2015

Climate Change Vulnerability in Contra Costa County: A Focus on Heat

CONTRA COSTA
HEALTH SERVICES

Table of Contents

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Executive Summary

There is widespread scientific consensus that the impacts of climate change on human health are already being observed, and are becoming increasingly significant. The U.S. Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO) and the California Department of Public Health (CDPH) all recognize climate change as a significant threat to public health. It is also widely recognized that some people are more vulnerable than others to the impacts of climate change. Where people live, their socioeconomic status, preexisting health conditions and occupation all influence their vulnerability. Contra Costa Health Services (CCHS) is working with CDPH to develop strategies to protect residents from these health threats. This report is an important first step towards that goal.

This report describes the vulnerability of different communities in Contra Costa County to the health impacts of climate change, with a focus on extreme heat events, or heat waves. The first part of the report describes the various health impacts of climate change that are expected to occur in Contra Costa County. The second part of the report focuses on extreme heat, which is the factor that will likely have largest impact on county residents. A series of maps help identify areas of the county that are more vulnerable to heat waves by showing differences in the social, health, economic and environmental characteristics between communities.

Health Impacts of Extreme Heat

The changing climate will affect the health of Contra Costa County residents in several direct and indirect ways. More frequent extreme heat events are expected to be the most important and most immediate threat to county residents. Extreme heat can result in heat exhaustion and heat stroke, and can worsen cardiovascular (heart and blood circulation) and respiratory (breathing) problems. Extreme heat can increase the risk of stroke, heart attack and asthma attacks.

Extreme Heat is Relative to Where You Live

CDC defines extreme heat as “summertime temperatures that are substantially hotter and/or more humid for a location at that time of year.” For bayside communities in West County, this could mean temperatures above 85°F, while for residents of East County this could mean temperatures above 95°F. Residents of historically cooler areas, such as West County, may be less accustomed to hot weather and may not be used to protecting themselves during hot weather. In addition to geographic differences in climate, environmental and socioeconomic factors can shape how hot weather affects county residents. Urban areas with lots of pavement and few trees tend to be hotter, and residents without access to cars or air conditioning will have a harder time finding a cool place for refuge during hot weather.

Other Health Impacts of Climate Change

Besides extreme heat, possible results of climate change affecting the health of county residents include:

- Worse air quality associated with hotter temperatures, in the form of ground-level ozone (smog), particulate matter (smoke and exhaust particles), and allergens (pollen and mold), which exacerbate respiratory and cardiovascular problems;
- Wildfires resulting from drought and hotter temperatures, leading to worse air quality, displacement of residents and psychological stress;
- Flooding in bayside communities as a result of sea level rise, leading to displacement of residents, damage to buildings, drinking water contamination and mold in homes;
- Infectious diseases such as West Nile Virus spread by mosquitoes, Valley Fever caused by fungus released from dry soil during drought conditions, and diarrheal diseases caused by bacteria in warming coastal waters.

Vulnerable Populations

Not all county residents are equally likely to be affected by the health impacts of climate change. Where people live, their socioeconomic status, preexisting health conditions and occupation all influence their vulnerability. Groups that are at higher risk for some or all of the health threats of climate change include:

- People working in physically demanding jobs, especially outdoors, such as construction, agriculture, landscaping, building maintenance and refinery operations;
- Elderly residents, young children and pregnant women;
- People with disabilities and/or preexisting health conditions, particularly respiratory and cardiovascular conditions;
- Low-income residents with limited access to transportation, air conditioning, or healthcare;
- Non-English speaking residents who may have difficulty accessing information.

Differences in Community Vulnerabilities

This report looks at a variety of information by census tract to evaluate differences in the vulnerability of communities throughout the county. A comparison of census tracts based on several social, economic, medical, biological and environmental characteristics highlights important differences in how extreme heat will likely affect the health of residents. A combination of the factors in this report shows the following communities to be at the greatest health risk from extreme heat:

- West County – Richmond, San Pablo and North Richmond
- East County – Pittsburg, Bay Point and Antioch
- Concord's Monument District
- Walnut Creek's Rossmoor area
- Bethel Island

All Cities Can Improve Resilience

Although some communities have a greater number of risk factors for extreme heat in this analysis, all cities in Contra Costa County can work to improve their resilience to extreme heat. Outreach to groups such as the elderly, people living alone and parents of young children, increasing public transit, translating relevant information into Spanish and other languages, and environmental improvements such as increasing tree coverage are all strategies to improve community resilience to extreme heat.

Contra Costa Health Services' Role

The information in this report shows that climate change is a serious health issue, and that many county residents may be vulnerable to impacts like extreme heat, for a variety of different reasons. CCHS hopes to support cities and other government agencies as they prepare for climate change and strengthen resiliency in Contra Costa County communities. CCHS' Public Health Division hosts a Climate Change and Health Working Group, which has the goals of bringing climate change and health equity considerations into the planning and operations of CCHS and other government agencies, connecting residents and community organizations to government decision-making and providing education on climate change and health.

Introduction

Current assessments of global and national climate change demonstrate that its effects are already here, and that impacts on human health will be significant.[1] These latest scientific studies emphasize the urgency of implementing climate change mitigations, but also the need to simultaneously prepare for climate change impacts.

Contra Costa Health Services (CCHS) is dedicated to understanding the health impacts of climate change in the county. We are developing strategies to protect the health of county residents, with an emphasis on the most vulnerable populations. This work is especially critical given the "climate gap," a term that describes the disproportionate burdens likely to be experienced by low-income communities and communities of color.[2] Without corrective action, climate change has the potential to exacerbate existing racial and economic health disparities. However, CCHS can't effectively do this work alone. It will be essential to build relationships across sectors to effectively prepare for the impacts of climate change in an equitable way. Our potential partners include county departments, local jurisdictions, state and regional agencies, special districts, utilities, community-based organizations, the business community, and of course county residents.

CCHS has already begun this collaborative work. For example, CCHS staff partnered with the county Department of Conservation and Development on its Climate Action Plan for the unincorporated areas of the county. The contribution included a health co-benefits analysis of the county's strategies for reducing greenhouse gas emissions.[3] CCHS has also been working with the Joint Policy Committee to incorporate a health component into their regional climate change adaptation strategy.[4] Staff in the Public Health Division have now established a Climate Change Working Group, which hopes to move forward with partners both within CCHS and across the county to build new relationships and develop effective strategies.

This report is designed to provide potential partners with an overview of some of the major ways that climate change could impact health in Contra Costa County. It focuses on extreme heat, which poses major health threats associated with climate change, with a special emphasis on vulnerability and health equity. The goal is to stimulate further discussion, planning, collaboration and programs to reduce the impacts of climate change and build resilience in Contra Costa's communities.

Mitigation & Adaptation

Climate change mitigation refers to efforts to reduce human impacts on the climate, such as strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks.

Climate change adaptation is preparation for the effects of climate to reduce harm to human and natural systems and identify potential benefits.

This report is primarily concerned with adaptation: understanding the health impacts of climate change, and especially extreme heat, in order to prepare and build resilience in Contra Costa County. However, there are also opportunities to develop strategies that support both mitigation and adaptation goals.

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[1] Intergovernmental Panel on Climate Change, Working Group II, Climate Change 2014: Impacts, Adaptation and Vulnerability, IPCC Assessment Reports (Intergovernmental Panel on Climate Change, 2014), http://www.ipcc.ch/report/ar5/wg2/.; U.S. Global Change Research Program, 2014 National Climate Assessment (Washington, D.C, 2014), http://nca2014.globalchange.gov/report

[2] Seth B. Shonkoff et al., "The Climate Gap: Environmental Health and Equity Implications of Climate Change and Mitigation Policies in California—a Review of the Literature," Climatic Change 109, no. 1 (December 1, 2011): 485–503, doi:10.1007/s10584-011-0310-7.

[3] Contra Costa County Community Development Division, Contra Costa County Draft Climate Action Plan (Martinez, CA: Contra Costa County Community Development Division, 2012), http://ca-contracostacounty.civicplus.com/DocumentCenter/Home/View/9013.

[4] Bay Area Joint Policy Committee, "Joint Policy Committee Projects," Bay Area Joint Policy Committee, 2014, http://www.abag.ca.gov/jointpolicy/projects.html#climate.

Organization Of The Report

This report provides a broad review of major health impacts associated with climate change in Contra Costa, specifically heat, worsening air quality, flooding and sea level rise, and increases in some communicable diseases. It continues with an in-depth exploration of extreme heat, the most direct way that climate change will affect health. This includes projections of rising temperatures and extreme heat days in the county, along with an analysis of heat-related illness during a 2006 heat wave.

The next section reviews a number of factors that increase vulnerability to extreme heat, including those related to biological and socioeconomic characteristics of individuals, as well as neighborhood characteristics and living conditions. We analyze the vulnerability factors by census tract with maps of each factor for the county. Vulnerability to heat is then explored in the county as a whole using an overlay analysis, which combines information from all of the factors. After looking at vulnerability by census tract, we then compare vulnerability to heat by jurisdictions.

In order to provide a deeper, qualitative assessment of both vulnerability and resilience, the report includes a case study of the Monument corridor neighborhood in Concord, based on interviews with residents and service providers. It then concludes with a discussion of broad principles for furthering this work at the intersection of climate change adaptation and health equity, and potential avenues for CCHS to support communities across the county in this work.

Major Health Impacts Of Climate Change In Contra Costa County

Rising Temperatures & Extreme Heat

The most direct way climate change will affect human health is through rising temperatures and extreme heat. Extreme heat is defined by the CDC as "summertime temperatures that are substantially hotter and/or more humid than average for location at that time of year."[5] Experts project that climate change will lead to a rise in average temperatures, and to more frequent and longer extreme heat events, or heat waves.[6] Studies have shown that higher ambient (or average) temperatures are associated with increased deaths from cardiovascular disease,[7] and extreme heat is one of the deadliest forms of natural disaster worldwide.[8] While temperatures in the Bay Area are lower than in the hottest parts of California, such as the Central Valley, extreme heat still poses significant health risks. People living in historically cooler areas may be less physically acclimatized to heat, less likely to recognize the need to protect themselves in the face of heat, and have less access to air conditioning.[9]

Extreme heat has direct impacts on health and can also exacerbate a number of pre-existing health conditions. The direct impacts range from mild heat stress and cramping to heat stroke, a serious and potentially fatal condition that occurs when a person's core body temperature rises above 104°F.[10] Heat stroke can lead rapidly to cardiac arrest, longer-term organ failure and/or neurological damage. Extreme heat also increases risk of heart attack and stroke, and is a particular concern for people with pre-existing cardiovascular, respiratory or cardio-pulmonary conditions.[11]

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[5]U.S. Global Change Research Program, 2014 National Climate Assessment (Washington, D.C, 2014), http://nca2014.globalchange.gov/report.

[6]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations (California Environmental Protection Agency and California Department of Public Health, 2013), http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf.

[7]Rupa Basu and Bart Ostro, "A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California," American Journal of Epidemiology 168, no. 6 (July 28, 2008), http://aje.oxfordjournals.org/content/168/6/632.full.pdf.

[8]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

[9]Ibid.

[10]Paul English et al., Public Health Impacts of Climate Change in California: Heat Related Illness and Mortality (California Department of Public Health, 2007), http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf.

[11]Ibid.

Air Quality

Climate change may also affect air quality in the county, through increases in ground-level ozone, allergens and wildfire smoke.

Ground–Level Ozone

Ground-level ozone, often referred to as smog, is created through interactions between heat, light and chemical emissions known as ozone precursors.[12] These ozone precursors are mainly the by-products of the combustion of fuels in cars, industrial facilities and power plants.[13] The hotter the temperature, the more ground-level ozone is produced. Furthermore, with hotter temperatures come increased use of air conditioning and electricity, leading to even higher emissions of ozone precursors.[14] A 2006 heat wave led to multiple days when ground-level ozone levels exceeded federal standards in Contra Costa. Nonattainment of these standards is an ongoing problem for the county, and in 2013 the American Lung Association gave Contra Costa an "F" grade for ozone pollution in its "State of the Air" rankings. This grade reflects that there were 10 days when ozone levels were considered unhealthy for sensitive populations such as children, the elderly and people with respiratory conditions.[15] Ozone is a significant health issue because it aggravates chronic respiratory illnesses like asthma, and can contribute to the development of bronchitis and pneumonia. Asthma is already a concern in the county, where approximately 19% of residents have been diagnosed with asthma, as compared to 14% statewide.[16] Racial health disparities in asthma prevalence are also significant: 35% of African Americans in the county had been diagnosed with asthma in 2013.[17] This reflects racial disparities at the state level, which research shows are not driven by biological factors, but by living conditions for African Americans, including disproportionate exposure to air pollutants.[18]

The Bay Area Air Quality Management District predicts that reductions in emissions of ozone precursors[19] will substantially decrease ground-level ozone levels across the Bay Area and the state in the future. There have already been significant improvements in air quality over the past several decades, driven by tighter regulation of stationary sources of pollution, enforcement of idling limits for diesel equipment, and incentivizing transitions from older, high-emitting vehicles to newer, lower-emitting vehicles, among other measures.[20] However, some research has indicated that rising temperatures due to climate change may largely offset the benefits of further emission reductions in the Bay Area.[21] Given that ozone already poses significant health risks in Contra Costa, it will be important to take steps to mitigate ozone's impacts on human health as temperatures rise.

Allergens

Warming temperatures, along with changes in precipitation, may also increase levels of indoor and outdoor allergens such as pollen and mold. There are no models that project specific changes in production or distribution of these allergens at the regional level. However, higher temperatures and greater concentrations of carbon dioxide are projected to increase pollen counts across the United States.[22] Pollen and other airborne allergens can act as asthma triggers and exacerbate chronic respiratory and cardiovascular illnesses.

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[12]Bay Area Air Quality Management District, "Air Quality in the Bay Area: Air Pollutants," Bay Area Air Quality Management District, January 30, 2013, http://www.baaqmd.gov/Divisions/Communications-and-Outreach/Air-Quality-in-the-Bay-Area/Air-Pollutants.aspx#po.

[13]Ibid.

[14]Elizabeth Perera and Todd Sanford, Climate Change and Your Health: Rising Temperatures, Worsening Ozone Pollution (Union of Concerned Scientists, June 2011), http://www.ucsusa.org/global_warming/science_and_impacts/impacts/climate-change-and-your-health.html.

[15]American Lung Association, "State of the Air 2013 - Contra Costa," American Lung Association, 2013, http://www.stateoftheair.org/2013/states/california/contra-costa-06013.html.

[16]California Health Interview Survey. CHIS 2011-2012 Public Use File. (Los Angeles: UCLA Center for Health Policy Research, 2012.)

[17]Ibid.

[18]Paul English et al., Public Health Impacts of Climate Change in California: Heat Related Illness and Mortality (California Department of Public Health, 2007), http://www.ehib.org/papers/Heat_Vulnerability_2007.pdf.

[19]Primarily nitrous oxide and volatile organic compounds.

[20]Bay Area Air Quality Management District, Bay Area 2010 Clean Air Plan. (2010)

[21]California Energy Commission, "California Building Climate Zone Map," 2014, http://www.energy.ca.gov/maps/renewable/building_climate_zones.html.

[22]"CDC - Program Overview - Climate and Health Program," accessed July 13, 2014, http://www.cdc.gov/nceh/information/climate_and_health.htm.

Wildfire

More frequent and intense wildfires are projected to occur across California, and fire danger is even greater, due to California's record-setting drought.[23] Increases in wildfire risk in the Bay Area are projected mainly for Marin County, although southern Contra Costa County may see a small increase in the area burned by wildfire.[24] In spite of these moderate increases in risk, large increases in damage are predicted in the Bay Area due to population growth and development at the urban-rural interface.[25] Fires both within and outside the county can impact residents' health through the spread of wildfire smoke, which can cause both acute and chronic respiratory and cardiovascular disease.[26] These risks from wildfire smoke are already present: In the fall of 2013, air quality advisories were issued for Contra Costa due to wildfires within the county, and in neighboring Solano County.[27]

Sea Level Rise & Flooding

Climate change may lead to up to 55 inches of sea level rise by the end of the 21st century. As a result, Contra Costa County is projected to see about a 40% increase in area of land susceptible to a 100-year flood event, with the cities of Richmond and Pittsburg the most impacted.[28] The health impacts of flooding are wide ranging. They include physical injury, displacement and associated stress and trauma, contamination of drinking water and indoor exposure to mold and bacterial contaminants.[29]

The San Francisco Bay Conservation and Development Commission (BCDC) along with the Association of Bay Area Governments (ABAG) are currently engaging in a Bay Area-wide assessment of community and housing vulnerability to hazards with a focus on earthquakes and sea level rise, with detailed case studies for several cities, including Richmond.[30] This project will hopefully help inform deeper understanding of vulnerability and adaptation strategies related to flooding and sea level rise.

[23]State of California, "Record Setting Drought Conditions Have Increased Fire Danger," California Drought, June 18, 2014, http://ca.gov/drought/news/story-53.html.

[24]California Emergency Management Agency and California Natural Resources Agency, California Adaptation Planning Guide: Understanding Regional Characteristics (California Emergency Management Agency, 2012).

[25]Hurteau et al. Matthew D., "Projected Effects of Climate and Development on California Wildfire Emissions through 2100," Environmental Science & Technology 48, no. 4 (February 18, 2014): 2298–2304, doi:10.1021/es4050133.

[26]California Natural Resources Agency, Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy - Public Draft, 2013, http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

[27]Bay Area Air Quality Management District, 2013.

[28]California Emergency Management Agency and California Natural Resources Agency, California Adaptation Planning Guide: Understanding Regional Characteristics.

[29]An Update to the 2009 California Climate Adaptation Strategy - Public Draft, 2013.

[30]Bay Conservation and Development Commission and Association of Bay Area Governments, "Housing and Community Risk," ABAG Earthquake and Hazards Program, August 28, 2014, http://quake.abag.ca.gov/projects/housing-and-community-risk/.

