fine Particulate Matter and Emergency Department Visits for Respiratory Disease in Four U.S. Cities. Environ Health Perspect.125(1):97-103.
	↓ Asthma Onset	Strong benefit with reduced traffic pollution	Tétreault LF, Doucet M, Gamache P, Fournier M, Brand A, Kosatsky T, Smargiassi A. 2016. Childhood Exposure to Ambient Air Pollutants and the Onset of Asthma: An Administrative Cohort Study in Québec. Environ Health Perspect. 124(8):1276-1282.
	↓ Asthma Symptoms	Strong benefit with reduced traffic pollution	Rabinovitch N, Strand M, Gelfand EW. 2006. Particulate levels are associated with early asthma worsening in children with persistent disease. *Am J Respir Crit Care Med.* 173(10):1098-1105.
Findings were used for qualitative analysis	↑ Lung Function Growth	Strong benefit with reduced traffic pollution	Gauderman, W.J.,Urman, R., Avol, E.,Berhane, K., McConnell, R, Rappaport, E., Chang, R., Lurmann, F., Gilliland F. 2015. Association of improved air quality with lung development in children. New England Journal of Medicine 372(10):905-913

	↓ Bronchitic symptoms	Strong benefit with reduced traffic pollution	Berhane, K. Chang, C-C., McConnell, R., Gauderman W.J., Avol, E., Rapappport E., Urman, R. Gilliland, F. 2016. Association of changes in air quality with bronchitic symptoms in children in California, 1993-2012. Journal of the American Medical Association. 315(14):1491-1501
	↓ Impaired cognitive development	Strong benefit with reduced traffic pollution	Ha S, Yeung E, Bell E, Insaf T, Ghassabian A, Bell G, Muscatiello N, Mendola P. 2019. Prenatal and early life exposures to ambient air pollution and development. Environ Res. 174:170-175. Harris MH, Gold DR, Rifas-Shiman SL,Melly SJ,,Zanobetti A,.Coull BA, Schwartz JD, Gryparis A, Kloog I, Koutrakis P, Bellinger DC, White RF, Sagiv SK, Oken E. 2015. Prenatal and Childhood Traffic-Related Pollution Exposure and Childhood Cognition in the Project Viva Cohort (Massachusetts, USA). Environ Health Perspect. 123(10):1072-1078. [published correction appears in Environ Health Perspect. 2019 Jun;127(6):69001].
	↓ Adverse birth outcomes including low birth weight and preterm birth	Strong benefit with reduced traffic pollution	Padula AM, Mortimer KM, Tager IB, Hammond SK, Lurmann FW, Yang W, Stevenson DK, Shaw GM. 2014. Traffic-related air pollution and risk of preterm birth in the San Joaquin Valley of California. Ann Epidemiol. 24(12):888-895. Wilhelm, M, Chosh, J.K., Su, J., Cockburn, M., Jerrett, M., Ritz, B. 2011. Traffic-related air toxics and preterm birth: a population-based case –control study in Los Angeles county, California. Environ Health 10(1), 1-12.

*Studies presented are representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

Improving health conditions for children growing up in highly polluted communities is critical and will result in life-long impacts and a wide range of benefits for California. As demonstrated by the quantitative health analysis in Chapter 3 (Economic and Health Evaluations), Appendix H (AB 32 GHG Inventory Sector Modeling) and Appendix C (AB 197 Measure Analysis) using updated health endpoints, the Scoping Plan is expected to show substantial quantifiable reductions in asthma symptoms, asthma onset, emergency room visits for respiratory causes, and respiratory hospitalizations. These health outcomes are calculated primarily for children's age groups. Based on research discussed in the chart in the Health Metrics section above, the reduction in air pollution and traffic impacts would also be expected to have a strong benefit in reducing adverse effects on lung function growth and cognitive development associated with air pollution. Reduced PM 2.5 pollution can also have strong benefits in improved birth outcomes compared to a future with higher pollution levels. These positive outcomes are estimated on a statewide average basis with consideration to ensure that health benefits are experienced equally in all communities. For the estimated directional health benefits for children's health and development see Table G-5. It is important to note that in the future CARB may be able to quantify health impacts for more of the health endpoints included pending results from ongoing research contracts.

Areas for Further Action

Reducing pollution impacts on children is a high priority for California given the substantial and lifelong benefits and must be paired with a wide range of efforts to reduce adverse childhood conditions. It is important to consider how actions can be implemented for equitable outcomes for children across California. State plans including the Scoping Plan and the California Transportation Plan include a strong emphasis on addressing the needs for resources, assistance, and actions to improve conditions and achieve emission reductions statewide and in impacted areas. Agencies have also committed to ongoing engagement of affected communities in carrying out these plans. While it will take time to achieve the Scoping Plan outcomes, actions can also be taken to reduce children's exposures now such as enhanced ventilation and filtration efforts in schools and continued efforts to increase urban greening and reduce urban heat islands that worsen pollution and have immediate benefits to children's health. These exposure reduction efforts should also consider equitable outcomes for vulnerable communities.

Economic Security

Background and Health Impacts

Climate change is expected to result in serious adverse socioeconomic effects across many sectors in California and globally. According to one economic analysis of climate risk[183] annual economic damage in California could range between $7.3 billion (low warming scenario) and $46.6 billion (high warming scenario). California agriculture production is critical to global food security and is uniquely vulnerable to climate change through adverse impacts from droughts, extreme heatwaves, weed, pests, disease, and wildfires. Certain areas in the State could face water shortages of up to

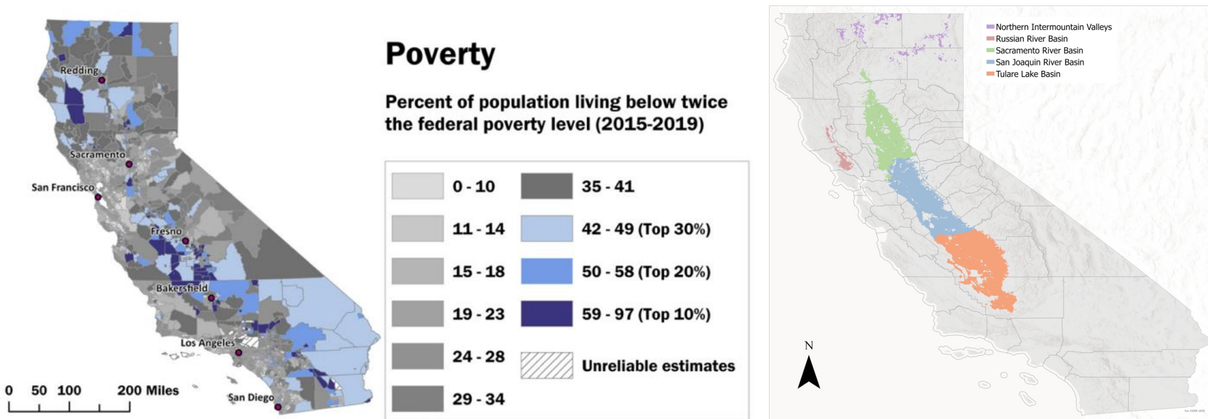
[183] Kahrl, Frederick, and David Roland-Holst. California climate risk and response. Department of Agricultural and Resource Economics, University of California, 2008.

16 percent by 2050 according to California's fourth climate assessment report with devastating consequences on food security and employment in the agriculture sector. Agriculture contributed around $47.1 billion (or 2 percent of the State gross domestic product (GDP), the largest of any other State) to California's economy in 2017. Economic impacts will also be felt in other areas of natural and working lands, energy, industrial, transportation and other sectors.

A 2022 preliminary report from the University of California[184] estimated the direct economic costs and employment losses of recent prolonged droughts. In 2015, the drought cost Central Valley agriculture an estimated $2.9 billion, and over 21,000 full-time jobs. And 2021 ended up as the second driest two-year period on record and resulted in economic damages estimated at $1.7 billion and more than 14,000 jobs lost. Overall, severe droughts events *alone* can erase on average tens of thousands of jobs every year from the agriculture sector. Furthermore, blue-collar work accounts for 96 percent of employment in the agriculture forestry, fishing, and hunting industry. The agriculture sector includes many of state's lowest paid workers with a median hourly wage of $11.23. Figure G-11 shows that agriculture regions experiencing droughts are often regions with the largest percentage of the population living below twice the federal poverty level, especially in the San Joaquin River Basin and in the Tulare Lake Basin. Overall, these figures illustrate the climate vulnerability of agricultural communities to economic impacts.

[184] Medellín-Azuara, J., Escriva-Bou, A., Abatzoglou, J.A., Viers, J.H, Cole, S.A., RodríguezFlores, J.M., and Sumner, D.A. (2022). Economic Impacts of the 2021 Drought on California Agriculture. Preliminary Report. University of California, Merced. Available at http://drought.ucmerced.edu.

Figure G-11: Under-resourced areas and drought affected agricultural areas



Source: (left) Percent of population living below twice the federal poverty level (2015-2019), adapted from the 2021 CalEnviroScreen 4.0 report, (right) Agriculture regions covered in drought impact assessment from Medellín-Azuara et al (2022). Economic Impacts of the 2021 Drought on California Agriculture. Preliminary Report. UC Merced.

Increasing wildfires have resulted in devastating damage to agricultural land, property, productivity, and major potential losses in workhours during harvest. Wildfires have the strongest impact on agriculture sectors in fire-prone areas, including wine grape cultivation, and ranching communities and grazing lands. While much of the agricultural land in the Central Valley has seen a limited impact, the Coastal ranges and foothill communities on the edge of the Sierras have seen greater impact throughout the State, and the intensity and frequency of wildfires are projected to increase in the state.[185] Altogether, the economic impact of recent wildfires on California's agriculture has been catastrophic and unprecedented.

Economic factors, such as income, income inequalities (among geographic regions), poverty, wealth (and debt), unemployment rate, and job security are among the strongest determinants of physical and mental health.[186, 187, 188] Along the entire income spectrum, higher income is associated with greater longevity and lower morbidity in the U.S.[189, 190] although negative health impacts are more pronounced for poverty- and deep-poverty-level incomes.[191, 192] Furthermore, it is likely that income sensitivity

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185 Goss, Michael, Daniel L. Swain, John T. Abatzoglou, Ali Sarhadi, Crystal A. Kolden, A. Park Williams, and Noah S. Diffenbaugh. "Climate change is increasing the likelihood of extreme autumn wildfire conditions across California." Environmental Research Letters 15, no. 9 (2020): 094016.
186 Chetty R, Stepner M, Abraham S, et al. 2016. The Association between Income and Life Expectancy in the United States, 2001-2014. JAMA. Published online April 10, 2016. doi:10.1001/jama.2016.4226.
187 Krueger PM, Burgard SA. Income, Occupations and Work. In: Rogers RG, Crimmins EM, editors. International Handbook of Adult Mortality. New York: Springer; 2011. pp. 263–288.
188 Osberg, L. (2021). Economic insecurity and well-being.
189 Marmot, Michael. "The influence of income on health: views of an epidemiologist." Health affairs 21, no. 2 (2002): 31-46.
190 Wolfe, Barbara. "Poverty and poor health: Can health care reform narrow the rich-poor gap." Focus 28, no. 2 (2011): 12.
191 Adler NE, Newman K. Socioeconomic disparities in health: pathways and policies. Health Affairs. 2002;21(2):60-76.
192 Chetty, R., M. Stepner, S. Abraham, S. Lin, B. Scuderi, N. Turner, A. Bergeron and D. Cutler (2016). "The association between income and life expectancy in the United States, 2001-2014." Jama 315(16): 1750-1766.

depends on gender, race, age, immigration status, and geographic location (urban vs. rural). According to one report, in the year 2000 about 133,000 deaths in the United States were attributable to individual-level poverty, 119,000 to income inequality, and 39,000 to area-level poverty.[193] These three indicators of poverty and economic inequality together led to nearly 300,000 deaths, or 12 percent of total deaths, in the U.S. that year. Climate mitigation measures that also yield economic benefits can, therefore, significantly improve population health, especially if the economic benefits are directed to the poorest and most susceptible and vulnerable communities, who often have restricted access to quality healthcare facilities.

