

Climate Change and Health Profile Report Solano County



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MESSAGE FROM CALIFORNIA DEPARTMENT OF PUBLIC HEALTH DIRECTOR DR. KAREN SMITH

I am pleased to present Climate Change and Health Profile reports for each of the counties in California. The reports provide climate change projections for counties, and identify vulnerabilities and assets to support local adaptation planning for climate change. The Climate Change and Health Profile reports are the first in a series of CalBRACE materials being developed by the CDPH Office of Health Equity to foster mobilization to prevent and reduce injury and disease related to climate change.

As we continue building capacity to address climate change we are also aligning CDPH's work with the Governor's Executive Order B-30-15, which specifically addresses the need for climate adaptation and "actions [that] should protect the state's most vulnerable populations." The mission of the Office of Health Equity is to achieve the highest level of health and mental health for all people, with special attention focused on those who have experienced socioeconomic disadvantage and historical injustice. These reports focus resources on planning to protect those most vulnerable to the health impacts of climate change. We are also working with others in California to achieve emissions reduction targets, in order to slow further climate changes. These steps further our goal of becoming the healthiest state in the nation.

Each California county will experience the health impacts of climate change uniquely. The CDPH Office of Health Equity's CalBRACE project provides tools and resources to counties so that they can prioritize and adopt climate change adaptation and preparation strategies that fit their communities and geographies.

Climate change challenges our commitment to achieve equity in health and wellbeing in California, as it deepens the need to take actions that reduce vulnerabilities and increase resilience to climate change in our communities. Faced with this challenge, we approach climate change planning as an opportunity to improve living conditions and social determinants of health so that we can improve health, equity, and address climate change. These reports are one component of a comprehensive approach to creating healthy equitable communities and building resilience to climate change impacts. I hope that these reports provide you with information you can apply as you join me in this effort to protect our communities from the preventable health impacts of climate change.

Sincerely,



Karen Smith, MD, MPH
CDPH Director and State Public Health Officer

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We also thank the many reviewers from county health departments who provided valuable feedback about local conditions and the challenges and opportunities that exist for them to take action to address health and climate change. The local health departments are the vital link to promote public health prevention and wellness in communities, cities, and neighborhoods.

Our work was informed and enriched by the teams from the staff of the CDC Climate-Ready States and Cities Initiative's program, Building Resilience Against Climate Effects (BRACE), grantee states and cities, collaboratives, and communities of practice.

Cover photo credits

California Fire Siege 2007, California Department of Forestry and Fire Protection (CAL FIRE); Jeff Poskanzer, California King Tides Project - Open Source; and California Division of Occupational Safety and Health (Cal/OSHA)

INTRODUCTION

Through legislation and Governor's Executive Orders, the State of California has mobilized to meet the challenges and opportunities posed by climate change. The overall strategy is embodied in reducing carbon emissions, promoting readiness for climate impacts, and conducting research to provide the best available science to guide our actions. In the course of this work, technical documents, strategies, and planning guidance have been produced by state agencies, including the California Department of Public Health (CDPH).

The *Climate Change and Health Profile Report* seeks to provide a county-level summary of information on current and projected risks from climate change and potential health impacts. This report represents a synthesis of information on climate change and health for California communities based on recently published reports of state agencies and other public data.

We have compiled and edited this wealth of information from technical documents and created a report accessible to public health professionals and their partners in state, regional, and local government, the private sector, and community-based organizations. We also highlight the public health dimensions of climate change along with its environmental impacts.

The content of this report was guided by a cooperative agreement between CDPH and the CDC Climate-Ready States and Cities Initiative's program *Building Resilience Against Climate Effects* (BRACE). The goals of BRACE are

to assist state health departments to build capacity for climate and health adaptation planning. This includes

using the best available climate science to project likely climate impacts, identifying climate-related health risks and populations vulnerable to these impacts, assessing the added burden of disease and injury that climate change may cause, identifying appropriate interventions, planning more resilient communities, and evaluating to improve the planning effort. Communities with economic, environmental, and social disadvantages are likely to bear disproportionate health impacts of climate change.

This *Climate Change and Health Profile Report* is intended to inform, empower, and nurture collaboration that seeks to protect and enhance the health and well-being of all California residents.

This report is part of a suite of tools that is being developed by the California Department of Public Health to support local, regional, and statewide efforts of the public health sector to build healthy, equitable, resilient, and adaptive communities ready to meet the challenges of climate change.

Along with a county-level climate change and health vulnerability assessment and state guidance documents, such as *Preparing California for Extreme Heat: Guidance and Recommendations*, the profile provides a knowledge base for taking informed action to address climate change.

BACKGROUND

What is climate change?



Modern life has entailed the burning of coal, natural gas, petroleum, and other fossil fuels in our power plants, factories, businesses, farms, homes, and cars. Key byproducts of energy production and consumption are carbon dioxide, methane, and other pollutants. These gases are called greenhouse or heat trapping gases because as they mix in the atmosphere, they create a barrier that stops heat produced by the sun from escaping the Earth's surface.

The changing climate is evident from observations of increased global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level rise.¹ The average carbon dioxide concentration in the atmosphere topped 400 parts per

million (ppm) in 2013, which far exceeds the range experienced over the last 650,000 years.^{1,2}

An overwhelming consensus of scientists now warns that climate change is due to human activities. This consensus extends to warning that if we do not curb our current carbon emissions, the increase in the planet's temperature will cause significant harm to natural systems and threaten our health and very existence.¹

Efforts to reduce carbon emissions, called mitigation, are imperative. Because of the longevity of atmospheric carbon dioxide, the increased levels already present will continue to cause climate impacts such as sea level rise and atmospheric warming that cannot be reversed.³ Adaptation is the term used to describe the measures we take to prepare for and respond to these inevitable climate changes.

An overwhelming consensus of scientists now warns that this climate change is due to human activities.

How does climate change impact climate and weather?

Changes in atmospheric and ocean temperatures affect the general behavior of Earth's water, including how the atmosphere holds water vapor as it warms. Along with



temperature, the timing, amount, and the manner in which the water circulates (i.e., the hydrologic cycle) or covers the Earth are all part of what defines our climate and weather.

Weather can be thought of as the short-term variability of local daily temperature, precipitation (i.e., rain, snow), wind, and events like storms (hurricanes, tornados, etc.) throughout a year. Climate can be thought of as the general pattern on a larger geographic area and time scale, usually in the span of decades.

California is unique in the United States and has a Mediterranean type of climate with a distinct dry season (May to October) and wet season (November to April)

which is modified by proximity to the coast or mountains and variable elevation.

The future amount of carbon emitted into the Earth's atmosphere has two broad drivers:

- the dependence of economic growth on fossil fuels, and
- the growth of the world's population.^{1,4}

Based on the different combinations of economic development strategies and population growth, scientists have constructed formal scenarios⁴ of future carbon emissions during the 21st century and predicted the associated climate impacts compared to a 1990 baseline.⁴ In an optimistic scenario, in which world economies become much less dependent on fossil fuels and the world population levels off after 2050¹, the average global temperature is predicted to increase by 1.8°C (3.2° F).

In a pessimistic scenario, in which we continue to emit greenhouse gases on the same current trajectory, climate models predict a 3.4° C (6.1° F) increase. This scenario is based on the assumption that the world continues its path of fossil fuel-intensive economic development and that the world population increases during the 21st century.

On the backdrop of gradually increasing temperatures and sea levels, these climate models also predict an increase in the frequency and intensity of extreme weather events such as hurricanes, floods, and droughts.¹ More information about climate models is described in Appendix 1.

WHAT ARE THE CLIMATE PROJECTIONS FOR THE BAY AREA REGION?

The impact of climate change in California varies across the state due to diversity in biophysical setting, climate, and jurisdictional characteristics. The California Adaptation Planning Guide organized the state into climate impact regions based on county boundaries in combination with projected climate impacts, existing environmental settings, socioeconomic factors, and regional designations and organizations.⁵ Figure 1 is a map of climate impact regions.