Infectious Disease

As temperatures warm, county residents may see greater exposure to some contagions, including West Nile Virus, Coccidioides species and vibrio. These infectious agents are all already present in the county, and potential increases are specifically associated with rising temperatures.

West Nile Virus

West Nile Virus is an illness that cycles between mosquitoes and birds, and humans can be infected if they are bitten by mosquitoes carrying the virus. While most people with West Nile Virus do not experience symptoms, about one in five people will develop a fever, and a small number of cases are accompanied by severe neurological conditions.[31] Hotter days and a longer warm season may increase the number of potential mosquito vectors as well as infection rates in mosquitoes and birds.[32] When high temperatures are combined with drought, birds and mosquitoes also gather in greater numbers at dwindling water sources.[33] This can amplify the likelihood of West Nile infection in birds and mosquitos, leading to more spillover infections in humans.

Coccidioides

Coccidioides, sometimes referred to as "cocci," is a soilborne fungus that releases spores into the air when soil is disrupted. The human infection caused by inhaling spores is called coccidioidomycosis or Valley Fever, which can lead to either chronic or acute symptoms.[34] In some people infection has no symptoms, while others experience flu-like illness or severe multisystemic disease.[35] Vegetation can prevent soil from being disrupted, so that fewer spores are released. But the combination of heat and drought associated with climate change can reduce vegetation and thus increase the dissemination of spores.[36]

Vibrio

Vibrios are naturally occurring bacteria found in warm coastal waters. Vibrio causes a severe diarrheal illness when people are exposed by eating contaminated seafood (especially raw oysters) or occasionally through water contact with broken skin. Vibrio concentrations increase as water warms.[37]

While all of the health concerns discussed above

[31]Centers for Disease Control and Prevention, "West Nile Virus," July 8, 2014, http://www.cdc.gov/westnile/.

[32]Paul R. Epstein, "West Nile Virus and the Climate," Journal of Urban Health : Bulletin of the New York Academy of Medicine 78, no. 2 (June 2001): 367–71, doi:10.1093/jurban/78.2.367.

[33]Contra Costa Mosquito & Vector Control District, "Contra Costa Mosquito & Vector Control District," Why Drought Years Can Increase the Risk of Mosquito-Borne Illness, 2014, http://www.contracostamosquito.com/drought_article.htm.

[34]Centers for Disease Control, "Valley Fever (Coccidioidomycosis)," Fungal Diseases: Types of Disease, May 22, 2014, http://www.cdc.gov/fungal/diseases/coccidioidomycosis/; Mayo Clinic Staff, "Valley Fever," Mayo Clinic: Diseases and Conditions, July 6, 2012, http://www.mayoclinic.org/diseases-conditions/valley-fever/basics/definition/con-20027390.

[35]Centers for Disease Control, "Valley Fever (Coccidioidomycosis)."

[36]Kellie Schmitt and Rebecca Plevin, "Changing Climate May Expand Valley Fever's Deadly Impact," Voice of OC, accessed September 11, 2014, http://www.voiceofoc.org/countywide/article_7708c652-fbb0-11e1-a72a-0019bb2963f4.html.

[37]M. L. Motes et al., "Influence of Water Temperature and Salinity on Vibrio Vulnificus in Northern Gulf and Atlantic Coast Oysters (Crassostrea Virginica)," Applied and Environmental Microbiology 64, no. 4 (April 1998): 1459–65.

Focus on Heat

are important, we have chosen to focus this report on extreme heat. Heat is the most direct way that climate change will impact human health, and state agencies have identified extreme heat and associated air pollution as primary concerns for adaptation in the Bay Area.[38] Heat already presents health risks in the county, where inland temperatures can regularly exceed 100°F in the summer. In a recent illustration of these risks, nearly two dozen people were treated for heat-related illnesses during a 2013 high school graduation ceremony in Brentwood, where temperatures reached 107°F.[39] While temperatures in the western part of the county are more moderate, people living in historically cooler areas may also be at risk. A better understanding of how climate change will affect heat in the county, and who may be most vulnerable, will lay the groundwork for policies and actions to build healthier communities and advance health equity. The remainder of this report takes a closer look at these issues.

How Will Climate Change Affect Heat Levels In Contra Costa County?

It is impossible to predict with certainty how temperatures and heat will change over the coming years. However, climatologists have made projections for increases in heat using models based on atmospheric conditions. These provide the best way to assess potential exposure to extreme heat. The projections are made for high-emissions scenarios, which assume "business as usual" in terms of greenhouse gas emissions, and low-emissions scenarios, which assume significant reductions in greenhouse gas emissions.[40] Data from these projections have been made publicly available through the California Energy Commission online at Cal-Adapt.org.

Across the Bay Area, including in Contra Costa County, annual mean temperatures are expected to rise between about 4° to 6°F by 2100, in comparison to a 1990 baseline period.[41] Consideration of changes in extreme heat are crucial from a health perspective, as extreme heat and heat waves are the deadliest weather-related events in the United States – and heat-related illness and death are almost entirely preventable.[42]

The National Weather Service states generally that there is significant danger of heat illness from prolonged exposure to a "Heat Index" of 103°F or higher.[43] The index is based on both temperature and humidity and is also known as "apparent temperature," or how hot the temperature feels to a human body. The CDC, meanwhile, defines extreme heat as "summertime temperatures that are substantially hotter and/or more humid than average for location at that time of year."[44]

When temperatures are significantly higher than usual, individuals may be less acclimatized, meaning their bodies are less able to adapt to the heat. People who live in areas where temperatures are typically cool may also not be behaviorally adapted to heat, and are less likely to have access to protective resources like air conditioning. The Heat Adaptation Workgroup of the California Climate Action Team recommends taking relative measures for extreme heat into consideration, which recognize the potential health effects on populations that are not acclimatized or behaviorally adapted to high temperatures.[45] We have considered projections for extreme heat within the county based on projected relative extreme heat days – days that are significantly hotter than usual compared to historic conditions – and on projected days with a temperature of 100°F or greater.

To explore projections for relative extreme heat days, the county was divided into two climate zones, based on

[38]California Emergency Management Agency and California Natural Resources Agency, California Adaptation Planning Guide: Understanding Regional Characteristics.

[39]Bay City News, "Nearly Two Dozen Treated for Sunstroke at Graduation Ceremony," ABC7 News, June 8, 2013, http://abclocal.go.com/kgo/story?section=news/local/east_bay&id=9132149.

[40]California Energy Commission Public Interest Research Program. "Cal-Adapt," 2014. http://cal-adapt.org/.

[41]These projections are based on an average of four different climate models. California Emergency Management Agency and California Natural Resources Agency, California Adaptation Planning Guide: Understanding Regional Characteristics (California Emergency Management Agency, 2012).

[42]George Luber and Michael McGeehin, "Climate Change and Extreme Heat Events," American Journal of Preventative Medicine 35, no. 5 (2008): 429–35.

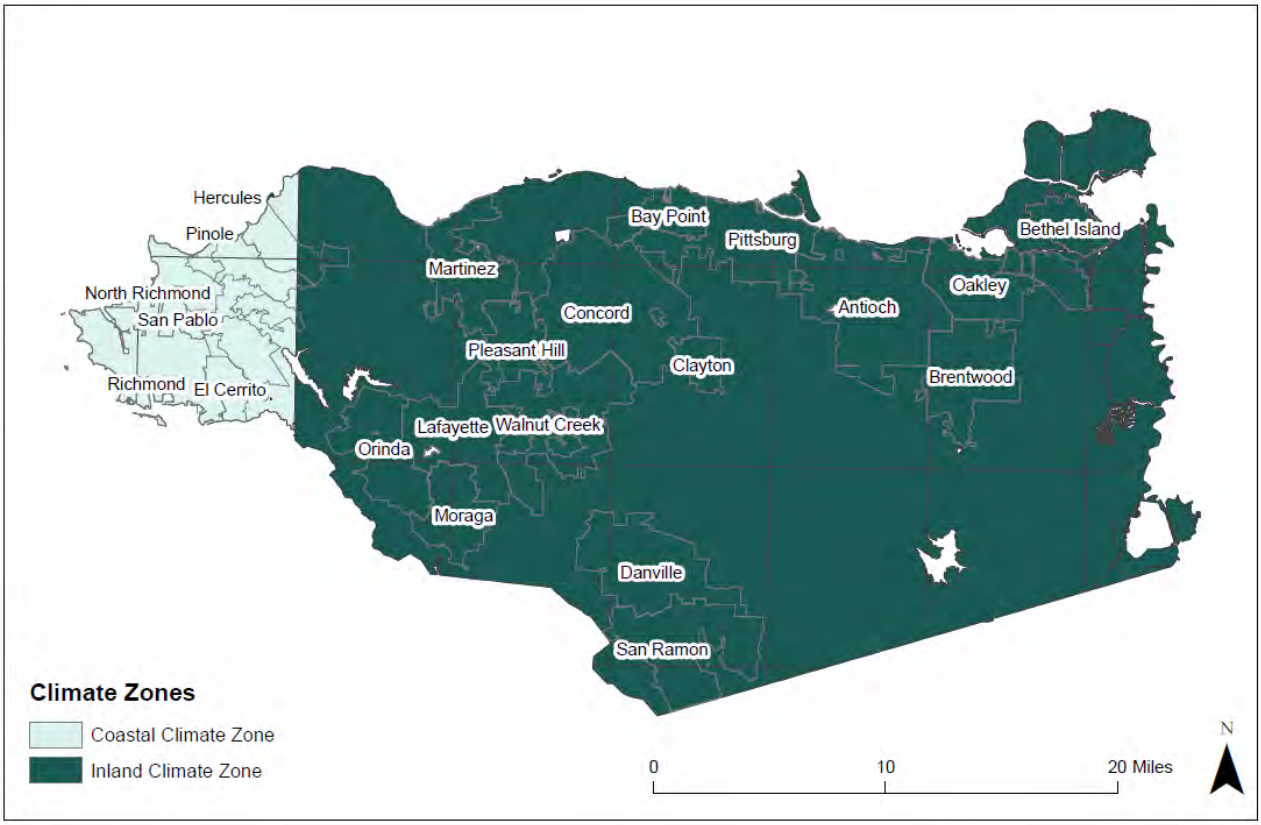
[43]National Weather Service, "What is the Heat Index?," National Weather Service Forecast Office, February 26, 2014, http://www.srh.noaa.gov/ama/?n=heatindex.

[44]Centers for Disease Control, "Extreme Heat: A Prevention Guide to Promote Your Personal Health and Safety."

[45]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

the 16 California climate zones classified by the California Energy Commission. Contra Costa contains two distinct climate zones, zones 3 and 12.[46] Here zone 3 is referred to as the coastal climate zone and zone 12 as the inland climate zone. Using data available at Cal-Adapt.org, projected extreme heat days were then averaged for each of the climate zones.[47] For these projections, an extreme heat day is hotter than the 98th percentile daily maximum temperature between 1961 and 1990. Because the coastal zone is historically cooler, its extreme heat thresholds are lower than in the inland climate zone. The

Figure 1: Approximation Of Climate Zones In Contra Costa County



average extreme heat threshold for the coastal zone is 84.6°F, while the average threshold for the inland zone is 95.8°F. Figures 2 and 3, on the next page, show projected annual extreme heat days by decade for the coastal and inland climate zones respectively. These figures include projections for high-emission scenarios, or "business as usual," and low-emission scenarios with significant greenhouse gas reductions.

Both zones show a significant increase in extreme heat days annually, especially under the "business as usual" scenario. Although its baseline temperature is lower, the coastal climate zone is projected to have more annual extreme heat days, with almost 70 days annually by the end of the 21st century under the "business as usual" scenario. Even with lower absolute temperatures, residents in the coastal climate zone may experience negative health impacts. As discussed above, people not regularly exposed to high heat may be less adapted, both physically and behaviorally, to high temperatures, and are less likely to have air conditioning.[48]

While the coastal region of the county may experience more relative extreme heat days, inland Contra Costa will continue to see higher temperatures. In Contra Costa, regular summer humidity could lead to a dangerous heat index for temperatures in the mid-90s and above.[49] Figure 4, on the next page, maps the annual number days

[46]California Energy Commission, "California Building Climate Zone Map."

[47]These projections are made using the Geophysical Fluids Dynamics Laboratory (GFDL) model by the Scripps Institute of Oceanography.

[48]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

[49]Pacific Energy Center, "The Pacific Energy Center's Guide to California Climate Zones," 2006, http://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zones_01-16.pdf.; National Weather Service, "What is the Heat Index?".

Figure 2: Projected Annual Extreme Heat Days Above 84.6°F For Coastal Climate Zone In Contra Costa County

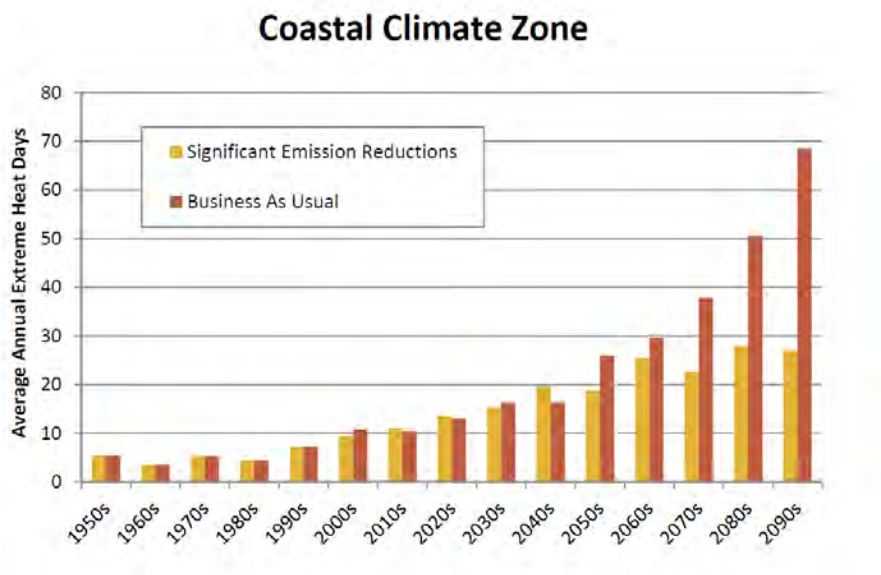
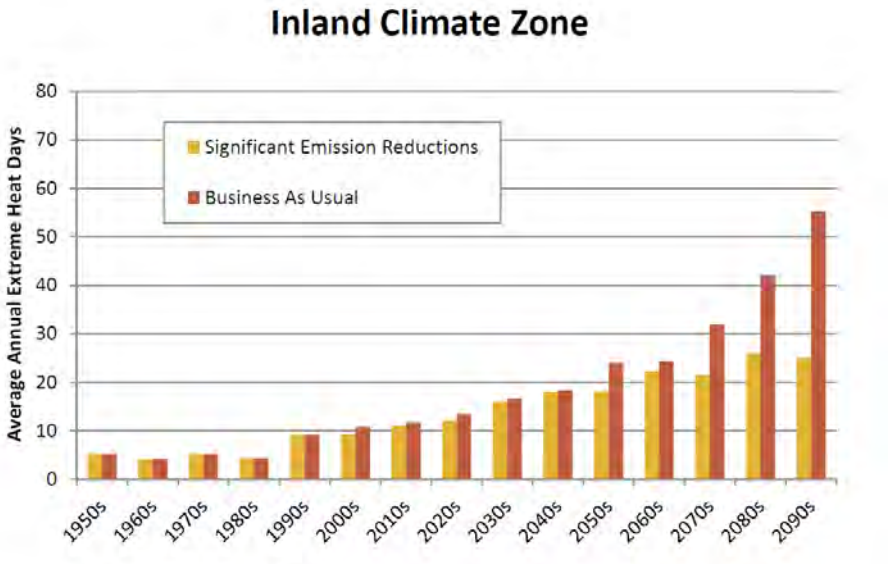
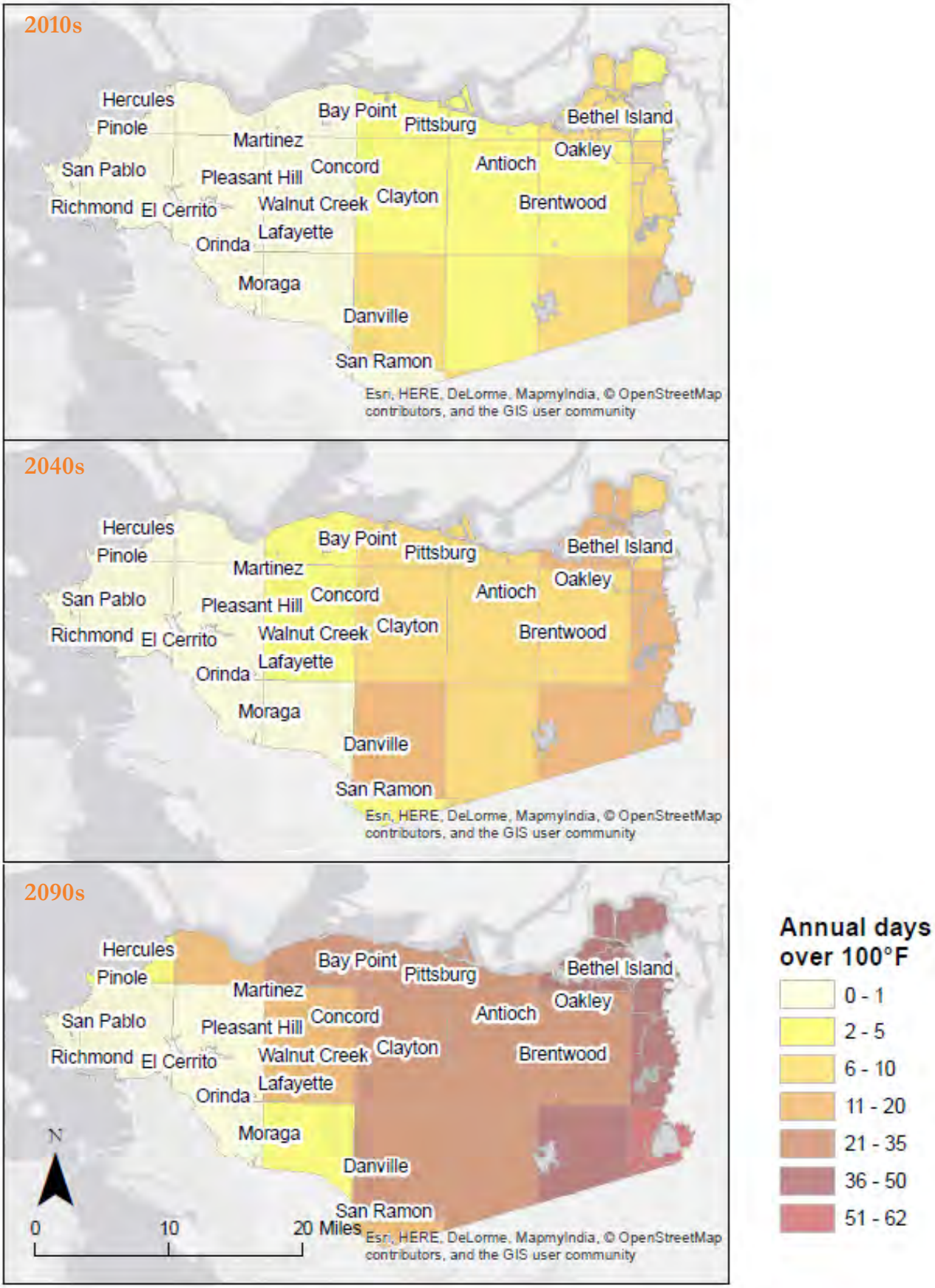


Figure 3: Projected Annual Extreme Heat Days Above 95.8°F For Inland Climate Zone In Contra Costa County



projected to be 100°F or higher during the decades from 2010 to 2019, 2040 to 2049 and 2090 to 2099. These maps are based on projections that assume "business as usual" in terms of greenhouse gas emissions. This measurement provides a snapshot of the increase in very hot days in the county, particularly if greenhouse gas emissions go unchecked. The hotter inland areas may see dozens of days above 100°F each year by the end of the century.