Research finds that income and health are tightly correlated.[194, 195, 196] A large body of literature has shown a consistent, strong, positive association between income inequalities and health. Income inequality has a stronger association with poorer health status than poverty.[197] A review of 98 studies examining income inequality and health found that it is likely that raising the incomes of the most disadvantaged will improve their health, help reduce health inequalities, and improve population health.[198]

Studies show robust associations between income inequality and lower life expectancy, higher rates of infant and child mortality, poor self-reported health, low birth weight, AIDS, depression, mental illness, and obesity. Mental stress from income change has also been shown to directly transfer to children living in the same household. Mental stress on children interferes with their developmental conditions which determine their adult educational attainment, earnings, health status, and life expectancy.[199] And these relationships are robust across the life span.[200] A 2016 study of children in eight Central Valley counties in California found disproportionately higher preventable disease hospitalization rates among children under four years of age living in low-income households.[201] Children raised in poverty are also more likely to experience chronic psychological stress increasing their adult risk for cardiovascular

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[193] Galea S, Tracy M, Hoggatt K et al. 2011. Estimated deaths attributable to social factors in the United States. Am J Public Health.

[194] Benzeval M, Bond L, Campbell M, Egan M, Lorenc T, Petticrew M, and Popham F (2014). How does money influence health? Available at *https://www.jrf.org.uk/report/how-does-money-influence-health*

[195] Kaplan, Robert M., Michael L. Spittel, and Daryn H. David, eds. Population health: behavioral and social science insights. Government Printing Office, 2015.

[196] Wolfe, Barbara, William Evans, and Teresa E. Seeman, eds. The biological consequences of socioeconomic inequalities. Russell Sage Foundation, 2012.

[197] Pickett K, Wilkinson R. Income inequality and health: A causal review. In Population Health: Behavior and Social Science Insights. US Department of Health & Human Services, Agency for Healthcare Research and Quality. Content last reviewed July 2015. Available at *https://www.ahrq.gov/professionals/education/curriculum-tools/population-health/pickett.html*

[198] Lynch, John, George Davey Smith, Sam AM Harper, Marianne Hillemeier, Nancy Ross, George A. Kaplan, and Michael Wolfson. "Is income inequality a determinant of population health? Part 1. A systematic review." The Milbank Quarterly 82, no. 1 (2004): 5-99.

[199] Case, Anne, Angela Fertig, and Christina Paxson. "The lasting impact of childhood health and circumstance." Journal of health economics 24, no. 2 (2005): 365-389.

[200] Chen E, Matthews KA, Boyce WT . Socioeconomic differences in children's health: how and why do these relationships change with age? Psychol Bull 2002; **128**: 295–329.

[201] Lessard, Lauren N., Emanuel Alcala, and John A. Capitman. "Pollution, poverty, and potentially preventable childhood morbidity in Central California." The Journal of pediatrics 168 (2016): 198-204.

disease, autoimmune disorders and premature mortality.[202] However, the relationship is complicated.[203, 204]

Evidence suggests consistent negative impacts of economic insecurity on mental health across the entire income distribution.[205] Importantly, perceived future risks and loss are more damaging to mental health than realized market volatilities.[206] These results point to a strong association between economic insecurity and poor physical and mental health outcomes for people at higher risk of losing employment, including shift, contractual, and seasonal workers which are disproportionately women, people of color, and people with low educational attainment. Poor working conditions are also strongly associated with poorer physical health and greater psychological distress (Table G-6).

Scoping Plan No Action Scenario

If no action is taken, fossil fuel dependence will continue to increase climate change impacts and wildfires, drought and other climate conditions will continue to erode important sectors of the California economy such as agriculture and other natural and working lands, energy, industrial, transportation and other sectors. Communities will continue to be adversely affected by fuel price spikes, wildfire damage, changes in agricultural productivity and the economic burden of health care costs linked to air pollution and other climate related health effects.

Scoping Plan Take Action Scenario

Investing in a resilient, greener, California economy that is not dependent on fossil fuels will improve economic security. This shift in investments away from fossil fuels will help California to weather volatile oil and gas commodity prices, large-scale economic disruptors (e.g., COVID-19 pandemic), the increasing energy demand for cooling in the residential and commercial sectors as global temperatures rise, and other destructive impacts of climate change, such as extreme weather, heat, drought, and sea-level rise (IPCC AR5). As such, climate mitigation strategies that yield economic security and growth will likely improve population-level health in California. Details of

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[202] Miller, Gregory E., Edith Chen, and Karen J. Parker. "Psychological stress in childhood and susceptibility to the chronic diseases of aging: moving toward a model of behavioral and biological mechanisms." Psychological bulletin 137, no. 6 (2011): 959.

[203] Miller, Gregory E., Margie E. Lachman, Edith Chen, Tara L. Gruenewald, Arun S. Karlamangla, and Teresa E. Seeman. "Pathways to resilience: Maternal nurturance as a buffer against the effects of childhood poverty on metabolic syndrome at midlife." Psychological science 22, no. 12 (2011): 1591-1599.

[204] Chen, Edith, Gregory E. Miller, Michael S. Kobor, and Steve W. Cole. "Maternal warmth buffers the effects of low early-life socioeconomic status on pro-inflammatory signaling in adulthood." Molecular psychiatry 16, no. 7 (2011): 729-737.

[205] D. Kopasker, C. Montagna, and K. Bender (2018). Economic Insecurity: A Socioeconomic Determinant of Mental Health. SSM-Population Health, 6:184–194

[206] Rohde, N., K.K. Tang, L. Osberg & P. Rao (2017). Is It Vulnerability or Economic Insecurity that matters for Health? Journal of Economic Behavior & Organization 2017, 134: 307-319.

the economic analysis for the Scoping Plan and the limitations can be found in Chapter 3 (Economic and Health Evaluations).

Health Indicators

The literature has consistently shown that economic insecurity negatively impacts life expectancy, physical, and mental health across the entire income ladder. To explain these relationships, several economic indicators, including income, wealth (and debt), unemployment rate, GDP, and working conditions have been used. Poorer health status also adversely affects an individual's job prospects and income,[207] and a negative feedback loop can emerge. Income change is tightly linked to decreased life expectancy, increased morbidity, and poorer mental health. Table G-6 summarizes some of the main findings from health literature investigating the role of economic indicators affecting life expectancy, morbidity and mental health.

Table G-6: Health co-benefit area - Increased economic security*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference

[207] Korpi T. Accumulating Disadvantage: Longitudinal Analyses of Unemployment and Physical Health in Representative Samples of the Swedish Population. European Sociological Review. 2001;17(3):255–273.

Findings were used for qualitative analysis	↑Income Change: Life expectancy Health status for general health and chronic conditions ↑Mental health	Strong benefits with increased economic security	Baird, S Friedman, J. Schady, N. 2011. Aggregate Income Shocks and Infant Mortality in the Developing World. *The Review of Economics and Statistics*, vol. 93, no. 3, 2011, pp. 847–856. Coope, C. Gunnell, D Hollingworth, W Hawton, K Kapur, N Fearn, V Wells, C Metcalfe, C. 2014. Suicide and the 2008 economic recession: Who is most at risk? Trends in suicide rates in England and Wales 2001–2011, Social Science & Medicine. Volume 117, 76-85 Benzeval M, Bond L, Campbell M, Egan M, Lorenc T, Petticrew M, Popham F. 2014. How does money influence health? Joseph Rowntree Foundation Lange S, Vollmer S. 2017. The effect of economic development on population health: a review of the empirical evidence. Br Med Bull. 1;121(1):47-60. Chetty, R Stepner, M Abraham, S Lin, S Scuderi, B Turner, N Bergeron, A Cutler, D. 2016. The Association between Income and Life Expectancy in the United States, 2001 - 2014 *The Journal of the American Medical Association, 315(16), 1750-1766* Wolfe, Barbara. 2011. Poverty and poor health: Can health care reform narrow the rich-poor gap. *Focus.* 28(2), 25-30. Sareen J, Afifi TO, McMillan KA, Asmundson GJG. 2011. Relationship Between Household Income and Mental Disorders: Findings from a Population-Based Longitudinal Study. *Arch Gen Psychiatry.* 68(4):419–427. Price RH, Choi JN, Vinokur AD. 2002. Links in the chain of adversity following job loss: how financial strain and loss of personal control lead to depression, impaired functioning, and poor health. J Occup Health Psychol.7(4):302-312.

	↑Income Equality: Health status for general health and chronic conditions	Strong benefits with increased economic security	Ferrie JE, Shipley MJ, Stansfeld SA, Marmot M. 2002. Effects of chronic job insecurity and change in job security on self-reported health, minor psychiatric morbidity, physiological measures, and health related behaviors in British civil servants: the Whitehall II study Journal of Epidemiology & Community Health. 56:450-454. Lynch J, Smith GD, Harper S, Hillemeier M, Ross N, Kaplan GA, Wolfson M. 2004. Is income inequality a determinant of population health? Part 1. A systematic review. Milbank Q. 82(1):5-99. Lorgelly, P. K., & Lindley, J. 2008. What is the relationship between income inequality and health? Evidence from the BHPS. *Health Economics, 17*(2), 249–265. Pickett KE, Wilkinson RG. 2015. Income inequality and health: a causal review. Soc Sci Med.128:316-326. Wilkinson RG and Pickett KE. 2006. Income Inequality and Population Health: A Review and Explanation of the Evidence. Social Science and Medicine 62, no. 7: 1768-1784. Wagstaff A, van Doorslaer E. 2000 Income inequality and health: what does the literature tell us? Annu Rev Public Health. 21:543-567. Burgard SA, Seefeldt KS, Zelner S. 2012. Housing instability and health: findings from the Michigan Recession and Recovery Study. Soc Sci Med. 75(12):2215-2224.

	↑ Gross domestic product (GDP, and GDP per capita): Life expectancy Health status	Strong benefits with increased economic security	Lange S, Vollmer S. 2017. The effect of economic development on population health: a review of the empirical evidence. Br Med Bull. 1;121(1):47-60.

*Income change includes recent job loss, prolonged unemployment, and shifts to lower paying jobs.
*Studies were chosen to demonstrate health metrics based on the strength of their evidence and are generally representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

The Scoping Plan shows a small impact on employment overall. Natural and Working Lands (NWL) was modeled separately and shows changes in economic activity, dependent on the scenario. While the NWL macro-economic model does count the increased economic activity in the affected industries, it does not quantify many of the important benefits if these actions were implemented. Benefits such as the reduced use of pesticides, amenity value of urban trees, and increased recreational opportunities are potentially significant.

As outlined in a study by the California Workforce Development Board, "Putting California on the High Road: A Jobs and Climate Action Plan for 2030," climate mitigation efforts have the potential to bring economic benefits in different economic sectors, including renewable energy generation and distribution, sustainable transportation, and NWL. Building a more resilient California economy, less prone to market volatility and less vulnerable to the worst impacts of climate change, will likely result in significant positive population-level health outcomes especially when coupled with fair working conditions.[208]

Areas for Further Action

Ensuring that the economic benefits generated under the Scoping Plan are equitably distributed, reaching climate vulnerable communities, and focusing investments in these areas will result in important additional health benefits. Incentives and investments could consider projects through an equity lens to determine if resources are sufficiently assisting vulnerable communities and increasing economic opportunities in green technologies and workforce development. Workers in the agriculture sector are particularly vulnerable to the worst impacts of climate change. Agricultural communities are already feeling the adverse impacts of prolonged droughts and wildfires.

