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2015 CalBRACE

Public Health Planning for Climate Change Adaptation in California

Section 2: Sacramento County Vulnerability Assessment

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Vulnerability Assessment Domains

Vulnerability assessments are a key tool to prepare and plan for climate and health impacts. This report identifies the populations and places most vulnerable to the health impact of climate change, particularly for extreme heat, wildfire, sea level rise, drought, and poor air quality. This is also a screening tool to assess vulnerabilities and adaptive capacities within a county jurisdiction to begin to identify what populations and what social vulnerabilities will need to be prioritized and addressed through strategic interventions in order to improve adaptive capacity and resilience to high impact exposures.

The suite of domains and indicators in this vulnerability assessment report is focused on assessing current and future climate change exposures (such as wildfires, extreme heat, air pollution, sea level rise, and drought), identifying the people and places most susceptible to health risks from climate exposures, and the capacity to adapt to a changing climate.

The indicators used in this assessment are organized in the following domains: environmental exposures, population sensitivity, and adaptive capacity.

ENVIRONMENTAL EXPOSURES DOMAIN

Environmental exposure refers to the magnitude, frequency, and duration of an environmental exposure or disease risk.

POPULATION SENSITIVITY DOMAIN

Sensitivity relates to the ability of a population to withstand climate-related exposure and its aftermath.

ADAPTIVE CAPACITY DOMAIN

Adaptive capacity refers to the broad range of responses and adjustments to the potential impacts of climate change, to moderate potential damages, to take advantage of opportunities, and to cope with the cons

Summary of Climate and Health Vulnerability Indicators

	Indicator	Metric
ENVIRONMENTAL EXPOSURES DOMAIN	**Extreme Heat Days**	Projected number of extreme heat days[1]
	Air Quality ($PM_{2.5}$)	Three-year annual mean concentration of particular matter ($PM_{2.5}$)[3, 6]
	Air Quality (ozone)	Three-year ozone concentration exceedance[3, 6]
	Drought	Palmer Drought Severity Index for August 2014[5]
	Wildfires	Percent of population currently living in high risk fire hazard zone*[4, 6]
POPULATION SENSITIVITIES DOMAIN	**Children**	Percent of population aged less than 5 years[6]
	Elderly	Percent of population aged 65 years or older[6]
	Poverty	Percent of population whose income in past year was below poverty level*[7]
	Education	Percent of population aged ≥ 25 years with less than high school educational attainment*[7]
	Race and Ethnicity	Percent of population within race and ethnicity groups[6]
	Outdoor Workers	Percent of population employed and aged ≥ 16 years working outdoor jobs*[7]
	Vehicle Ownership	Percent of occupied households with no vehicle ownership*[7]
	Linguistic Isolation	Percent of households with no one aged ≥ 14 years speaking English*[7]
	Physical Disability	Percent of population with physical disability (ambulatory disability)*[7]
	Mental Disability	Percent of population with mental disability (cognitive disability)*[7]
	Health Care Access	Percent of population without health insurance[8]
	Violent Crimes Rate	Number of violent crimes per 1,000 residents[9]
ADAPTIVE CAPACITY DOMAIN	**Air Conditioning**	Percent of population with air conditioning ownership*[10, 6]
	Tree canopy	Percent of area not covered by tree canopy*[11, 6]
	Impervious Surfaces	Percent of area covered by impervious surfaces*[11, 6]
	Public Transit Access (for urban areas)	Percent of population residing within 0.5 mile of bus/ferry/ferry stop with < 15 minutes waiting time during peak commute hours[12]

**Indicator is weighted by population, which means the value of the indicator will be higher or lower depending on population density in the locality.*

Data Sources:

1: CalAdapt, Scripps Institute of Oceanography (projected 2050, 2090)
2: CalAdapt; Pacific Institute; U.S. Geological Survey (USGS) (projected 2100)
3. California Air Resources Board (2009-2011); CalEnviroScreen 2.0 (2009-2011)
4: California Department of Forestry and Fire (CAL FIRE) (2007)
5: WestWide Drought Tracker (2014); U.S. Drought Portal
6: U.S. Decennial Census by U.S. Census Bureau(2010)
7: American Community Survey (ACS) by U.S. Census Bureau(2006-2010)
8: American Community Survey (ACS) by U.S. Census Bureau, (2008-2012)
9: Uniform Crime Reports from U.S. Federal Bureau of Investigation (2010)
10: Residential Appliance Saturation Survey (RASS) (2009)
11: National Land Cover Database (NLCD) (2011)
12: San Diego Association of Governments (2012); Southern California Association of Governments (2012); Bay Area Metropolitan Transportation Commission (2012); Sacramento Area Council of Governments (2008)

Climate and Health Vulnerability for Sacramento County

Sacramento County faces climate change exposures that pose considerable health risks to the population, especially to a number of vulnerable groups. This report summarizes findings from the Sacramento County climate and health vulnerability assessment.

Sacramento County will be affected by environmental exposures which will pose a hazard to their population health. Under high emissions scenario, projected number of extreme heat days over 101°F are projected to increase to 27 by 2050 and 76 by 2090 in Sacramento County. Higher temperatures favor the formation of air pollutants; In 2009-2011, Sacramento County had 0.09 ppm level of ozone exceedance and 9 $\mu g/m^3$ concentration of ambient particular matter ($PM_{2.5}$) posing a health hazard to populations exposed to these levels of air pollution. Increasing temperatures and changes in precipitation may lead to longer, more severe droughts and increased water demands. Droughts also contribute to increased risk of wildfires.

Certain populations disproportionately experience the health impacts of climate change. Sacramento County's population includes 99,315 children and 156,067 elderly persons, both groups have increased risk of the health impacts of climate change. Persons with disabilities may be disproportionately impacted by climate change and Sacramento County population includes 78,086 persons with mental disability (cognitive disability) and 91,100 persons with physical disability. Communities of color may be disproportionately impacted and 52% of the population in Sacramento County's belongs to communities of color.

Climate change impacts add to the cumulative stresses currently faced by populations who have certain socioeconomic characteristics or live in geographic areas that have increased risk. In 2010, 14% (195,320 residents) of the population in Sacramento County was living beneath the federal poverty level. The violent crimes rate is 6 per 100,000 persons and 15% of persons (133,956 residents) aged 25 years or older have less than a high school educational attainment. Insurance coverage is a key determinant of timely access and utilization of health services, and 15% of the population (212,476 residents) does not have health insurance. Sacramento County has 7% of linguistically isolated households (35,595 households) which may face barriers in accessing or understanding emergency or health warnings in the event of extreme weather and disasters.

Adaptive capacity is important for building resilience against the impacts of climate change. Areas with high imperviousness and low tree canopy cover can lead to urban heat islands which pose health concerns related to increased heat and poor air quality. Urban greening can reduce air pollution and may have a local cooling effect. Sacramento County has a population-weighted average 48% of impervious surfaces and 87% of areas without tree canopy cover. Access to public transit provides enhanced opportunity to relocate to cooler or safer spaces in the event of heat waves or other extreme weather. In Sacramento County, 81% of the population (1,171,500 residents) is living in areas with poor access to public transit.

[brief interpretation section to be completed by epidemiologist]

Climate and Health Vulnerability for X County

Figure 1. Risk of climate and health impacts related to select climate and health vulnerability indicators relative to state average, Sacramento County, California

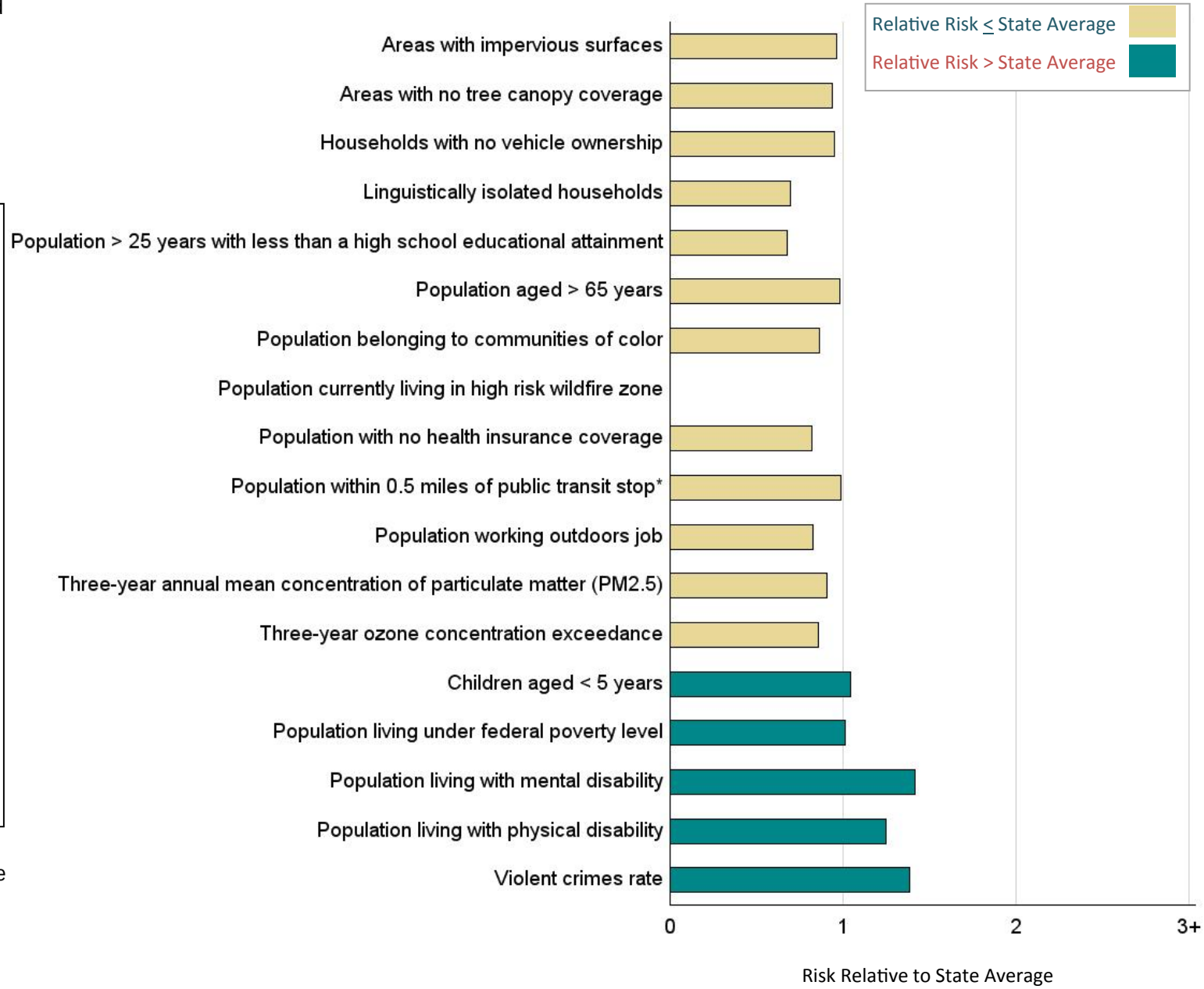
This chart is intended to be a screening tool to visualize general information about county risk compared to the state of California.

A relative risk (RR) estimate greater than one indicates a risk greater than the state average.

RR = county risk / state risk

Heat and drought risk are not included in this summary chart because there is no statewide measure to compare with county estimates.

*public transit access estimates represent risk relative to the local metropolitan region.



Environmental Exposures

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Heat

What is the challenge?

Periods of warmer temperatures and heat waves are expected to increase in frequency, intensity, and duration throughout the 21st Century. Increased temperatures add to the heat load of buildings in urban areas and intensify existing urban heat islands (a phenomenon in which urban areas are warmer than the surrounding non-urban areas) in areas that are most heavily populated. There will be increases in annual average temperature of up to 5^0 F by the 2030s and up to 10^0 F by the end of the century or sooner, although not every day will be hotter than current averages. Minimum nighttime temperatures are also projected to increase. For example, the 2006 California heat wave brought higher temperatures combined with increased humidity, particularly at night time.

Why is this important to climate and health?

Sustained high heat days and heat waves directly affect human health through heat-related illnesses such as heat stroke, heat exhaustion, and dehydration, as well as other illnesses and premature deaths from cardiovascular or respiratory diseases. Heat waves are associated with increased hospital admissions for cardiovascular, kidney (including kidney stones), mental health, diabetes, and respiratory disorders.

Extremely stressful climate exposures such as heat waves may lead to adverse birth outcomes including pre-term birth, low-birth weight, stillbirth, and maternal complications. In California, two separate examinations of a statewide heat wave in 2006 showed excess deaths ranging from 6% to 9% daily for each 10°F increase in temperature.

Who is most impacted?