Figure 4: Projected Average Annual Days Hotter Than 100°F In Contra Costa County In The 2010s, 2040s & 2090s

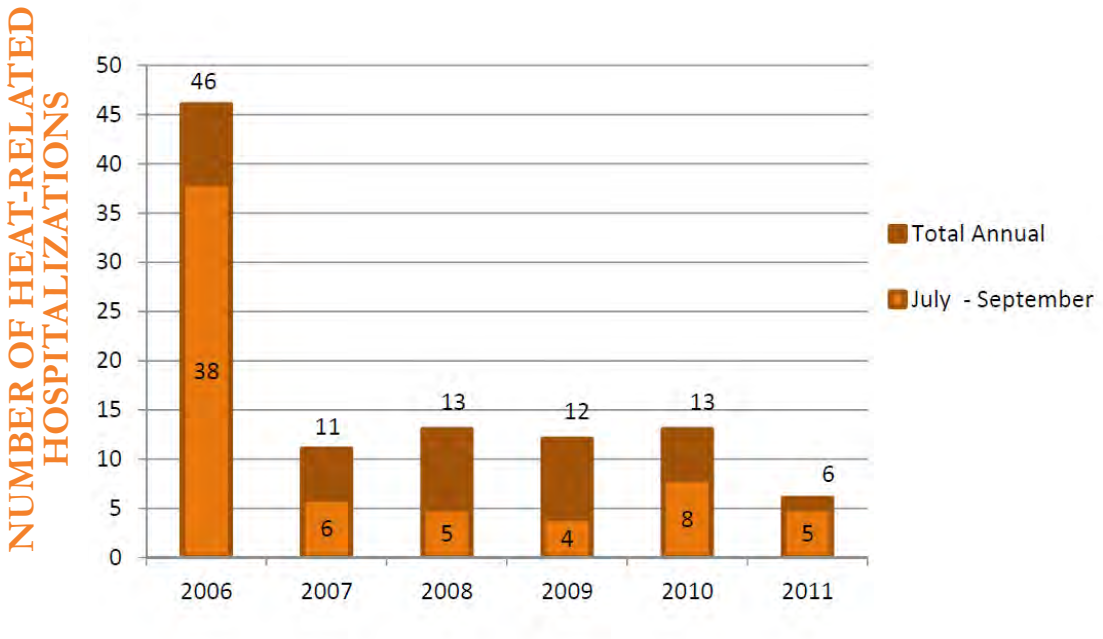


Source: Scripps Institute of Oceanography Projections from Cal-Adapt.org, using GFDL climate model

2006 Heat Wave

There was a major heat wave in California from mid- to late July 2006, with 10 days of record-breaking temperatures. Across the state, at least 140 extreme heat-related deaths were reported, and researchers estimate that the heat wave resulted in over 16,166 more emergency department visits than average and 1,182 more hospitalizations than average.[50] Figure 5 shows heat-related hospitalizations for the years 2006 to 2011 in Contra Costa. The data show that a significantly higher number of people were hospitalized for heat-related illness during the summer months of 2006 than in later years.

Figure 5: Heat-Related Hospitalizations In Contra Costa County, 2006–2011



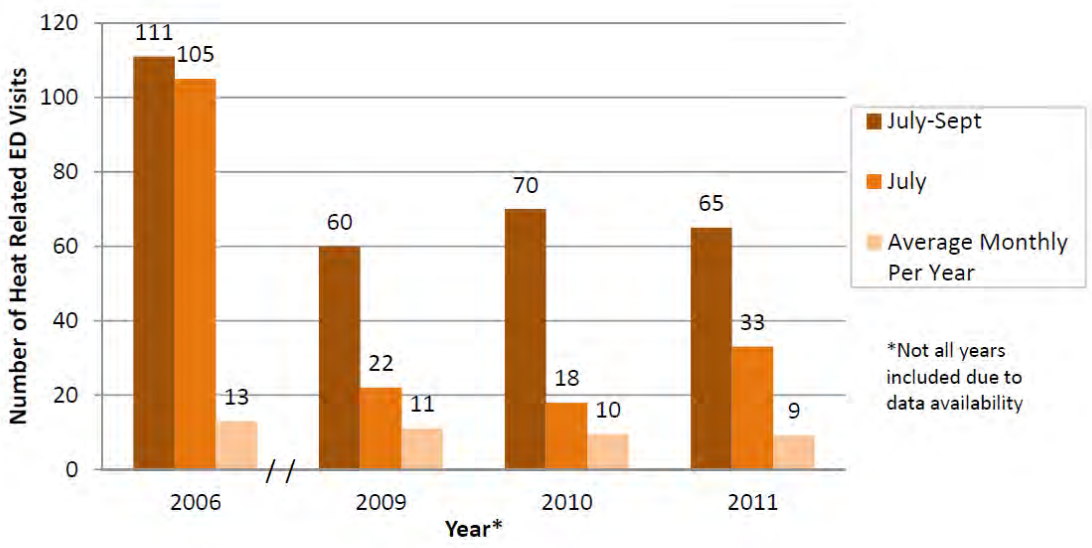
Source: The California Office of Statewide Health Planning and Development

Only the most severe heat-related illnesses require hospitalizations, while less-severe illnesses may need emergency care without admission to a hospital. The county also saw an increase in emergency department (ED) visits for heat illness during the heat wave. Figure 6 shows ED visits for July, all summer months and annual averages for 2006 compared to 2009 to 2011.[51] During July 2006, Contra Costa saw 105 ED visits for heat-related illness. This also meant a higher average number of monthly visits during 2006 compared to 2009 to 2011. Table 1 compares annual ED visits for these same years separated into the coastal and inland climate zones defined above. The data are approximated to the climate zones

[50]Kim Knowlton et al., "The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits," Environmental Health Perspectives 117, no. 1 (January 2009): 61–67, doi:10.1289/ehp.11594.

[51]2006 is compared to the years 2009-2011 owing to data availability.

Figure 6: Heat Related Emergency Department Visits In Contra Costa County, 2006 & 2009–2011



Source: The California Office of Statewide Health Planning and Development

based on zip codes. 2006 saw a greater number and rate of ED visits per 10,000 people in both climate zones, when compared to the average of 2009–2011. However, the hotter inland climate zone saw higher rates and a greater difference in rate between heat wave and non-heat wave years. This experience within Contra Costa County is different than statewide, where cooler coastal counties saw a greater increase in heat-related illness during the heat wave.

Contra Costa County also exceeded the daily maximum standards for ground-level ozone on multiple days during the 2006 heat wave.[52] Figure 7 shows maximum and average daily temperatures during mid- to late July 2006, along with 1– and 8–hour maximum levels of ground level ozone.

The increase in heat-related illnesses during the 2006 heat wave, along with the dangerous levels of ozone, show that extreme heat already poses threats to health in the county. As extreme heat events increase with climate change, these threats are likely to become more severe.

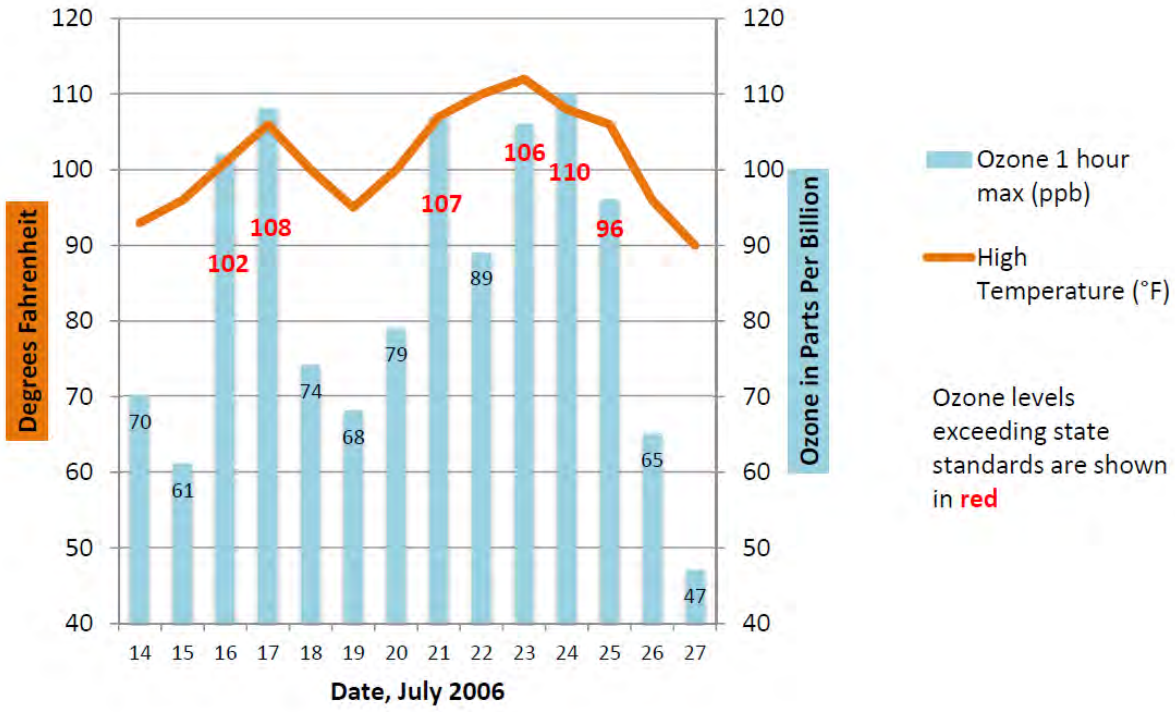
Table 1: Heat Related Emergency Department Visits In Coastal & Inland Climate Zones In Contra Costa County, 2006 & 2009–2011

	Year 2006			Average Per Year 2009–2011		
	Coastal Climate Zone	Inland Climate Zone	All County	Coastal Climate Zone	Inland Climate Zone	All County
Number of ED Visits	30	172	202	23.7	105.7	129.3
Rate of ED Visits per 10,000 People	1.3	2.2	1.9	1.0	1.3	1.2

Source: California Statewide Office Of Planning Health & Development

[52]Ozone measurements are from the Bay Area Air Quality Management District at the Concord Monitoring Station.

Figure 7: Temperatures & Ozone Levels At Concord Monitoring Station During 2006 Heat Wave



Source: Bay Area Air Quality Management District

Vulnerability To Heat

These projections indicate that Contra Costa residents will have to cope with increasing numbers of extreme heat events in the coming decades. However, vulnerability to extreme heat is not distributed evenly across the population—some individuals and populations are at increased risk. In many cases, populations most at risk of heat illness are already disproportionately burdened by health problems in the county. Vulnerability is related to biological factors such as age, socioeconomic factors and living conditions, including characteristics of the built environment. Identifying vulnerabilities is an important step in pursuing climate change adaptation that addresses future health impacts and existing health disparities in order to advance health equity.

Methods

To conduct an initial assessment and enhance understanding of the people and places that may be most susceptible to extreme heat, existing data about vulnerabilities are mapped on the following pages. The selection of factors is based on existing literature about biological, social, medical and environmental vulnerabilities, and on availability of data. The vulnerabilities discussed are listed in Table 2, and are discussed further along with the individual maps. Two additional factors, outdoor workers and neighborhood social cohesion, are discussed but are not mapped due to data availability.

The factors are mapped by 2010 census tracts, and in each map the tracts are divided into five categories.[53] [54] In the maps, tracts in darker colors are those considered more vulnerable.

After mapping each factor, Figure 21 shows a map that combines all values for each tract with an overlay analysis using the average standard score for all the

[53]ESRI, "Classifying Numerical Fields for Graduated Symbology," ArcGIS Resources, 2012, http://resources.arcgis.com/en/help/main/10.1/index.html#//00s50000001r000000.

[54]Categories were derived using a statistical technique called natural breaks. Natural breaks create groups of data that maximize variability between categories while minimizing variability within each category.

Table 2: Analyzed Factors Contributing To Vulnerability To Extreme Heat

Category	Vulnerability Factor	Data Source
Biological	Percent of population under 5	US Census, 2007–2011 American Community Survey
	Percent of population over 65	US Census, 2007–2011 American Community Survey
Social & Economic	Percent of population below 200% of the Federal Poverty Level	US Census, 2007–2011 American Community Survey
	Percent of population living alone	US Census, 2007–2011 American Community Survey
	Percent of population African-American	US Census, 2007–2011 American Community Survey
	Percent of households linguistically isolated	US Census, 2007–2011 American Community Survey
Medical	Asthma hospitalization and ED visit rate	California Office of Statewide Health Planning and Development, 2009–2011
Living Conditions	Percent of households without access to a vehicle	US Census, 2007–2011 American Community Survey
	Average daily transit pickups	Metropolitan Transportation Commission, 2009
	Percent treeless area	US Department of the Interior, National Land Cover Database, 2011
	Percent impervious surface	US Department of the Interior, National Land Cover Database, 2011
	Percent households without air conditioning	CA Department of Public Health, 2009 California Energy Survey, provided by The Pacific Institute
	Portion of daily maximum 8 hour ozone concentration over the state standard	CalEnviroScreen analysis of CA Air Resources Board, 2009–2011

factors. A standard score, also known as a z-score, is a statistical technique for standardizing data. The standard score is a measure of how different a data point is from the average value, and these scores allow for better comparisons across different datasets.

This method provides one way of comparing overall vulnerability to heat in areas across the county, by showing where multiple forms of vulnerability exist in the county. But it is important to note that it in no way serves as a definitive or objective indication of vulnerability. Each factor is weighted equally, so this method does not account for how much each factor contributes to overall risk, how factors could be related to one another, or to how they may act synergistically.

In addition to comparing vulnerability by census tract across the county, an additional analysis compares these same factors by city.

Data Limitations

This analysis does not include measurements for some important factors that increase vulnerability to heat owing to data limitations. These include the exposure of outdoor workers to the elements, chronic disease prevalence, and social cohesion. These factors are discussed below, along with their data limitations.