[208] Putting California on the High Road: A Jobs and Climate Action Plan for 2030, June 2020, California Workforce Development Board

Food Security

Background and Heath Impacts

The food system is under pressure from numerous factors, including climate change and a growing population.[209] Climate change can affect food production and exacerbate factors that limit food availability. Agriculture in California is uniquely vulnerable to climate change through adverse impacts from droughts, extreme heatwaves, weeds, pests, disease, and wildfires. Rural, low-income populations in California, including farmworkers, experience food insecurity all while they work on or live near California farms in producing over half of the nation's fruits and vegetables.[210] Food security is defined as stable access to affordable, sufficient food for an active, healthy life, and is a basic human right.[211] Food insecurity among California households is a persistent issue; the rate of food insecurity among households was 11.7 percent from 2000-2002, 15.6 percent from 2010-2012 and 11.8 percent from 2014-2016.[212] In other words, approximately 1 in 8 Californians do not know where their next meal will come from. One in five children go hungry every night in California, a rate that is higher than the national average.[213]

A common concern linked to and exacerbating food insecurity is the prevalence of food deserts in California. Food deserts are areas where there are limited options for healthy fresh foods and residents have limited means, such as transportation options, to access grocery stores which are located further away.[214] Several research studies have linked food deserts to higher disease rates[215] and socioeconomic and racial/ethnic disparities.[216] In California, 27.4 percent (2,195 out of 8,024) and 6.8 percent (542 out of 8,024) of populated tracts were designated as food deserts (based on a distance of 0.5 miles in urban areas or 10 miles in rural areas from a supermarket for the former and 1 or 10 miles for the latter) and 15.9 percent (5.92 out of 37.3 million) and 3.3 percent (1.22 out of 37.3 million) of Californians were estimated to have low access to supermarkets.[217] When combined with low transportation options,

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[209] IPCC. Special Report on Climate Change and Land. 2021. https://www.ipcc.ch/srccl/

[210] California Department of Food and Agriculture. 2022. California Agricultural Production Statistics. https://www.cdfa.ca.gov/Statistics/

[211] CDPH. *Portrait of Promise: The California Statewide Plan to Promote Health and Mental Health Equity. 2015. https://www.phrases.org/wp-content/uploads/2020/06/CA-Statewide-Plan-to-Promote-Health-and-Mental-Health-Equity.pdf*

[212] Hilmers A, Hilmers DC, Dave J. Neighborhood disparities in access to healthy foods and their effects on environmental justice. Am J Public Health. 2012 Sep;102(9):1644-54. doi: 10.2105/AJPH.2012.300865. Epub 2012 Jul 19. PMID: 22813465; PMCID: PMC3482049.

[213] CalRecycle. SB 1383 Education and Outreach Resources. 2022. https://calrecycle.ca.gov/organics/slcp/education/

[214] USDA ERS (2017). Food Access Research Atlas. United States Department of Agriculture Economic Research Service. Washington, D.C.

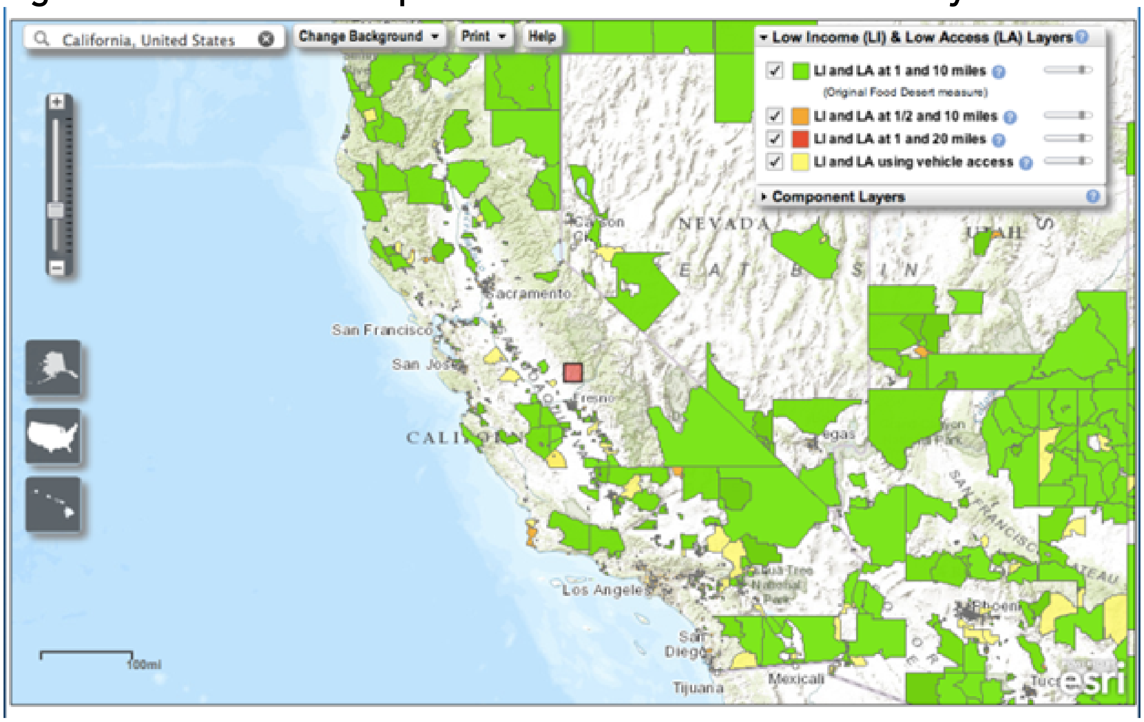
[215] USDA ERS (2017). Food Access Research Atlas. United States Department of Agriculture Economic Research Service. Washington, D.C.

[216] Hilmers A, Hilmers DC, Dave J. Neighborhood disparities in access to healthy foods and their effects on environmental justice. Am J Public Health. 2012 Sep;102(9):1644-54. doi: 10.2105/AJPH.2012.300865. Epub 2012 Jul 19. PMID: 22813465; PMCID: PMC3482049.

[217] USDA ERS (2017). Food Access Research Atlas. United States Department of Agriculture Economic Research Service. Washington, D.C.

many Californians struggle with accessing healthy foods. See Figure G-12 for a California map that shows areas identified by USDA as food deserts marked in green.

Figure G-12: California map with food desert areas identified by USDA research



Source: *https://www.ers.usda.gov/data-products/food-access-research-atlas*

Millions of Californians suffer from food insecurity while over two billion pounds of edible healthy foods are disposed in California landfills each year.[218] CalRecycle has determined that recovering just one ton of edible food could provide more than 1600 meals. Achieving the goal of SB 1383 to recover 20% of edible food that would otherwise go to waste can provide over 350 million meals to Californians in need. In addition, the State's food rescue efforts have a significant climate benefit: reducing landfill disposal of organic waste reduces emissions of methane, a potent climate-forcing greenhouse gas. Since 2018, CalRecycle's Food Waste Prevention and Rescue Grant Program has kept over 100 million pounds of food out landfills, achieving GHG reductions equivalent to more than 20,000 cars off the road.[219]

[218] CalRecycle. 2018 Disposal-Facility-Based Characterization of Solid Waste in California (DRRR-2020-1666) https://www2.calrecycle.ca.gov/Publications/Details/1666

[219] CalRecycle. Food Recovery in California. 2022. *https://calrecycle.ca.gov/organics/slcp/foodrecovery/#:~:text=Senate%20Bill%201383%20and%20Food,to%20feed%20people%20in%20need*

Scoping Plan No Action Scenario

Food security is related to both food supplies and the distribution of food. From a global perspective, the greater the impacts of climate change, the greater the impact on food supplies. Since agriculture is highly linked to climate, as the climate shifts agricultural production is impacted. Increasing temperatures, changing precipitation patterns, and extreme weather events are expected to negatively impact food production. Disease and pests linked to changing climate conditions are also expected to worsen productivity in many regions.[220] As the ocean warms, the availability of seafood is impacted.[221] Food becomes less nutritious with higher CO2 concentrations.[222] Some crops that were once suitable in California climates may no longer be suitable due to shifting weather patterns.[223] All these factors impact food production, and as food supplies are impacted, the availability of food is expected to be reduced which in turn will lead to higher prices. Additionally, subsistence farmers whose livelihoods depend on the food they grow directly and the livestock they manage, a common practice among the 109 tribes that live in California, will be impacted as their agricultural yields are adversely impacted. Storage, transport, and distribution of foods may also be impacted by climate change. Climate change-related impacts on food security will be felt most by vulnerable communities, which are already disproportionately food insecure and often live in or near food deserts.

Scoping Plan Take Action Scenario

Food insecurity is a complex and multi-faceted health concern that involves socio-economic factors beyond the reach of the Scoping Plan. However, there is potential to significantly improve food security, access to healthy foods and related health outcomes as a direct benefit and co-benefit of climate change programs. There are several ways that State programs support or encourage efforts to increase food security. For example, CalRecycle is implementing organic waste reduction requirements toward the goal of 40 percent reduction in methane emissions by 2030 as part of California's Short-Lived Climate Pollutant (SLCP) Strategy. CalRecyle has adopted a portfolio of policies and measures in coordination with local jurisdictions to reduce organic waste from landfills by 75 percent from 2014 levels by 2025.

State and local agencies are working together under CalRecycle's SLCP regulations to put organic waste resources to beneficial uses. For example, local jurisdictions are diverting organics from landfills to composting facilities and thereby increase availability and application of compost materials. Composting returns nutrients to the

[220] IPCC. Special Report on Climate Change and Land. 2021. https://www.ipcc.ch/srccl/
[221] Stokstad. Warming oceans are hurting seafood supply—and things are getting worse. 2019. https://www.science.org/content/article/warming-oceans-are-hurting-seafood-supply-and-things-are-getting-worse
[222] Myers, S., Zanobetti, A., Kloog, I. et al. Increasing CO2 threatens human nutrition. Nature 510, 139–142 (2014). https://doi.org/10.1038/nature13179
[223] Kerr, A., Dialesandro, J., Steenwerth, K. et al. Vulnerability of California specialty crops to projected mid-century temperature changes. Climatic Change **148,** 419–436 (2018). https://doi.org/10.1007/s10584-017-2011-3

soil, builds organic soil matter, improves water holding capacity, increases carbon sequestration, helps with landscaping and erosion control and avoids the use of fossil fuel-intense inorganic fertilizers. Improved soil health is linked to better food security as agricultural lands continue to perform well.[224] Additionally, CalRecycle is also working to redirect no less than 20 percent of edible food that would otherwise be disposed in landfills by 2025 to reduce poverty-induced hunger. CalRecycle's Food Waste Prevention and Rescue Grant program provides grant funding using greenhouse gas reduction funds to assist with food recovery efforts.[225] Continuing efforts to increase the rates of food recovery and the number of adults and children that are supported through food recovery programs will extend these benefits into the future.

CARB assists in implementation of CDFA's Healthy Stores Refrigeration Grant Program for the purchase of climate-friendly refrigeration systems for mom-and-pop corner stores, small businesses, and food donation programs in low-income and low-food access areas throughout California. The program helps to stock local fresh foods such as produce, meat, nuts, dairy, eggs, and other minimally processed and ethnic foods. The refrigeration units supported with this grant are energy efficient, saving small businesses and food donation programs money on their energy bills, and use the best available climate-friendly refrigerant technologies available on the market. The program directly impacts food access in areas where healthy fresh foods are not easily available or accessible by local residents.