Populations with the greatest exposure to health impacts from, or with greater difficulty preparing for extreme heat events and receiving access to care may include:

- Elderly, children, infants, and pregnant women
- People with pre-existing chronic disease (e.g., respiratory, cardiovascular disease, diabetes, cerebrovascular diseases, respiratory diseases, and acute allergies)
- People who engage in vigorous physical activity including agricultural and outdoor workers, athletes (especially young athletes), military personnel, and outdoor recreationists
- Populations with low socioeconomic status
- Socially or geographically isolated populations
- People living with a disability
- People in cooler areas less acclimatized to heat, with less awareness of ways to reduce exposure, and with housing not designed for warmer conditions
- Residents of urban areas, of the highest floors of apartment buildings, and without air-conditioning
- Specific race/ethnic groups
- People taking certain medications related to specific heart conditions or mental health

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Heat

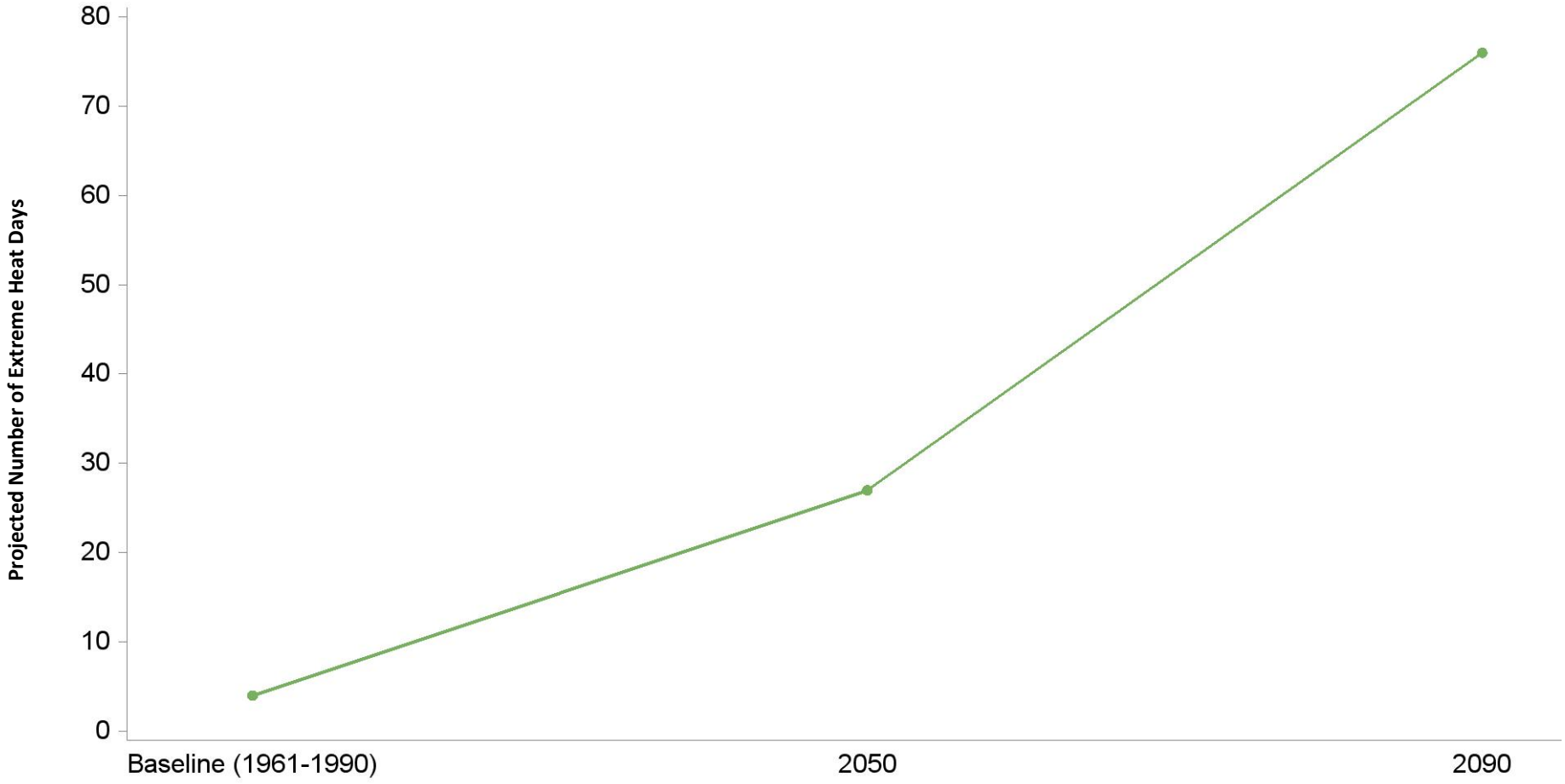


Figure 2. Projected number of extreme heat days > 101 °F in Sacramento City, Sacramento County, California, 2050 and 2090 scenario

Source: Cal-Adapt, *Scripps Institution of Oceanography.*

Cal-Adapt defines extreme heat days as above the 98th percentile of the computed maximum temperature for each location using 1961-1990 data for the May to October warm season *using GFLD CM2.1 Global Climate Model.* Data shown here only represents modeled trends for the county seat city of Sacramento County and may not reflect countywide trends. For an interactive map of urban heat islands in select areas, visit www.calepa.ca.gov/UrbanHeat/Maps

Air Quality (Particulate Matter)

What is the challenge?

Particulate matter ($PM_{2.5}$) is an extremely small pollutant and is capable of reaching deep into the lungs causing a host of diseases including lung cancer, heart disease, respiratory disease, and acute respiratory infections, particularly in children. Higher temperatures favor the formation of ground-level ozone and other secondary air pollutants created from chemical reactions with pollutants directly emitted from power plants, motor vehicles, and other sources. With projected increasing temperatures, demand for electric power generation will increase and may contribute further to poor air quality.

Why is this important to climate and health?

Clean air is a fundamental determinant of health. Degradation of air quality will compound the health hazards posed by warmer temperature. The health impacts of air pollution are likely to be worsened by climate change. In California, the Air Resources Board estimated that, given the $PM_{2.5}$ levels between 2004 and 2006, more than nine thousand deaths could be prevented each year if California met its current statewide $PM_{2.5}$ standard of 12 mg/m^3. Both short-term and long-term exposures to $PM_{2.5}$ increase the risk of cardiovascular disease and death. Exposure is linked to adverse respiratory outcomes such as chronic obstructive lung disease, hospital and emergency department admissions for asthma, increased respiratory symptoms, altered pulmonary function, and pulmonary inflammation among asthmatic children. Reports have indicated that $PM_{2.5}$ effects birth weight and infant mortality, especially due to respiratory causes during the post-neonatal period.

Who is most impacted?

- Elderly and children
- People with chronic underlying disease (e.g. diabetes, respiratory diseases)
- Urban residents, communities with low socioeconomic status
- Agricultural and outdoor workers, and those who are active outdoors

Table X. Three-year Annual Mean Concentration of Particulate Matter (PM2.5)* weighted by population, Sacramento County, California, 2009-2011

	Concentration (µg/m^3)	Total Population
Sacramento County	**9**	**1,418,788**
California	10	37,253,956

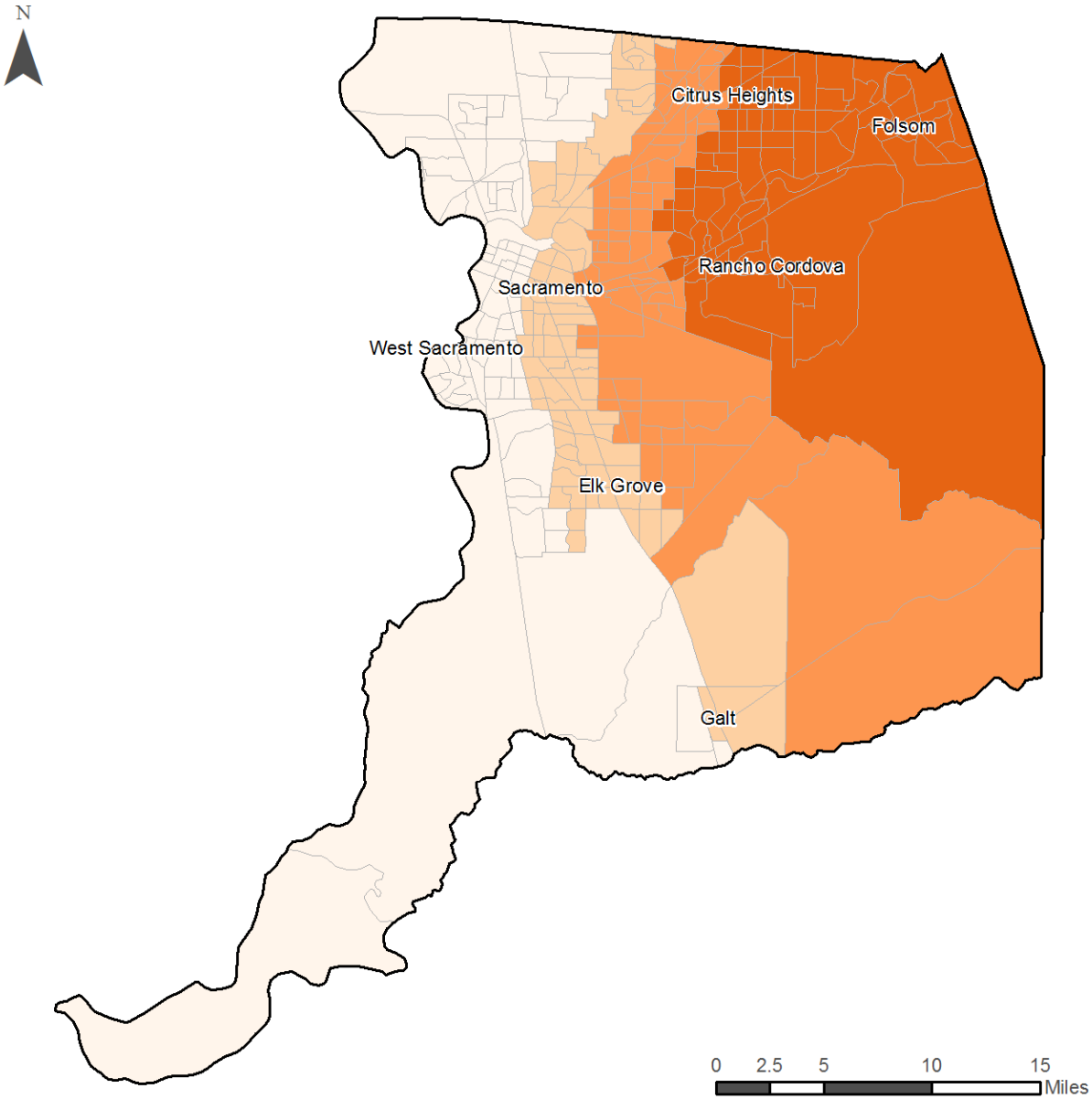
*Particulate Matter ($PM_{2.5}$) is defined as the annual mean ambient concentration of fine particulate matter with size 2.5 µg/m^3.

Source: Data obtained from California Air Resources Board (CARB), 2009-2011. Analysis done by the Office of Environmental Health Hazard Assessment (OEHHA) California Communities Environmental Screening Tool (CalEnviroScreen 2.0) and further analysis s done by UC Davis and CDPH. County-level estimates for race/ethnicity groups were obtained using residential data from U.S. Census 2010.

Air Quality (Particulate Matter)

Figure 6. Annual Concentration of Fine Particulate Matter ($PM_{2.5}$), by Census Tracts, Sacramento County, California, 2009-2011

*Particulate Matter ($PM_{2.5}$) is defined as the three-year annual mean ambient concentration of fine particulate matter with size 2.5 µg/m³. Per California Air Resources Board, ambient air quality standard for fine particular matter ($PM_{2.5}$) is 12 µg/m³. Estimates are not available for census tracts with centers more than 50 km from the nearest air quality monitoring station.



(in ug/m^3)

- 8.14 - 8.75
- 8.76 - 9.16
- 9.17 - 9.44
- 9.45 - 9.90
- Census Tract Boundaries

Source: Data obtained from CARB, 2009-2011. Analysis done by OEHHA CalEnviroScreen 2.0, U.S. Census 2010 and further analysis done by UC Davis and CDPH using U.S. Census Bureau 2010 data.

Air Quality (Ozone)

What is the challenge?

Higher temperatures favor the formation of ground-level ozone and other secondary air pollutants created from chemical reactions with pollutants directly emitted from power plants, motor vehicles, and other sources. With the projected increasing temperatures, demand for electric power generation will increase and may contribute further to poor air quality. Ozone that forms at the ground-level and fine particulate matter (described separately) are two indicators of air pollution that are linked to short- and long-term adverse health effects.

Why is this important to climate and health?