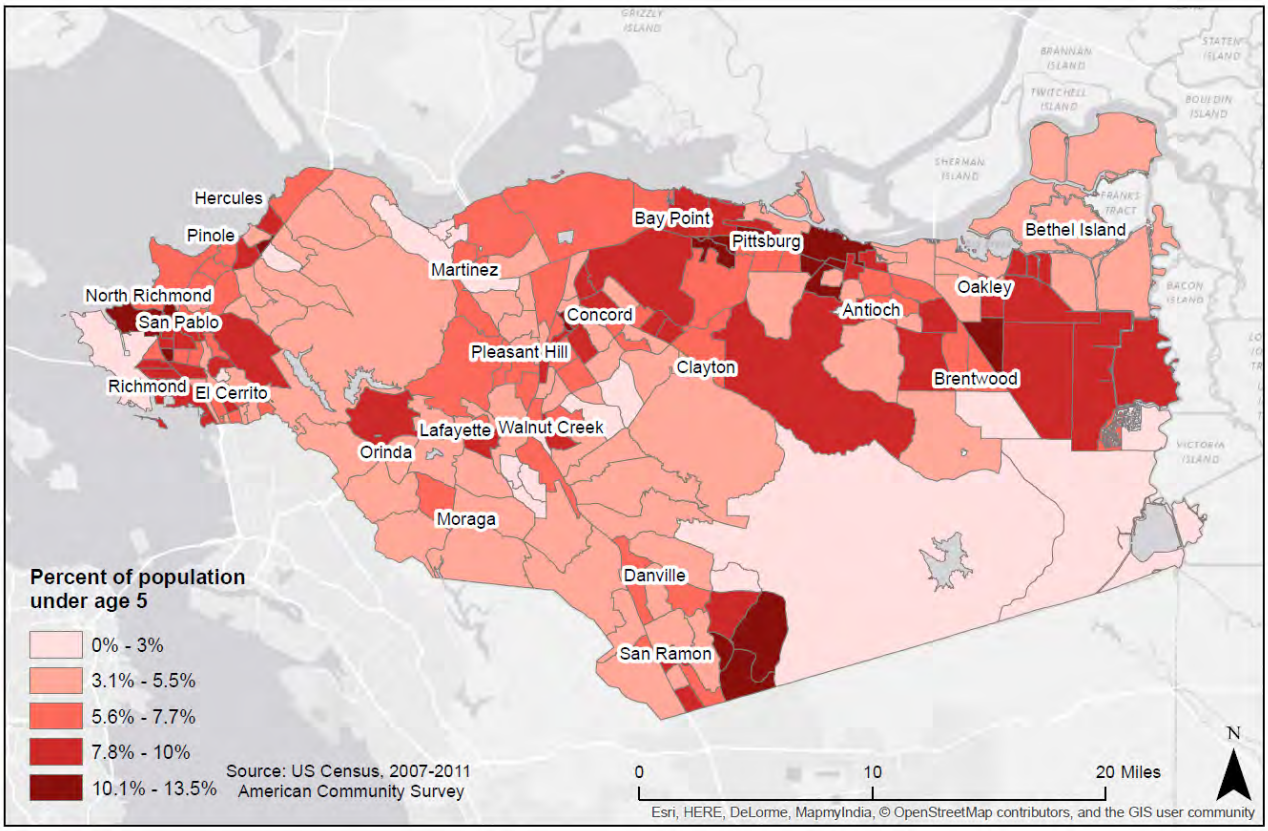
Biological Vulnerabilities

Age is an extensively cited risk factor for heat-related illness and death, with infants, children, and the elderly most vulnerable.[55] Infants and young children are physiologically less able to regulate their body temperatures than adults, and children also may simply not recognize the need to hydrate and cool down when overheated.[56] Seniors are physiologically vulnerable to heat due to reduced physical ability to acclimatize, as well as the prevalence of pre-existing medical conditions in that population.

Young Children

Figure 8 shows the percentage of the population under the age of 5 by census tract. High concentrations of children live in parts of Concord, Richmond, Pittsburg, Brentwood and San Ramon.

Figure 8: Percentage Of Population Under Age 5 By Census Tract, 2007–2011



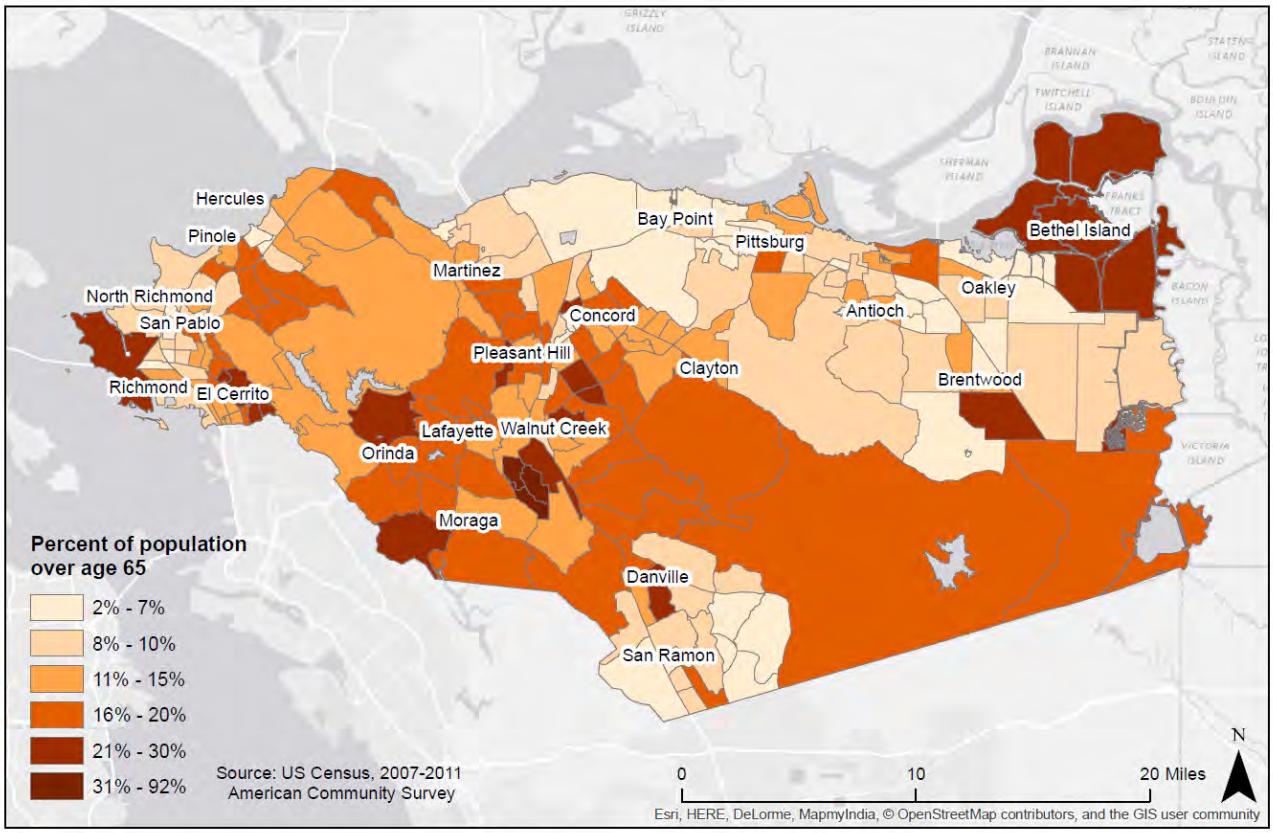
Elderly Residents

Figure 9, showing the percentage of the population over age 65, illustrates that census tracts with a higher percentage of elderly residents tend to also have lower percentages of young children. Particular census tracts in the county have a much higher concentration of elderly residents due to both institutional and residential retirement communities. In particular, some tracts in central Contra Costa County, Bethel Island, the eastern part of Richmond, and several census tracts in Walnut Creek. To better illustrate the variation in the concentration of elderly in non-retirement communities, the data for this map was divided into six categories.

[55]Rupa Basu and Jonathan M. Samet, "Relation between Elevated Ambient Temperature and Mortality: A Review of the Epidemiologic Evidence," Epidemiologic Reviews 24, no. 2 (December 1, 2002): 190–202, doi:10.1093/epirev/mxf007.; Rupa Basu, Francesca Dominici, and Jonathan M. Samet, "Temperature and Mortality among the Elderly in the United States: A Comparison of Epidemiologic Methods," Epidemiology (Cambridge, Mass.) 16, no. 1 (January 2005): 58–66.

[56]English et al., Public Health Impacts of Climate Change in California: Heat Related Illness and Mortality.

Figure 9: Percentage Of Population Over Age 65 By Census Tract, 2007–2011



Working Condition Vulnerabilities

Outdoor workers are highly susceptible to heat, both because their work requires them to be outside and because physical exertion heightens risk of heat-related illness. Some outdoor workers wear heavy protective clothing that can amplify the impacts of heat.[57] In particular, new outdoor workers who have not yet adjusted to high temperatures may be at heightened risk.[58] Key industries of concern within Contra Costa County include agriculture, construction, building maintenance, landscaping and refinery operations. Vulnerability may also be compounded for informal day laborers and/or undocumented immigrants, as they may work in unregulated environments.[59] Outdoor workers were not mapped in this analysis because they are most at risk at their place of work, rather than where they live. The location of landscapers and construction workers may change regularly, for example, making it challenging to analyze the location of such work through mapping at the county level.

[57]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

[58]Ibid.

[59]Rachel Morello-Frosch et al., The Climate Gap: Inequalities on How Climate Change Hurts Americans and How to Close the Gap (USC Dornsife Program for Environmental and Regional Equity, May 2009), http://dornsife.usc.edu/assets/sites/242/docs/ClimateGapReport_full_report_web.pdf.

Social and Economic Vulnerabilities

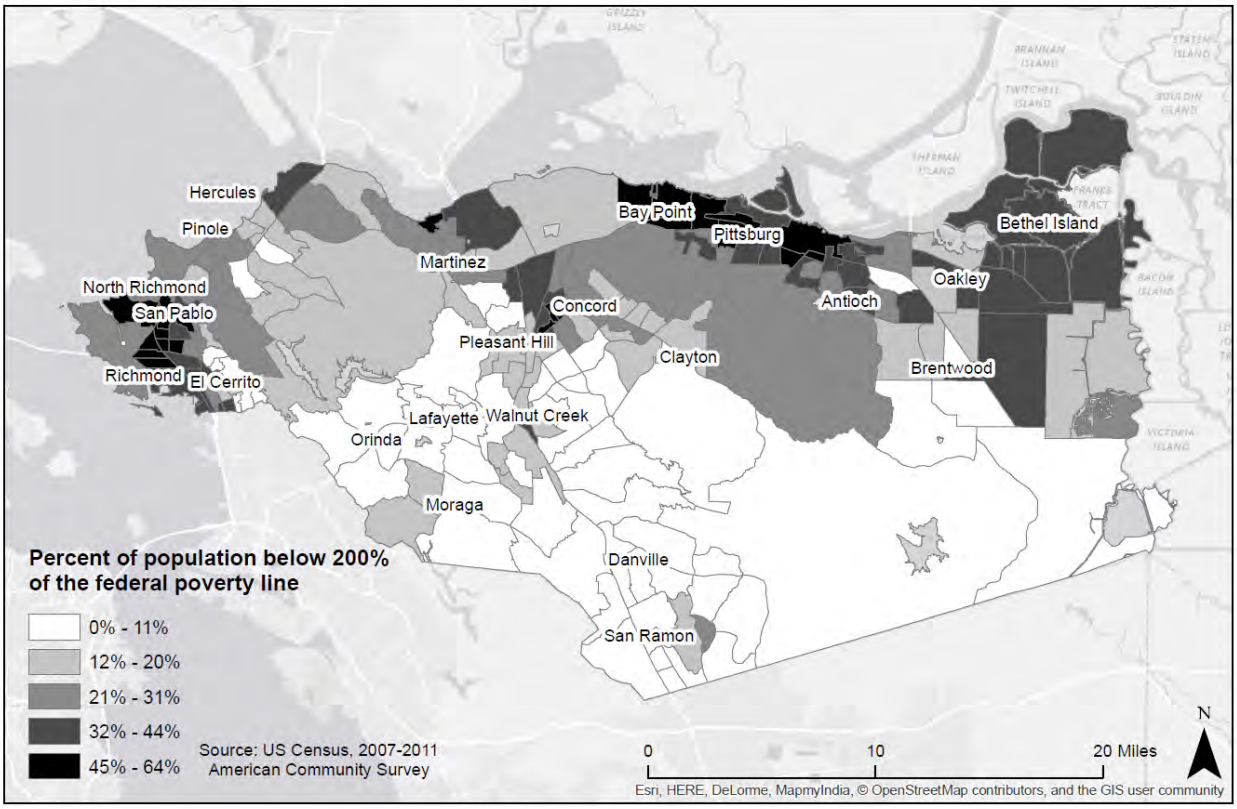
Social and economic conditions also shape vulnerability to health impacts from extreme heat. Climate change has the potential to deepen existing racial and economic health disparities without appropriately targeted adaptation strategies.[60] Racial and economic inequities within Contra Costa County already demonstrate stark differences in health outcomes: In 2000, life expectancy for residents living in high-poverty census tracts was 6.5 years lower than for residents living in low-poverty tracts, while from 2005–2007 the life expectancy of African-American residents was 6 to 13 years lower than other racial groups.[61] Attention to how such inequalities shape vulnerability to climate change is crucial to planning for adaptation that can advance health equity.

Poverty

Poverty is associated with greater vulnerability to heat in a number of potential ways. The long-standing association between low-income and poor health outcomes, as well as pre-existing health conditions among people in poverty, plays a key role in vulnerability.[62] Low-income people who are uninsured may be less likely to seek medical help if they do become ill, may live in poor quality housing, and may also be less likely to use fans or air conditioning out of concern for high utility bills.[63]

Figure 10 shows the percentage of population living below 200% of the federal poverty level by census tract, with the highest rates of poverty in central Richmond, North Richmond and San Pablo, tracts in Concord and Martinez, and in Bay Point, Pittsburg and Antioch. When planning for climate adaptation, it will be important to consider the contexts for vulnerability in these areas. For example, the high poverty rate in one shoreline census tract in Martinez is driven largely by the presence of the Martinez Detention Facility.

Figure 10: Percentage Of Population Below 200% Of The Federal Poverty Level, 2007–2011



[60]Shonkoff et al., "The Climate Gap."

[61]Contra Costa Health Services, Community Health Indicators for Contra Costa County, 2010, http://cchealth.org/health-data/hospital-council/.

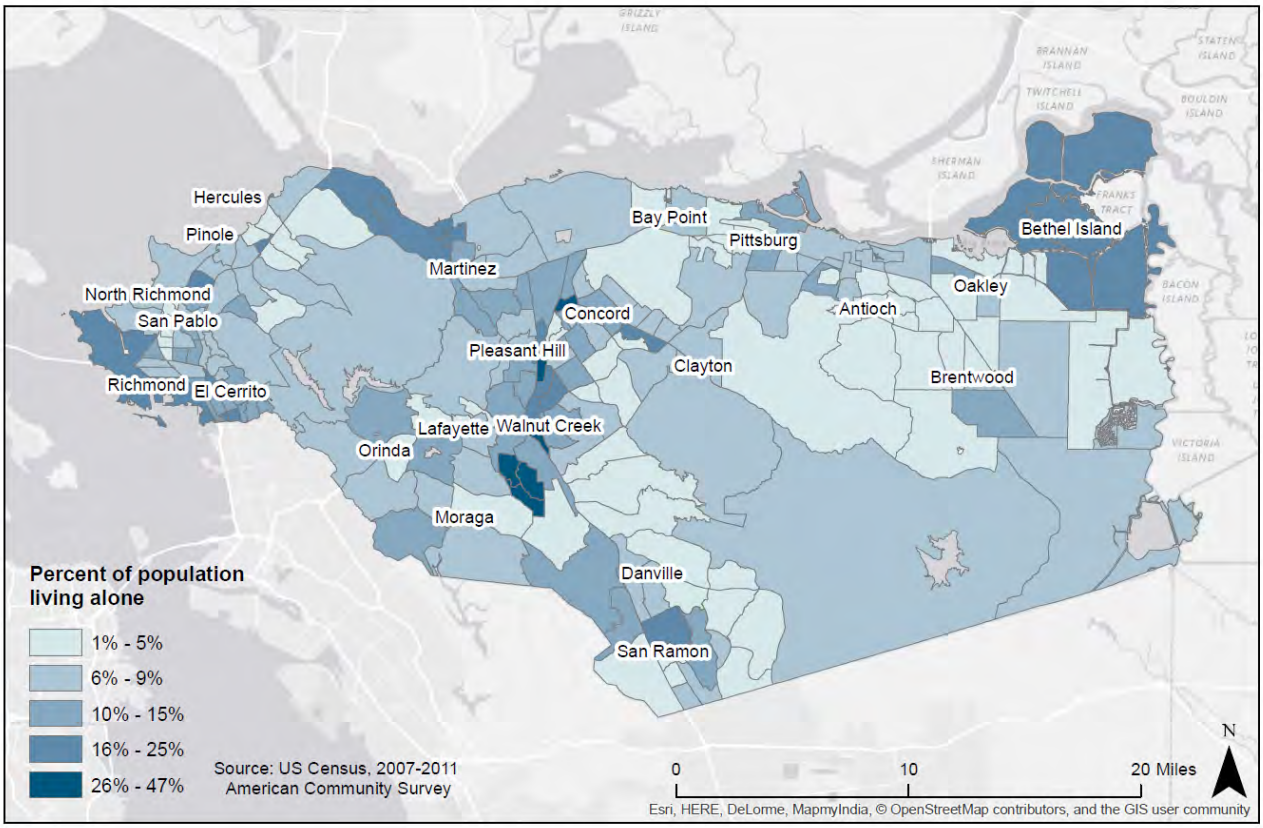
[62]Shonkoff et al., "The Climate Gap."

[63]Luber and McGeehin, "Climate Change and Extreme Heat Events."

People Living Alone

In many heat waves, people who live alone and are socially isolated have had higher risk of death. Elderly people who live alone are at greater risk in particular, and may be less likely or able to seek help if they become ill.[64] Figure 11 shows the percentage of the population living alone, with significant overlap with the same tracts that are home to a large percentage of elderly people, notably the tracts where the Rossmoor retirement community is located. People living in supportive senior housing, such as Rossmoor, may have access to protective resources, including staff paying attention to their wellbeing. Moving forward, it will also be important to understand what types of social connection and protective resources are available to people living alone in different housing and neighborhoods within the county.