In addition to policies and programs that reduce food waste, California's programs and policies to manage and protect NWL are also critical to maintaining the resilience of agricultural lands and the communities they support.[226] Management of NWL through the implementation of climate smart agricultural practices reduce GHG emissions while ensuring food security.[227] The IPCC also recognizes land management as a critical solution to ensuring food security. California's Health Soils Initiative, funded in part by greenhouse gas reduction funds, is one example of a NWL program supporting agricultural land resiliency. This program provides financial incentives to California agricultural growers and ranchers to implement conservation management practices such as applying compost, that improve soil health while reducing GHG emissions. Improving soil health has many benefits including sequestering carbon and reducing GHG emissions, improved plant health, improved water retention and infiltration capacity, improved water quality, reduced erosion and dust, and improved biological diversity and wildlife habitat. Healthy soils also conserve water, which is

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224 CARB. Final Short-Lived Climate Pollutant Reduction Strategy. 2017. https://ww2.arb.ca.gov/resources/documents/slcp-strategy-final#:~:text=The%20Short%2DLived%20Climate%20Pollutant,)%2C%20and%20anthropogenic%20black%20carbon.

225 CalRecycle *Food Waste Prevention and Rescue Grant Program - CalRecycle Home Page*

226 CARB. California's 2017 Climate Change Scoping Plan. 2017. *https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf*

227 CARB. Final Short-Lived Climate Pollutant Reduction Strategy. 2017. *https://ww2.arb.ca.gov/resources/documents/slcp-strategy-final#:~:text=The%20Short%2DLived%20Climate%20Pollutant,)%2C%20and%20anthropogenic%20black%20carbon*

becoming scarcer and is vital to maintaining agricultural production and thus alleviating food insecurity. The IPCC lists maintaining healthy soils as a key to ensuring food security.[228]

Health Indicators

Food insecurity and the lack of access to healthy, nutritious foods has been linked to numerous adverse health impacts and, conversely, food security is associated with positive health outcomes (See Table below for a list of key health impacts).

[228] IPCC. Special Report on Climate Change and Land. 2021. *https://www.ipcc.ch/srccl/*

Table G-7: Health co-benefit area - Increased food security*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for qualitative analysis	↓Mental health conditions ↓ Iron deficiency (pregnant women) ↓ Chronic diseases such as Cardiovascular disease, Diabetes Hypertension	Strong benefits with increased food security	Gundersen C, Ziliak JP. 2015. Food Insecurity and Health Outcomes. Health Aff (Millwood). 34(11):1830-1839. Liu, Y., & Eicher-Miller, H. A. 2021. Food Insecurity and Cardiovascular Disease Risk. *Current atherosclerosis reports*, *23*(6), 24.
	↑Life expectancy	Strong benefit with increased food security	Gundersen C, Ziliak JP. 2015. Food Insecurity and Health Outcomes. Health Aff (Millwood). 34(11):1830-1839.
	↓Children's mental health conditions ↓ Children's cognitive problems ↓ Children's behavioral health problems ↓ Children's iron deficiency ↓ Children's oral health problems	Strong benefit with increased food security	Gundersen C, Ziliak JP. 2015. Food Insecurity and Health Outcomes. Health Aff (Millwood). 34(11):1830-1839.

*Studies were chosen based on the strength of the health evidence for the association between each topic area and health outcomes and are generally representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

The health impacts of food insecurity are well documented. Food insecure adults are more likely to suffer from cardiac illness and depression in addition to other chronic health conditions. Children that suffer from food insecurity have higher rates of developmental and mental health challenges.[229] Efforts that improve the health of agricultural soils, improving mobility and access to grocery stores and healthy food options, increasing recovery of edible foods and redirecting it to food insecure children and adults can all have a positive impact on health and this is particularly important since there is evidence that air pollution effects can be exacerbated by nutritional deficiencies. The directional health benefits anticipated are indicated in Table G-7 showing the Health Metrics.

Areas for Further Action

Climate change-related impacts on food security will be felt most by vulnerable communities, which are already disproportionately food insecure and live in/near food deserts. There are many areas requiring coordinated and concentrated efforts across state government to improve food security including reducing food deserts and food waste. Additionally, communities with a higher of prevalence of unhealthy food options such as fast food and convenience stores, compared to healthy food options such as supermarkets with healthy foods, are characterized by higher rates of chronic health conditions. CalRecycle, in coordination with local jurisdictions, is helping build partnerships with local organizations such as homeless shelters, food banks, and community kitchens to recover and provide food for people that are food insecure, which are predominantly people of color, children, and low-income groups.

Extending and enhancing existing food recovery programs and developing longer-term and more ambitious targets to recover most, if not all, edible foods in the waste stream and redirect it to those in need can assist communities with higher levels of food insecurity. Also, as California's transportation system is revamped to become carbon neutral, there could be special attention given to improving food access and reducing the prevalence of food deserts by directly improving transit/mobility options to supermarkets and grocery stores. A demographic racial and ethnic characterization and a geographic assessment will be important in identifying which specific groups and communities continue to experience higher levels of food insecurity and planning strategies to assist these areas.

Plant-rich diets are more sustainable and can be more affordable while animal-rich products require more exhaustive resources, i.e., more land for managing livestock and growing crops for livestock, additional water among others. Plant-rich diets have environmental benefits because they are associated with fewer GHG emissions[230] and they been linked to numerous health benefits.[231]

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[229] CDPH. *Portrait of Promise: The California Statewide Plan to Promote Health and Mental Health Equity. 2015. https://www.phrases.org/wp-content/uploads/2020/06/CA-Statewide-Plan-to-Promote-Health-and-Mental-Health-Equity.pdf*
[230] IPCC. Special Report on Climate Change and Land. 2021. https://www.ipcc.ch/srccl/
[231] Crous-Bou M, Molinuevo JL, Sala-Vila A. Plant-Rich Dietary Patterns, Plant Foods and Nutrients, and Telomere Length. Adv Nutr. 2019;10(Suppl_4):S296-S303. doi:10.1093/advances/nmz026

Mobility and Physical Activity

Background and Health Impacts

Physical activity is one of the most important healthy lifestyle choices and lack of activity increases health burdens. Research shows that regular physical activity improves health in people of all ages. For example, physical activity can improve heart and lung function and muscular fitness, bone strength, mental function, and sleep quality. Physical activity can help individuals maintain a healthy weight and reduce symptoms of depression. A sedentary lifestyle contributes to chronic illness including obesity, heart disease, Type 2 diabetes, stroke, and some types of cancer.[232] Changes in transportation mode away from driving can significantly increase physical activity leading to many valuable health benefits.

The U.S. Department of Health and Human Services recommends adults get a minimum of 150 minutes and up to 300 minutes of moderate-intensity aerobic physical activity or a minimum of 75 minutes and up to 150 minutes of vigorous-intensity physical activity every week; children age 6-17 are recommended to get 60 minutes of moderate-to-vigorous physical activity daily, and children are also recommended to perform a mixture of aerobic and muscle-strengthening exercise.[233] However, nearly half of American adults do not meet recommended physical activity levels. In California 21.2 percent of adults reported doing no physical activity other than their jobs and in low-income groups this number was 30.5 percent.[234]

Sustainable development outcomes that create compact, mixed-use communities with safe options for walking and bicycling lead to increased physical activity through active transportation and reduced vehicle miles travelled (VMT). Active transportation includes bicycling and walking for transportation (active transportation) and even walking or biking trips to access transit. Research studies show that active transportation can result in improved cardiovascular health, blood pressure, mental health benefits, and reductions in mortality, diabetes, and obesity. Public transit use can be a helpful way to increase physical activity. Studies show that public transit use results in health benefits through increased walking/steps, physical activity, energy expenditure, and reduced risks of BMI. In addition to health benefits from physical activity, active transportation can increase social cohesion and economic opportunities in communities.

California's efforts to build sustainable communities that increase active transportation and transit options and reduce VMT rely on implementing a broad range of concurrent

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[232] U.S. Department of Health and Human Services. Obesity Data/Statistics. minorityhealth.hhs.gov/templates/browse.aspx?lvl=3&lvlid=550. Accessed 2011.
[233] U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans- 2nd edition. https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf.
[234] *https://www.americashealthrankings.org/explore/annual/measure/Sedentary/state/CA*

actions in transportation, land use, and housing across all levels of government. Appendix E (Sustainable Communities) presents a policy framework that identifies four strategy areas for action and articulates how the State can promote sustainable and equitable development and transportation patterns in each area. The four strategy areas for action include transportation planning and funding, transportation system management, new mobility, and land use and development. The California Transportation Plan for 2050[235] and the Climate Action Plan for Transportation Infrastructure (CAPTI)[236] are additional state frameworks to integrate transportation policies and investments with greenhouse gas goals.

Scoping Plan No Action Scenario

Vehicle dependent travel continues to dominate the vast majority of trips and a significant percentage of California's population does not meet physical activity guidelines.[237] The CTP finds that the current level of active travel is at 13 percent of all trips. CARB's Draft 2022 Progress Report on implementation of SB 375[238] found that emissions from statewide passenger vehicle travel per capita were increasing and going in the wrong direction. The pandemic had a temporary impact on this trend. By the end of 2021, VMT was at pre-pandemic levels.

These trends reflect historic patterns of growth that continue to shape the state today. While California has grown to be the fifth largest economy in the world, with world-class cities and thriving communities, its residents are too often left with little choice but to spend significant time and money driving from place to place due to housing affordability or other issues. Growth patterns have placed disproportionate burdens on low-income residents, who end up paying the highest proportion of their wages for housing and commuting. The percentage of students actively commuting (walking or biking) to school in the US declined from 48 percent in 1969 to only 13 percent in 2009.[239]

Scoping Plan Take Action Scenario

The Scoping Plan includes a goal of reducing VMT per capita by 30 percent below 2019 levels by 2045. Strategy areas for achieving sustainable and equitable development and transportation patterns that support VMT reduction are highlighted in Appendix E (Sustainable Communities). A key theme discussed in the appendix is the need for strong further action, including state and local action, to achieve VMT reduction goals. Reducing VMT while increasing mobility and physical activity will boost community resiliency and health benefits in communities. Additional information

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[235] *https://dot.ca.gov/-/media/dot-media/programs/transportation-planning/documents/ctp-2050-v3-a11y.pdf*
[236] https://calsta.ca.gov/-/media/calsta-media/documents/capti-july-2021-a11y.pdf
[237] https://www.americashealthrankings.org/explore/annual/measure/Sedentary/state/CA
[238] *https://ww2.arb.ca.gov/sites/default/files/2018-11/Final2018Report_SB150_112618_02_Report.pdf*
[239] McDonald NC, Brown AL, Marchetti LM, Pedroso MS. U.S. school travel, 2009 an assessment of trends. Am J Prev Med. 2011 Aug;41(2):146-51. doi: 10.1016/j.amepre.2011.04.006. PMID: 21767721.

on SB 375 program implementation, challenges and next steps will be available as part of the next update of the SB 375 progress tracking report. A draft of the 2022 Progress Report is anticipated for release in Spring 2022 *Tracking Progress - Sustainable Communities | California Air Resources Board*

In order to demonstrate the enormous public health benefits of VMT reduction, CARB worked with CDPH to quantify the benefits of the CTP for 2050. This calculation provides an illustrative example of potential benefits from decreasing vehicle miles travelled and thus increasing active transit modes. The CTP has a goal of increasing active modes of travel and transit from the current level of 13 percent to a level of 23 percent of all travel trips. While the CTP goal of 23 percent for active modes of travel by 2050 is not a VMT reduction target, it can be used to analyze active transportation health benefits through the Healthy Mobility Options Tool and helps illustrate the significant reductions in health outcomes achievable due to increased physical activity.