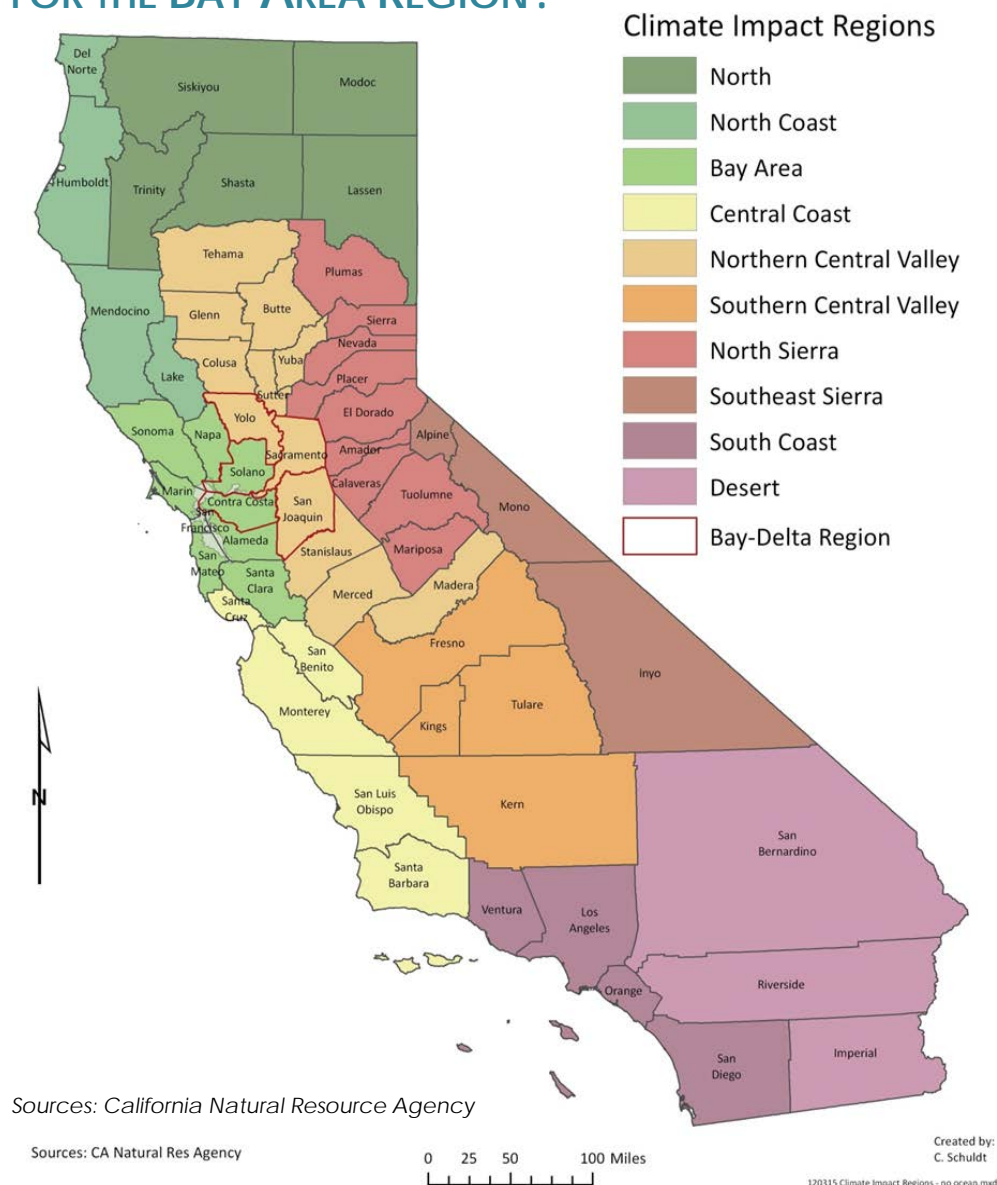


Figure 1. California Climate Impact Regions designated in the *California Climate Adaptation Planning Guide*⁵

Table 1 summarizes Cal-Adapt projections for the Bay Area Region and is intended to identify the major types of changes projected for the region. Regional projections may differ from county level projections.

Table 1. Summary of Cal-Adapt Climate Projections for the Bay Area Region⁵

RANGES	
Temperature Change, 1990-2100	January: Increase in average temperature of 2°F by 2050 and up to 5°F. July: Increase in average temperature of 4°F by 2050 and up to more than 6°F by 2100. <i>(Modeled high temperatures – average of all models; high carbon emissions scenario)</i>
Precipitation	Precipitation varies widely in this region, with annual totals over 40 inches in northern Sonoma County to roughly 15 inches in the eastern portions of Solano and Contra Costa counties. A moderate decline in annual rainfall, 1 to 3 inches by 2050 and 4 to 5 inches by 2090, is projected throughout the region. <i>(CCSM3 climate model; high carbon emissions scenario)</i>
Sea Level Rise	By 2100, sea levels may rise up to 66 inches, posing considerable threats to coastal areas and particularly to low-lying areas adjacent to San Francisco bay. The number of acres vulnerable to flooding is expected to increase 20 to 30 percent in most parts of the Bay Area, with some areas projected for increases over 40 percent. Coastal areas are estimated to experience an increase of approximately 15 percent in the acreage.
Heat Wave	Along the coast, particularly to the south, heat wave is defined as five days over 72°F to 77°F; in other areas the threshold is in the mid- to upper 90s. Over most of the region, a limited increase in the number of heat waves is expected by 2050, with only the eastern areas expecting more than one or two more per year. By 2100, between six and 10 more heat waves can be expected per year.
Fire Risk	There is little change in projected fire risk in this region, save for the slight increases expected in western Marin County. <i>(GFDL model, high carbon emissions scenario)</i>

Source: Public Interest Energy Research, 2011. Cal-Adapt⁶; OPC 2013. State of California Sea-level Rise Guidance Document⁷

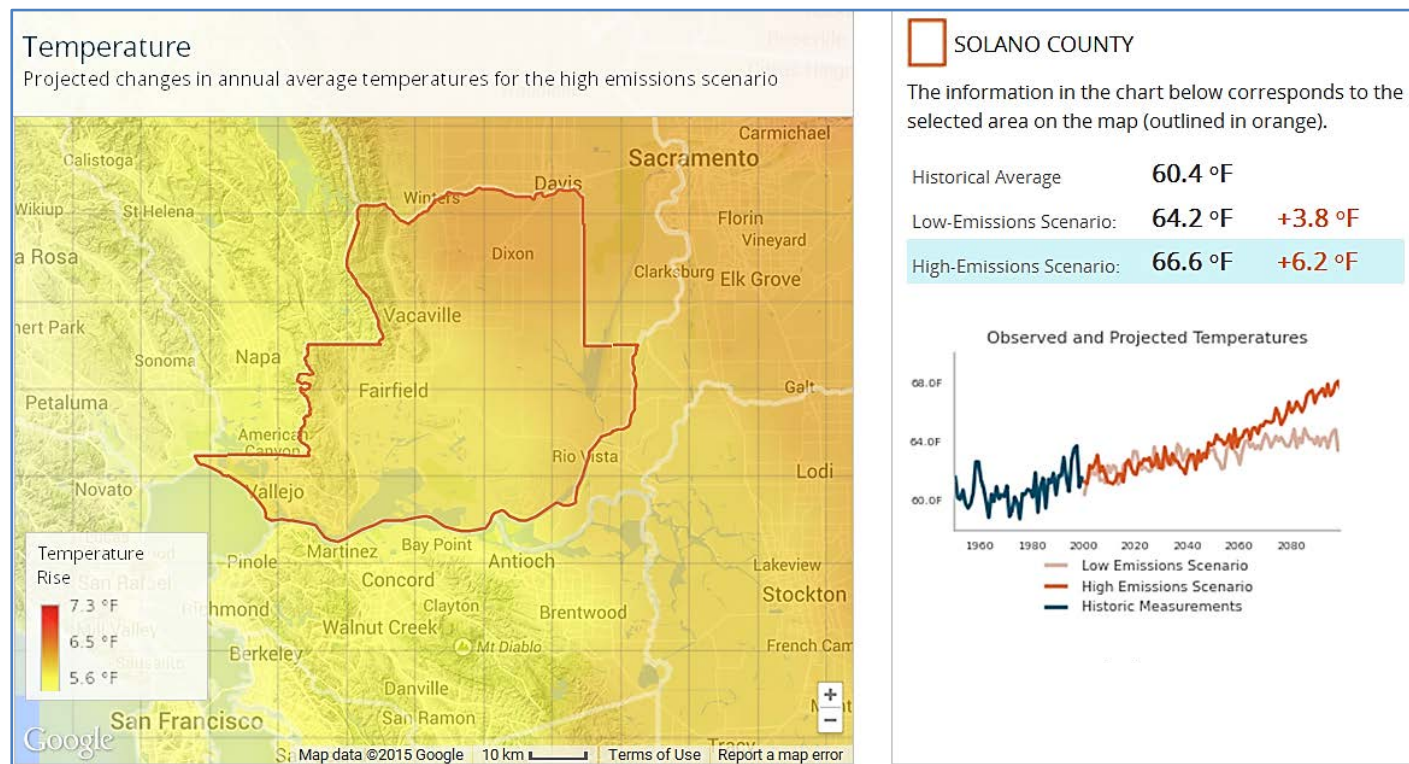
WHAT ARE THE CLIMATE PROJECTIONS FOR SOLANO COUNTY?