Figure 11: Percent Of Population Living Alone By Census Tract, 2007–2011



Race & Ethnicity

Race is also a factor in vulnerability to heat, and African Americans in the United States have been found to be at higher risk of illness and death from heat, including during the 2006 California heat wave.[65] There is no biological basis for this greater burden of illness among African Americans; rather it has been linked to factors including poverty, neighborhood conditions, access to air conditioning and vehicle ownership.[66] These disparities are also associated with higher rates of pre-existing health conditions among African Americans, which in Contra Costa County as elsewhere include cardiovascular disease and hypertension.[67] Long-standing patterns of racial residential segregation and institutional racism mean that African Americans disproportionately live in high-poverty, disinvested neighborhoods, regardless of income. There is evidence that during the 1995 heat wave in Chicago, African Americans died at a higher rate than other racial groups in part because the neighborhoods where they lived had higher rates of violence, fewer high-quality public spaces and little commercial activity, making vulnerable elderly

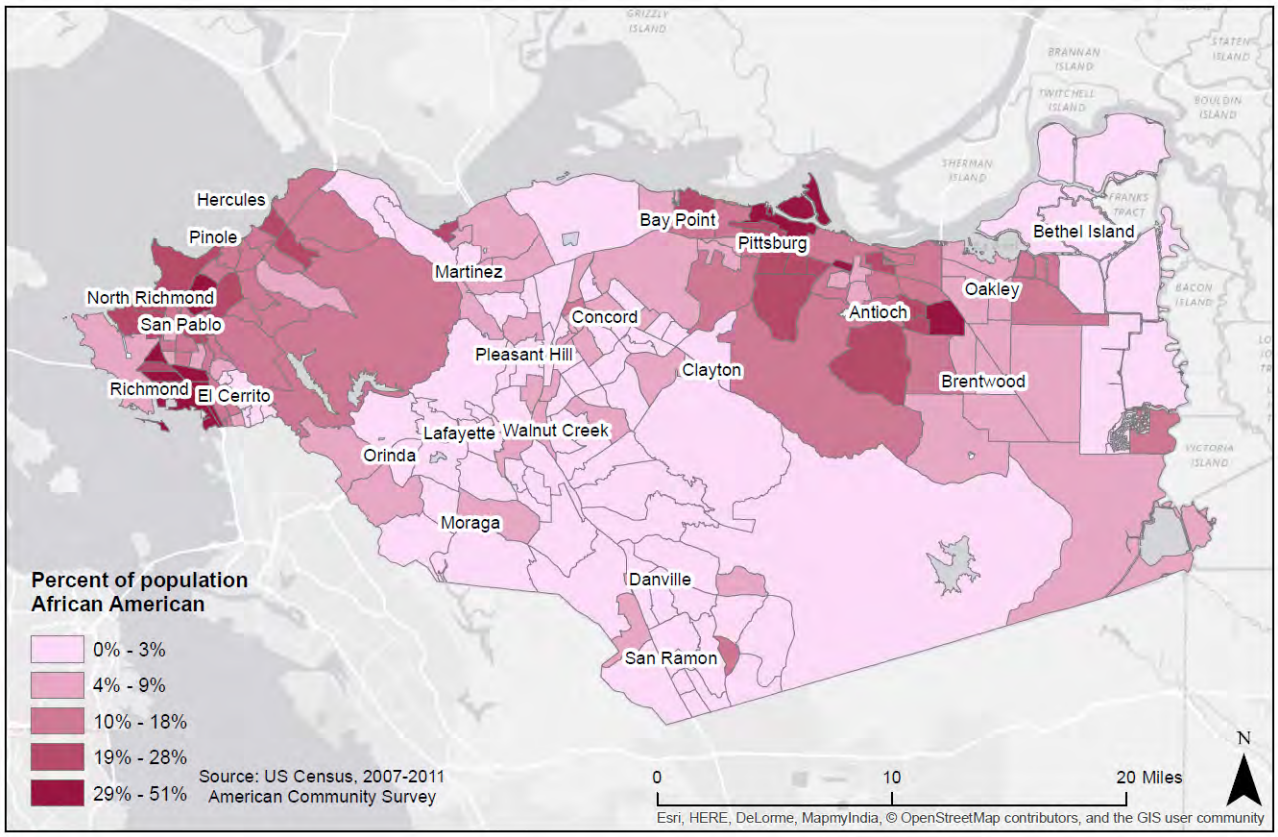
[64]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

[65]Rupa Basu and Bart Ostro, "A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California."

[66]Morello-Frosch et al., The Climate Gap: Inequalities on How Climate Change Hurts Americans and How to Close the Gap.

[67]Contra Costa Health Services, Community Health Indicators for Contra Costa County.

Figure 12: Percent Of Population African American By Census Tract, 2007–2011



residents less likely to leave their homes.[68]

Figure 12 shows the percentage of the population that is African American by census tract, with the largest percentages in tracts in Richmond, North Richmond, Pittsburg and Antioch.

Linguistic Isolation

Linguistic isolation is a risk factor that may prevent people from seeking help in the case of heat-related illness, or from accessing health warnings and recommendations during heat waves if such warnings are available only in English.[69] The data used to represent this vulnerability are obtained from the US Census Bureau, which defines linguistic isolation as a household in which residents report that no one over the age of 14 speaks English "well" or "very well." It is important to note that this definition does not necessarily capture "isolation," since many residents of the county who do not speak English may still have strong community ties based on communication in languages other than English. However, identifying those areas where households are defined as linguistically isolated remains important to ensure that public communications are accessible to community residents in their primary languages.

Figure 13 shows the percentage of households that are linguistically isolated, with the highest proportions in Richmond, Concord and San Pablo.

It is important to note that while the majority of people in the county who do not speak English very well are Spanish speakers, many speak other languages, especially Asian and Pacific Islander languages. More detailed information about languages will be needed to ensure that information in the case of an extreme heat event is accessible to all county residents.

Car Access

Cars allow people to more easily access both formal and informal cooling centers, or simply to travel to cooler areas.[70] Areas where large numbers of households do not have access to private vehicles may be important sites to strengthen public transit, and also to provide mass transportation options to cooling centers during extreme heat events.

[68]Eric Klinenberg, Heat Wave: A Social Autopsy of Disaster in Chicago (University of Chicago Press, 2003).

[69]Heather Cooley et al., Social Vulnerability to Climate Change in California (California Energy Commission, July 2012), http://www.energy.ca.gov/2012publications/CEC-500-2012-013/CEC-500-2012-013.pdf.

[70]Manuel Pastor et al., Minding the Climate Gap: What's At Stake If California's Climate Law Isn't Done Right and Right Away (USC Dornsife Program for Environmental and Regional Equity, 2010), http://dornsife.usc.edu/assets/sites/242/docs/mindingthegap_executive_summary.pdf.

Figure 13: Percent Of Linguistically Isolated Households By Census Tract, 2007–2011

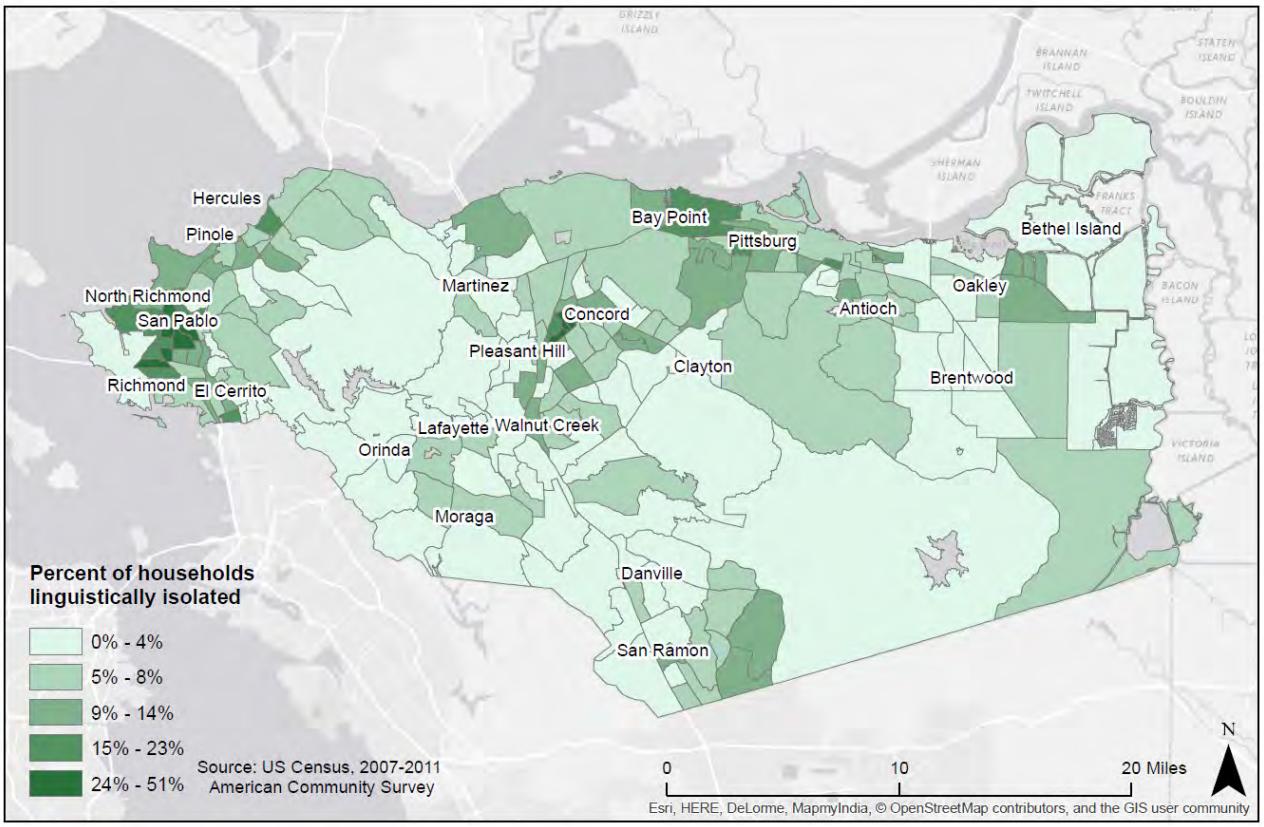


Figure 14: Percentage Of Households Without A Vehicle By Census Tract, 2007–2011

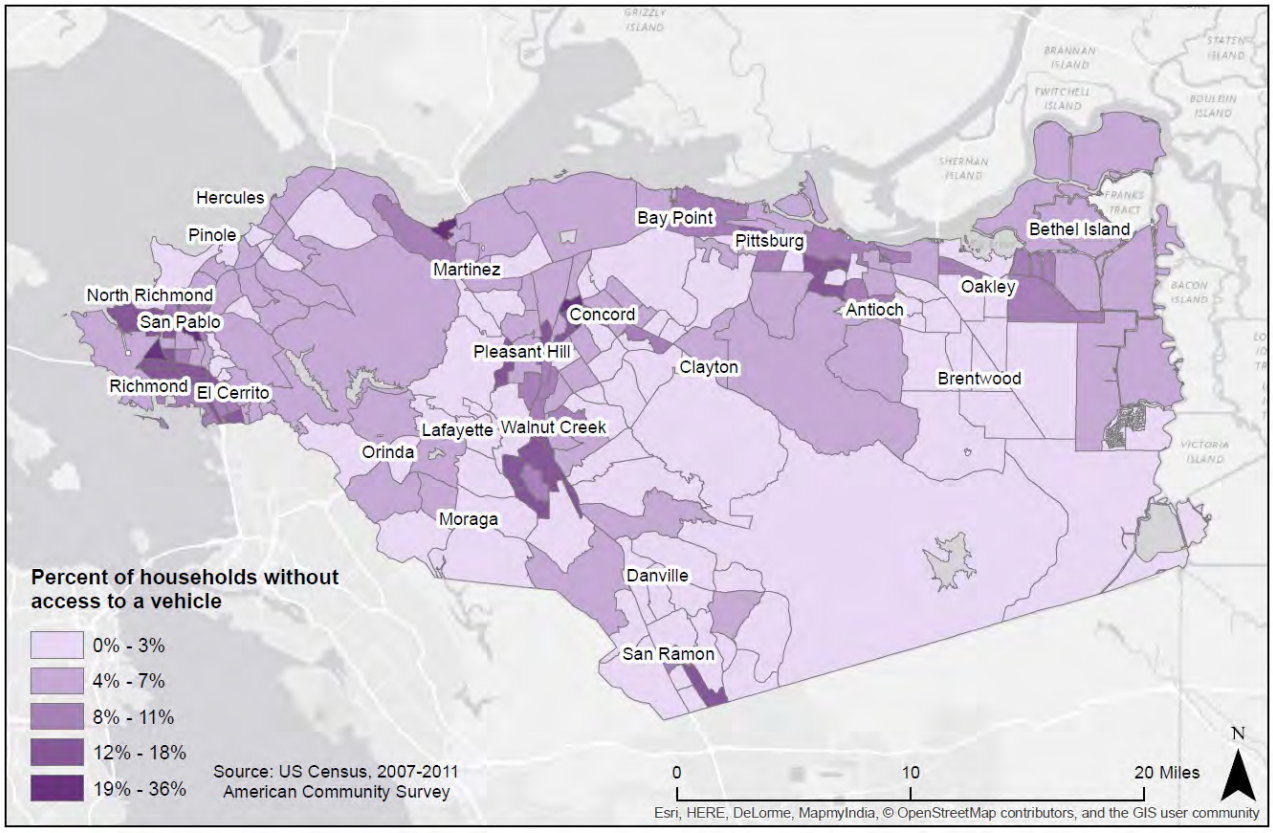
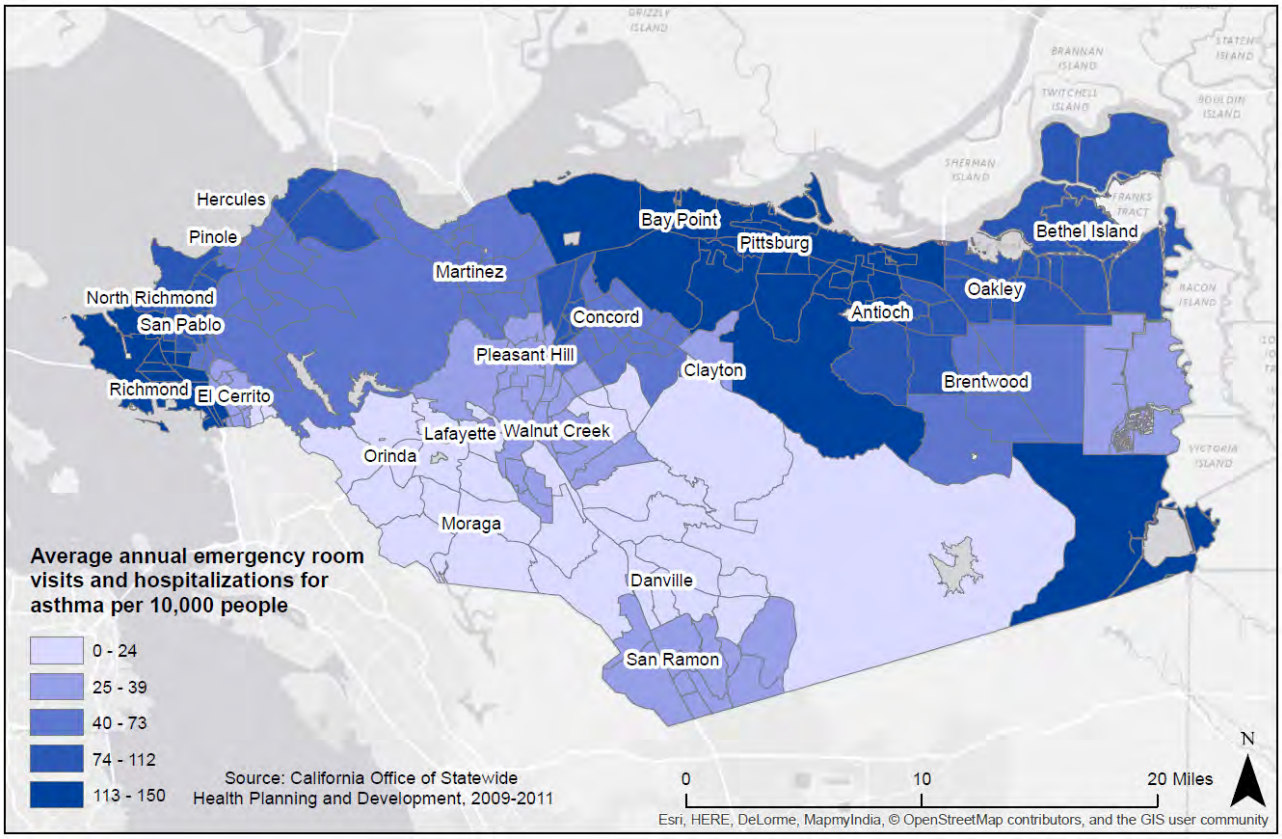


Figure 14 shows the percent of households without a vehicle by census tract, highlighting tracts within Concord, Richmond, Martinez and San Pablo with the highest percentages of carless households. Again, in the tract in Martinez, low car ownership may reflect the population housed in the detention facility.

Neighborhood Social Factors

Social cohesion and strong community ties are important resilience factors during natural disasters, including extreme heat events, and low social connection and cohesion can make community residents more vulnerable to extreme heat.[71] During the 1995 Chicago heat wave, African Americans were at increased risk in part because they were more likely to live in neighborhoods with low levels of social cohesion, and so were less likely to leave their homes. Social cohesion is challenging to measure—although proxy indicators such as voter participation and number of community-based organizations are sometimes used—and is not mapped here. This issue of social cohesion is explored qualitatively through a case study of the Monument corridor neighborhood in Concord on page 34. Although it is not measured here, attention to social cohesion remains important in planning for adaptation, and using planning processes that require the participation and engagement of the community can provide benefits not only in ensuring that strategies are relevant and effective, but can also build protective place-based community ties among county residents.