CARB and CDPH used the Health Mobility Options Tool to quantify the health benefits for a change in trip mode types. In the CTP 2050 scenario calculated using HMOT, CARB and CDPH used the following trip modes: 2 percent for a combination of biking, air and intercity rail and 10 percent for walking with 11 percent for transit use for the combined scenario. CARB and CDPH have compared the “business as usual” scenario in 2050 to a CTP scenario for 2050 that increases active transportation to 23 percent through a mix of changes in land use planning and transportation and increases in biking, walking, transit use. While the tool does not measure impacts of specific strategies to increase active transportation, it measures the benefits of increased time spent in physical activity depending on the mode share of different active transportation options.

Health Indicators

The Healthy Mobility Options Tool[240] uses well established impacts from the literature on the benefits of physical activity to calculate the potential decrease in chronic disease from increased active transport and transit use and reduced vehicle trips (see the health outcomes measured in the chart below). The results are quantified in terms of either avoided deaths or increases in disability adjusted life years (DALYs).

[240] https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM/

Table G-8: Health co-benefit area - Increased active transportation*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for quantitative analysis	↓Cardiovascular diseases	Strong benefits with increased active transport	Hamer M, Chida Y. 2008. Walking and primary prevention: a meta-analysis of prospective cohort studies. *British Journal of Sports Medicine.* 42:238–243
	↓Colon cancer	Strong benefits with increased active transport	Harriss DJ, Atkinson G, Batterham A, et al. 2009. Lifestyle factors and colorectal cancer risk (2): a systematic review and meta-analysis of associations with leisure-time physical activity. *Colorectal Disease.* 11:689-701
	↓Breast cancer	Strong benefits with increased active transport	Monninkhof EM, Elias SG, Vlems FA, et al. 2007. Physical activity and breast cancer: a systematic review. *Epidemiology.* 18:137-157
	↓Diabetes	Strong benefits with increased active transport	Jeon CY, Lokken RP, Hu FB, van Dam RM. 2007. Physical activity of moderate intensity and risk of type 2 diabetes: a systematic review. *Diabetes Care*. 30:744-752.
	↓Dementia	Strong benefits with increased active transport	Hamer M, Chida Y. 2009. Physical activity and risk of neurodegenerative disease: a systematic review of prospective evidence. *Psychological Medicine*. 39:3-11
	↓Lung cancer	Strong benefits with increased active transport	Pope CA, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, et al. 2002. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA.* 287:1132-1141
	↓Respiratory disease	Strong benefits with increased	Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, et al. 2009. Extended Follow-up and Spatial Analysis of the American Cancer Society Study Linking

		active transport	Particulate Air Pollution and Mortality. Boston: Health Effects Institute Ritz B, Wilhelm M, Zhao Y. 2006. Air pollution and infant death in Southern California, 1989-2000. *Pediatrics.* 118:493-502
	↓Depression	Strong benefits with increased active transport	Woodcock J, Edwards P, Tonne C, Armstrong BG, Ashiru O, Banister D, et al. 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. Supplementary web appendix. *The Lancet.* 374:1930-1943
	↑Increase road traffic injuries	Disbenefit with increased active transport	Mueller N, Rojas-Rueda D, Cole-Hunter T, de Nazelle A, Dons E, Gerike R, Götschi T, Int Panis L, Kahlmeier S, Nieuwenhuijsen M. 2015. Health impact assessment of active transportation: A systematic review. Prev Med. 76:103-114.

*Studies were chosen based on the strength of the health evidence for the association between each topic area and health outcomes. In this case studies are included from the HMOT quantitative tool. The studies are generally representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

The scale of the health benefits that can be achieved from reducing chronic illness through active transportation are large. CARB and CDPH used the Healthy Mobility Options Tool (HMOT) to calculate the health benefits of active transportation from the California Transportation Plan (CTP) 2050 compared to business as usual for 2050. The HMOT estimated that a total of 7,941 deaths would be avoided in 2050 for the "combined scenario" that increases active transportation, increases transit and decreases vehicle miles traveled through land use planning. This would correspond to the 8th leading cause of death in the state, based on 2017 data.[241] CARB and CDPH also used the HMOT tool to estimate avoided deaths due to reductions in the individual chronic diseases examined. The greatest benefits are due to reductions in cardiovascular health impacts and dementia impacts. Tables G-9 and G-10 demonstrate the quantifiable health benefits of the Scoping Plan outcomes for mobility and physical activity shown both as a combined table and a table with results calculated for individual chronic disease outcomes.

[241] https://www.cdc.gov/nchs/pressroom/states/california/california.htm

Table G-9: Quantified health benefits from active transportation - Annual change in the burden of disease, combined scenario compared to BAU 2050

Pathway	Avoided Deaths		Decrease in Disability Adjusted Life Year (DALYs)	
	PAF (%)	Count	PAF (%)	Value
Physical Activity	3.3	7,838	3.4	102,642
Air Pollution	< 0.1	15.7	< 0.1	147
Road Traffic Injuries	2.2	88.2	2.2	4,293
Total	1.8	7,941	1.9	107,082
PAF, population attributable fraction; DALY, disability adjusted life year.				

Table G-10: Quantified health benefits from active transportation - Annual change in the burden of disease by chronic disease outcome combined scenario compared to BAU 2050

Cause	Path way	Change				PAF (%)			
		Deaths	YLL	YLD	DALY	Deaths	YLL	YLD	DALY
Ischemic Heart Disease	PA	3,499	34,759	3,153	37,912	3.8	4.3	4.3	4.3
Dementia	PA	1,601	10,657	7,176	17,833	2.6	2.6	2.6	2.6
Stroke	PA	1,187	11,370	3,562	14,932	3.9	4.2	4.3	4.2
Hypertensive Heart Disease	PA	726	7,448	265	7,713	4	4.5	4.1	4.5
Diabetes	PA	601	8,066	6,290	14,356	3.7	4.3	4.4	4.4

Colon Cancer	PA	132	1,602	134	1,736	1.6	1.6	1.6	1.6
Breast Cancer	PA	90.9	1,343	331	1,674	1.3	1.4	1.3	1.4
Depression	PA	0	0	6,485	6,485	0	0	1.7	1.7
Ischemic Heart Disease	PA+ PM	3,506	34,817	3,153	37,970	3.8	4.3	4.3	4.3
Stroke	PA+ PM	1,189	11,388	3,562	14,951	3.9	4.2	4.3	4.2
Hypertensive Heart Disease	PA+ PM	727	7,460	265	7,725	4	4.5	4.1	4.5
Ischemic Heart Disease	PM	6.8	60.1	0	60.1	< 0.1	< 0.1	0	< 0.1
Respiratory diseases	PM	2.7	23.7	0	23.7	< 0.1	< 0.1	0	< 0.1
Stroke	PM	2.3	19.4	0	19.4	< 0.1	< 0.1	0	< 0.1
Lung Cancer	PM	1.9	23	0	23	< 0.1	< 0.1	0	< 0.1
Hypertensive Heart Disease	PM	1.4	12.2	0	12.2	< 0.1	< 0.1	0	< 0.1
Inflammatory Heart Disease	PM	0.6	8.3	0	8.3	< 0.1	< 0.1	0	< 0.1
Acute resp infections	PM	< 0.1	< 0.1	0	< 0.1	< 0.1	< 0.1	0	< 0.1
Road Traffic* Injuries	RTI	88.2	3,190	1,103	4,293	2	2	3.3	2.2

PA, physical activity, PM; fine particulate matter, PM2.5; RTI, road traffic injuries; PAF, population attributable fraction; YLL, years of life lost; YLD, years living with disability; DALY, disability adjusted life year;

Using the HMOT tool for different racial groups in California shows the distribution seen in different racial groups (See Table G-11). The higher numbers in the White group reflect the fact that this group has a lower level of baseline walking and biking and is more car dependent and therefore sees the greatest change in activity with an increase in transit use and active transport.

Table G-11: Quantified health benefits from active transportation by race compared to BAU 2050

Pathway	Reduced Deaths by Race				
	Total	White	Asian	Black	Latino
Physical Activity	7,838	4,366	1,012	513	1,983
Air Pollution	15.7	7.3	1.6	1.1	3.9
Road Traffic Injuries	88.2	42.7	-2.3	1.6	46.7
Total	7,941	4,416	1,012	516	2,034

Note that negative values indicate an increase in deaths

As shown by the HMOT results, increasing active transportation and transit that replaces vehicular trips and reduces VMT significantly improves overall health, prevents, or reduces the risk of developing many chronic conditions, reduces costs in statewide health care, and cuts GHG emissions and air pollution.[242] Reduced VMT can also help to reduce the total number of motor vehicle injuries and fatalities, improve air quality, and enhance mental health and well-being through enhanced social connections.[243]

Areas for Further Action

Significant disparities exist across the state in the availability of safe, convenient, and affordable transportation. Vulnerable communities suffer from reduced access to transportation and reduced safety infrastructure. In addition, a lack of nearby jobs and poor housing choices means that members of under-resourced communities have

[242] Maizlish N. Increasing walking, cycling, and transit: improving Californians' health, saving costs, and reducing greenhouse gases. 2016. https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/Maizlish-2016-Increasing-Walking-Cycling-Transit-Technical-Report-rev8-17-ADA.pdf

[243] Younger M, Morrow-Almeida HR, Vindigni SM, Dannenberg AL. The built environment, climate change, and health: opportunities for co-benefits. Am J Prev Med. 2008 Nov;35(5):517-26. doi: 10.1016/j.amepre.2008.08.017. PMID: 18929978.

longer commutes. The uniqueness of local circumstances including accessibility of transit, built environment features (e.g., bike paths, crosswalks), and related development policies at local levels can be critical factors for improved utilization of active transportation and public transit. Increased efforts to provide access to mobility options in vulnerable communities, to increase access to jobs, health care and health food resources and reduce obstacles to active transportation will help mitigate these concerns. Several factors may contribute to low rates of walking and biking in communities including trips from home to school such as: lack of sidewalks, high volumes and speeds of vehicular traffic, unsafe road crossings, concerns about children traveling on their own, long distances between homes, schools and workplaces, and high rates of auto ownership.[244, 245] Efforts to improve infrastructure can increase the opportunities to use active transportation modes. CARB has included a more comprehensive discussion of transportation disparities and ways to assist communities in Appendix E (Sustainable Communities).

Although active transportation and public transportation as an alternative to driving will have a host of health benefits as described above, active transportation can increase traffic injuries/fatalities without other safety infrastructures.[246] However, studies have also shown that when more people are walking and biking the number of traffic injuries is reduced, this effect is called "safety in numbers". Therefore, as more jurisdictions promote active transportation and provide safer walking and biking infrastructure, this concern can be reduced. In addition, a zero-emission fleet will also greatly reduce the exposure to near source traffic emissions to those walking and biking near traffic sources. With increasing climate change, planning for shade and cool pavements and other ways to reduce the impact of heat will be important to both encourage and ensure the safety of those using active transport. As mentioned above, additional strategies can be used to mitigate the potential for injuries and fatalities through improved infrastructure. Achieving VMT reduction goals and increasing active transportation while promoting equity will require concerted action at every level of government as described in the framework presented in Appendix E (Sustainable Communities).

[244] Noreen C. McDonald & Annette E. Aalborg (2009) Why Parents Drive Children to School: Implications for Safe Routes to School Programs, Journal of the American Planning Association, 75:3, 331-342, DOI: 10.1080/01944360902988794

[245] Chillón P, Hales D, Vaughn A, Gizlice Z, Ni A, Ward DS. A cross-sectional study of demographic, environmental and parental barriers to active school travel among children in the United States. Int J Behav Nutr Phys Act. 2014 May 9;11:61. doi: 10.1186/1479-5868-11-61. PMID: 24885862; PMCID: PMC4032634.

[246] Maizlish N, Woodcock J, Co S, Ostro B, Fanai A, Fairley D. Health cobenefits and transportation-related reductions in greenhouse gas emissions in the San Francisco Bay area. Am J Public Health. 2013 Apr;103(4):703-9. doi: 10.2105/AJPH.2012.300939. Epub 2013 Feb 14. PMID: 23409903; PMCID: PMC3673232.