Projected Temperature Changes in Solano County

Overall, temperatures are expected to rise substantially throughout this century. During the next few decades, scenarios project average temperature to rise between 1°F and 2.3°F in California.⁶ The projected temperature increases begin to diverge at mid-century so that, by the

end of the century, the temperature increases projected in the higher emissions scenario are approximately twice as high as those projected in the lower emissions scenario. Figure 2 shows the projected temperature changes in 2099 scenarios for Solano County.⁶

Figure 2. Projected changes in annual average temperature in future carbon emissions scenarios, Solano County, 2099⁶



Current Fire Hazard Severity Zones in Solano County

While all of California is subject to some degree of fire hazard, there are specific features that make some areas more hazardous.⁸ Figure 3 visualizes current fire hazard severity zones in Solano County.

Fire Hazard Severity Zones (FHSZ) were developed using a computer model.⁸ They predict the physical damage a fire is likely to cause based on the factors that influence fire likelihood and behavior.⁸ Many factors are considered such as fire history, existing and potential fuel (natural vegetation), flame length, blowing embers, terrain, and typical weather for the area.^{8,9}

Fire Hazard Severity Zones are categorized into three categories:

- **Moderate**

Wildland areas supporting areas of typically low fire frequency and relatively modest fire behavior, or developed/urbanized areas with a very high density of non-burnable surfaces (including roadways, irrigated lawn/parks, and low total vegetation cover (<30%) that is highly fragmented and low in flammability).⁹

- **High**

Wildland areas supporting medium- to high-hazard fire behavior and roughly average burn probabilities, or developed/urbanized areas with moderate vegetation cover and more limited non-burnable cover. Vegetation cover typically ranges from 30-50% and is only partially fragmented.⁹

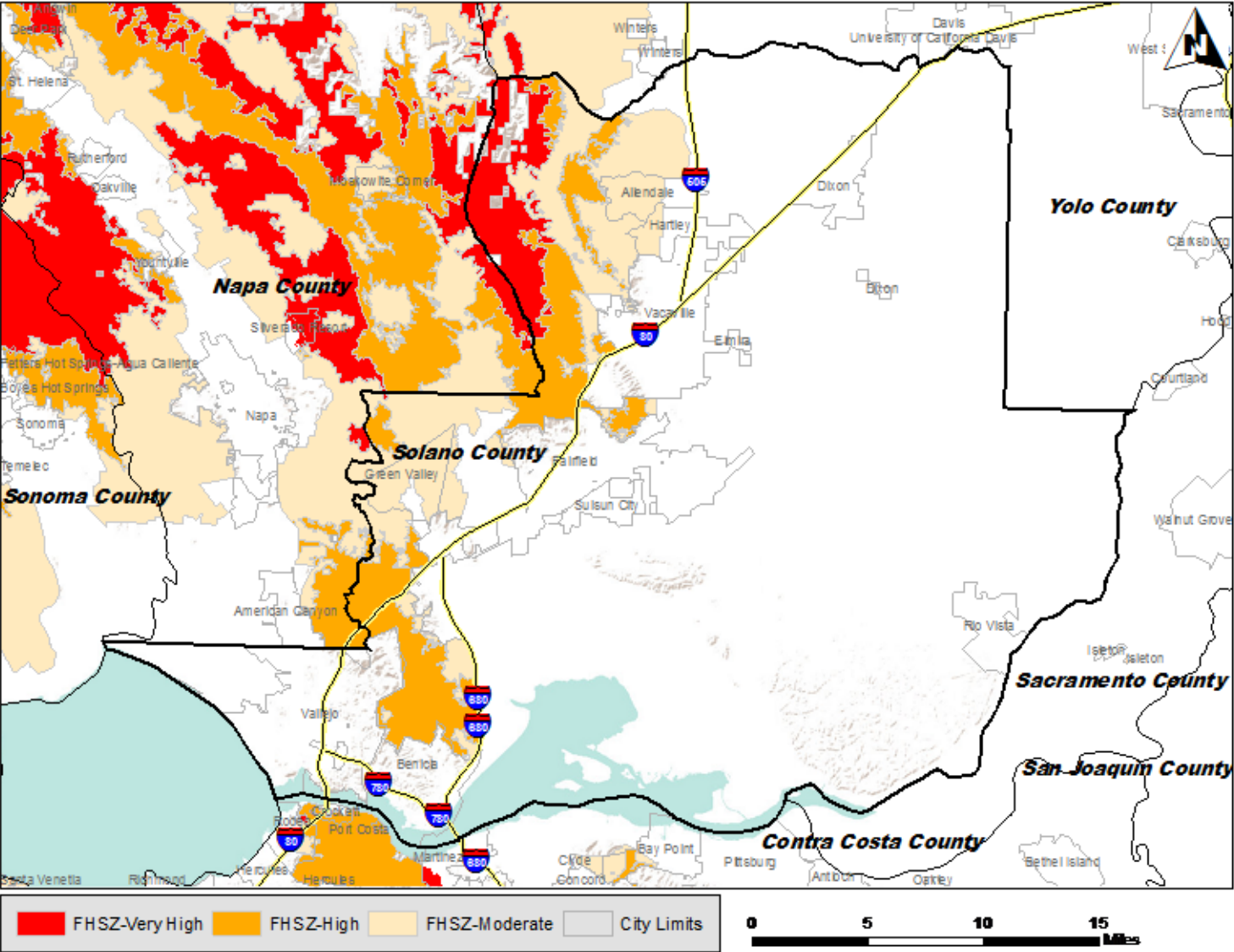
- **Very High**

Wildland areas supporting high to extreme fire behavior resulting from climax fuels typified by well-developed surface-fuel profiles (e.g., mature chaparral) or forested systems where crown fire is likely, or developed/urban areas typically with high vegetation density (>70% cover) and associated high fuel continuity. This allows for flames to spread over much of the area impeded only by isolated non-burnable areas.⁹

The FHSZ rating system is more completely described at http://frap.fire.ca.gov/projects/hazard/fhsz_review_instructionsv1_3b.pdf.

Figure 3. Current Fire Hazard Severity Zones (FHSZ), Solano County, 2007⁹

Note: Map includes only state and local responsibility areas.



Projected Wildfire Acreage in Solano County

Periodic natural fire is an important ecosystem disturbance. Uncontrolled wildfires, however, can be extremely damaging to communities and ecosystems. Fire can promote vegetation and wildlife diversity, release nutrients into the soil, and eliminate heavy accumulation of underbrush that can fuel catastrophic fires.

The map below (Figure 4) displays the projected increase or decrease in potential area burned based on projections of the Coupled Global Climate Model (version 3) for the high carbon emissions scenario in 2085.⁶ The bar graphs to the right of the map in Figure 4 illustrate

the projected time trend over the 21st century for both the high and low emissions scenarios. Please note that these data are modeled solely on climate projections and do not take landscape and fuel sources into account. The projections of acreage burned are expressed in terms of the relative increase or decrease (greater or less than 1) from a 2010 baseline for fires that consume at least 490 acres. The 2010 baseline reflects historic data from 1980-1989 and trends through 2010. Data on the number of fires and the acreage burned are described later in this report.