Figure 15: ED Visits & Hospitalizations For Asthma Per 10,000 People By Census Tract, 2009–2011



Medical Vulnerability

Pre-existing chronic health conditions, including cardiovascular disease, respiratory disease and diabetes, elevate risk of heat-related illness and death.[72] Medical vulnerability is impacted both by prevalence of chronic diseases and their management. Data showing prevalence of chronic disease are not readily available at a geographic scale smaller than the county. However, information is available about hospitalization and emergency department (ED) visits for asthma by zip code, which was then approximated

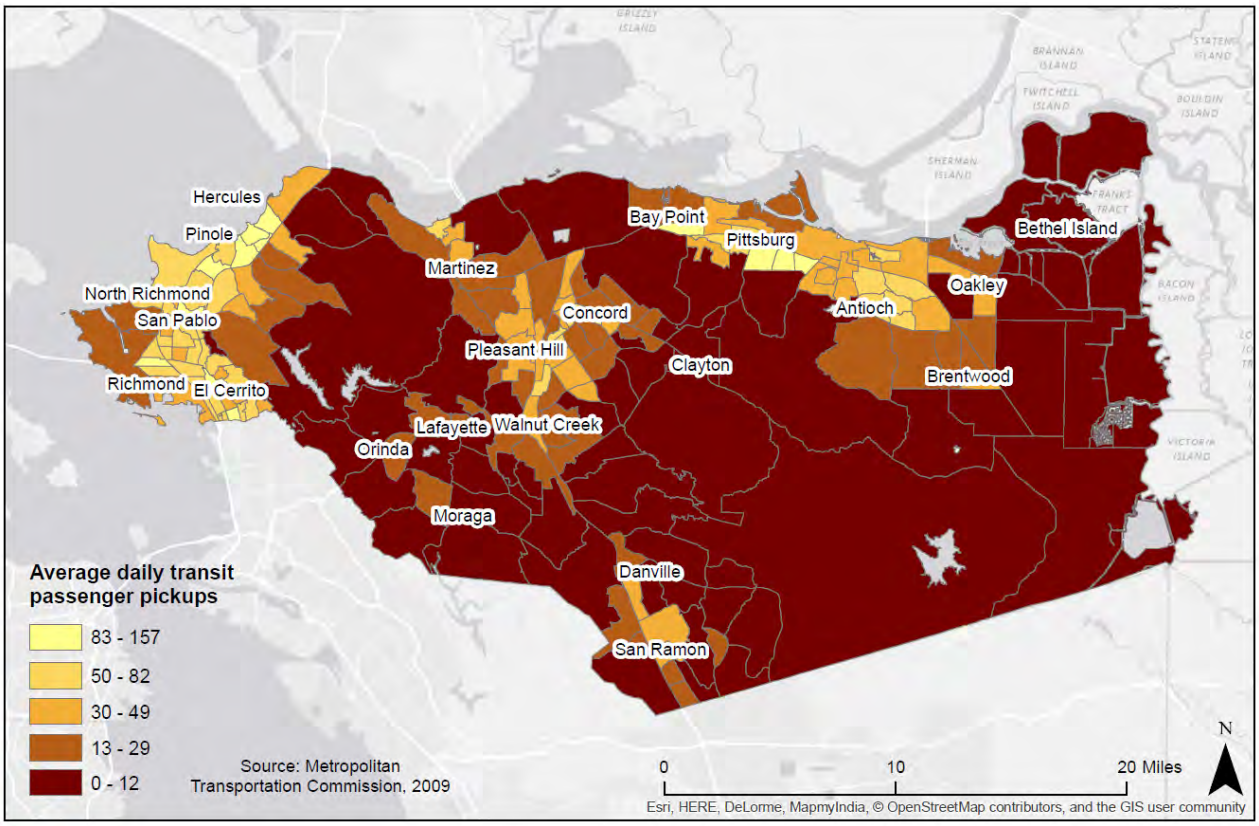
[71]Klinenberg, Heat Wave.

[72]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

to census tracts.[73] This is not equivalent to asthma prevalence, but serves as a measure of asthma management. ED visits are driven both by prevalence and a lack of access to ongoing medical care, leading to severe asthma attacks that require emergency attention.

Figure 15 shows average rates of hospitalization and ED visits for asthma per 10,000 residents for 2009 to 2011, with the highest rates in Richmond, North Richmond, cities in eastern Contra Costa County and in the southeast area of the county.

Figure 16: Estimated Average Daily Transit (Bus, Rail, & Ferry) Pickups By Census Tract, 2009



Living Condition Vulnerabilities

Vulnerability to heat is also tied to conditions in which people live, including neighborhood conditions such as the built environment and air quality, and housing characteristics such as air conditioning availability. Identifying interventions that increase resiliency by improving overall neighborhood conditions may be especially important since they present opportunities for health and climate change mitigation co-benefits, or actions that both reduce greenhouse gas emissions and improve public health. For example, access to public transit is a community-level amenity that can enhance resilience to extreme heat by improving mobility, particularly among those without access to cars,[74] while improving access to transit can also provide co-benefits related to greenhouse gas emission reductions and improved air quality.

Public Transit

Car ownership may help residents to access cooler areas during extreme heat events, but public transit is a key community-level amenity contributing to mobility.[75] Figure 16 shows the average frequency of daily public transit pickups in 2009, estimated for each census tract using data from the Metropolitan Transportation Commission. This measure includes pickups by bus, rail and ferry. Most jurisdictions where the county's population is concentrated contain some

[73]Data are available from the CA Office of Statewide Health Planning and Development on ED visits and hospitalizations for asthma by zip code. To approximate the rates per census tract, population conversion factors from the Missouri Census Data Center Geographic Correspondence Engine were used, for Census 2010 geography. The conversion factors are available at http://mcdc.missouri.edu/websas/geocorr12.html. It was assumed that asthma ED visits and hospitalizations were distributed evenly across the zip codes for this analysis.

[74]Environmental Health Tracking Program, ASTHO Climate Change Population Vulnerability Screening Tool (California Department of Public Health, 2011), http://www.ehib.org/projects/ehss01/Climate%20change%20vulnerability%20report_ASTHO.pdf.; Rupa Basu and Bart Ostro, "A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California."

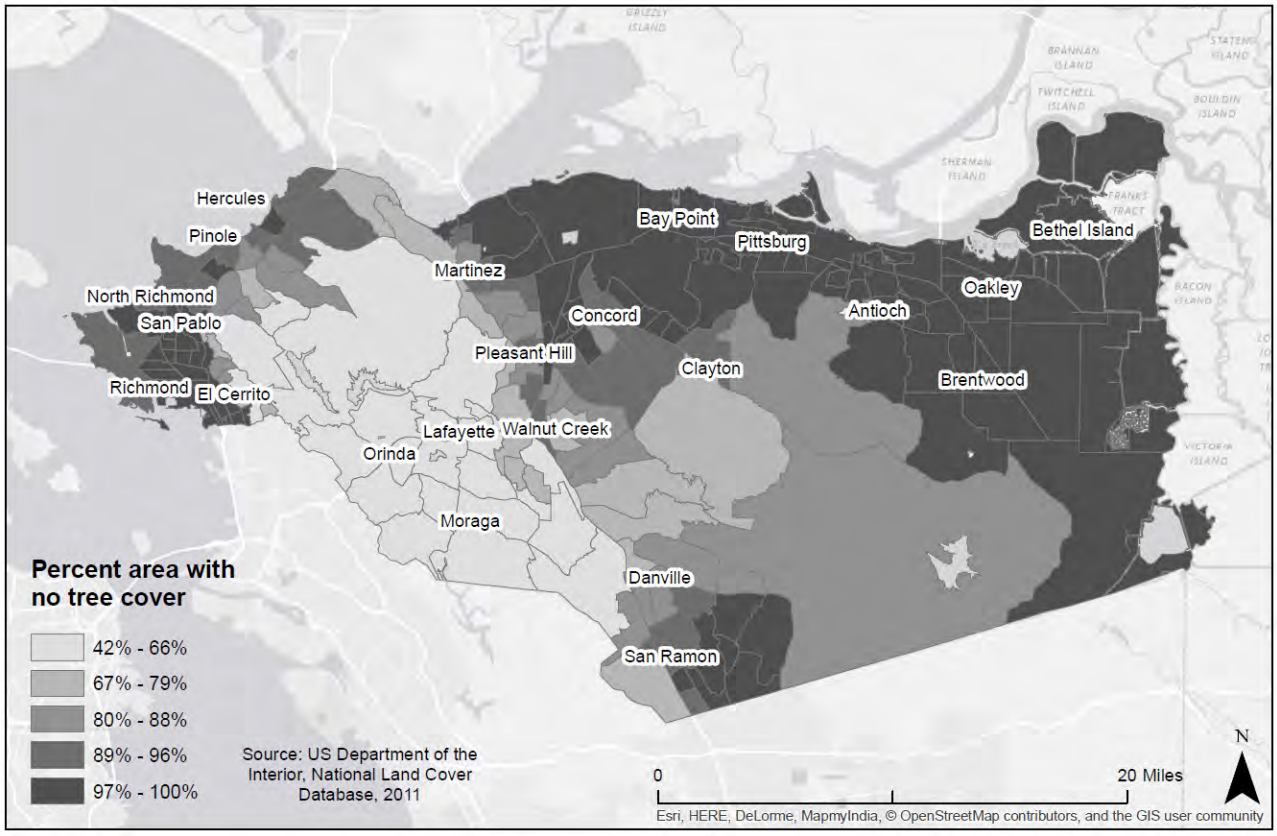
[75]Environmental Health Tracking Program, ASTHO Climate Change Population Vulnerability Screening Tool.

tracts with relatively frequent transit pickups along with others that are poorly served by transit. Locations where car ownership is low that are also poorly served by transit may be at greater risk.

Urban Heat Islands: Tree Cover & Impervious Surfaces

The urban heat island effect is one of the most important aspects of how neighborhood conditions can exacerbate extreme heat. Urban heat islands are areas with little tree cover and significant portions of land covered by impervious surfaces, or artificial

Figure 17: Percent Area With No Tree Cover By Census Tract, 2001



structures covered with impenetrable materials, such as pavement and rooftops. Temperatures in these areas may be significantly hotter than in surrounding areas, especially at night, as impervious surfaces retain heat absorbed throughout the day.[76] Addressing heat islands may also be an important lever for health equity, as researchers have found that low-income people and people of color are more likely to live in areas with land cover characteristics conducive to urban heat islands.[77] Actions to reduce the heat island effect also offer mitigation co-benefits, as increased tree cover can store carbon dioxide, as well as provide shade that reduces energy consumption needed for cooling buildings.[78]

Data for characteristics of urban heat islands are available from the U.S. Department of the Interior, showing tree canopy and impervious surfaces derived from satellite images. Using these images, treeless areas and impervious surfaces within the county have been averaged by census tract.

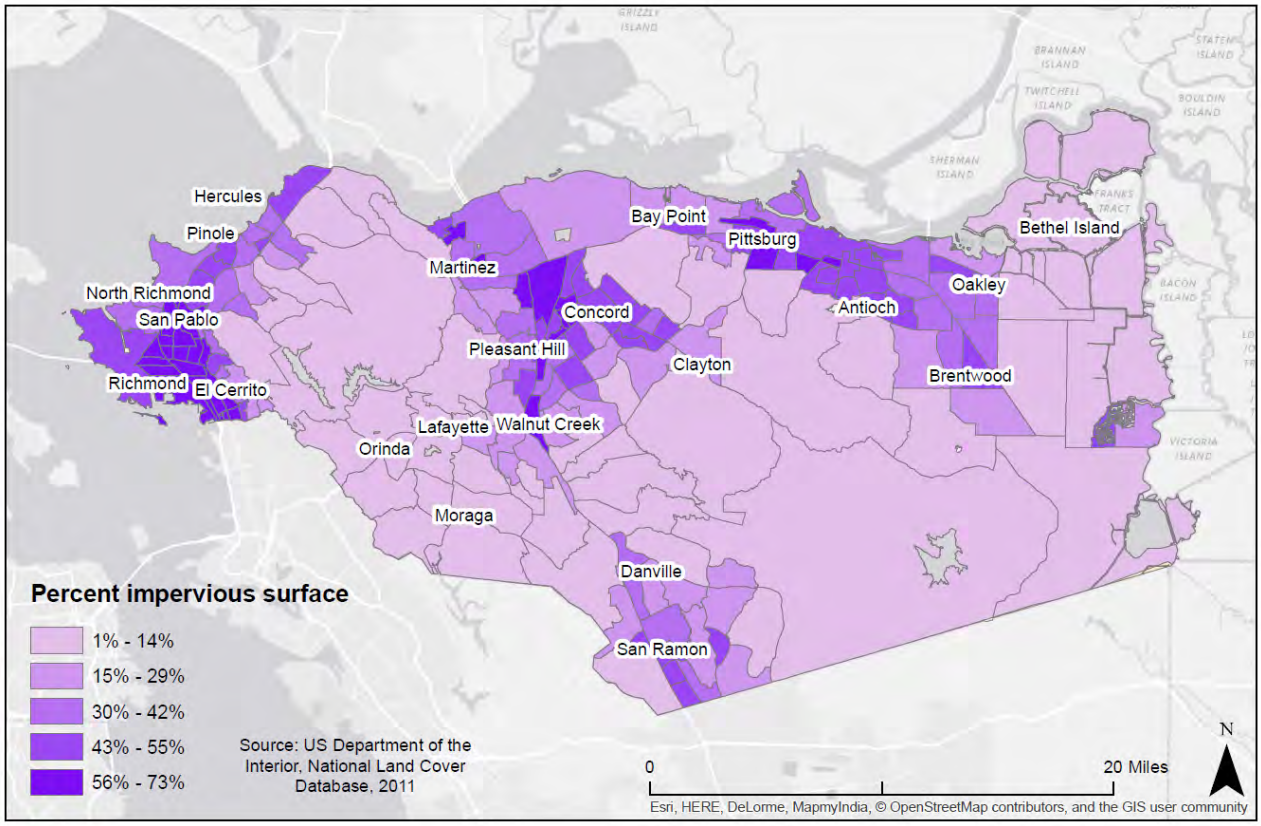
Figure 17 shows the percentage of treeless area within the county by census tract in 2001, using a dataset recently updated for 2011. This map shows that many cities contain areas with very little continuous tree cover, including most of the cities in East and West County, along with significant parts of

[76]United States Environmental Protection Agency, "What Is an Urban Heat Island?," EPA State and Local Climate Protection Program, 2014, http://www.epa.gov/hiri/about/index.htm.

[77]Bill M. Jesdale, Rachel Morello-Frosch, and Lara Cushing, "The Racial/Ethnic Distribution of Heat Risk–Related Land Cover in Relation to Residential Segregation," Environmental Health Perspectives 121, no. 7 (May 14, 2013): 811–17, doi:10.1289/ehp.1205919.

[78]Solange Gould and Kathy Dervin, Climate Action for Health: Integrating Health Into Climate Action Planning (California Department of Public Health, February 2012), http://www.cdph.ca.gov/programs/CCDPHP/Documents/CAPS_and_Health_Published3-22-12.pdf.

Figure 18: Percent Impervious Surface By Census Tract, 2011



Martinez, Concord, Danville and San Ramon.

Figure 18, showing percentage of impervious surfaces by census tract in 2011, indicates that areas with high percentages of impervious surfaces exist in many of the same urban areas with little tree cover. In particular, areas with high percentages of impervious surfaces are concentrated in North Richmond, San Pablo, Richmond and El Cerrito, and in some tracts in cities in Central and East County.

Air Conditioning

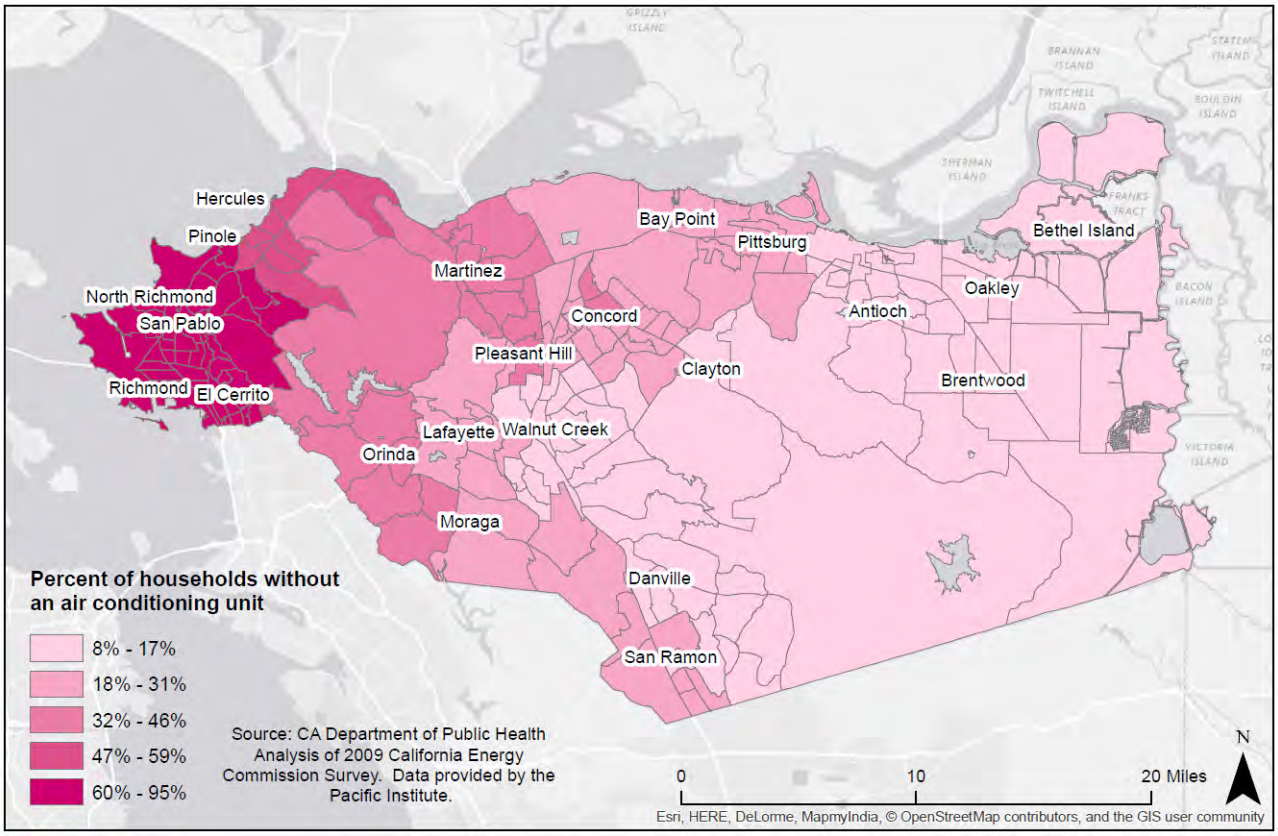
Air conditioner ownership helps protect against extreme heat events. This fact presents a challenge, because while air conditioners allow households to adapt to extreme heat, increased household air conditioning could counter mitigation goals by leading to more greenhouse gas emissions, and could also strain energy capacity.[79] However, identifying areas where few households have air conditioners is important to ensure they are adequately served by cooling centers and outreach during extreme heat events. As noted above, access to air conditioning is also a key factor in linking heat susceptibility to poverty and race: poor households are less likely to have air conditioning or to use it even if they do, and lack of air conditioning may be one of the drivers of racial inequities in morbidity and mortality during heat waves.[80]

[79]Public Health Workgroup, California Climate Action Team, Preparing California for Extreme Heat: Guidance and Recommendations.