Affordable Housing

Background and Health Impacts

Housing is one of the social determinants of health. The stability of housing, housing quality, and conditions inside the home, the cost of housing and the environmental and social characteristics of the places people live all affect health.[247] This section will mainly focus on housing affordability, which is a factor in development of sustainable land use and transportation patterns.

State efforts that decrease VMT, including SB 375 policies and the framework in Appendix E (Sustainable Communities), building decarbonization and efficiency improvements as discussed in Appendix F (Building Decarbonization) and policies that support investments in affordable housing and NWL management programs will all play important roles in supporting affordable housing access. The policy framework in Appendix E to advance VMT reduction includes a policy goal of accelerating production of affordable housing in forms and locations that advance VMT reduction and affirmatively further fair housing policy objectives.

Poor quality housing can contribute to infectious disease, chronic illness, asthma, injuries and reduced mental health.[248] A lack of affordable housing, among other factors, contributes to reduced medical care and poor performance of children in schools, worsening of children's health and behavioral problems.[249] Stress, both physical and financial, on individuals from housing cost burdens can result in worsening mental health and adverse health behaviors. Being behind on rent can have health impacts on families and children reducing both physical and mental health.[250] Homelessness has even more health risks including increased mortality and illness.[251]

Low-income people of color are the most impacted by the lack of access to affordable housing. With a reduced cost burden of housing, families can spend more on health care and a better diet. Reduced stress from struggling financially to pay high housing costs will result in improved health. Studies have shown that home ownership results in better mental and physical health compared to renting homes[252] and having a stable

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[247] *Housing And Health: An Overview Of The Literature | Health Affairs. https://www.healthaffairs.org/do/10.1377/hpb20180313.396577/*

[248] James Krieger, MD, MPH, and Donna L. Higgins, PhD Housing and Health: Time Again for Public Health Action May 2002, Vol 92, No. 5 | American Journal of Public Health

[249] Braveman P, Dekker M, Egerter S, Sadegh-Nobari T, Pollack C. 2011. Issue Brief: Housing and Health. Robert Wood Johnson Foundation. https://www.rwjf.org/en/library/research/2011/05/housing-and-health.html

[250] Children's HealthWatch. 2011. Behind Closed Doors: The Hidden Health Impacts of Being Behind on Rent. https://childrenshealthwatch.org/wp-content/uploads/behindcloseddoors_report_jan11-.pdf

[251] Auerswald CL, Lin JS, Parriott A. 2016. Six-year mortality in a street-recruited cohort of homeless youth in San Francisco, California. PeerJ 4:e1909 *https://doi.org/10.7717/peerj.1909*

[252] Connolly, Sheelah, Dermot O'Reilly, and Michael Rosato. 2010. "House Value as an Indicator of Cumulative Wealth Is Strongly Related to Morbidity and Mortality Risk in Older People: A Census-Based CrossSectional and Longitudinal Study." International Journal of Epidemiology 39 (2): 383–391. in https://nhc.org/wp-content/uploads/2017/03/The-Impacts-of-Affordable-Housing-on-Health-A-Research-Summary.pdf

home situation also contributes to health. One study in New York City showed that when families had affordable rent payments they were able to increase their discretionary income by 77 percent, allowing funds to be spent on health insurance, food, and education, or to save for a down payment on a home.[253] Access to affordable housing promotes mental and physical health and reduces hospital visits,[254] reducing health care costs.

Scoping Plan No Action Scenario

Appendix E (Sustainable Communities) of the Scoping Plan presents strategies to accelerate production of affordable housing in forms and locations that reduce VMT reduction and increase housing affordability and access. In a No Action Scenario, affordable housing will not be impacted by the implementation of strategies in Appendix E of the Scoping Plan. Without the land use and housing actions proposed in Appendix E (Sustainable Communities), in coordination with the Natural and Working Lands outcomes in the Scoping Plan, wildfires will remain on the current trajectory. As discussed elsewhere in the Scoping Plan, wildfires have increased and are projected to continue to increase with climate change. Communities near forests and other wooded areas are at particular risk for wildfires.

Scoping Plan Take Action Scenario

The Scoping Plan's proposed actions to reduce vehicle miles travelled support compact, sustainable communities with increased access to affordable housing and expanded mobility options like walking, cycling and public transportation that help reduce greenhouse gas emissions and promote public health. In particular, the proposed actions in Appendix E (Sustainable Communities) related to land use and housing would help to spur housing production in forms and locations that reduce VMT and increase housing affordability and access. Additionally, new housing will meet today's higher standards of energy efficiency, materials, and air quality, which will mean heathier buildings indoors for residents. Equitable transition to building decarbonization will also impact housing access. New research from Rocky Mountain Institute has found that constructing all-electric homes without any gas service is cheaper than building homes with both gas and electric.[255] According to the study, use of wind and solar means utilities can lock in long-term, low rates and avoid the price shocks to gas customers. In addition, with heat pump technology, new heat pump

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[253] "Housing And Health: An Overview Of The Literature," Health Affairs Health Policy Brief, June 7, 2018. DOI: 10.1377/hpb20180313.396577

[254] Kottke T, Abariotes A, Spoonheim JB. Access to Affordable Housing Promotes Health and Well-Being and Reduces Hospital Visits. Perm J. 2018;22:17-079. doi: 10.7812/TPP/17-079.

[255] Billimoria, Sherri, Mike Henchen, Leia Guccione, and Leah Louis-Prescott. The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings. Rocky Mountain Institute, 2018, *http://www.rmi.org/insights/reports/economics-electrifying-buildings/*

electric appliances are four times as efficient as gas appliances — and don't emit any air pollution in the home.

Health Indicators

Based on the literature reviewed above, Table G-12 includes key studies showing associations between lack of affordable housing and health impacts.

Table G-12: Health co-benefit area - Affordable housing*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for qualitative analysis	↓ Infectious disease, ↓ Chronic illness ↓ Asthma ↓ Injuries ↓ Reduced mental health concerns	Strongly decreased by an increase in affordable housing	James Krieger and Donna L. Higgins. 2002. Housing and Health: Time Again for Public Health Action. American Journal of Public Health, 92(5), 758-768

	↓ Poor performance of children in schools, ↓ Worsening of children's health ↓ Behavioral problems for children	Strongly decreased by an increase in affordable housing	Braveman P, Dekker M, Egerter S, Sadegh-Nobari T, And Pollack C. 2011. How Does Housing Affect Health? Housing and Health. Robert Wood Johnson Foundation. https://www.rwjf.org/en/library/research/2011/05/housing-and-health.html

*Studies were chosen based on the strength of health evidence for the association between each topic area and health outcomes are generally representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

Actions to support SB 375 and VMT reduction goals, including the recommended framework in Appendix E (Sustainable Communities) are aligned with affordable housing goals. Other actions that can promote affordable housing include providing investments in home energy efficiency and decarbonization, aligning state investments in ways that promote affordable housing while also increasing transportation choices and reducing vehicle emissions, and improving the safety of homes in fire prone areas. The qualitative analysis in Chart G-12 above demonstrates the directional benefits of actions that contribute to housing affordability.

Areas for Further Action

Concerted state action and coordination among multiple agencies is needed to achieve sustainable community and transportation goals, including affordable housing, and a framework to achieve these goals is included in Appendix E (Sustainable Communities). It will be essential to ensure that these efforts benefit all members of communities. Investment programs such as the AHSC Program has created guidelines, scoring incentives and anti-displacement strategies.[256] Appendix E (Sustainable Communities) covers issues around displacement and includes policies in the recommended framework to avoid displacement as communities are transitioning to more sustainable transportation and development patterns.

[256] California Housing and Community Development. New AHSC Report Highlights Climate & Economic Benefits of 11,300 Sustainable Homes - California Housing Partnership (chpc.net). 2021

Urban Greening

Background and Health Impacts

Urban greening is well recognized as an important amenity but the need for greenness and the inherent health benefits are not always well understood. Low-income communities and communities of color consistently show a lack of lack of urban greening and higher percentages of concrete, asphalt, and impervious surfaces. A nationwide study found that census tracks in urban areas with higher poverty and higher percentages of Black residents have less access to green space.[257] Research has shown that lower income neighborhoods of color in California have a greater presence of concrete and heat-trapping surfaces and a lower amount of tree cover.[258] Areas with reduced urban greening have the potential to create areas of higher temperatures as heat is reflected from pavements and buildings. These pockets of higher temperatures are called heat islands and they are a common feature in low-income communities and communities of color. Heat islands contribute to worsened air quality and health outcomes. Heat is known to be associated with adverse birth outcomes[259] and mortality[260], including mortality in the young[261] as discussed in more detail in the heat impacts section. Conversely, strategies that preserve and create urban parks, green space, natural infrastructure, and sustainable agricultural practices support public health. The increase of urban forests and urban greening can have substantial benefits that can offset the cost of planting and maintaining urban green areas. Studies have demonstrated a range of improved health outcomes associated with increased contact with nature and greenness.[262, 263] A recent meta-review presented the benefits of increased urban greening in cities as one of several co-benefits of carbon neutral communities along with increasing public and active transportation.[264]

Research has found that urban greening is associated with improvements in general health, enhanced brain development in children, improved cognitive function in adults and improved mental health as well as reductions in chronic disease such as diabetes

[257] Wen M, Zhang X, Harris CD, Holt JB, Croft JB. Spatial disparities in the distribution of parks and green spaces in the USA. Ann Behav Med. 2013 February ; 45(Suppl 1): 18–27. doi:10.1007/s12160-012-9426-x.

[258] Morello-Frosch, R., and B. Jesdale. 2008. Unpublished impervious surface and tree cover data. Data for this analysis was derived from: U.S. Geological Survey's National Land Cover Dataset 2001. *www.mrlc.gov/nlcd.php*, accessed on June 20, 2007; and ESRI's ArcMap census boundary files *www.census.gov/geo/www/cob/bdy_files.html* , accessed June 6, 2008. Found in the Climate Gap *https://dornsife.usc.edu/pere/climategap/*https://dornsife.usc.edu/pere/climategap/

[259] Bekkar B, Pacheco S, Basu R, DeNicola N. Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. JAMA Netw Open. 2020 Jun 1;3(6):e208243. doi: 10.1001/jamanetworkopen.2020.8243.

[260] Kovats, R. S., and S. Hajat. 2008. "Heat stress and public health: A critical review." Annu Rev Public Health 29: 41–55.

[261] Rupa, Basu 2009 High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008 Environmental Health 2009, 8:40 doi:10.1186/1476-069X-8-40

[262] Kuo, M. How might contact with nature promote human health? Promising mechanisms and a possible central pathway Front. Psychol., 25 August 2015 | *https://doi.org/10.3389/fpsyg.2015.01093.*

[263] Wolf KL, Lam ST, McKeen JK, Richardson GR, van den Bosch M, Bardekjian AC. 2020. Urban trees and human health: a scoping review. Int. J. Environ. Res. Public Health 17(12):4371.