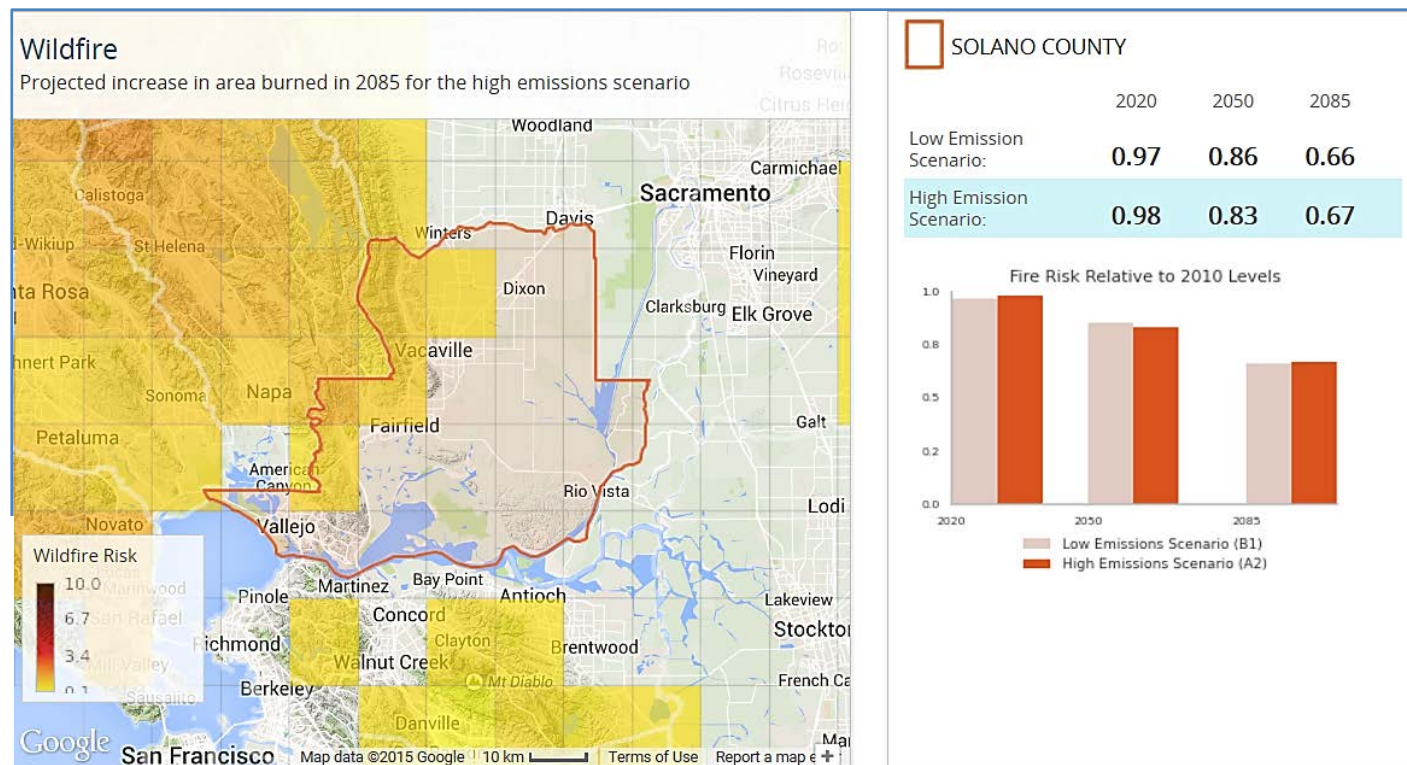


Figure 4. Relative increase in wildfire acreage in future carbon emission scenarios, Solano County^{6A}

Projected Sea Level Rise in Solano County

California's coastline, which includes more than 2,000 miles of open coast and enclosed bays, is vulnerable to a range of natural hazards, including storms, extreme high tides, and rising sea levels.⁶

Sea level rise increases the threat of coastal flooding.¹⁰ Climate change models indicate that California may see up to a 66 inch (167 cm) rise in sea level within this century.⁷

The map in Figure 5 displays areas that may be inundated during an extreme flood event known as a 100-year flood.¹¹ The 100-year flood is used as a standard for planning, insurance, and environmental regulations. The 100-year flood means that, in any given year, there is a 1% chance a flood risk area will be flooded. "100-year flood"

is a technical term and does not imply that floods of this magnitude can only occur once every hundred years.

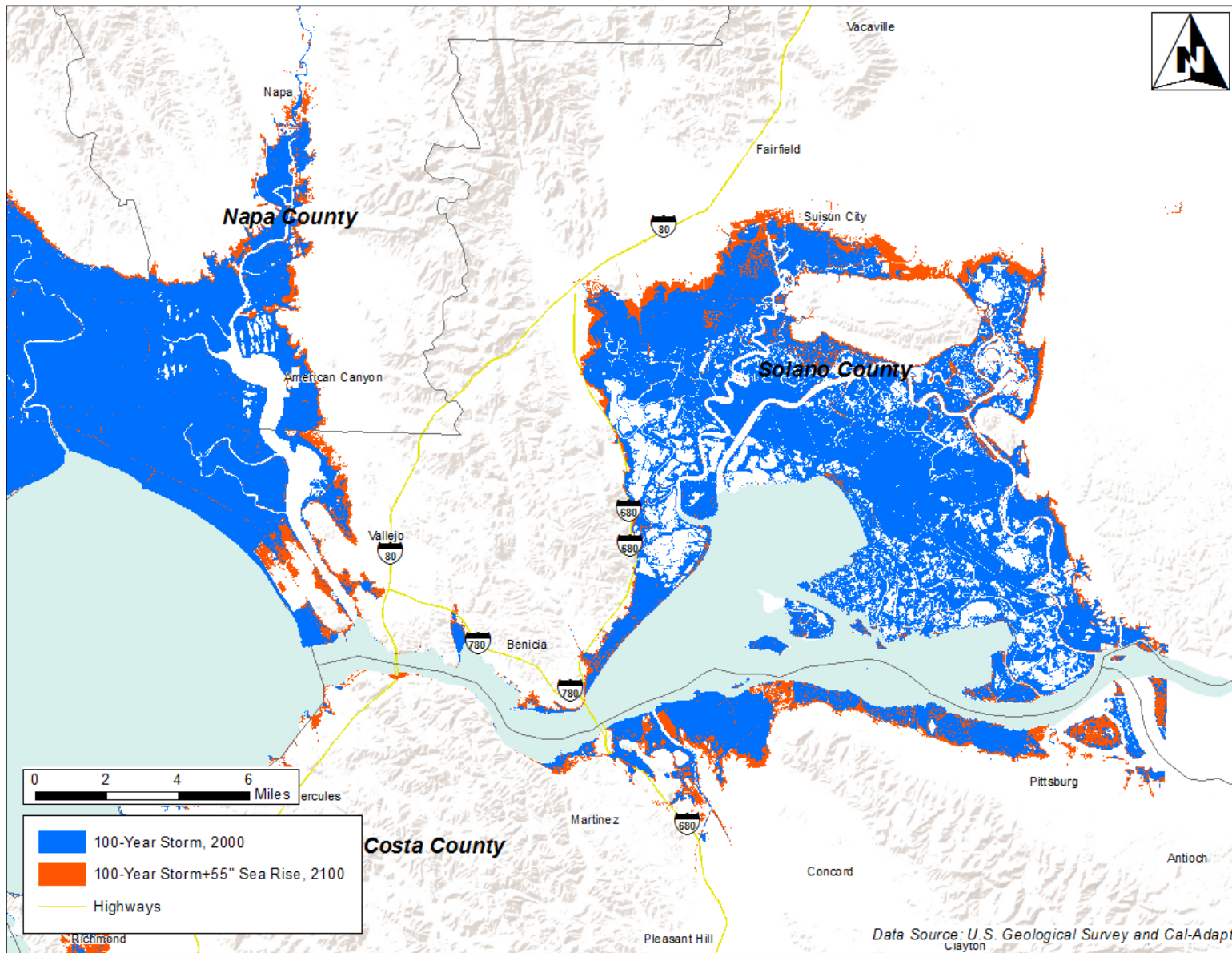
The blue color indicates areas already threatened today.¹¹ The red color represents the area projected to be threatened for a 55-inch sea level rise, which is consistent with a high carbon emissions scenario.¹¹ The map does not take into account protective structures, such as levees, or the effects of wind and waves.¹¹

For in depth planning and estimating risks from sea level rise, the California Ocean Protection Council highly recommends integrating shoreline changes, bathtub effect, and 100-year storm flood. The *State Sea Level Rise Policy Guidance* Document is being updated in 2017.

Resources

- California Ocean Protection Council 2013; State of California Sea-level Rise Guidance Document
http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf
- For more in depth resources for county-specific values for acres vulnerable to flooding please see:
Sea Level Rise and Coastal Flood Web Tools Comparison Matrix: California
<http://sealevel.climatecentral.org/matrix/CA.html>

Figure 5. Baseline inundation areas for a 100-year flood (2000) and modeled scenario with additional 55 inches of sea level rise (2100), Solano County⁶ Note: Current SLR projections are 66 inches above sea level.⁷