The health impacts of air pollution are likely to be modified by climate change, due mainly to the exposure of populations to increased levels of air pollutants and the enhanced pollutant emission and production rates in a warmer climate. Most California residents are currently exposed to levels at or above the current State ozone standard during some parts of the year. Studies have shown that exposure to ozone is associated with decreased lung function, respiratory symptoms, hospitalizations for cardiopulmonary causes, emergency room visits for asthma, and premature death. At higher daily concentrations, ozone increases asthma attacks, hospital admissions, daily mortality, and days of restricted activity and school absences. In California, the Air Resources Board estimated that 630 deaths, 4,200 hospital admissions, and 4.7 million lost school days could be prevented each year if California met its current statewide standard of 0.070 ppm for ozone (8-hour average).

Who is most impacted?

- Children may be more affected by ozone than the general population due to effects on the developing lung and to relatively higher exposure than adults.
- People with chronic underlying diseases (e.g., respiratory diseases)
- Agricultural and outdoor workers, and those who are active outdoors

Table X. Ozone Exceedance* weighted by population, Sacramento County, California, 2009-2011

	Concentration (ppm)	Total Population
Sacramento County	**0.09**	**1,418,788**
California	0.11	37,253,956

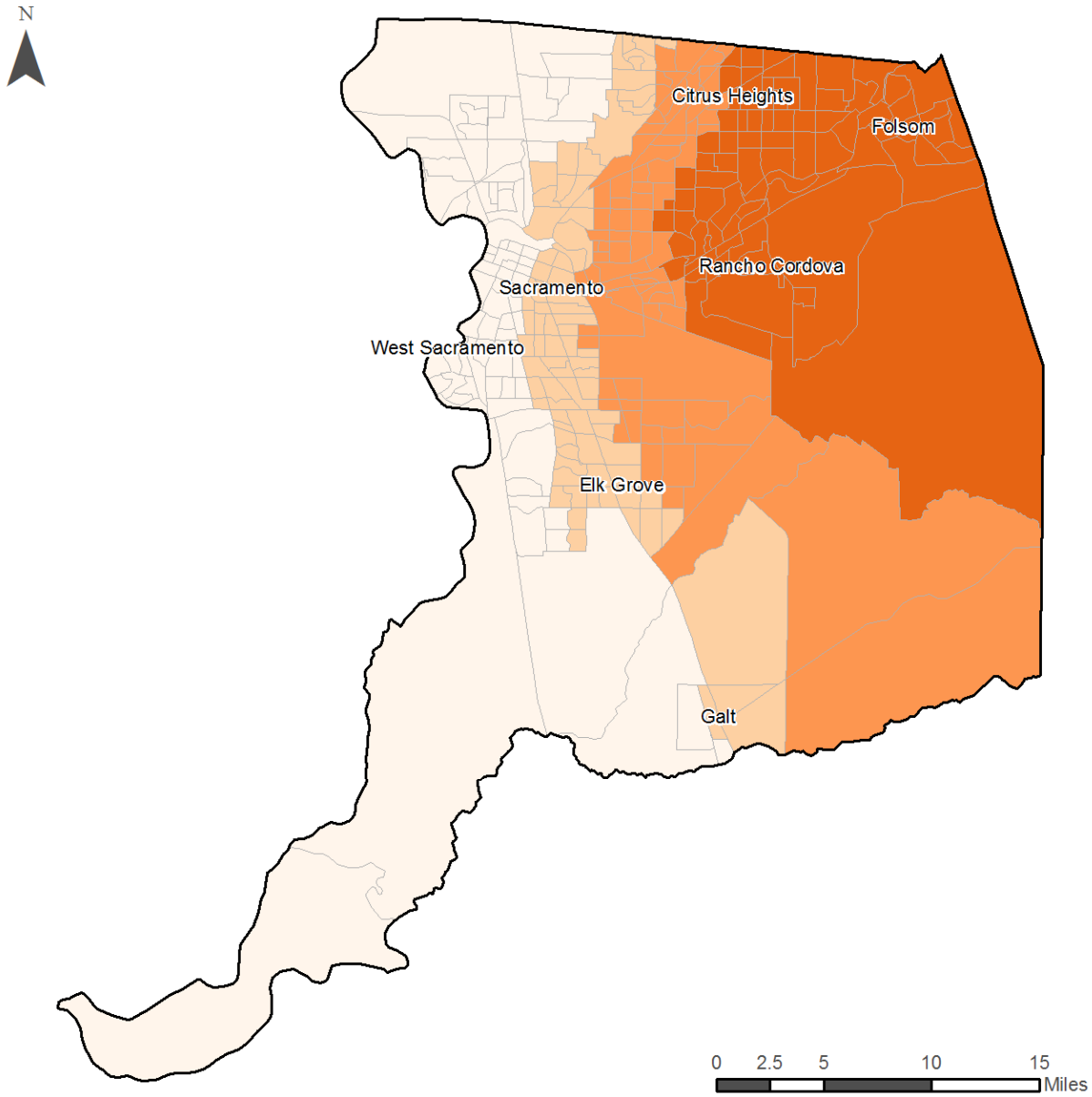
**Ozone exceedance in this analysis is defined as a the amount of the daily maximum 8-hour ozone concentration that exceeded the 8-hour California standard (0.070 ppm), averaged over 2009-2011.*

Source: Data obtained from California Air Resources Board (CARB), 2009-2011. Analysis done by Office of Environmental Health Hazard Assessment (OEHHA) California Communities Environmental Screening Tool (CalEnviroScreen 2.0) and further analysis done by UC Davis and CDPH. County-level estimates for race/ethnicity groups were obtained using residential data from U.S. Census 2010.

Air Quality (Ozone)

Figure 8. Ozone exceedance*, by Census Tracts, Sacramento County, California, 2009-2011

*Ozone exceedance in this analysis is defined as a the amount of the daily maximum 8-hour ozone concentration that exceeded the 8-hour California standard (0.070 ppm), averaged over 2009-2011. Estimates are not available for census tracts with centers more than 50 km from the nearest air quality monitoring station.



(in ppm)

- 0.02 - 0.04
- 0.05 - 0.06
- 0.07 - 0.12
- 0.13 - 0.37
- Census Tract Boundaries

Source: Data obtained from CARB, 2009-2011. Analysis done by OEHHA CalEnviroScreen 2.0, U.S. Census 2010 and further analysis done by UC Davis and CDPH using U.S. Census Bureau 2010 data.

Drought

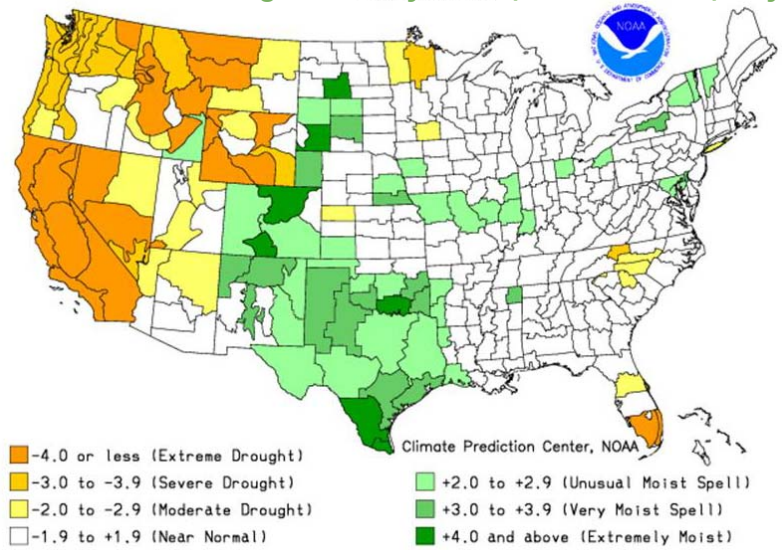
What is the challenge?

Increasing temperatures and changes in precipitation may lead to longer, more severe droughts and increased water demands. Higher temperatures also cause earlier snowmelt and less snowpack. By 2050, California is projected to have a loss of at least 25 percent of the Sierra snowpack, an important source of urban, agricultural and environmental water. Droughts contribute to water shortages thus compromising the quality of life of California populations, especially for rural and vulnerable communities.

Why is this important to climate and health?

Public health impacts may include deterioration of the quality and quantity of drinking water and food, compromise of the air quality due to increased wildfires and dust storms, and diminished living conditions due to scarce energy, sanitation, and increased incidence in disease and illness. As water flow decreases, the concentration of pollutants and contaminants in water may increase. Decreased water access can lead to less hand washing and other personal hygiene practices, increasing the risk of infections. Climate change alters the range, biogeography, and growth of microbes and the vectors of food, water, and vector-borne illnesses. Changes in aquatic environments can favor toxins that accumulate in seafood and fresh and salt water algal blooms. Drought decreases crop yields causing both food shortages and price increases. Higher food prices can lead to food insecurity, obesity, and malnutrition in households with low income. The economic hardship associated with increasing food prices, and lack of adequate water for operations can cause psychological distress and other negative behavioral impacts. Some of the sectors which may be affected include water suppliers, tourism, transportation, energy and fisheries, and especially the agricultural sector. In 2014, water shortage caused large cuts in the farm land use resulting in a cut of 17,000 jobs greatly impacting farm communities.

Figure 11. Palmer Drought Severity Index, United States, July 2015



Source: U.S. Drought Portal

Droughts also contribute to increased wildfires resulting in increased concentrations of particulates in the air. This results in respiratory tract problems, especially for those with existing chronic respiratory illnesses. The scale of drought impacts depend on the length and severity of drought.

Who is most impacted?

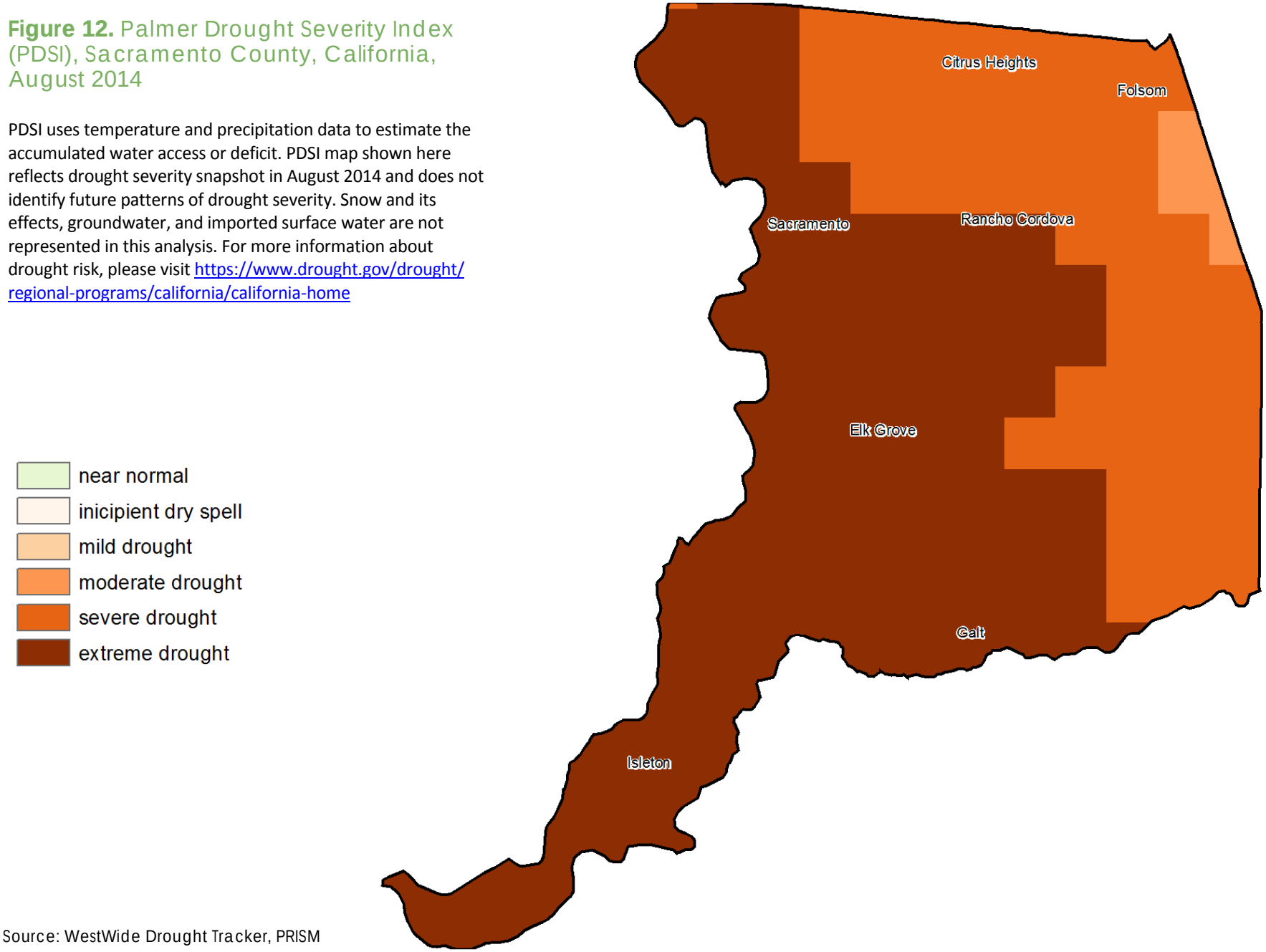
Communities impacted most by the health impacts of drought include:

- Elderly, children, individuals of low socioeconomic status, and rural communities,
- Hospitalized patients and nursing homes residents
- Communities with small water systems or private wells
- Communities who rely on electrical equipment to survive (as related to hydroelectric power) and river communities
- Farmers and agricultural workers

Drought

Figure 12. Palmer Drought Severity Index (PDSI), Sacramento County, California, August 2014

PDSI uses temperature and precipitation data to estimate the accumulated water access or deficit. PDSI map shown here reflects drought severity snapshot in August 2014 and does not identify future patterns of drought severity. Snow and its effects, groundwater, and imported surface water are not represented in this analysis. For more information about drought risk, please visit https://www.drought.gov/drought/regional-programs/california/california-home



Source: WestWide Drought Tracker, PRISM

Wildfire

What is the challenge?