[264] Nieuwenhuijsen, Mark J., Green Infrastructure and Health Annu. Rev. Public Health 2021. 42:317–28

and cardiovascular disease and reductions in premature mortality.[265] There is consistent evidence that urban greening exposure during pregnancy is positively associated with birth weight.[266] There is a strong association between neighborhood greenness and reduced risk of stress and mental health symptoms and prevalence of depression[267, 268, 269, 270, 271, 272] and the effects may be stronger in lower income communities. A nationwide study found that an increase in urban greening was associated with 37% lower odds of depression in low-income neighborhoods, compared to 27% and 21% lower odds of depression in medium- and high-income neighborhoods, respectively.[273]

Urban greening may influence health by promoting physical activity and social contact; decreasing stress; and mitigating air pollution, noise, and heat exposure.[274] Lovasi et al. (2008) found that an increase in street tree density of about 343 trees per km2 was associated with a lower prevalence of asthma in children in New York, although there was no effect on hospitalizations for asthma.[275] Urban greening is associated with reduced overweight and obesity in both adults[276] and in children.[277] A recent systematic review reported a consistent association between higher residential greenness and a lower risk of mortality due to cardiovascular diseases. One study found that by significantly increasing tree canopy citywide in Philadelphia from 16.6% to 30% a total of 403 premature deaths would be preventable annually.[278]

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[265] Nieuwenhuijsen, Mark J., Green Infrastructure and Health Annu. Rev. Public Health 2021. 42:317–28

[266] Zhan, Y., Liu, J., Lu, Z., Yue, H., Zhang, J., & Jiang, Y. (2020). Influence of residential greenness on adverse pregnancy outcomes: A systematic review and dose-response meta-analysis. Science of The Total Environment, 718, 137420. *https://doi.org/10.1016/j.scitotenv.2020.137420*

[267] Astell-Burt T, Feng X, Kolt GS. 2013. Mental health benefits of neighbourhood green space are stronger among physically active adults in middle-to-older age: evidence from 260,061 Australians. Prev Med. 57(5):601-606.

[268] Ward Thompson C, Roe J, Aspinall P, Mitchell R Clow A. 2012. More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. Landscape and Urban Planning. 105(3):221-229.

[269] Nutsford D, Pearson AL, Kingham S. 2013. An ecological study investigating the association between access to urban green space and mental health. Public Health.127(11):1005-1011.

[270] de Vries S, van Dillen SM, Groenewegen PP, Spreeuwenberg P. 2013. Streetscape greenery and health: stress, social cohesion and physical activity as mediators. Soc Sci Med. 94:26-33.

[271] Lee AC, Maheswaran R. 2011. The health benefits of urban green spaces: a review of the evidence. J Public Health (Oxf). 33(2):212-22.

[272] Triguero-Mas M, Dadvand P, Cirach M, Martínez D, Medina A, Mompart A, Basagaña X, Gražulevičienė R, Nieuwenhuijsen MJ. 2015. Natural outdoor environments and mental and physical health: relationships and mechanisms. Environ Int. 77:35-41.

[273] Brown SC, Perrino T, Lombard J, Wang K, Toro M, Rundek T, Gutierrez CM, Dong C, Plater-Zyberk E, Nardi MI, Kardys J, Szapocznik J. Health Disparities in the Relationship of Neighborhood Greenness to Mental Health Outcomes in 249,405 U.S. Medicare Beneficiaries. Int. J. Environ. Res. Public Health **2018**, 15, 430; doi:10.3390/ijerph15030430

[274] Nieuwenhuijsen, Mark J., Green Infrastructure and Health Annu. Rev. Public Health 2021. 42:317–28

[275] Lovasi GS,Quinn JW,Neckerman KM, Perzanowski MS, Rundle A. 2008. Children living in areas with more street trees have lower prevalence of asthma. J. Epidemiol. Community Health 62(7):647–49

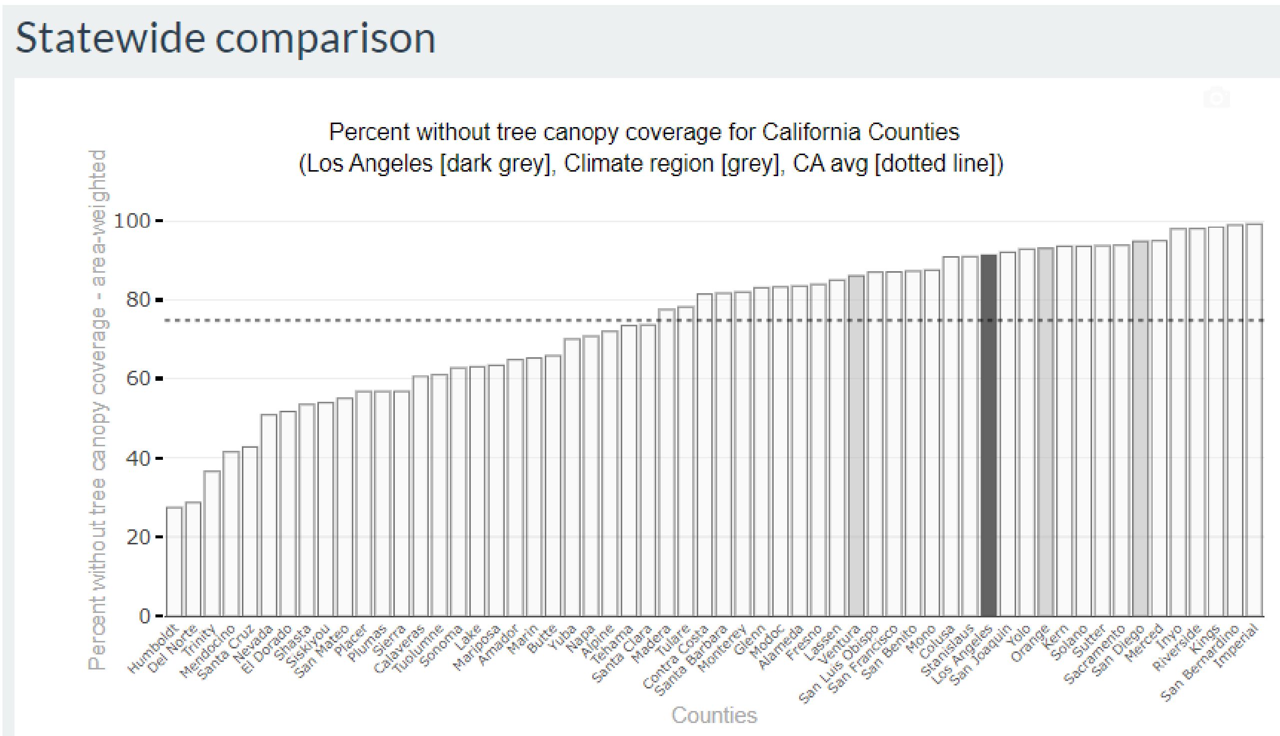
[276] Mona Mowafi, Zeinab Khadr, Gary Bennett, Allan Hill, Ichiro Kawachi, S.V. Subramanian. 2012. Is access to neighborhood green space associated with BMI among Egyptians? A multilevel study of Cairo neighborhoods *https://doi.org/10.1016/j.healthplace.2011.12.002*

[277] Dadvand, P.; Villanueva, C.M.; Font-Ribera, L.; Martinez, D.; Basagaña, X.; Belmonte, J.; Vrijheid, M.; Gražulevičienė, R.; Kogevinas, M.; Nieuwenhuijsen, M.J. Risks and benefits of green spaces for children: A cross-sectional study of associations with sedentary behavior, obesity, asthma, and allergy. Environ. Health Perspect. **2014**, 122, 1329–1335.

[278] Kondo MC, Mueller N, Locke DH, Roman LA, Rojas-Rueda D, et al. 2020. Health impact assessment of Philadelphia's 2025 tree canopy cover goals. Lancet Planet. Health 4(4):e149–57

Communities experience unequal levels of urban greening in California. The *Climate Change and Health Vulnerability Indicators for California* visualization map provides individual county information on the percent of area without tree canopy coverage. Figure G-13 below shows that Los Angeles County and thirty-one other counties are more vulnerable, with an above-average area without tree canopy coverage.

Figure G-13: Percent without tree canopy coverage for Los Angeles County vs. other California counties



Source: Climate Change and Health Vulnerability Indicators for California
https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx

Several California programs are aimed at increasing urban greening. The California Natural Resources Agency Urban Greening Program funds projects that reduce GHG emissions by sequestering carbon, decreasing energy consumption, and reducing vehicle miles traveled. The program emphasizes carbon sequestration and the mitigation of GHG emissions through projects that expand the urban tree canopy by planting trees and developing low carbon means of transportation through bicycle paths and lanes or pedestrian facilities. Expanding the urban tree canopy not only increases carbon sequestration directly, but also helps urban communities adapt to the adverse effects of climate change by providing shade to the public, reducing energy costs associated with cooling, and filtering air pollutants and stormwater runoff.[279]

Scoping Plan No Action Scenario

Urban greening has remained at relatively low levels on average even though increased greenness is known to have substantial benefits. CARB estimated the urban tree canopy cover in California to range from 12.1 percent in 1995 to a high of 15.5 in 2016, so in that period overall urban tree canopy has only increased 3.4 percent.[280] With no action the state can expect a continued slow growth in urban greening.

Scoping Plan Take Action Scenario

Scoping Plan outcomes to increase the health of natural and working lands and support more sustainable development patterns will increase urban greening statewide. Actions included in the Scoping Plan include investments in tree planting in urban areas and implementation efforts aimed at achieving SB 375 goals. CARB estimates that urban tree canopy will increase (include metrics of increase) and that more sustainable community planning will protect natural resources and open space. With an increase in urban greening, particularly in low-income communities and other vulnerable communities, California would experience substantial benefits from improved health outcomes for asthma, depression, mortality, life expectancy and birth outcomes.

Health Indicators

Research showing the strength and direction of beneficial findings in the association between increased urban greening and health outcomes are listed in the Table G-13 below. Researchers under contract to CARB have identified key studies that can be used to quantify health improvements including life expectancy and birth outcomes associated with increased levels of urban greening. Additional studies are listed showing reduced health outcomes for mortality, asthma prevalence and depression linked to urban greening that can be used in qualitative assessment.

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[279] https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf

[280] CARB. Technical Support Document for the Natural & Working Lands Inventory. 2018. https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory_technical.pdf

Table G-13: Health co-benefit area - Increased urban greening*

Qualitative or Quantitative	Health Outcome	Direction of Effect	Reference
Findings were used for Qualitative Analysis	↓Mortality	Strong benefit with increased urban greening	Gascon, M., Triguero-Mas, M., Martínez, D., Dadvand, P., Rojas-Rueda, D., Plasència, A., & Nieuwenhuijsen, M. J. 2016. Residential green spaces and mortality: A systematic review. *Environment International*, *86*, 60–67. Rojas-Rueda D., Nieuwenhuijsen M.J., Gascon M., Perez-Leon D., & Mudu P. 2019. Green spaces and mortality: A systematic review and meta-analysis of cohort studies. *The Lancet Planetary Health*, *3*(11), e469–e477.
	↑Life Expectancy	Strong benefit with increased urban greening	Yanez, E., Aboelata, M., & Bains, J. 2020. *Park Equity, Life Expectancy, and Power Building: Research Synopsis*. Prevention Institute.
	↓Pregnancy outcomes Low birth weight and small for gestational age	Strong benefit with increased urban greening	Zhan, Y., Liu, J., Lu, Z., Yue, H., Zhang, J., & Jiang, Y. 2020. Influence of residential greenness on adverse pregnancy outcomes: A systematic review and dose-response meta-analysis. *Science of The Total Environment*, *718*, 137420.
Findings could be used for Quantitative Analysis	↓Mortality	Strong benefit with increased tree canopy	Kondo MC, Mueller N, Locke DH, Roman LA, Rojas-Rueda D, et al. 2020. Health impact assessment of Philadelphia's 2025 tree canopy cover goals. Lancet Planet. Health 4(4):e149–157.