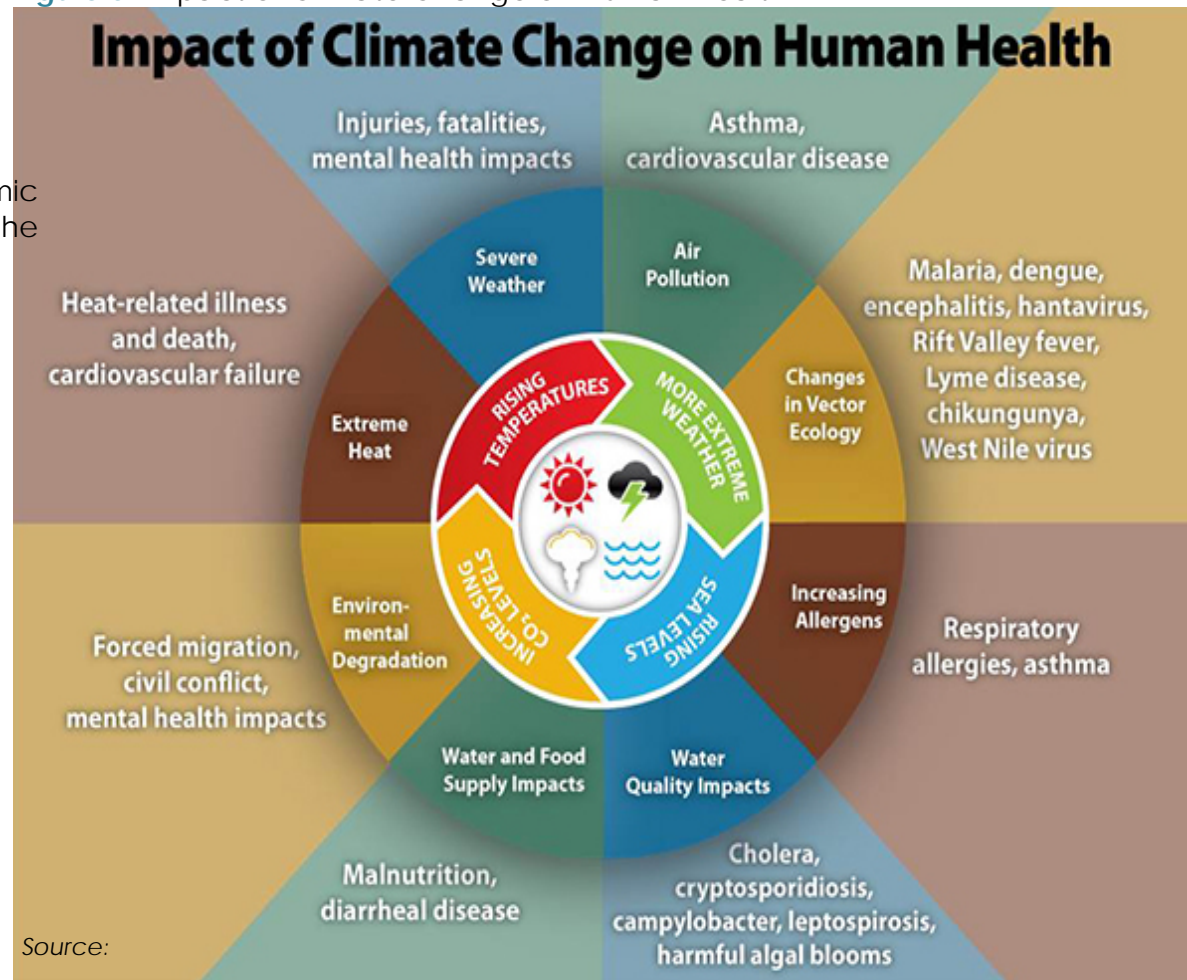
OVERVIEW OF CLIMATE CHANGE AND HEALTH IMPACTS

Researchers have examined the pathways in which increased temperatures and hydrologic extremes can impact health and generally recognize three main pathways: direct exposures, indirect exposures, and socioeconomic disruption (Figure 6).¹² Based on the review of weather-related natural disasters and historical patterns^{13,14} and scientific judgment, public health researchers have suggested the nature and direction of health harms or benefits.^{12,15}

Extreme Weather-Related Injury, Displacement, and Mental Health

Extreme weather events (storms, flooding) cause fatal and nonfatal injuries from drowning, being struck by objects, fire, explosions, electrocution, or exposure to toxic materials. A widespread weather-related natural disaster may destroy or ruin housing, schools and businesses and cause temporary or permanent displacement. Individuals and families may experience post-traumatic stress, depression, and increased risk of suicide.^{16,17}

Figure 6. Impact of Climate Change on Human Health



Health Impacts of Heat

Increased temperatures manifested as heat waves and sustained high heat days directly harm human health through heat-related illnesses (mild heat stress to fatal heat stroke) and the exacerbation of pre-existing conditions in the medically fragile, chronically ill, and vulnerable.^{18,19} Increased heat also intensifies the photochemical reactions that produce smog and ground level ozone and fine particulates (PM_{2.5}), which contribute to and exacerbate respiratory disease in children and adults. Increased heat and carbon dioxide enhance the growth of plants that produce pollen, which are associated with allergies. Increased temperatures add to the heat load of buildings in urban areas and exacerbate existing urban heat islands adding to the risk of high ambient temperatures.

Health Impacts of Drought

Lack of moisture, already at a severe level in California due to a current multi-year drought and decades of fuel accumulation from historical forestry and fire suppression practices, increases the risk of wildfires.²⁰ Devastating wildfires like the Rim Fire of 2013 impact watersheds and increase the risk of landslides or mudslides, and sediment in run-off that reduce water quality. In addition to fire-related injuries, local and regional transport of smoke, ash, and fine particles increases respiratory and cardiovascular risks.

Increasing temperatures and changes in precipitation may lead to intensified drought conditions.²¹ Drought decreases the availability and quality of water for humans. This includes reduced water levels to fight

wildfires. Drought may increase exposure to health hazards including wildfires, dust storms, extreme heat events, flash flooding, degraded water quality, and reduced water quantity.²² Dust storms associated with drought conditions have been associated with increased incidents of Valley fever, a fungal pathogen.²²

Vector-borne Illnesses

Climatic changes alter the range, biogeography, and growth of microbes and the vectors of food, water, and vector-borne illnesses.²² This includes the changes in aquatic environments that could increase harmful algal blooms and lead to increases in foodborne and waterborne illnesses.²¹

Food Insecurity

Climate change is expected to have global impacts on food production and distribution systems.²² This can cause food prices to increase, which makes food less affordable and increases food insecurity, obesity, and malnutrition in economically constrained households.²²

Sea Level Rise, Mold, and Indoor Air Quality

Through sea level rise, salt water may intrude into coastal aquifers thus reducing quality and quantity of water supply. Coastal erosion can contribute to the loss of recreational venues and pose a variety of hazards to infrastructure and public safety. Water intrusion into buildings can result in mold contamination leading to indoor air quality problems.²²

Socioeconomic Disruption

Widespread social and economic disruption includes damage to the infrastructure for the delivery of health services and for general economic well-being. Health care facilities, water treatment plants, and roads for emergency responders and transportation for health care personnel can be damaged in climate-related extreme weather events. Increased burden of disease and injury will test the surge capacity of health care facilities. Economic disruption can lead to income loss, income insecurity, food insecurity, housing insecurity, and mental health problems, which in turn may increase substance abuse, suicide,^{23,24} and other health problems.

Energy production and distribution is also threatened by heat and wildfires through loss of efficiency, generating capacity, and fires disrupting transmission lines. California's ports that provide the gateway to goods for California, national, and international markets are at risk from sea level rise and coastal storms.

WHICH POPULATION SUBGROUPS ARE PARTICULARLY VULNERABLE?

All Californians are vulnerable to the health impacts of climate change. Even if one is fortunate to live, work, study, or play in a place without direct contact with wildfires, flooding, or sea level rise, no one can entirely avoid excessive heat or the indirect effects of extreme weather events. The table in Appendix 2 summarizes the populations more vulnerable to the health impacts of climate change.

Based on medical reviews of individuals who died during heat waves and other extreme weather events, those who are particularly vulnerable to the direct effects of climate change include the very old and very young, individuals who have chronic medical conditions and psychiatric illness, people taking multiple medications, people without means for evacuation (no access to public transit or private cars), people who are socially isolated, medically fragile people, and people living in institutions.¹⁷ Acclimatization to heat may help reduce risks from heat waves in the healthy general population, but may not be sufficient to protect those with underlying medical conditions.

A much larger part of the population is vulnerable to intermediate or socioeconomic factors such as preexisting physical and mental health conditions, cultural or physical isolation, occupations involving outside or high risk work, a precarious socioeconomic status, or lack of social cohesion and collective efficacy. Collective efficacy and local community cohesion may be associated with effective action to plan and coordinate responses to climate threats.²⁰

The underlying burden of disease and injury accounted for by the social determinants of health²⁵ considers the economic, service, and built environments in which people live, work, learn, and play.²⁶ Climate change magnifies existing health disparities. Disadvantaged populations, such as those with low education, experiencing racial segregation, low social support, poverty, and income inequality face disproportionate climate-related health burden.²⁷

Community resilience refers to actions taken by individuals, neighborhoods, organizations, and multiple sectors of government to resist and overcome obstacles and to promptly recover from climate threats. In the short term, this may include traditional elements of public health preparedness and community development. However, in the long term, this may include actions to broadly promote population health and decrease the number of people with physical and mental conditions rooted in the social determinants of health.

Health inequities based on race/ethnicity, income, geography (urban/rural) are widespread today in California.²⁶ Even without climate change, demographic changes already underway will increase the size of vulnerable populations in California in the coming decades. The population is aging and the share of individuals aged 65 or more years will increase from 13 percent in 2010 to 19 percent in 2050.²⁸ In many California communities, racial and ethnic minorities constitute the majority of residents.

WHAT ARE THE HEALTH STATUS, HEALTH INEQUITIES, AND POPULATION VULNERABILITIES IN SOLANO COUNTY?

Climate change impacts the health and well-being of Californians. Estimates for health status, health inequities, and population vulnerabilities are summarized in Figures 7 and 8.

There is a broad range of environmental hazards attributed to climate change including heat waves, wildfires and wildfire smoke, air pollution, sea level rise and inland flooding.

All Californians are at risk from extreme heat. In 2010, approximately 1% (6,114 residents) of the county's population lived in fire hazard zones of moderate to very high severity. From 1980 to 1989 (a pre-climate change baseline), 24 wildfires at least 490 acres in size consumed a total of 112,892 acres in the Bay Area Region.