[80]Shonkoff et al., "The Climate Gap."

While comprehensive information on air conditioner ownership is not readily available, models have been derived from the 2009 California Energy Commission Appliances Survey. Figure 19 displays air conditioner ownership by census tract based on a model developed from this survey by the California Department of Public Health, and made available by the Pacific Institute.[81] It shows that households in historically cooler areas, and areas with older housing stock, are less likely to have home air conditioning.

Figure 19: Percentage Of Households Without Air Conditioning By Census Tract, 2009



Ground–Level Ozone

Existing air quality in the county is important, since heat can worsen air pollution. Air pollution models indicate that increases in temperature may counteract the reductions in emissions expected to bring down ground-level ozone over the coming decades.[82] Poor air quality and attendant negative health effects are already a significant environmental justice concern within the Bay Area, where low-income communities of color experience some of the most polluted air.[83] Without increased efforts to protect respiratory health, those residents currently suffering from high ozone levels may not experience the health benefits of emissions reductions.

Figure 20 shows areas in the county where ground-level ozone concentration exceeded the state standard from 2009 to 2011. This data was modeled by the California Office of Environmental Health Hazard Assessment based on air monitoring data from the California Air Resources Board, for use in Cal Enviro Screen, an environmental justice screening tool.[84] Wind and elevation patterns within the county and surrounding region lead to higher concentrations of ground-level ozone in the east and southeast areas of the county. According to this model, some of the highest concentrations are in areas with relatively low populations, but Bethel Island and cities within East County also show comparatively elevated concentrations.

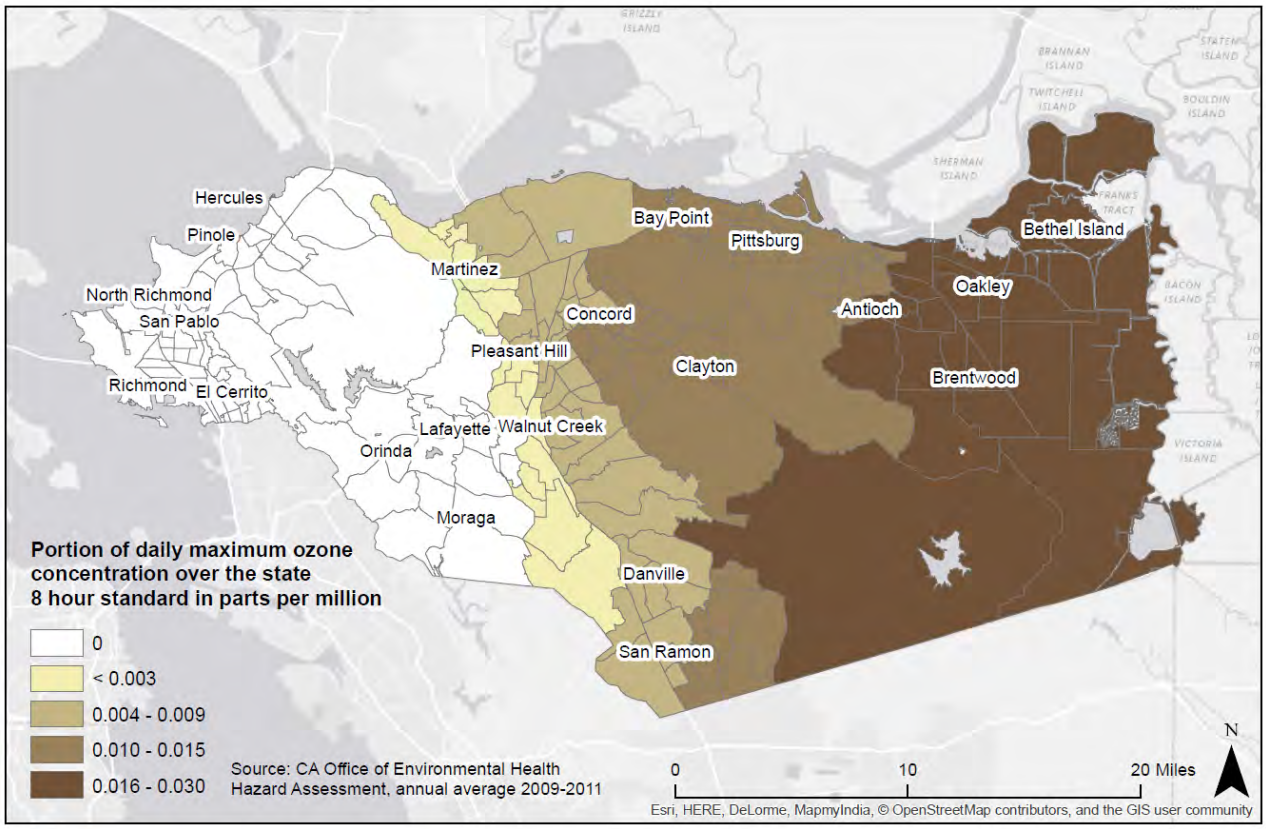
[81]The Pacific Institute analysis was available for 2000 census tracts, which are slightly different than 2010 census tracts. The data were converted to 2010 census tracts using U.S. Census Bureau relationship files available at https://www.census.gov/geo/maps-data/data/relationship.html

[82]Allison L. Steiner et al., "Influence of Future Climate and Emissions on Regional Air Quality in California," Journal of Geophysical Research: Atmospheres 111, no. D18 (September 27, 2006): D18303, doi:10.1029/2005JD006935.

[83]Manuel Pastor, Rachel Morello-Frosch, and James Sadd, Still Toxic After All These Years: Air Quality and Environmental Justic in the San Francisco Bay Area (Center for Justice, Tolerance & Community, University of Santa Cruz, 2007), http://cjtc.ucsc.edu/docs/bay_final.pdf.

[84]California Office of Environmental Health Hazard Assessment, "CalEnviroScreen 2.0," CA OEHHA Environmental Justice, 2014, http://oehha.ca.gov/ej/ces2.html.

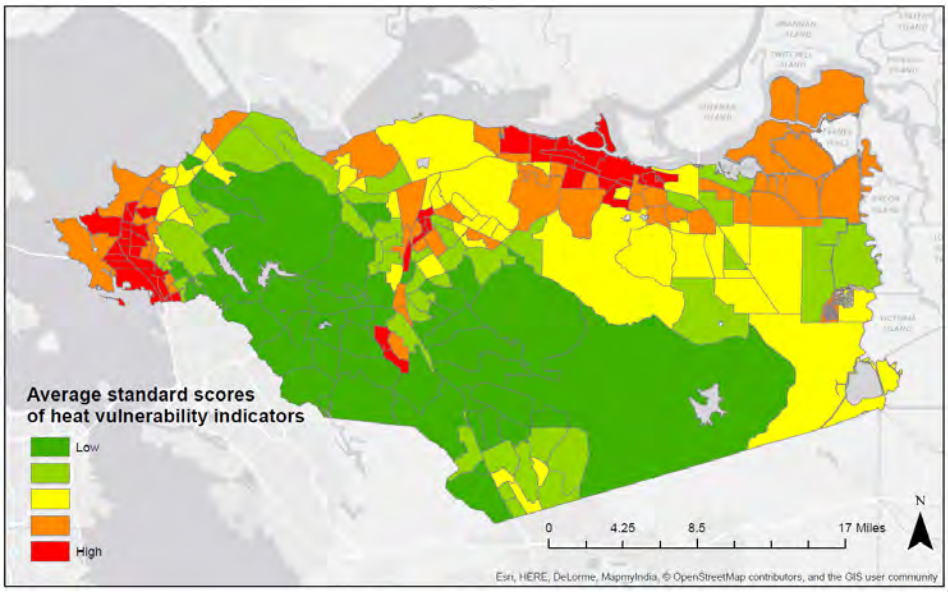
Figure 20: Ground–Level Ozone Concentration Over The California Standard By Zip Code, 2009–2011



Combined Vulnerabilities Across Contra Costa County

Figure 21 displays a map of combined vulnerability factors across the county. The factors were combined using an averaged standard score (z-score), a measurement of how far they differ from average conditions. Each factor was weighted equally, and the census tracts in red are those with the highest average. A high average score for a census tract may be driven by high ranking for a large number of vulnerability factors, or by very high outlier values for a small number of factors. For the most part, these areas of high vulnerability are also aligned with the county's population centers.

Figure 21: Average Z-Scores Of Heat Vulnerability Indicators By Census Tract, Showing An Equal Number Of Census Tracts In Each Category



Figures 22 through 26 display some areas of the county with high overall vulnerability, along with descriptions of which factors are contributing to the vulnerability.

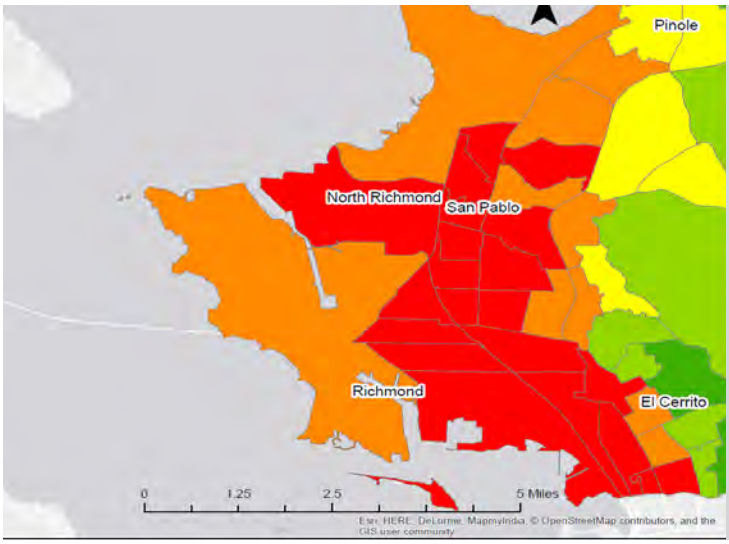


Figure 22: West County

- Children under 5
- Poverty
- African-American residents
- Linguistic isolation
- Asthma
- No vehicle access
- Treeless area
- Impervious surfaces
- No air conditioning

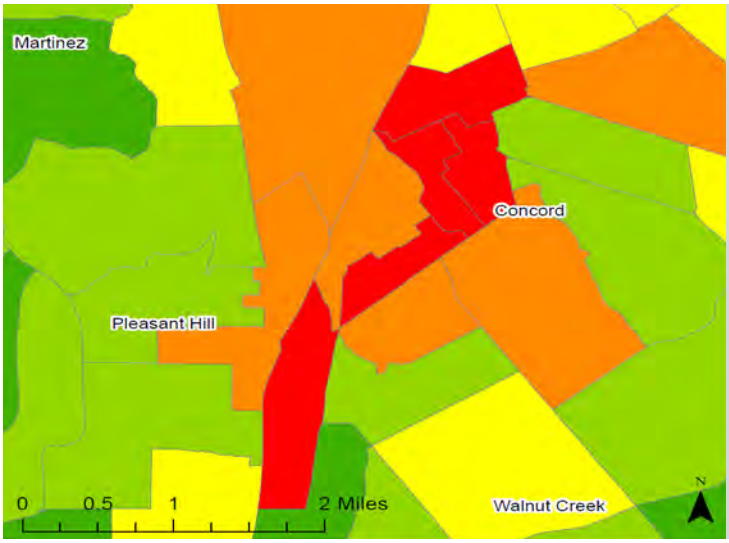


Figure 23: Monument Corridor In Concord

- Children under 5
- Poverty
- Linguistic isolation
- No vehicle access
- Treeless area
- Impervious surfaces
- Asthma

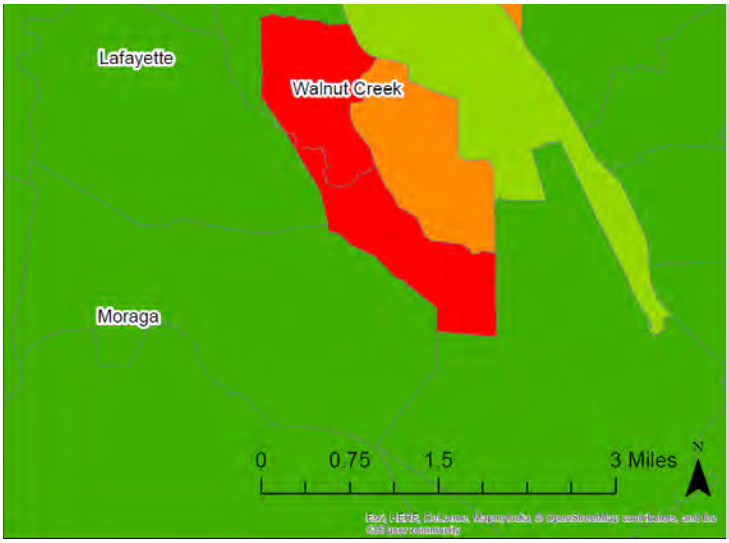


Figure 24: Rossmoor Area In Walnut Creek

- Elderly residents
- People living alone
- No vehicle access

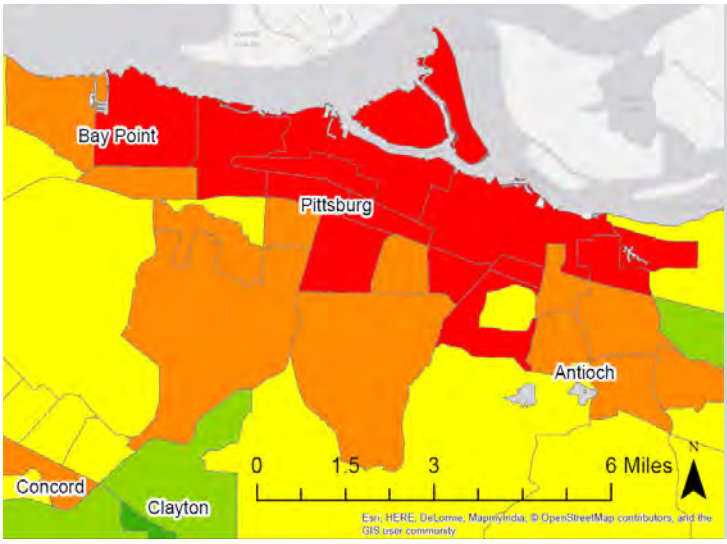


Figure 25: East County

- Children under 5
- Poverty
- African American residents
- Linguistic isolation
- Asthma
- Treeless area
- Impervious surfaces
- Ozone pollution

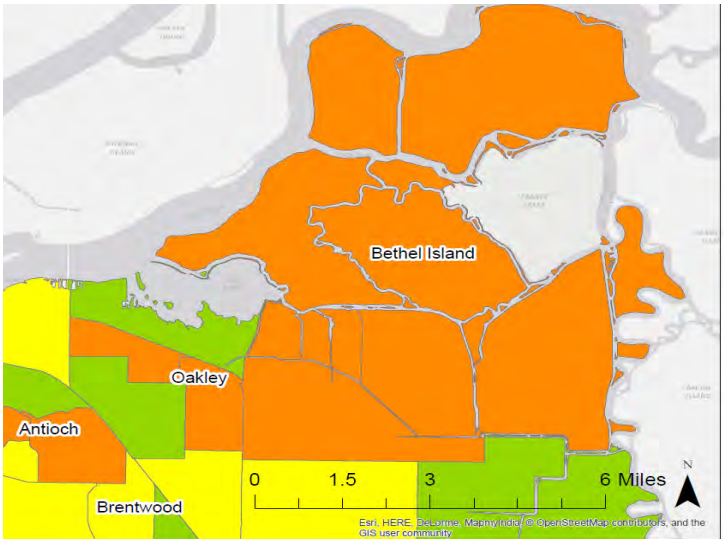


Figure 26: Bethel Island

- Elderly residents
- People living alone
- No transit access
- Treeless area
- Ozone pollution

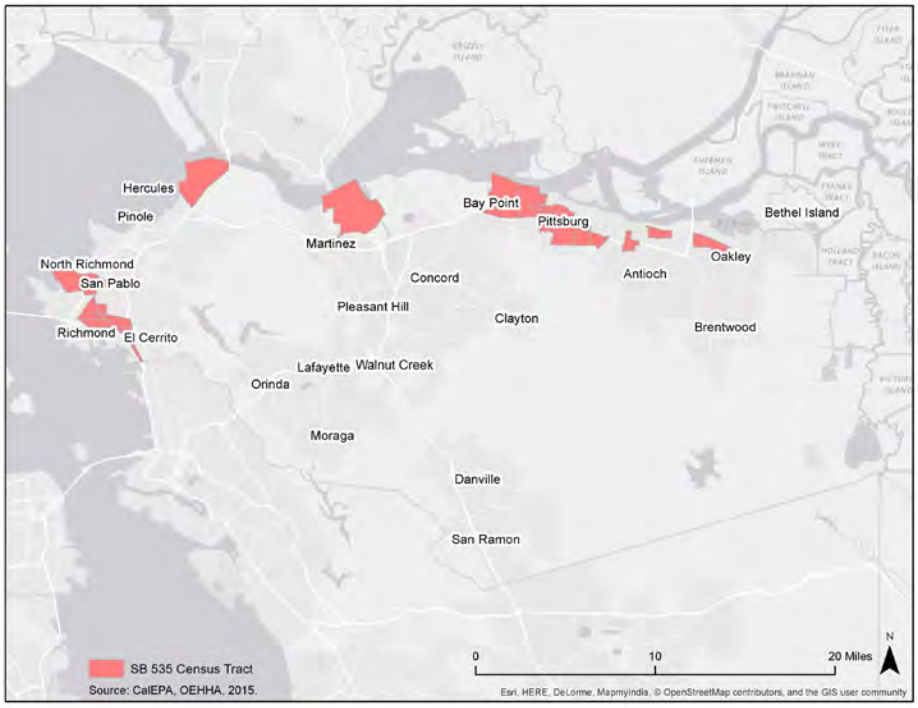
Vulnerabilities By Jurisdiction

The vulnerability factors mapped by census tract were also analyzed by jurisdiction, using data for cities in their entirety, rather than by census tract. This analysis does not provide the neighborhood scale analysis included above, but allows for more direct comparison of overlapping vulnerabilities in different jurisdictions. To create Table 3, the same vulnerability factors were mapped by jurisdiction, and jurisdictions were then divided into three categories using natural breaks, where “high” is the most vulnerable and “low” is the least vulnerable. An average z-score was also calculated for each jurisdiction, and they are listed in the table from high to low z-score, meaning that North Richmond had the highest average z-score for all of the vulnerability factors, while Lafayette had the lowest.