	↓Reduced asthma prevalence	Strong benefit with increase in street trees	Lovasi GS, Quinn JW,Neckerman KM, Perzanowski MS, Rundle A. 2008. Children living in areas with more street trees have lower prevalence of asthma. J. Epidemiol. Community Health 62(7):647–649.
	↓Depression	Strong benefit with increased urban greening	Astell-Burt T, Feng X, Kolt GS. 2013. Mental health benefits of neighbourhood green space are stronger among physically active adults in middle-to-older age: evidence from 260,061 Australians. Prev Med. 57(5):601-606. Ward Thompson C, Roe J, Aspinall P, Mitchell R Clow A. 2012. More green space is linked to less stress in deprived communities: Evidence from salivary cortisol patterns. Landscape and Urban Planning. 105(3):221-229. Nutsford D, Pearson AL, Kingham S. 2013. An ecological study investigating the association between access to urban green space and mental health. Public Health.127(11):1005-1011 de Vries S, van Dillen SM, Groenewegen PP, Spreeuwenberg P. 2013. Streetscape greenery and health: stress, social cohesion and physical activity as mediators. Soc Sci Med. 94:26-33 Lee AC, Maheswaran R. 2011. The health benefits of urban green spaces: a review of the evidence. J Public Health (Oxf). 33(2):212-222 Triguero-Mas M, Dadvand P, Cirach M, Martínez D, Medina A, Mompart A, Basagaña X, Gražulevičienė R, Nieuwenhuijsen MJ. 2015. Natural outdoor environments and mental and physical health: relationships and mechanisms. Environ Int. 77:35-41.

*Studies were chosen based on the strength of the health evidence for the association between each topic area and health outcomes. The studies are generally representative of a broader body of literature on each health endpoint.

Health Benefits of Scoping Plan Outcomes

The Scoping Plan outcomes related to Natural and Working Lands are expected to result in increases in urban tree canopy. Based on that increase in tree canopy combined with the relationships shown for health metrics given in Table G-13 above, this analysis shows directional evidence for reduced mortality, increase in life expectancy, and reduced risk of asthma outcomes, adverse birth outcomes, and depression.

Areas for Further Action

A carbon neutral California is a greener California. Increasing urban greening in our cities will improve both physical and mental health. However, current measures of urban greening document that low-income communities and communities highly impacted by environmental pollution do not have as many green spaces, trees, or parks that can reduce heat, provide space for increased social interaction and increase mental and physical health.[281] Instead, many communities are dominated by concrete and asphalt surfaces. This lack of green space increases health impacts in communities and reduces life expectancy. As noted earlier, the addition of greenspace will have greater impact per unit in under-resourced communities due to the range of cumulative effects contributing to health harm. Ensuring equitable distribution of additional green space for vulnerable communities is an ongoing priority to realize the wide range of health benefits described in this section. Securing the necessary resources and investments to increase and maintain urban greening and reduce urban heat islands in under-resourced communities is an ongoing challenge, but vital to provide important health benefits. Investments aligned with outcomes called for in the Scoping Plan, the Natural Resources Agency Urban Greening Program and other state and local efforts are important ways to address these needs. In increasing urban greening in vulnerable communities, it is also important to recognize the possibility of urban greening increasing housing and property values and displacing residents, called "green gentrification.[282, 283] Actions to increase urban greening should be designed to mitigate against displacement to ensure existing residents benefit from health improvements.

Summary of Analysis of Health Benefits

In summary, the qualitative analysis of the no-action versus take-action scenarios for the Scoping Plan shows an overwhelming benefit for the state in moving forward to carbon neutrality while continuing efforts to increase health equity and resilience in individual communities. Development and implementation of actions to achieve the outcomes called for in the Final 2022 Scoping Plan should consider how to engage affected communities in implementation, address the existing health and opportunity gaps and pursue equitable implementation statewide and locally. As climate change impacts increase, the Final 2022 Scoping Plan actions together with implementation

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[281] https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf

[282] Wolch, J. R., Byrne, J. & Newell, J. P. Urban green space, public health, and environmental justice: the challenge of making cities 'just green enough. Landsc. Urban Plan. **125**, 234–244 (2014).

[283] Jennings, V., Gaither, C. J. & Gragg, R. S. Promoting environmental justice through urban green space access: a synopsis. Environ. Justice **5**, 1–7 (2012).

efforts will not only reduce greenhouse gases that contribute to climate change but can also reduce near-term air pollution and other climate related health effects and promote more resilient communities that are better able to prepare for and recover from extreme climate events. This health analysis identifies a wide range of possible physical and mental health benefits to communities strongly associated with Scoping Plan outcomes. The magnitude of positive health effects, including reductions in chronic illness and avoided early deaths is extremely large as demonstrated in the quantitative elements of the analysis and these benefits would help everyone but especially highly impacted communities. Overall summaries of the directional benefits by co-benefit area are included in this appendix with studies listed that were used for qualitative and quantitative analysis of health effects (See Table G-14 and G-15). A summary of the future actions in areas of concern for under resourced communities from each co-benefit area is also included (See Table G-16).

Table G-14: Overview of directional analysis for health co-benefit areas (heat, affordable housing, food security, economic security, urban greening)

Quantitative vs. Qualitative	Health Co-Benefit Areas				
	Reduced Heat Impacts	Increased Affordable Housing	Increased Food Security	Increased Economic Security	Increased Urban Greening
Findings were used for qualitative analysis	↓ Mortality (Xu et al., 2016) ↓ Emergency Room Visits for cardiovascular and respiratory causes and intestinal infections (Basu et al., 2012) ↓ Hospitalization for cardiovascular, respiratory causes (Guirguis et al., 2018) ↓ Preterm Birth (Basu et al., 2010; Avalos, et al., 2017; Basu, et al., 2017; Ha et al., 2017) ↓ Mental Illness (Rupa et al., 2018)	↓ Infectious Disease (Krieger and Higgins, 2002) ↓ Chronic Illness (Krieger and Higgins, 2002) ↓ Asthma (Krieger and Higgins, 2002) ↓ Injuries (Krieger and Higgins, 2002) ↓ Mental Illness (Krieger and Higgins, 2002) ↑ Children's Performance in Schools (Braveman et al., 2011) ↑ Children's Health	↓ Mental Illness (Gundersen and Ziliak, 2015) ↓ Iron Deficiency (Gundersen and Ziliak, 2015) ↓ Chronic Diseases (Gundersen and Ziliak, 2015; Liu and Eicher-Miller, 2021) ↑ Life Expectancy (Gundersen and Ziliak, 2015) ↓ Children's Mental Illness (Gundersen and Ziliak, 2015)	↑ Life Expectancy (Baird et al., 2011; Benzeval et al., 2014; Coope et al., 2014; Lange and Vollmer, 2017) ↑ Health Status (Ferrie et al., 2002; Lynch et al., 2004; Lorgelly and Lindley, 2008; Pickett and Wilkinson, 2009; Wagstaff and Doorslaer, 2000; Wolfe, 2011; Burgard et al., 2012; Benzeval et al., 2014; Pickett et al., 2015; Lange and Vollmer, 2017)	↓ Mortality (Gascon et al., 2016; Rojas-Rueda et al., 2019) ↓ Adverse Birth Outcomes including low birth weight and small for gestational age (Zhan et al., 2020) ↑ Life Expectancy (Yanez et al., 2020) ↓ Mortality (Kondo et al., 2020) ↓ Asthma Prevalence (Lovasi et al., 2008) ↓ Depression (Lee et al., 2011; Ward et al., 2012; Astell-Burt et al., 2013; Nutsford et al., 2013; de Vries et al., 2013; Reklaiyiene et

		(Braveman et al., 2011) ↓ Children's Behavioral Problems (Braveman et al., 2011)	↓ Children's Cognitive Problems (Gundersen and Ziliak, 2015) ↓ Children's Behavioral Health Problems (Gundersen and Ziliak, 2015) ↓ Children's Iron Deficiency (Gundersen and Ziliak, 2015) ↓ Children's Oral Health Problems (Gundersen and Ziliak, 2015)	↑ Mental Health (Price et al., 2002; Sareen et al., 2012; Benzeval et al., 2014)	al., 2014; Triguero-Mas et al., 20

Table G-15: Overview of directional analysis for health co-benefit areas (reduced traffic pollution, wildfire smoke and mobility and physical activity)

Quantitative vs. Qualitative	Health Co-Benefit Areas		
	Reduced Traffic Pollution	Reduced Wildfire Smoke	Increased Physical Activity
Findings were used for quantitative analysis	↓ Children's Respiratory Outcomes, Hospital Admissions (Bell et al., 2015) ↓ Children's Respiratory Outcomes, Emergency Room Visits (Krall et al., 2017) ↓ Children's Asthma Onset (Tetreault et al., 2016) ↓ Children's Asthma Symptoms (Rabinovitch et al., 2006)	↓ All-Cause Mortality (Doubleday et al., 2020) ↓ Asthma, Hospital Admissions (Delfino et al., 2009; Reid et al., 2019) ↓ COPD, Hospital Admissions (Delfino et al., 2009; Reid et al., 2019) ↓ All Respiratory Outcomes, Hospital Admissions (Delfino et al., 2009; Reid et al., 2019; Aguilera et al., 2021) ↓ Asthma, Emergency Room Visits (Hutchinson et al., 2018; Reid et al., 2019) ↓ All Respiratory Outcomes, Emergency Room Visits (Hutchinson et al., 2018; Reid et al., 2019) ↓ All Cardiac Outcomes, Emergency Room Visits (Malig et al., 2021)	↓ Cardiovascular Diseases (Hamer and Chida, 2008) ↓ Colon Cancer (Harriss et al., 2009) ↓ Breast Cancer (Monninkhof et al., 2007) ↓ Diabetes (Jeon et al., 2007) ↓ Dementia (Hamer and Chida, 2009) ↓ Lung Cancer (Pope et al., 2002) ↓ Respiratory Disease (Krewski et al., 2009) ↓ Depression (Woodcock et al., 2009) ↑ Traffic Accidents (Mueller et al., 2015)
Findings were used for qualitative analysis	↑ Children's Lung Function Growth (Gauderman et al., 2015)		

	↓ Children's Bronchitic Symptoms (Berhane et al., 2016) ↓ Children's Impaired Cognitive Development (Harris et al., 2015; Ha et al., 2019) ↓ Children's Adverse Birth Outcomes including low birth weight and preterm birth (Wilhelm et al., 2011; Padula et al., 2014)		

Table G-16: Areas of future action for under resourced communities*

Co-Benefit Areas	Highly Impacted Groups	Key Areas for Further Action
Heat Impacts	Outdoor workers Unhoused populations Indigenous, low income and communities of color People without air conditioning	Better resources for outdoor workers Health resources and cooling centers for under-resourced communities Sustainable housing with adequate cooling Adequate access to transportation to cooling centers
Wildfires and Smoke Impacts	Living in the wildland-urban interface Low income, indigenous communities Older persons	Defensible space around homes, particularly in rural areas Access to Clean Air Shelters, filtration, weatherizing for low-income communities Increase outreach and resources for vulnerable communities, access to transportation to clean air shelters
Children's Health and Development	Children in communities of color and low-income communities	Better filtration in schools and homes Increase access to green parks Reduce exposure to traffic pollution by reducing traffic sources, increasing vegetative buffers
Economic Security	Communities with agricultural area jobs impacted by climate change Communities with industry jobs related to fossil combustion	Prioritize areas for re-training where jobs are vulnerable due to climate change; Increase training opportunities in areas including green technologies, renewable energy, reforestation or other areas consistent with Scoping Plan
Food Security	Low-income families Communities with food deserts	Reduce food waste and increase access to low-cost food Increase access to healthy food through support of food stores and transit to food stores

Mobility and Physical Activity	Low income and communities of color	Increase infrastructure to make cycling and walking safe and accessible in all communities including sidewalks, shade, safe crossings, bike lanes Increase access to transit
Affordable Housing	Lower income families Communities of color	Increase opportunities for affordable, sustainable housing in all communities Consider ways to reduce displacement
Urban Greening	Low income and communities of color	Increase urban greening in low-income communities including parks, green roofs, shade trees Address the resource challenges for communities to increase and maintain urban greening

*See Areas for Further Action under each co-benefit area in Appendix G