In addition to heat and wildfire, the county is at risk of hazards posed by sea level rise and coastal flooding. In 2010, approximately 3,593 residents lived on coastal blocks that were at risk of inundation from a 100-year flood. With an additional 55 inches of sea level rise, which is toward the upper end of projections for the year 2100, the inundation zone would potentially include 16,636 residents. This is likely an underestimate as more recent climate change models indicate that California may see up to a 66 inch (167 cm) rise in sea level within this century.¹⁰

Climate change affects the social and environmental drivers of health outcomes. The effects of climate change can exacerbate existing health conditions and

compound the risks of adverse health outcomes. The age-adjusted death rate, which takes into account the effect of the population's age distribution, is a basic indicator of the health status of communities.

In 2010, the age-adjusted death rate in Solano County was higher than the state average. Disparities in death rates among race/ethnicity groups highlight how certain populations disproportionately experience health impacts. Within the county, the highest death rate occurred among Pacific Islanders and the lowest death rate occurred among Hispanics/Latinos.

In 2012, nearly 52% of adults (159,093) reported one or more chronic health conditions including heart disease, diabetes, asthma, severe mental stress or high blood pressure. In 2012, 23% of adults reported having been diagnosed with asthma. In 2012 approximately 36% of adults were obese (statewide average was 25%). In 2012, nearly 11% of residents aged 5 years and older had a mental or physical disability (statewide average was 10%).

In 2005-2010, there was an annual average of 43 heat-related emergency room visits and an age-adjusted rate of 10 emergency room visits per 100,000 persons (the statewide age-adjusted rate was 10 emergency room visits per 100,000 persons).

Among climate-vulnerable groups in 2010 were 26,852 children under the age of 5 years and 46,847 adults aged 65 years and older. In 2010, there were

approximately 11,544 people living in nursing homes, dormitories, and other group quarters where institutional authorities would need to provide transportation in the event of emergencies.

Social and demographic factors and inequities affect individual and community vulnerability to the health impacts of climate change. In 2010, 6% of households (8,261) did not have a household member 14 years or older who spoke English proficiently (called linguistically isolated; statewide average was 10%). In 2010, approximately 14% of adults aged 25 years and older had less than a high school education (statewide average was 19%).

In 2010, 10% of the population had incomes below the poverty level (the statewide average was 14%). Twenty percent of households paid 50% or more of their annual income on rent or a home mortgage (statewide average was 22%). In 2012, approximately 53,000 (56%) of low-income residents reported they did not have reliable access to a sufficient amount of affordable, nutritious food (called food insecurity; statewide average was 42%).

In 2010, Solano County had approximately 13,135 outdoor workers whose occupation increased their risk of heat illness. In 2010, roughly five percent of households did not own a vehicle that could be used for evacuation (statewide average was 8%). In 2012, approximately 79% of residents did not live within a half mile to frequent public transit. In 2009, approximately 18% of households were estimated to lack air conditioning, a strategy to counter adverse effects of heat (statewide average was 36%). In 2011, tree canopy, which provides shade and

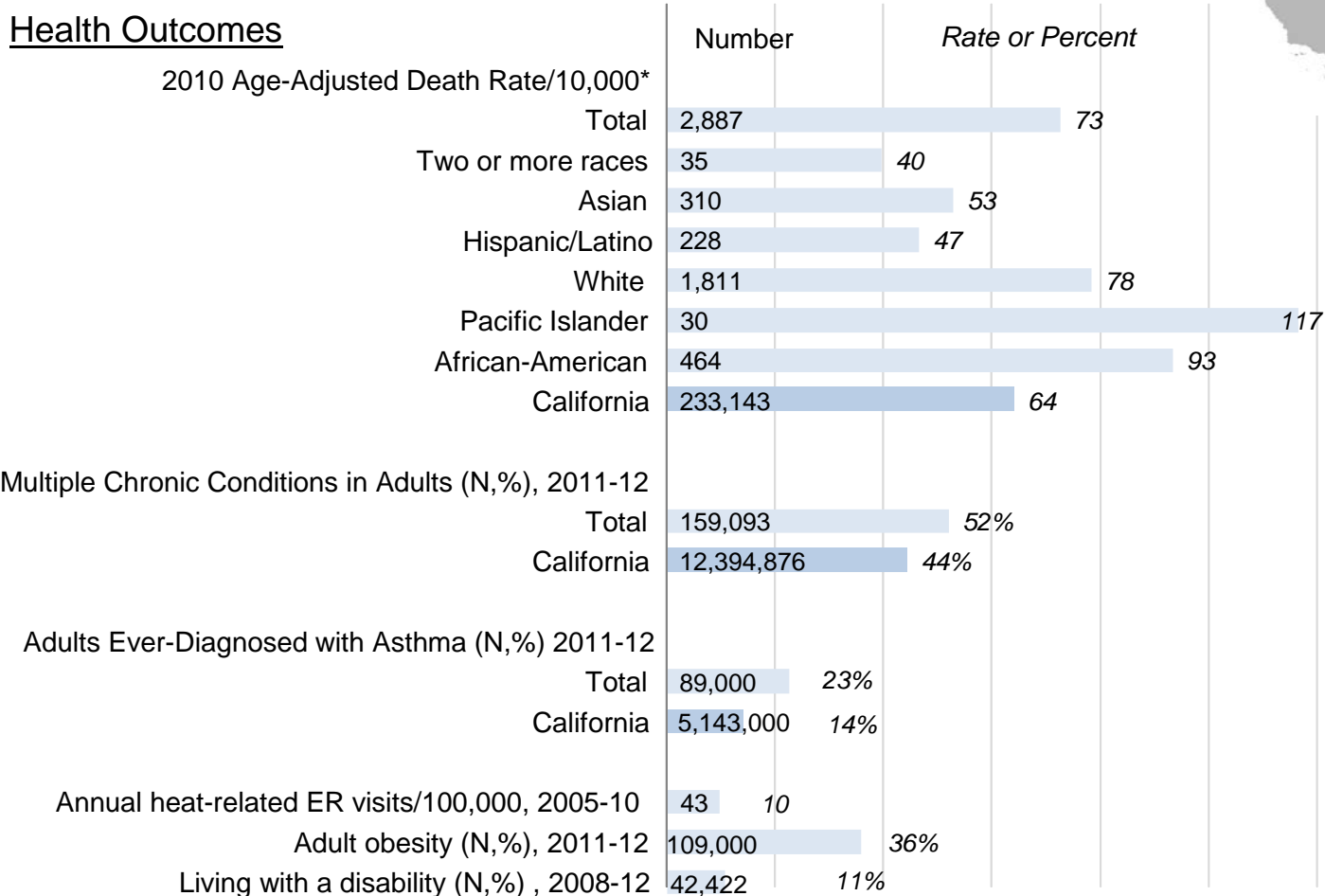
other environmental benefits, was present on 9% of the county's land area (statewide average was 8%).

Social capital is embedded in social relationships and networks and refers to the existence of trust and mutual aid among the members of society.^{29,30} These relationships are important in building resilience when confronted with extreme climates.³⁰ There is evidence that populations with higher levels of political participation also have greater social capital.^{31,32} Sixty-one percent of registered voters voted in the 2010 general election (statewide average was 58%).

Natural disasters worsened by climate change increase the displacement of victims, which in turn increase population densities and tensions over resources.^{33,34} Violent crime also increases during heat events.³⁵ Safe neighborhoods that are free of crime and violence are an integral component of healthy neighborhoods and community resilience. In 2010, Solano County experienced approximately 5 violent crimes per 1,000 residents (statewide rate was 4 per 1,000 residents).