Wildfire activity in California has greatly increased in recent years. The increase has been attributed to warmer spring and summer temperatures, reduced precipitation associated with warmer temperatures, reduced snow pack and earlier snowmelts, and longer, drier summer seasons in some middle and upper elevation forests. These trends are expected to continue under plausible climate change scenarios.

Why is this important to climate and health?

Wildfires can lead to injuries and deaths from burns, smoke inhalation, and displacement. Persons with chronic health conditions may face challenges in accessing health services and other public resources which may be under increased pressure during wildfires. Further health impacts include psychological reactions to an extreme event, such as trauma from displacement and evacuation. Wildfire smoke is composed of thousands of microscopic chemical compounds. Smoke and ash particles can travel many miles from the original fire location. There very small particles can penetrate deep into the lungs and can cause changes in lung function. Air pollution from wildfires affects eye and respiratory conditions such as asthma, chronic obstructive pulmonary disease, and other cardiovascular and respiratory diseases. Chemical residues from burning vegetation may contaminate land, soil, or watersheds through sediment run-off from landslides or mudslides and particulate matter deposition; these affects may lead to longer term threats to human and ecosystem health.

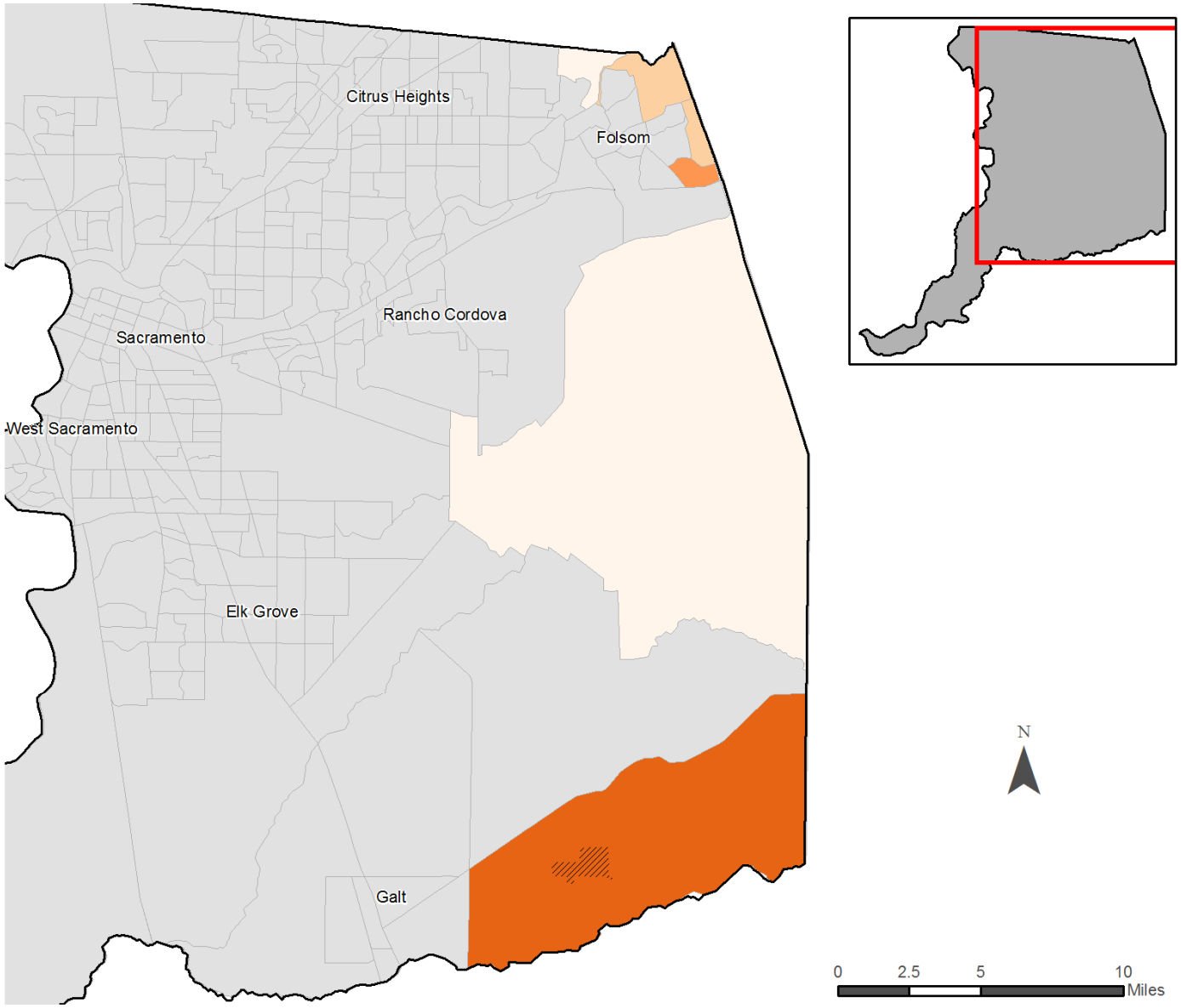
Who is most impacted?

- People who live in the vicinity of fires
- People who live downwind from fire are impacted from wildfire smoke
- Elderly, young children, pregnant women, those of low socioeconomic status, smokers, people with pre-existing diseases (especially cardiac and respiratory)
- Agricultural and outdoor workers, firefighters
- Communities with decreased access to information about risk mitigation and without adequate emergency preparedness, including the presence of an early warning system

Wildfire

Figure 10. Population living in very high wildfire risk areas* by Census Tracts, Sacramento County, California, 2007

*CAL FIRE defines very high wildfire risk areas (also referred to as fire hazard severity zones) to be areas with wildland areas supporting high to extreme fire behavior. Factors taken into account include vegetation, topography, weather, crown fire potential, and ember production and movement. Risk of exposure to wildfire smoke and smoke dispersion is not included in this analysis which limits the ability to assess the broader health impacts of wildfires.



Source: California Department of Forestry and Fire (CAL FIRE), 2007; U.S. Census 2010. Analysis by UC Davis and CDPH.

Population Sensitivity

Children	20
Elderly	22
Education	24
Poverty	25
Race and Ethnicity	26
Outdoor Workers	30
Car Ownership	31
Linguistic Isolation	32
Physical Disability	33
Mental Disability	34
Health Care Access	35
Violent Crimes	37

Children

What is the challenge?

Children, primarily because of physiological and developmental factors, are disproportionately impacted from the effects of heat waves, air pollution, infectious illnesses, and trauma resulting from climate change and extreme weather events.

Why is this important to health?

Children under 5 years old are especially vulnerable to the health impacts of climate change, particularly air pollution, because they are rapidly growing, both physically and mentally: their lungs are developing, they breathe at a higher rate than adults, and they spend more time outdoors. Children, infants, and pregnant women are vulnerable to increased heat exposure because they may not be able to efficiently thermoregulate; in particular, infants have a greater risk for mortality and specific illnesses from heat exposures. Additionally, children depend on their caregivers for response to extreme weather events such as hurricanes and floods. Conditions like injury, death, infectious diseases, malnourishment and posttraumatic stress are more common in children than adults after extreme weather events. Additionally, intensely stressful exposures may lead to adverse birth outcomes including pre-term birth, low-birth weight, stillbirth, and maternal complications. During the 2003 wildfires in Southern California, respiratory hospital admissions related to wildfires increased 8.3% among children under 5 years old. Exposure to air pollution increases the risk for allergen sensitization in children under 5 years old and increases risk for hospitalization for bronchiolitis and death among infants. Increased levels of air pollution also can increase asthma related emergency department visits and hospitalizations. Mold growth at home after flooding events can be associated with a increases in lower respiratory symptoms.

Who is most impacted?

- Children under 5 years old, infants, and pregnant women
- Children in low-income, rural, immigrant, or linguistically isolated households
- Children with pre-existing disease (especially cardiac and respiratory)
- Children who spend considerable time outdoors

Figure 13. Percent of Children Under 5 Years Old by Race/Ethnicity, Sacramento County, CA 2010

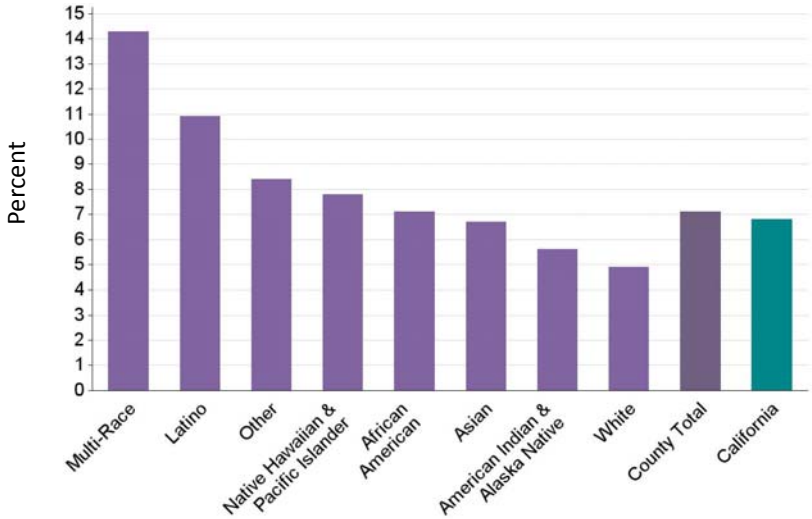


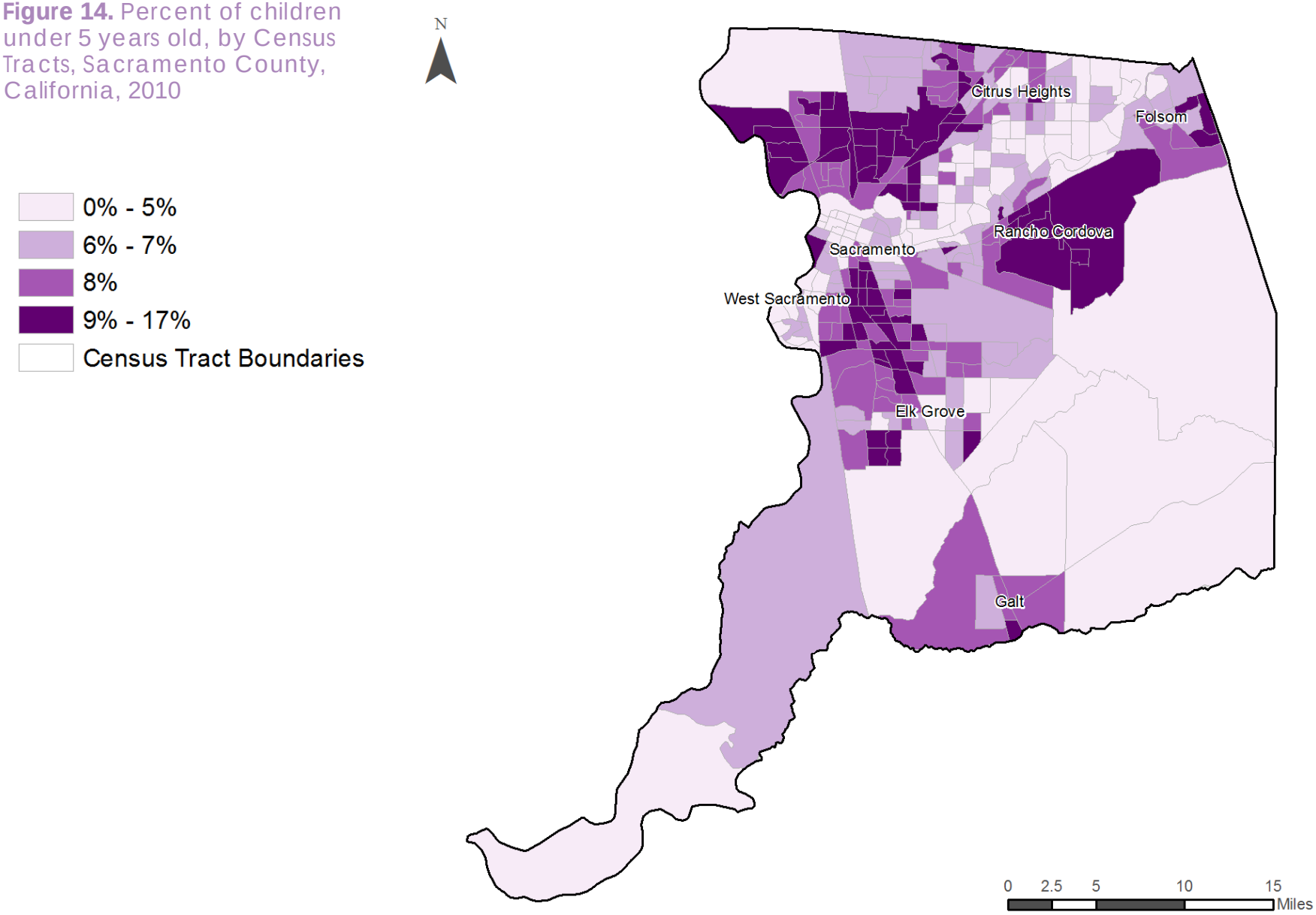
Table X. Cities and Towns (> 1,000 Population) with Highest Percent of Children < 5 years of age, Sacramento County, California, 2010

City/Town	Percent	Total Population
Lemon Hill	**10%**	**13,729**
Parkway	**10%**	**14,670**
Foothill Farms	**9%**	**33,121**
Sacramento County	**7%**	**1,418,788**
California	**7%**	37,253,956

Sample population includes group quarters. *Source: U.S. Decennial Census 2010.*

Children

Figure 14. Percent of children under 5 years old, by Census Tracts, Sacramento County, California, 2010



Source: U.S. Decennial Census 2010.