Table 3: Vulnerabilities To Extreme Heat By Jurisdiction

	Biological		Socio-Economic				Medical	Living Conditions						
City or Place Name	**Under 5**	**Over 65**	**Poverty**	**Living Alone**	**African American Race**	**Linguistic Isolation**	**Asthma**	**Access to Car**	**Public Transit**	**Treeless Area**	**Impervious Surfaces**	**Air Conditioning**	**Ozone**	**Average Standard Score**
North Richmond	Medium	Low	High	Low	High	High	High	High	Low	High	High	High	Low	High
San Pablo	High	Low	High	Low	Medium	High	Medium	High	Low	High	High	High	Low	
Richmond	High	Low	High	Medium	High	High	High	Medium	Low	Medium	Medium	High	Low	
Bay Point	High	Low	High	Low	Medium	High	High	Medium	Low	High	Medium	Low	Medium	
Pittsburg	High	Low	High	Low	Medium	Medium	High	Medium	Low	High	Medium	Low	Medium	
Bethel Island	Low	High	High	High	Low	Low	Medium	Medium	High	High	Low	Low	High	
Antioch	High	Low	High	Low	Medium	Medium	High	Medium	Low	High	Medium	Low	High	
Concord	High	Low	Medium	Medium	Low	Medium	Medium	Medium	Medium	High	Medium	Low	Medium	
El Cerrito	High	Medium	Medium	Medium	Low	Medium	Low	Medium	Low	Medium	High	High	Low	
Oakley	High	Low	Medium	Low	Low	Medium	Medium	Low	High	High	Low	Low	High	
Walnut Creek	Medium	High	Low	High	Low	Medium	Low	Medium	High	Medium	Medium	Low	Low	
Brentwood	High	Low	Medium	Low	Low	Low	Medium	Low	Medium	High	Medium	Low	High	
Pleasant Hill	Medium	Medium	Medium	Medium	Low	Medium	Low	Medium	Medium	Medium	Medium	Medium	Low	
Pinole	Medium	Medium	Medium	Low	Medium	Medium	Medium	Medium	Low	Medium	Medium	High	Low	
San Ramon	High	Low	Low	Low	Low	Medium	Low	Low	Medium	High	Medium	Low	Medium	
Martinez	Medium	Low	Medium	Medium	Low	Low	Medium	Low	Medium	Medium	Medium	Medium	Low	
Hercules	Medium	Low	Low	Low	Medium	Medium	Medium	Low	Low	Medium	Medium	Medium	Low	
Clayton	Medium	Medium	Low	Low	Low	Low	Low	Low	High	High	Medium	Low	Medium	
Danville	Medium	Medium	Low	Low	Low	Low	Low	Low	High	Medium	Low	Low	Medium	
Moraga	Medium	Medium	Low	Low	Low	Low	Low	Low	High	Medium	Low	Medium	Low	
Orinda	High	Medium	Low	Low	Low	Low	Low	Low	High	Low	Low	Medium	Low	
Lafayette	Medium	Medium	Low	Low	Low	Low	Low	Low	High	Low	Low	Low	Low	Low

Figure 27: Relationship to Disadvantaged Communities under SB 535



Relationship to Disadvantaged Communities under SB 535

Contra Costa County's ability to adapt and build resiliency to increased heat and heat waves will be partially tied to its ability to secure funding to implement programs and policies. Senate Bill 535 provides a potentially important funding source by directing funds from the statewide greenhouse gas cap-and-trade program to local programs and policies that benefit disadvantaged communities.

The California Global Warming Solutions Act of 2006 required the California Air Resources Board (CARB) to adopt a statewide program to reduce greenhouse gas emissions in the state to at least 1990 levels by 2020. CARB subsequently developed several programs under this authorization, including a market-based cap-and-trade program. Funds received by the state from the distribution of emissions allowances as part of this program must be used to further reduce emissions of greenhouse gases. Some of these greenhouse gas reduction measures, such as tree planting and weatherization programs, also provide adaptive benefits to increased heat and heat waves.

Senate Bill 535 (Leon), passed in 2012, directed a quarter of the proceeds from the Greenhouse Gas Reduction Fund to projects that provide a benefit to disadvantaged communities. The legislation gives the California Environmental Protection Agency (CalEPA) responsibility for identifying those communities. In October 2014 CalEPA released its list of disadvantaged communities for the purpose of SB 535. To inform its decisions, CalEPA relied on the California Communities Environmental Health Screening Tool (CalEnviroScreen), a tool that assesses all census tracts in California to identify the areas disproportionately burdened by and vulnerable to multiple sources of pollution.

A comparison of the census tracts identified as disadvantaged communities for SB 535 in Contra Costa County (figure 27) to the combined vulnerabilities map developed for this report (figure 21) shows many similarities, as well as several significant differences. Several census tracts in Richmond, Bay Point, Pittsburg and Antioch that are designated as disadvantaged communities by SB 535 are also ranked in the highest quartile as vulnerable to heat by this report. However, several census tracts identified as disadvantaged communities by SB 535 in Rodeo, Martinez and Oakley are only ranked in the second highest quartile in this report. Also, several census tracts in Richmond, Walnut Creek, Concord, Pittsburg and Antioch ranked in the highest quartile in this report are not designated as disadvantaged communities by SB 535.

These differences in outcome are due to the use of different methodologies for this report and for SB 535, since the factors being evaluated were different – vulnerability to heat for this report, and overall environmental health disadvantage for SB 535. Primarily, the SB 535 methodology placed a higher emphasis on the potential exposure to toxic chemicals in assessing impacts. These differences must be considered when pursuing funding options and when determining where to allocate resources.

Case Study: Monument Corridor in Concord

While quantitative analysis of vulnerability factors provides an important first look at vulnerability to heat within Contra Costa County, effective planning for adaptation and health will require a deeper understanding of neighborhood context, and prioritization of resident voices and experience. The following case study offers a qualitative exploration of vulnerability to heat in the Monument Boulevard corridor in Concord. While the City of Concord as a whole ranks about in the middle of Contra Costa cities in the vulnerability analysis by jurisdiction, the Monument corridor stands out starkly as a vulnerable cluster of census tracts.

Concord is located in central Contra Costa County, in the inland climate zone, which will continue to see high temperatures that will increase as the climate changes. The Monument corridor is a high-poverty neighborhood—over half of residents live below 200% of the federal poverty level—with the highest residential density in the county, containing about 12% of the city's land area but nearly a third of its population.[85] About 63% of the neighborhood's residents are Latino, and about 42% are not U.S. citizens, with the majority of immigrants originally from Mexico.[86] The neighborhood also has some of the highest rates of linguistic isolation in the county, with many households consisting of monolingual Spanish speakers. In one census tract within the neighborhood, 50% of households do not include someone over age 14 who speaks English very well.[87] In order to identify some key resources and potential barriers to protecting residents from extreme heat, three stakeholders at key community-based organizations (CBOs) in the Monument corridor were interviewed. These CBOs work closely with a variety of neighborhood residents, including families, seniors and day laborers.

Interviewees emphasized that most low-income residents in the Monument corridor live in older apartment buildings without air conditioning, and on hot summer days many of them seek refuge in commercial spaces. Many residents may head to a nearby mall: "[S]ince the mall has air conditioning," one stakeholder noted, "it will get packed with people just waiting for the day to go by."[88] Another stakeholder who works with seniors through Catholic Charities of the East Bay agreed that elderly residents sometimes head to the mall. Yet she knows the bus ride can be prohibitive for those without cars, and so when it gets very hot senior residents may instead walk to closer restaurants and businesses.[89] They also sometimes cool off at the Concord Senior Center, as well as at the senior center in adjacent Pleasant Hill, which is closer for some Monument residents. She regularly conducts outreach within the neighborhood, and knows that residents living in senior housing have some degree of supervision, but she worries about those living alone. She emphasized a need for education efforts about the risks of heat, and that these should occur in conjunction with other service outreach, and in multiple languages: "Many people are monolingual, [we] need to make sure information is not only in Spanish but also in Cantonese and Vietnamese."[90]

A stakeholder from the Monument Crisis Center also underscored this linguistic diversity among seniors, highlighting the need for communication that is

[85]"About Our Community," Monument Community Partnership, accessed April 11, 2014, http://monumentimpact.org/aboutus.

[86]U.S. Census, American Community Survey, 2007-2011.

[87]Ibid.

[88]Stakeholder 1: Monument Community Partnership, telephone interview, February 6, 2014.

[89]Stakeholder 2: Catholic Charities East Bay, telephone interview, February 15, 2014.

[90]Ibid

accessible not only to Spanish and English speakers, but also to a variety of residents speaking Asian languages. Monument Crisis Center is a neighborhood-based safety net organization offering a wide variety of services, including twice-per-month bilingual bingo events for seniors in English and Spanish. These events are increasingly serving Chinese, Vietnamese and Filipino-American seniors, and have grown significantly over the past several years, attracting a growing number of Monument residents as well as seniors from across Contra Costa County.[91] News about the events has spread almost entirely through word of mouth, indicating strong social networks among potentially vulnerable low-income seniors. These networks might also be mobilized to prioritize resident voices in planning for resilience, and to develop and distribute effective educational strategies about extreme heat.[92]

Stakeholder 1, who also lives in the Monument corridor, works with many undocumented residents at the Monument Community Partnership (MCP). She acknowledged that undocumented residents may be hesitant to seek out services offered by government agencies, but noted that local schools and churches are spaces where many residents feel safe regardless of their immigration status.[93] Bilingual Spanish-English parent liaisons in the local elementary school have helped many parents connect to school activities, and she felt that cooling centers located in schools would likely be used by Monument families, particularly if they offered activities for kids. Churches could also serve as important points of outreach, as well as be tapped to disseminate information about how residents can protect themselves from extreme heat. This stakeholder also highlighted La Clínica de La Raza, a community clinic, as a trusted neighborhood organization that could serve an important role in communicating with Monument residents during extreme heat emergencies.

In addition to residents, many day laborers gather along Detroit Avenue, a major thoroughfare in the Monument neighborhood. The MCP runs a day laborer program that works with employers to ensure good working conditions for participants, but not all workers are involved in it. In an interview, the stakeholder from MCP expressed significant concerns about undocumented day laborers in particular: “We’re concerned that they don’t have access to water, that they get dehydrated fast, and that we don’t have…communication with them.” She communicated that there is a lack of public water fountains, and that a broader and more pressing issue is ensuring that workers have access to water at job sites outside of the neighborhood.[94]

These interviews shed light on some important resources that could help build resilience to extreme heat in the Monument community: social networks among seniors, existing senior outreach that could be coupled with education and resources to protect residents during heat emergencies, and the importance of trusted institutions like schools, churches, and clinics. They also point to potential partnerships with local businesses that residents rely on to cool off during the hottest days. The perspectives shared by stakeholders make clear that outreach and resources about how residents can protect themselves from extreme heat, and what resources are available to them, must be accessible in multiple languages. Special consideration will be needed for developing strategies that are safe and accessible for undocumented residents, and that ensure the health and safety of vulnerable day laborers.

[91]Stakeholder 3: Monument Crisis Center, telephone interview, March 27, 2014.

[92]Ibid.

[93]Stakeholder 1, Author interview.

[94]Stakeholder 1, Author interview.

Discussion

The projections and data discussed in this report show that climate change is a serious health issue, and that many residents across the county may be vulnerable to impacts such as extreme heat for a variety of different reasons. CCHS hopes to support individual jurisdictions and other agencies as they prepare for climate change and strengthen resiliency in communities across the county. Our recommendations at this point are broad, since we know that developing specific strategies for feasible and equitable policies will require further collaboration across multiple sectors. These planning processes also need to prioritize the voices of county residents, especially people most likely to experience the negative impacts of climate change. To begin this dialogue, we have identified some basic guiding principles, along with more specific roles that the CCHS Climate Change and Health Working Group hope to contribute. We also include some additional resources that may be useful in developing strategies moving forward.

Principles

- Jurisdictions in Contra Costa County should plan for climate change, and include both mitigation and resiliency. The projections discussed in this paper show that even with major reductions in greenhouse gas emissions, Contra Costa County will likely experience changes such as rising temperatures and flooding. Climate change adaptation should be pursued in concert with ongoing efforts to reduce emissions. Building resilience to climate impacts can have multiple benefits in creating safer and stronger communities in the county. Planning and preparation can occur through a number of processes, including standalone Climate Action or Adaptation Plans, and/or by incorporating adaptation into existing plans such as General Plans or Hazard Mitigation Plans.
- Health and health equity should be incorporated into climate change planning. Both mitigation and adaptation planning should consider human health and incorporate strategies that support public health within the county. Specifically, they should prioritize health equity, and identify solutions that build resiliency with vulnerable populations that already experience disproportionate health burdens. As the data in this report show, many of the people likely to be the most vulnerable to extreme heat already face health inequities associated with social determinants of health such as poverty, and neighborhood conditions such as air pollution.
- Collaboration and community engagement are key. Climate change impacts, including extreme heat, will not be isolated within one sector in the county or among one group of people. For example, building resilience will require engaging with seniors, families with young children, outdoor workers and their employers, as well as with community organizers and residents in low-income communities throughout the county. Adapting to hotter temperatures means both working with emergency services to plan responses to extreme heat events and with city planners to build cooler neighborhoods that lessen the heat island effect. It will also mean ensuring meaningful participation and incorporating community voices as these plans move forward. As the Monument case study shows, residents and local organizations have intimate knowledge of resources as well as risks in their neighborhoods and communities, and must be partners in building solutions. Community organizing and resident participation are also opportunities to build social connection and cohesion, with added protective benefits.

Contra Costa Health Services' Role

The Public Health Division of CCHS now hosts a Climate Change and Health Working Group, which hopes to expand and invites participation from divisions across CCHS. The Working Group also looks forward to helping bring multiple sectors and actors in Contra Costa into conversation with each other. The key roles for the Working Group include:

- Integrating health and equity considerations into climate analyses and plans that other agencies or jurisdictions are conducting, including
  - Highlighting vulnerabilities and means to redress existing inequities
  - Bringing a focus on community capacity building and opportunities to strengthen social cohesion
- Bringing considerations about climate change into CCHS' own operations and planning.
- Connecting with residents and community organizations, especially within vulnerable communities, to bridge community capacity building with government decision-making.
- Providing education on the connections between climate change and health, both internally within CCHS and externally with other parties working on climate change mitigation and adaptation.

Select Resources on Climate Change, Health, and Extreme Heat

Preparing California For Extreme Heat (2013)

www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf

- This state level report was prepared by the Public Health Working Group of California's Climate Action Team. It includes recommendations for strategies at local, regional and state levels for building cooler communities and preparing for emergencies, and also discusses relevant partner agencies and organizations.

Reducing Urban Heat Islands: Compendium Of Strategies (2008)

www.epa.gov/heatisland/resources/compendium.htm

- The United States Environmental Protection Agency has compiled this resource with more in-depth information on heat islands and approaches to reducing temperatures in urban areas.

Integrating Health Into Climate Action Plans (2012)

www.cdph.ca.gov/programs/CCDPHP/Documents/CAPS_and_Health_Published3-22-12.pdf

- The California Department of Public Health offers strategies for bringing health and health equity into climate action planning, which includes content on adaptation.

CalBRACE Resources Page

www.cdph.ca.gov/programs/Pages/CalBRACE.aspx

- The CalBRACE (Building Resilience Against Climate Effects) program is a California Department of Public Health effort funded by the Centers for Disease Control and Prevention. The program's resource page includes links to a variety of useful documents, including many sources used in this report.

Conclusion

The evidence is clear that health risks presented by climate change and extreme heat are serious, and that, without action, they have the potential to worsen existing health disparities. Yet acting to build resilience in Contra Costa County's communities and prepare for climate change also presents new opportunities for collaborative efforts to improve health and advance equity. The vulnerability analysis for extreme heat developed in this report will hopefully serve to catalyze conversations across sectors and direct equitable climate adaptation planning. Extreme heat, while important, is only one piece of the puzzle. Further work may be needed to explore other climate impacts in greater depth, and/or at different scales. Moving from this vulnerability assessment into planning for action, CCHS and actors across the county will have new openings to support the health of residents today while preparing for the changes that climate change will bring.

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