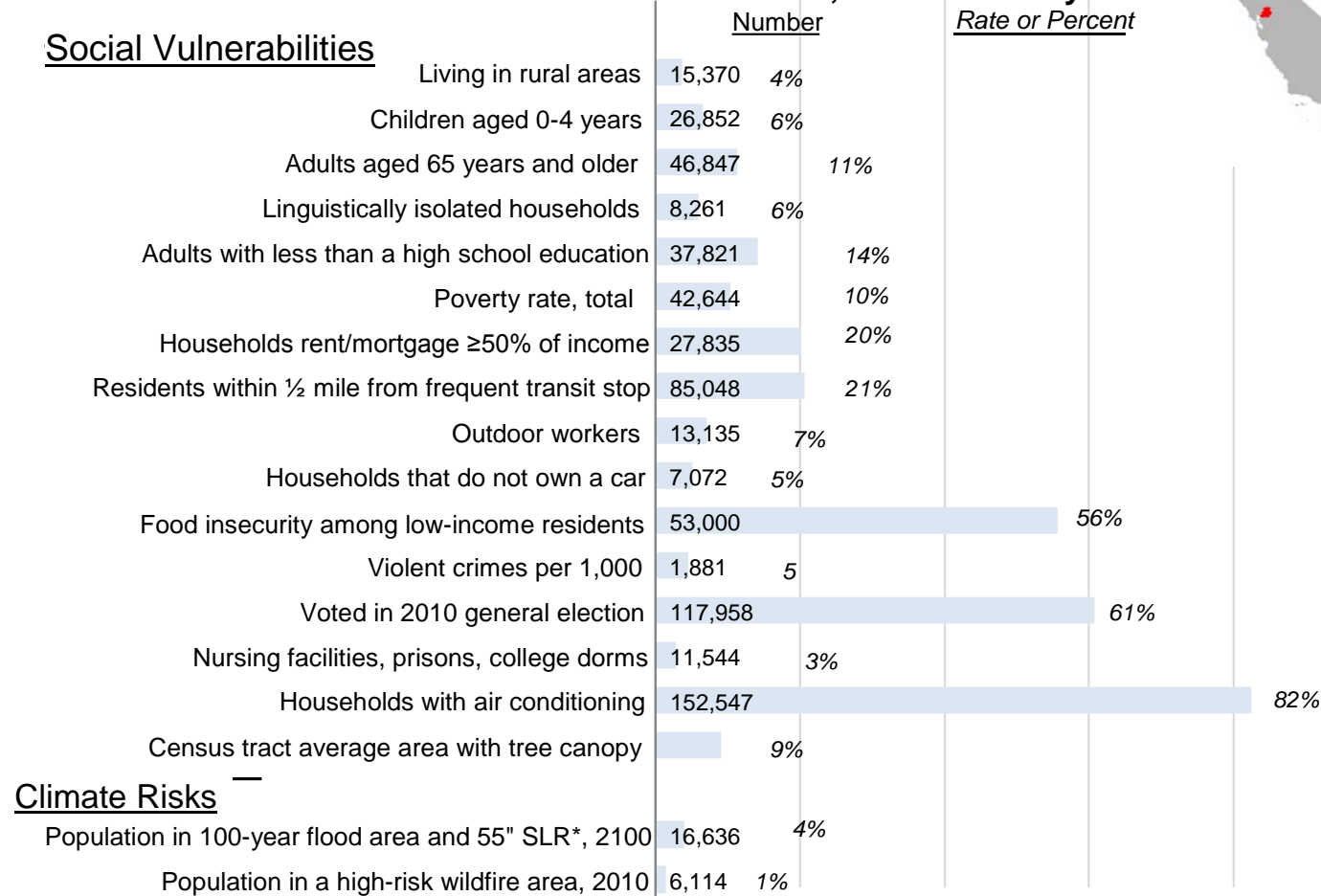
These findings highlight specific populations that are most susceptible to health risks, as well as the social determinants of health and adaptive capacity that contributes to resilience or conversely intensifies the impacts from climate change.

Figure 7. Profile of Health Outcomes and Inequities, Social Vulnerabilities and Climate Risks, Solano County



* Groups with less than 20 observations are not presented

Figure 8. Profile of Health Outcomes and Inequities, Social Vulnerabilities and Climate Risks, Solano County



*Current sea level rise (SLR) projections are up to 66 inches by 2100.⁷

Data sources for indicators in Figures 7 and 8 are described in Appendix 3.

SELECTED PUBLIC HEALTH STRATEGIES AND ACTIONS FOR ADAPTING TO CLIMATE CHANGE

Findings from this report describe climate risks in Solano County and highlight certain populations who are most susceptible to health risks from current and future climate change exposures. Some of the changes due to climate change will occur over the long term, but broad shifts in our weather can be seen now and will result in many direct and indirect health risks.

Coping with a changing climate presents opportunities for local health departments and partners to consider policies, actions, and infrastructure design that will not just protect the public from climate change threats, but also establish health equity, resiliency, and sustainability. A critical step for building resilience is to improve capacity of communities to prepare, respond, and recover from

climate-related health risks. Steps need to be taken to ensure that the most vulnerable populations have access to information, services, and resources to prepare and respond to climate risks.

The goal of public health adaptation strategies is to minimize the negative health impacts of climate change. A selection of the near-term and long-term strategies and actions steps for adapting to climate change are outlined in Table 2. These include community education and engagement, public health workforce development, identification of co-benefits, bolstering existing functions of public health preparedness and surveillance, multi-sectorial partnership building, and research.

Table 2. Selected public health strategies and action steps for adapting to climate change³⁶

STRATEGIES	NEAR-TERM ACTIONS	LONG-TERM TERM ACTIONS
1. Promote community resilience to climate change to reduce vulnerability	<ul style="list-style-type: none"> • Promote healthy, built environments • Identify and reduce health vulnerabilities • Improve food security and quality 	<ul style="list-style-type: none"> • Promote food sustainability • Reduce heat islands • Support social and community engagement • Promote increased access to health care
2. Educate, empower and engage California residents, organizations and businesses to reduce vulnerability through mitigation and adaptation	<ul style="list-style-type: none"> • Educational outreach campaign tying into existing efforts • Specific outreach to vulnerable populations 	<ul style="list-style-type: none"> • Proactive social marketing campaign

3. Identify and promote mitigation and adaptation strategies with public health co-benefits	<ul style="list-style-type: none"> • Identify and prioritize strategies with public health co-benefits 	
4. Establish, improve and maintain mechanisms for robust rapid surveillance of environmental conditions, climate-related illness, vulnerabilities, protective factors and adaptive capacities	<ul style="list-style-type: none"> • Monitor outcomes (state and local) • Develop existing environmental contaminant biomonitoring • Maintain and upgrade water accessibility information • Improve heat warning systems 	<ul style="list-style-type: none"> • Convert to electronic surveillance systems to improve disease reporting, management and surveillance
5. Improve and sustain public health preparedness and emergency response	<ul style="list-style-type: none"> • CDPH and local health departments should refine existing preparedness plans and conduct exercises 	
6. Work in multi-sectoral partnerships (local, regional, state and federal)	<ul style="list-style-type: none"> • Expand training and education to build collaborative capacity 	
7. Conduct applied research to enable enhanced promotion and protection of human health	<ul style="list-style-type: none"> • Vulnerability assessments • Research collaboration • Assess local impacts on health 	
8. Implement policy changes at local, regional and national levels	<ul style="list-style-type: none"> • Policy collaboration with stakeholders • Occupational safety standards 	<ul style="list-style-type: none"> • Model policies and training • Public engagement
9. Identify, develop and maintain adequate funding for implementation of public health adaptation strategy	<ul style="list-style-type: none"> • Identify and develop funding mechanisms 	<ul style="list-style-type: none"> • Develop funding mechanisms/AB32 for education and research

Source: California Natural Resources Agency³⁶ (http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf)

RESOURCES

This report brought together recently published, technical information from state-sponsored research and planning documents, including:

- California Climate Change Adaptation Planning Guide, 2012
http://resources.ca.gov/climate/safeguarding/adaptation_policy_guide/
- Safeguarding California: Reducing Climate Risk, 2014
http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf
- California Climate Adaptation Strategy, 2009
http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf
- Cal-Adapt: Exploring California's Climate Change Research
<http://cal-adapt.org/>
- Preparing California for Extreme Heat: Guidance and Recommendations
http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf

For more information and resources for climate change adaptation and public health planning, please visit:

- CDPH CalBRACE web page
<http://www.cdph.ca.gov/programs/Pages/CalBRACE.aspx>
- CDPH Climate Change and Health Team web page
<https://www.cdph.ca.gov/programs/Pages/ClimateChange.aspx>
- CDC BRACE web page
<http://www.cdc.gov/climateandhealth/default.htm>
- The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment 2016
<https://health2016.globalchange.gov/>
- Urban Heat Island Index for California
<http://calepa.ca.gov/UrbanHeat/Maps/default.htm>

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APPENDIX 1: HOW ARE FUTURE CHANGES IN CLIMATE PREDICTED?

Scientists use historical weather data and mathematical models to describe historical trends and to predict the impacts of global warming.³ Historical data show that on average sea levels are already rising, primarily from the expansion of water.¹ Historical data also show that in the past century average temperatures are increasing, polar ice and glaciers are melting at increased rates, and snow pack in mountains is diminishing compared to time periods in which human-generated carbon emissions were relatively small.¹

Climate models are computer simulation over time of the Earth's atmosphere and oceans taking into account solar radiation, surface reflection, circulating air masses and wind, heat stored in oceans, sea ice, evaporation from land surfaces and green plants, cloud cover, and other factors. A key input to climate projection models is the current and projected amount of carbon dioxide and other greenhouse gases emitted into the atmosphere.

The future amount of carbon emitted into the Earth's atmosphere has two broad drivers:

- the dependence of economic growth on fossil fuels, and
- the growth of the world's population.