Elderly

What is the challenge?

Climate change is increasing the severity and frequency of heat waves and extreme weather events which poses a risk to elderly populations. Aging impairs muscle strength, coordination, cognitive ability, immune system, regulation of body temperature. In addition, the proportion of elderly population in the United States is increasing and California is one of nine states where most Americans aged 65 years and older reside.

Why is this important to health?

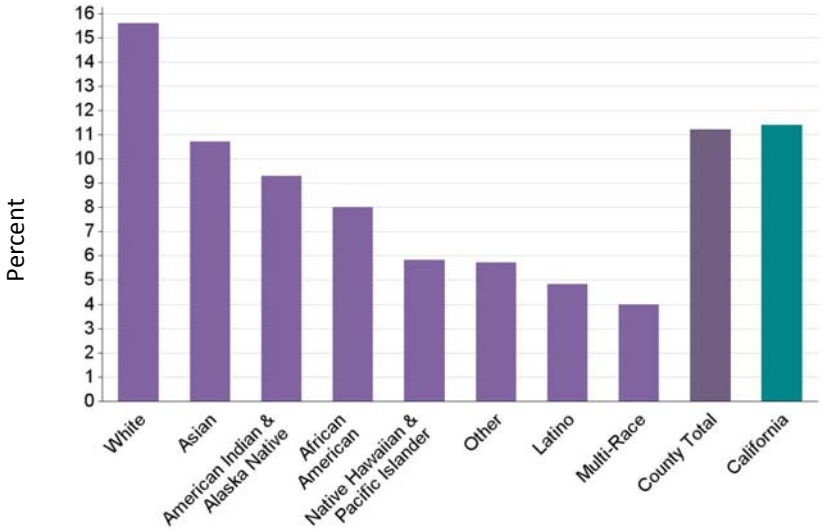
Growing evidence suggests that injury, disease, and death are greatest among the elderly during heatwaves. Acute kidney failure, electrolyte imbalance and inflammation were the most common heat related health effects among elderly in the 2006 California heat wave. Side effects of some medications intensified the heat-related conditions in elderly. Pre-existing health conditions among the elderly can increase susceptibility to more severe consequences of infectious diseases. Elderly with limited mobility can have increased risk of flood-related impacts. During the 2003 Southern California wildfires, respiratory hospital admissions related to wildfire smoke increased 10% among adults 65 years of age and older. Several studies show that elderly are at increased risk of West Nile virus infection with climate change predicted to increase the overall risk of transmission in California.

Who is most impacted?

Elderly populations with the following characteristics are at an increased risk of health impacts from climate change:

- Elderly ages 65 years or older
- Elderly who are socially isolated or dependent of care
- Elderly women or elderly of low socioeconomic status
- Elderly of African-American race and Latino/Hispanic ethnicity
- Elderly with multiple chronic conditions (e.g., cardiovascular diseases, respiratory illnesses, diabetes)

Figure 15. Percent of Elderly Age 65 and Older by Race/Ethnicity, Sacramento County, CA 2010



*Unreliable Data (Relative Standard Error > 30%)

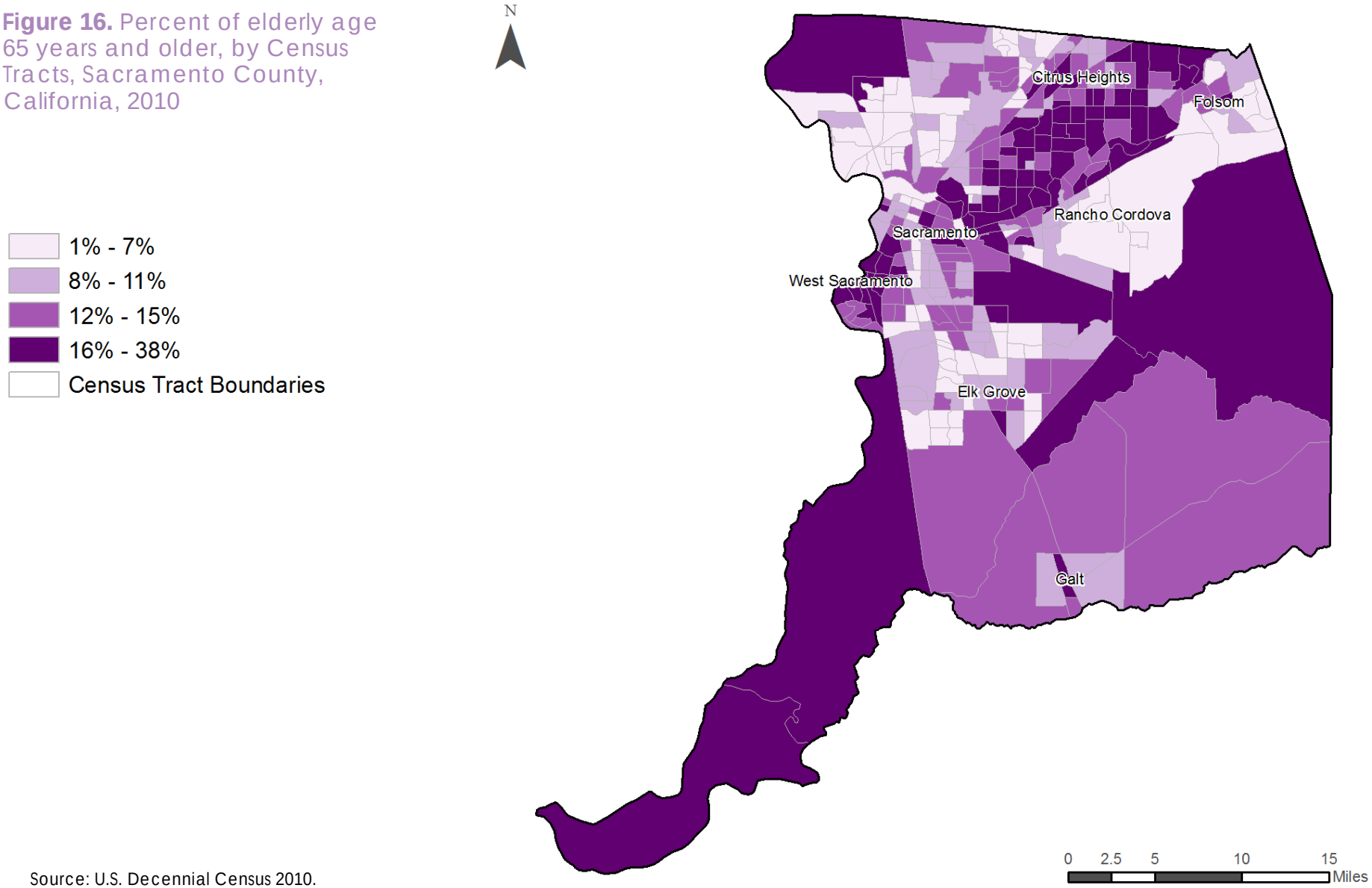
Sample population includes group quarters. *Source: U.S. Decennial Census 2010.*

Table X. Cities and Towns (> 1,000 Population) within Highest Percent of Elderly ≥ 65 years of age, Sacramento County, California, 2010

City/Town	Percent	Total Population
Rancho Murieta	**24%**	**5,488**
Gold River	20%	7,912
Fair Oaks	19%	30,912
Sacramento County	11%	1,418,788
California	**11%**	37,253,956

Elderly

Figure 16. Percent of elderly age 65 years and older, by Census Tracts, Sacramento County, California, 2010



Source: U.S. Decennial Census 2010.

Poverty

What is the challenge?

Poverty increases the vulnerability to climate impacts and communities in poverty have fewer resources to evacuate during natural disasters such as wildfires. Poverty reduces the capacity to adapt to rising food, water, or energy prices making it harder for low-income communities to rebuild after a disaster, especially since fewer low-income people have insurance. Additionally, people with low to middle income have less access to health care and receive worse quality of care than people with high income. Those with low incomes are also more likely to reside in housing that sustain worse damage due to lower quality construction.

Why is this important to health?

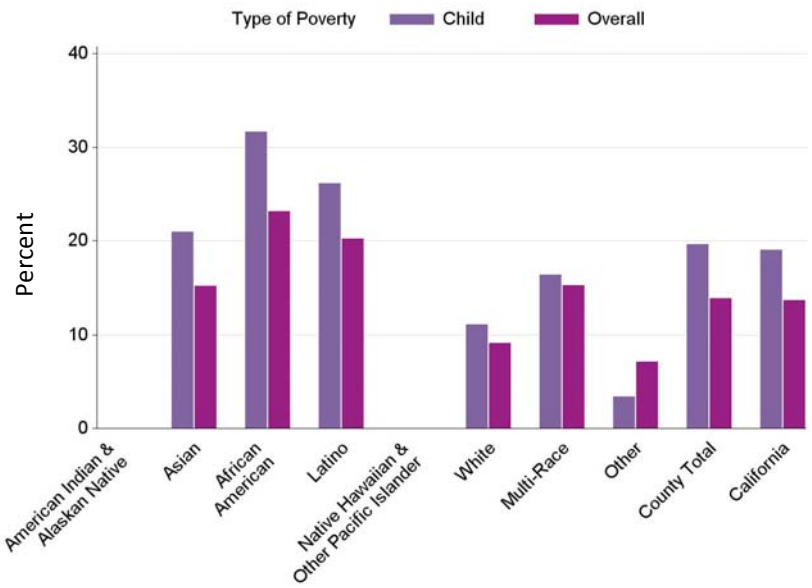
Existing health disparities and other inequities increase vulnerability of low-income communities and some communities of color to the health impacts of climate change. It's been estimated that 133,250 (6%) of the 2.4 million U.S. deaths in 2000 could be attributed to poverty. In a longitudinal study it was observed that people living in concentrated poverty areas had higher rates of obesity, diabetes, and depression than residents that moved out of those same areas. Potential impacts of climate change on higher food cost and food scarcity will magnify current inequalities in food access.

Who is most impacted?

Health burdens due to poverty disproportionately impact the following populations:

- Populations who are unemployed, disabled, homeless, or uneducated,
- Racial, ethnic, and linguistic groups and migrants.
- Children: Some children in low-income families grow up in environments that are harmful to their development and health. Children in low-income immigrant families may face barriers in access to services.
- Person with psychiatric disorders, including neurotic disorders, functional psychoses and alcohol and drug dependence.