Based on the different combinations of economic development strategies and population growth, scientists have constructed formal scenarios⁴ of future carbon emissions during the 21st century and predicted their associated climate impacts compared to a 1990 baseline.⁶

The average global temperature is predicted to increase by 1.8°C (3.2° F) for an optimistic scenario called B1 in which world economies become much less dependent on fossil fuels and the world population levels off after 2050.¹ In a pessimistic scenario called A2, climate models predict a 3.4° C (6.1° F) increase, based on the assumption that the world continues its path of fossil fuel intensive economic development and that the world population increases during the 21st century.

On the backdrop of gradually increasing temperatures and sea levels, the climate models also predict an increase in the frequency and intensity of extreme weather events such as hurricanes, floods and droughts¹. Using these global climate models as a starting point, the Scripps Institution of Oceanography at the University of California, San Diego has further refined climate impacts in California to 12 km grids (7 by 7 miles).⁶ This allows California communities to have local data to inform climate adaptation planning.

APPENDIX 2: PUBLIC HEALTH IMPACTS OF CLIMATE CHANGE IN CALIFORNIA

CLIMATE CHANGE EXPOSURES	HEALTH IMPACTS	POPULATIONS MOST AFFECTED
Extreme Heat	<ul style="list-style-type: none"> • Premature death • Cardiovascular stress and failure • Heat-related illnesses such as heat stroke, heat exhaustion, and kidney stones 	<ul style="list-style-type: none"> • Elderly • Children • Diabetics • Low-income • Urban residents • People with respiratory diseases • Agricultural workers • Those active outdoors
Poor Air Quality/ Air Pollution	<ul style="list-style-type: none"> • Increased asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory diseases 	<ul style="list-style-type: none"> • Children • Elderly • People with respiratory diseases • Low income • Those active outdoors
Wildfires	<ul style="list-style-type: none"> • Injuries and death from burns and smoke inhalation • Eye and respiratory illnesses due to air pollution • Exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular and respiratory diseases • Risk from erosion and land slippage after wildfires • Displacement and loss of homes 	<ul style="list-style-type: none"> • People with respiratory diseases

CLIMATE CHANGE EXPOSURES	HEALTH IMPACTS	POPULATIONS MOST AFFECTED
Severe Weather, Extreme Rainfall, Floods, Water Issues	<ul style="list-style-type: none"> • Population displacement, loss of home and livelihood • Death from drowning • Injuries • Damage to potable water, wastewater, and irrigation systems, resulting in decrease in quality/quantity of water supply and disruption to agriculture • Water- and food-borne diseases from sewage overflow 	<ul style="list-style-type: none"> • Coastal residents, and residents in flood-prone areas • Elderly • Children • Low income
Increased average temperature	<ul style="list-style-type: none"> • Cardiovascular disease • Increased number and range of: • Vector-borne disease, such as West Nile virus, malaria, Hantavirus, or plague • Water-borne disease, such as cholera and <i>E. coli</i> • Food-borne disease, such as <i>salmonella</i> poisoning • Harmful algal blooms causing skin disease and poisoning • Allergies caused by pollen, and rashes from plants such as poison ivy or stinging nettle • Vulnerability to wildfires and air pollution 	<ul style="list-style-type: none"> • Children • Elderly • Agricultural workers • Those active outdoors • People with respiratory disease • People with acute allergies
Agricultural Changes	<ul style="list-style-type: none"> • Changing patterns and yields of crops, pests, and weed species, resulting in higher prices for food and food insecurity, hunger, and malnutrition • Changes in agriculture/forestry, leading to lost or displaced jobs and unemployment 	<ul style="list-style-type: none"> • Agricultural workers • Rural communities • Low income • Elderly • Children

CLIMATE CHANGE EXPOSURES	HEALTH IMPACTS	POPULATIONS MOST AFFECTED
Drought	<ul style="list-style-type: none"> • Hunger and malnutrition caused by disruption in food and water supply, increased cost and conflict over food and water • Food- and water-borne disease • Emergence of new contagious and vector-borne disease 	<ul style="list-style-type: none"> • Low income • Elderly • Children
All Impacts	<p>Mental Health Disorders: (e.g., depression, anxiety, Post-Traumatic Stress Disorder, substance abuse, and other conditions) caused by:</p> <ul style="list-style-type: none"> • Disruption, displacement, and migration • Loss of home, lives, and livelihood <p>Health Care Impacts</p> <ul style="list-style-type: none"> • Increased rates of illness and disease, emergency room use, and related costs borne by employers, health plans, and residents • Damage to health facilities 	<ul style="list-style-type: none"> • All populations • Low income • Health care staff

Sources:

- *Climate Action for Health: Integrating Public Health Into Climate Action Planning*. California Department of Public Health³⁷
- *Public Health-Related Impacts of Climate Change in California, A Report From: California Climate Change Center*³⁸
- *Global Climate Change Impacts in the United States*, Cambridge University Press³⁹
- *Centers for Disease Control and Prevention, Climate and Health Program*⁴⁰

APPENDIX 3: DATA SOURCES

DATA SOURCE	INDICATOR
1. California Department of Forestry and Fire Protection (CalFIRE). Fire and Resource Assessment Program; http://frap.cdf.ca.gov/ .	<ul style="list-style-type: none"> • Population in a high-risk wildfire area
2. Center for Health Statistics and Informatics. <i>Vital Statistics Query System</i> . Sacramento, CA: California Department of Public Health; 2004. www.apps.cdph.ca.gov/vsq/default.asp .	<ul style="list-style-type: none"> • Age-Adjusted Death Rate / 10,000 with race/ethnicity stratification
3. Environmental Health Tracking Program. Heat-Related Illness Data Query Options. Environmental Health Investigations Branch, California Department of Public Health, Richmond, CA http://www.ehib.org/page.jsp?page_key=913 .	<ul style="list-style-type: none"> • Annual heat-related ER visits / 100,000
4. Federal Bureau of Investigation. <i>Uniform Crime Reports</i> . DS. Washington, DC: U.S. Department of Justice, Federal Bureau of Investigation; 2011. https://www.fbi.gov/about-us/cjis/ucr/ucr .	<ul style="list-style-type: none"> • Violent crimes per 1,000
5. Heberger M, Cooley H, Herrera P, Gleick P, Moore E. <i>The Impacts of Sea Level Rise on the California Coast</i> . Oakland, CA: Pacific Institute; 2009. http://www.pacinst.org/wp-content/uploads/2013/02/exec_sum11.pdf .	<ul style="list-style-type: none"> • Population in 100-year flood prone area (for coastal counties) • Population in 100-year flood area and 55" of sea level rise (for coastal counties)
6. Palmgren C, Stevens N, Goldberg M, Barnes R, Rothkin K. <i>California Residential Appliance Saturation Survey</i> . Oakland, CA: KEMA, Inc.; 2009.	<ul style="list-style-type: none"> • Households with air conditioning
7. Public Interest Energy Research (PIER) Program. <i>Cal-adapt: Exploring California's Climate Change Research</i> . Sacramento: California Energy	<ul style="list-style-type: none"> • Historical record of wildfires and acres

<p>Commission; 2011. http://cal-adapt.org.</p>	<p>consumed</p>
<p>8. UCLA Center for Health Policy Research. <i>California Health Interview Survey</i>. Los Angeles, CA: UCLA Center for Health Policy Research; 2009. http://www.chis.ucla.edu/main/default.asp?page=dac (multiple chronic conditions, asthma, food insecurity (<200% poverty.</p>	<ul style="list-style-type: none"> • Multiple chronic conditions in adults • Adults ever-diagnosed with asthma • Food insecurity (low-income residents) • Adult obesity
<p>9. U.S. Census Bureau. <i>American Community Survey or SF1 file (Living with disability, living in rural areas, population aged < 5 years and >65 years living alone, linguistically isolated, poverty rate, housing cost burden, outdoor workers, group quarters)</i> DS. Washington, DC: U.S. Census Bureau; 2012. http://factfinder2.census.gov.</p>	<ul style="list-style-type: none"> • Living with disability (age 5 and older) • Living in rural areas • Children aged 0-4 years • Adults aged 65 years and older • Linguistically isolated households • Poverty rate, total • Households rent/mortgage \geq50% of income • Outdoor workers • Households that do not own a car • Nursing facilities, prisons, college dorms • Adults with less than a high school education
<p>10. US Environmental Protection Agency. <i>National Land Cover Data</i>; http://www.epa.gov/mlc/nlcd-2001.html. Accessed March 24, 2011.</p>	<ul style="list-style-type: none"> • Census tract average area with tree canopy
<p>11. Southern California Association of Governments (SCAG), Metropolitan Transportation Commission (MTC), Sacramento Council of Governments (SACOG), and population data from the U.S. Census Bureau.</p>	<ul style="list-style-type: none"> • Residents within ½ mile from frequent transit stop
<p>12. Statewide Database, University of California Berkeley Law, Center for Research, California Secretary of State, Elections Division, Reports of Registration, California Department of Finance, Demographic Unit.</p>	<ul style="list-style-type: none"> • Registered voters who voted in 2010 general election