Figure 18. Percent of Population Living in Poverty by Race/Ethnicity, Sacramento County, CA 2006-2010

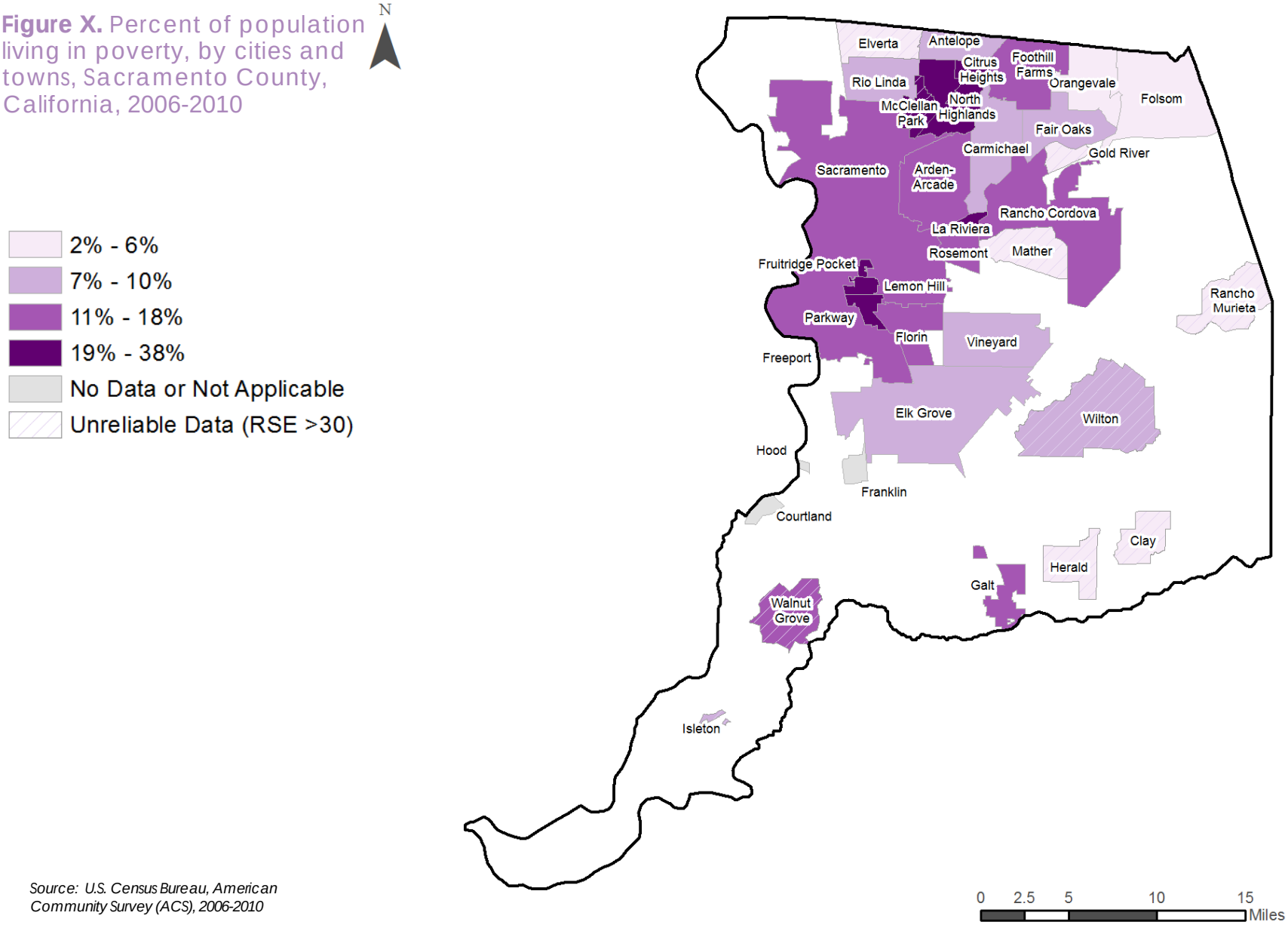


Poverty defined as individuals whose income in the past 12 months is below the federal poverty level.

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Poverty

Figure X. Percent of population living in poverty, by cities and towns, Sacramento County, California, 2006-2010



Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Education

What is the challenge?

Completion of formal education such as high school and college is a key pathway to employment and access to higher paying jobs that can provide food, housing, transportation, health insurance, and other determinants of health. Lack of educational attainment increases the vulnerability to stressors and hazards, including climate exposures such as heat waves, by decreasing adaptability and protective measures. Climate exposures, such as heat, drought and wildfires amplify the pre-existing health inequities of low educational attainment.

Why is this important to health?

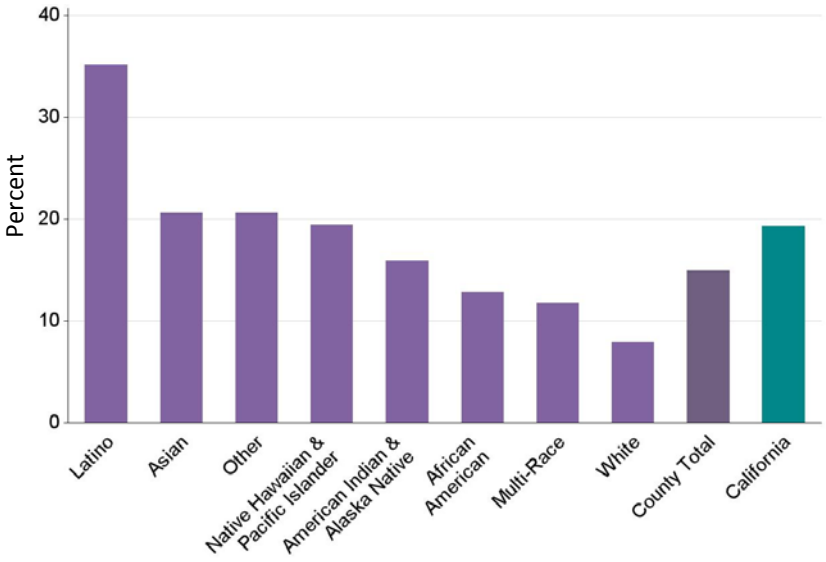
Education is a determinant of health with broad impacts on standards of living and social interaction, with consequences for the health of individuals and communities. Education is linked with social and psychological factors, including sense of control, social standing and support. These factors can improve health by reducing stress, influencing health-related behaviors and providing practical and emotional support. Approximately 245,000 (10%) of the 2.4 million U.S. deaths in 2000 were attributable to low education. Low education is also associated with poorer self-reported health status, higher infant mortality rates, lower cancer screening rates, and many other negative health outcomes and behaviors. It is estimated that raising the health to that of college educated would result in annual gains of over 1 trillion dollars of increased health value.

Who is most impacted?

Health burdens due to low educational attainment disproportionately impact the following populations:

- African Americans, Hispanics, and other race/ethnicities are disproportionately represented among high school dropouts when compared to Whites
- Communities of low socio-economic status

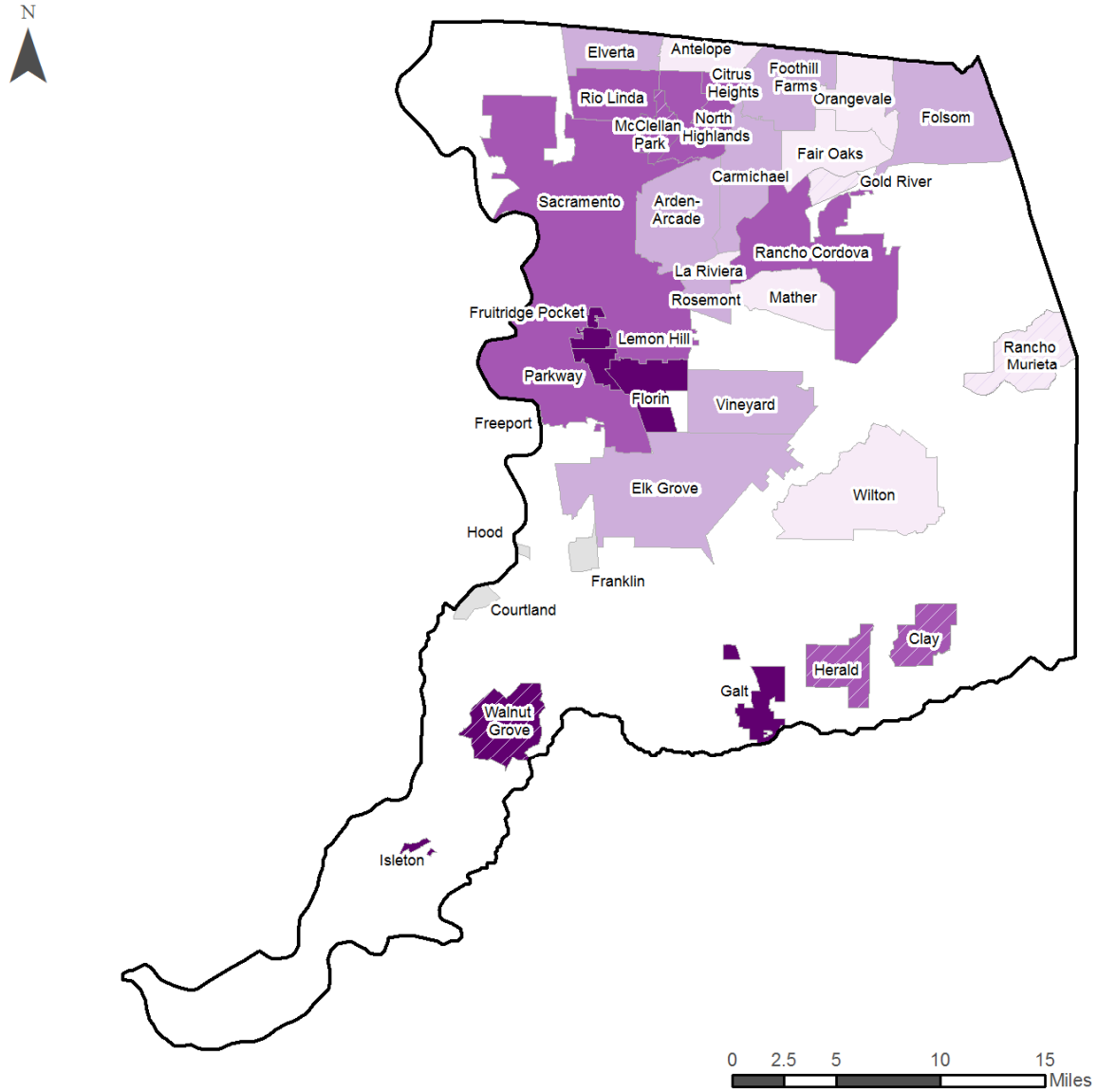
Figure 17. Percent of Population with less than high school educational attainment (ages 25 and older), by Race/Ethnicity, Sacramento County, CA 2006-2010



Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Education

Figure X. Percent of population age 25 years and older with less than a high school educational attainment, by cities and towns, Sacramento County, California, 2006-2010



Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Race and Ethnicity

What is the challenge?

Racial and ethnic communities of color are more likely to reside in areas with greater wildfire and flooding threats, more heat-absorbing surfaces and fewer public transit routes. These populations also experience disproportionate levels of increased population sensitivity including lower income, poorer physical health, multiple chronic conditions, language barriers, more elderly living alone, occupational exposures such as outdoor environments, and less access to air conditioning.

Why is this important to health?

The combination of greater exposure risk, increased sensitivity and reduced adaptive capacity compound the overall vulnerability to the health impacts of climate change. In Hurricane Katrina, many residents in low-income communities and communities of color were killed, injured, or had difficulty evacuating and recovering from the storm.

Who is most impacted?

- Communities of low socio-economic status
- Communities with decreased access to information about risk mitigation
- Prevalence of central air conditioning among Black households was less than half that among White households in national study examining 4 urban cities, and deaths among Blacks were more strongly associated with hot temperatures.
- Nationally, African-Americans were 52% more likely, Asians 32% more likely, and Hispanics 21% more likely than Whites to live in high risk-related land cover where impervious surfaces covered more than half the ground and more than half the population lacked tree canopy.
- African-Americans were 8.6 times more likely and Latinos were 4.5 times more likely than Whites to reside in high risk areas that have greater climate change threats, according to a study in Fresno County. These high risk areas typically have a greater proportion of elderly living alone and lower adaptive capacity (i.e., less social cohesion, less transportation options, and fewer air conditioners).

Figure 19. Percent of Population by Race/Ethnicity Groups, Sacramento County, CA 2010

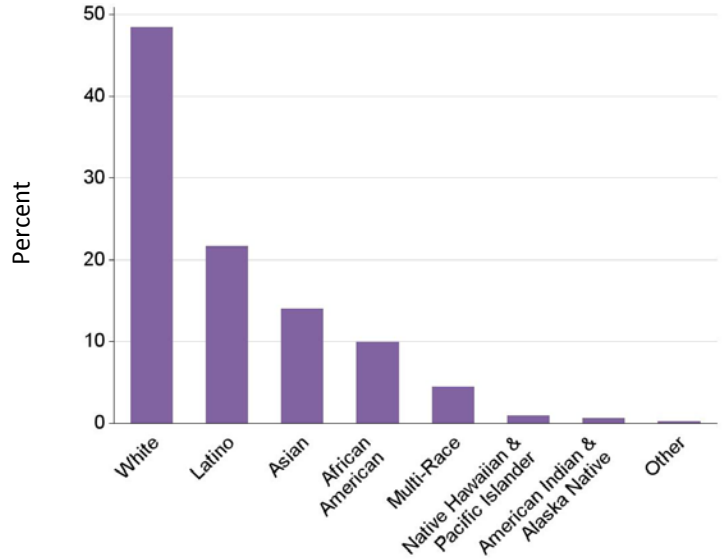


Table X. Cities and Towns (> 1,000 Population) With Highest Percent of Population Belonging to Communities of Color, Sacramento County, California, 2010

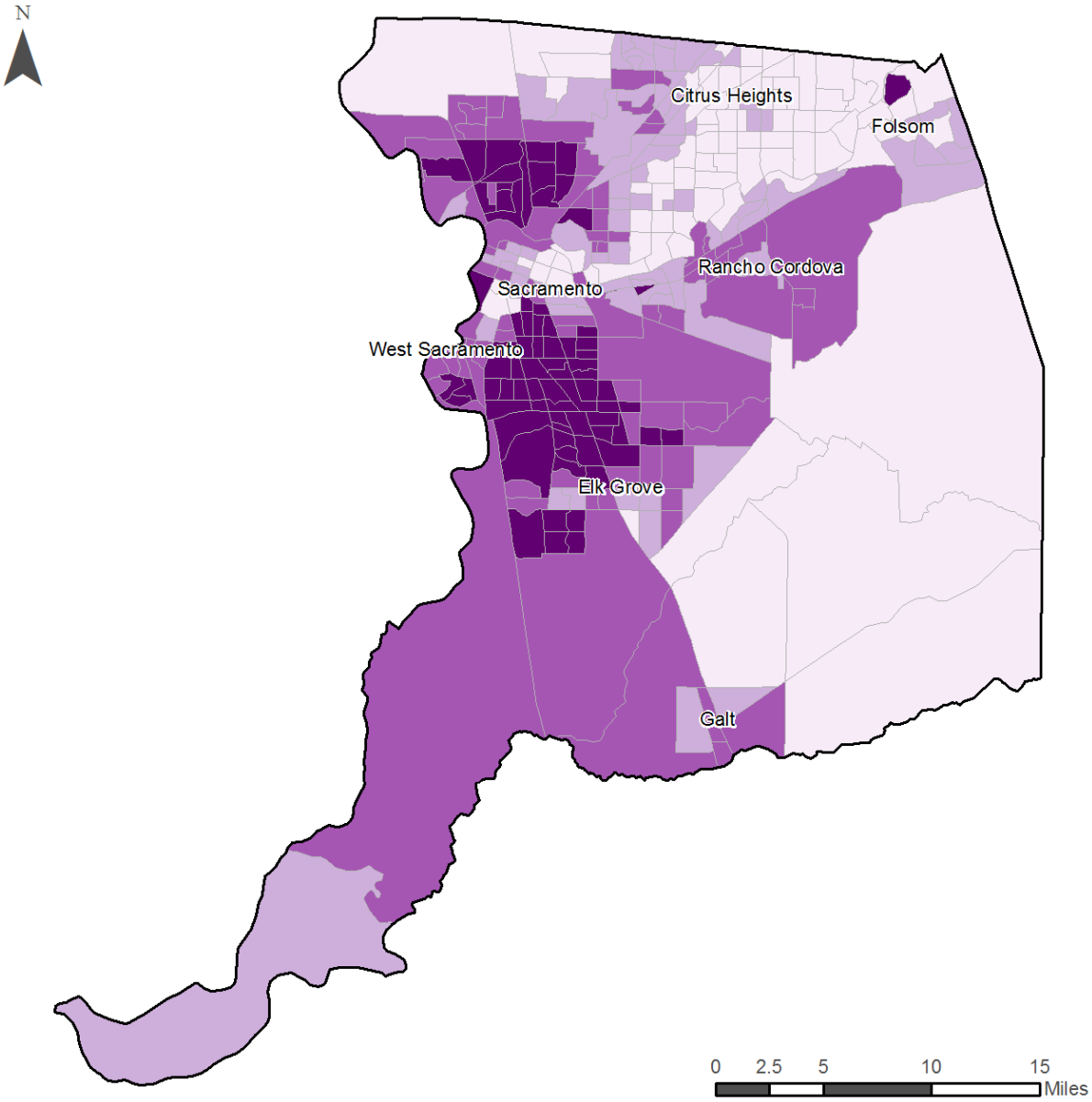
City/Town	Percent	Total Population
Fruitridge Pocket	**83%**	**5,800**
Lemon Hill	82%	13,729
Parkway	79%	14,670
Sacramento County	**52%**	1,418,788
California	60%	37,253,956

Sample population includes group quarters
Source: 2010 U.S. Decennial Census

Race and Ethnicity

Figure 20. Percent of population belonging to communities of color, by Census Tracts, Sacramento County, California, 2010

Population estimated includes group quarters which may have race/ethnicity distributions that are different from household populations.



Source: 2010 U.S. Decennial Census

Outdoor Workers

What is the challenge?

Working in an environment that is excessively hot poses a risk for heat health effects among persons who work outdoors.

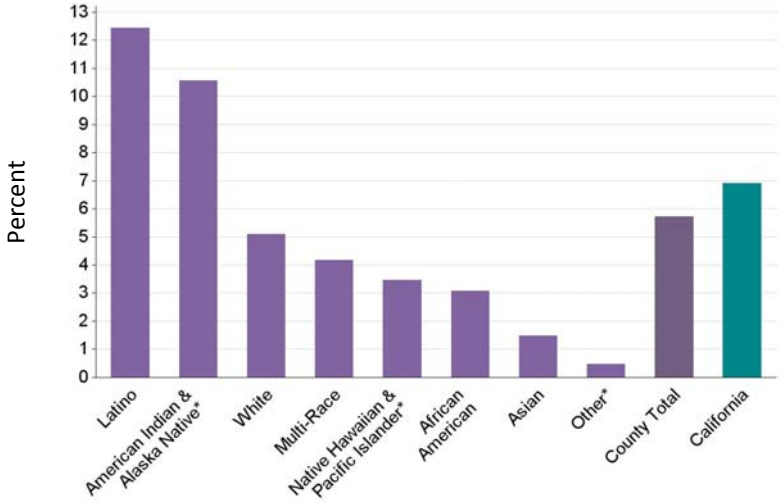
Why is this important to health?

Heat-related illness among miners, construction workers, farm laborers, first responders, and military personnel may be the most common cause of nonfatal environmental emergency department admission in the United States. California's agricultural and construction workers have experienced severe heat-related illness and death. During 1992-2006, the United States had a total of 68 crop workers die from heat stroke, representing a heat stroke rate of nearly 20 times greater than all civilian workers in the country.

Who is most impacted?

- Farm workers and day laborers: This population tends to have lower incomes and belong to communities of color, both factors which increase the risk of adverse health effects due to climate change.
- Immigrants: The socioeconomic status of immigrants in California who work in the agricultural and construction sectors makes them particularly vulnerable because of long workdays under strenuous conditions, language barriers, limited capacity to protect their rights, and exposure to chemicals such as pesticides.

Figure 23. Percent of Population Working Outdoor Jobs, by Race/Ethnicity Groups, Sacramento County, CA 2006-2010



*Unreliable Data (Relative Standard Error > 30%)

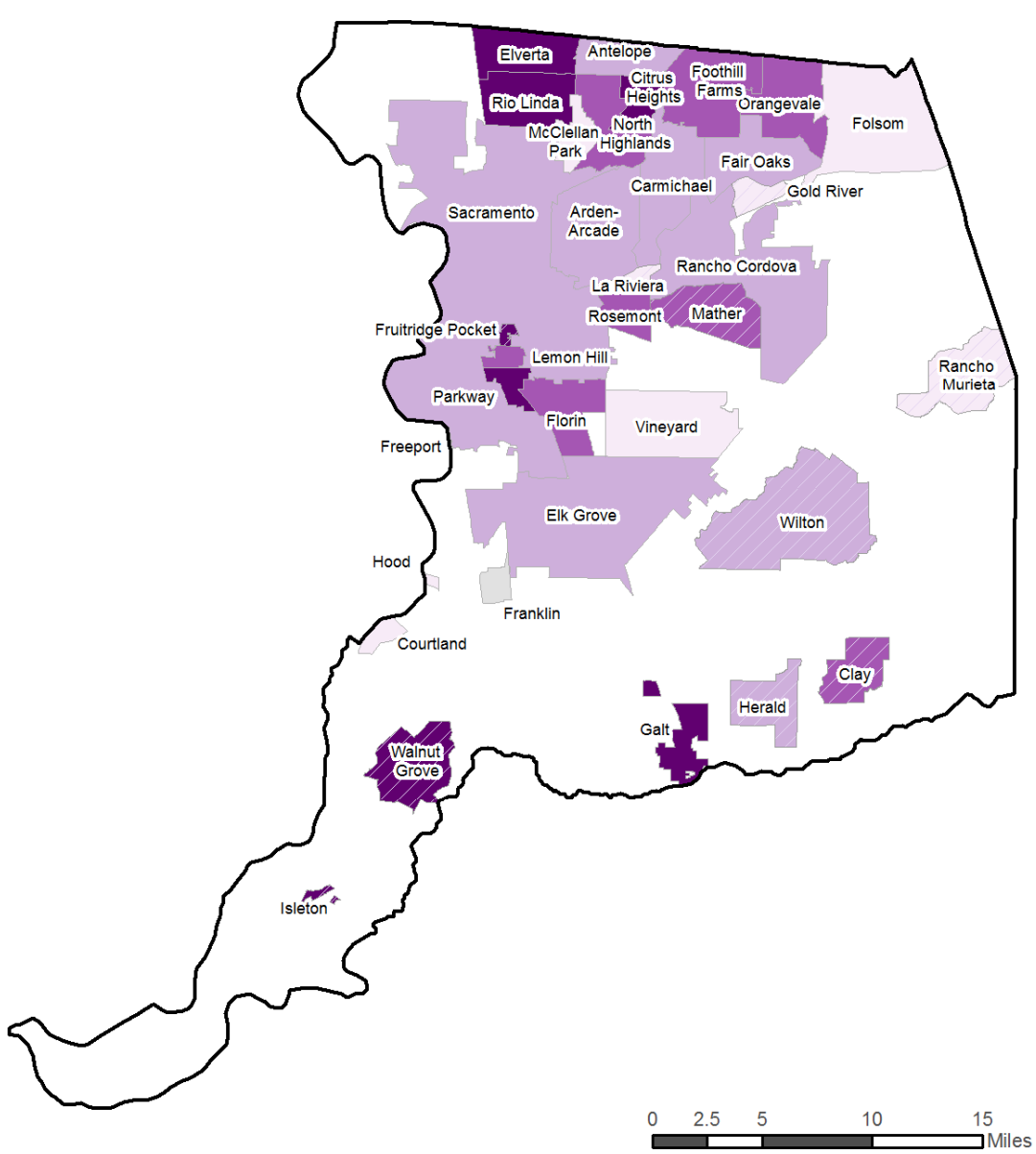
Sample population includes all civilian noninstitutionalized employed population 16 years and older. Estimates are based on residency and some outdoor workers, particularly migrant workers, may travel far from their residence for work.

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Outdoor Workers

Figure 20. Percent of population working outdoor jobs, by cities and towns, Sacramento County, California, 2006 - 2010

Sample population includes all civilian noninstitutionalized employed population 16 years and older. Estimates are based on residency and some outdoor workers, particularly migrant workers, may travel far from their residence for work.



- 0% - 3%
- 4% - 6%
- 7% - 9%
- 10% - 19%
- No Data or Not Applicable
- Unreliable Data (RSE >30)

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Vehicle Ownership

What is the challenge?

Vehicle ownership is a measure of mobility and access to transportation. Transportation is a critical resource during heat waves and other extreme weather events. For example, flooding may require emergency evacuation of populations living in coastal and low-lying areas, and may also require adequate sheltering for displaced populations.

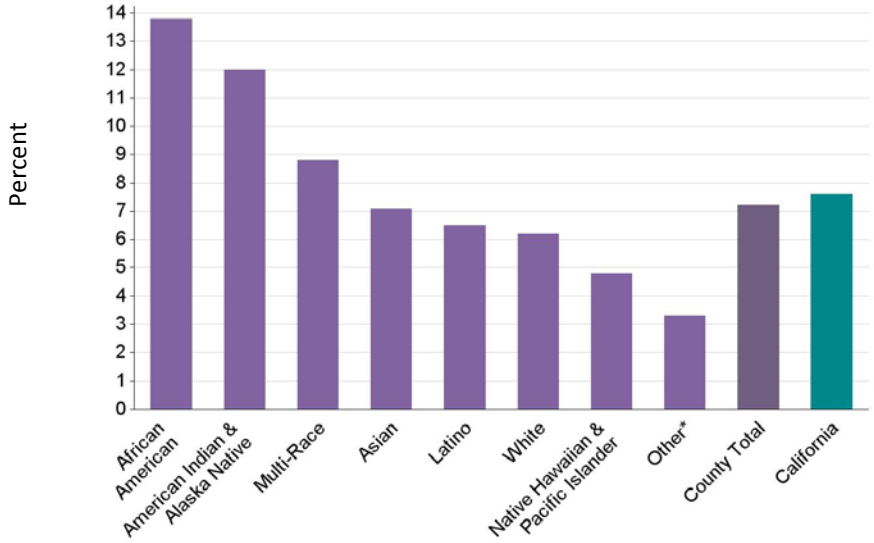
Why is this important to health?

Car ownership is important during extreme weather events because it improves access to cooling centers or shelter from environmental exposure such as wildfire, air pollution, heat waves, or flooding.

Who is most impacted?

- Urban areas generally have lower rates of automobile ownership, particularly in inner city populations with low income.
- Some communities of color are more likely to have limited or no access to a car which increases their risk of being impacted during heat and other extreme weather events. A survey among predominantly poor and African American Hurricane Katrina evacuees revealed that 34% reported lack of a car or other means of transportation as the main reason for not evacuating the storm's danger.
- Populations with higher rates of people of color and poverty are less likely to own cars. In the Los Angeles-Long Beach Metropolitan Area, higher proportions of African-Americans (20%), Latino (17%), and Asian (10%) households do not have access to a car compared to White households (8%).

Figure 24. Percent of Households With No Vehicle Ownership, by Race/Ethnicity Groups, Sacramento County, CA 2006-2010



*Unreliable Data (Relative Standard Error > 30%)

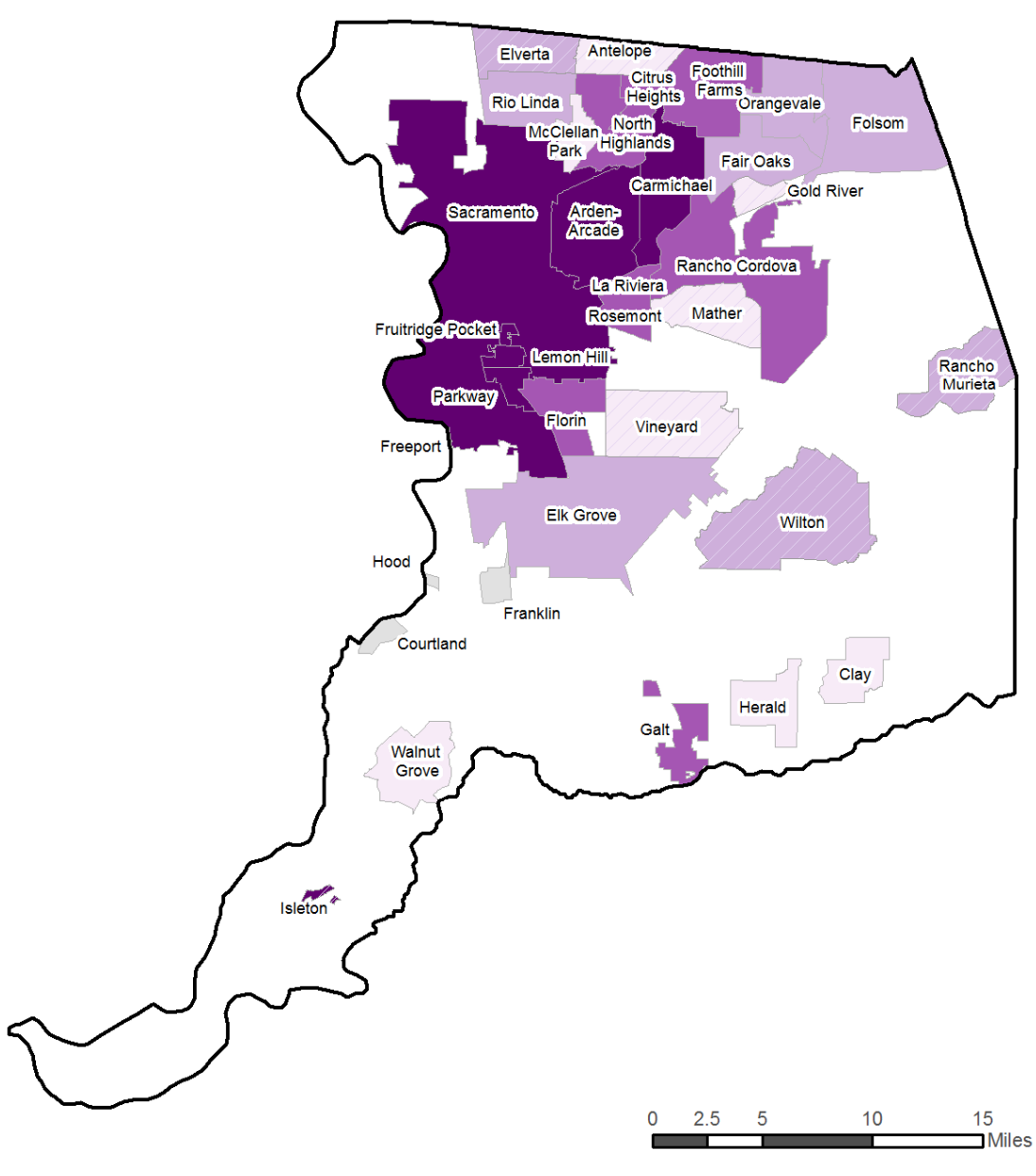
Sample population includes all occupied housing units. Vehicles kept at home but used only for business purposes are excluded. Data not available at place level and census tract level .

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Vehicle Ownership

Figure 20. Percent of households with no vehicle ownership, by cities and towns, Sacramento County, California, 2006 - 2010

Sample population includes all occupied housing units. Vehicles kept at home but used only for business purposes are excluded. Data not available at place level and census tract level .



0% - 2%
3% - 4%
5% - 9%
10% - 17%
No Data or Not Applicable
Unreliable Data (RSE >30)

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Linguistic Isolation

What is the challenge?

Climate change and resulting natural disasters and extreme temperatures pose a serious public health concern for people who are linguistically isolated. A household is linguistically isolated when all persons 14 years of age or older speak a language other than English and none speak English very well.

Why is this important to health?

Linguistic isolation may hinder protective behaviors during extreme weather and disasters by limiting access to or understanding of emergency or health warnings. Failure to evacuate or take shelter in place during coastal storms or other extreme weather events increases vulnerability or susceptibility to injury or death. Low literacy in people who are linguistically isolated can be another barrier to access critical health and safety information. Additionally, natural disasters and extreme weather can disrupt management of chronic conditions for people who are socially or linguistically isolated. A study found that people who live in linguistically isolated households were at increased risk of extreme heat-related health problems and more heat distress calls to 911.

Who is most impacted?

Language barriers can be an issue not only for new immigrants from non-English speaking countries, but also older first generation migrants who revert to their first languages later in life due to aging. Also, recently arrived people who are older sometimes can only communicate with people their own age as the younger generation do not speak the traditional dialects.

Table X. Percent of Linguistically Isolated Households, Sacramento County, California, 2006-2010

	Percent	Total Households
Sacramento County	7%	508,499
California	10%	12,392,852

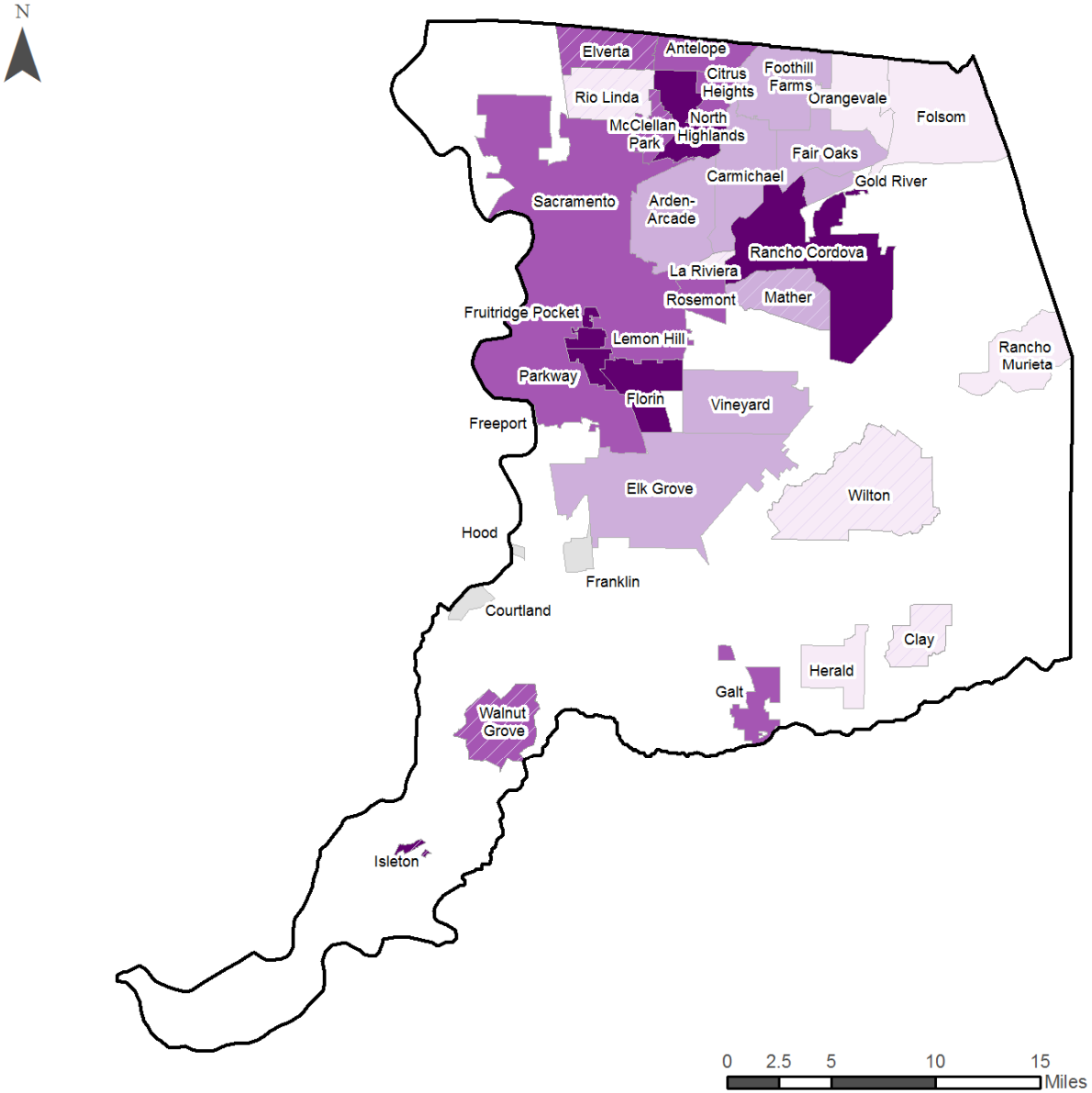
Linguistically isolated households is defined as households in which no one 14 years of age and over speaks English only, speaks a language other than English at home, or speaks English "Very Well". People who speak a language other than English outside of the home are not reported as speaking a language other than English.

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Linguistic Isolation

Figure 20. Percent of linguistically isolated households, by cities and towns, Sacramento County, California, 2006 - 2010

Linguistically isolated households is defined as households in which no one 14 years of age and over speaks English only, speaks a language other than English at home, or speaks English "Very Well". People who speak a language other than English outside of the home are not reported as speaking a language other than English.



- 0% - 2%
- 3% - 6%
- 7% - 10%
- 11% - 26%
- No Data or Not Applicable
- Unreliable Data (RSE >30)

Source: U.S. Census Bureau, American Community Survey (ACS), 2006-2010

Physical Disability

What is the challenge?

Climate change is expected to cause increased hardship for persons with physical disabilities during emergencies due to extreme weather events and displacement as a result of flooding, erosion, and agricultural disruptions. Persons with physical disabilities face disadvantage with limited resources and mobility during the phases of evacuation, response, and recovery.

Why is this important to health?

Key issues that may impact quality of life and well-being of persons with a physical disability as a result of extreme weather and climate change exposures include the following: food insecurity and resulting malnutrition; decreased access to clean water, sanitation and hygiene; reduced access to shelter and basic services; and displacement or migration. People with disabilities are disadvantaged in their ability to adapt to physical displacement due to difficulty in mobility and access to resources. Population displacement compromises medical care which increases the risk of disease exposure and can worsen existing medical conditions. People with disability may have multiple medical conditions and may be recipients of multiple treatments; thus, their decreased access to medical services (health care) and increased risk of disease exposure can greatly impact their health.

Who is most impacted?

Populations with physical disability have increased vulnerability to the health impacts of climate change include the following:

- Persons with less education, less income, and living in an urban area
- Persons who belong to marginalized groups based on gender, race, ethnicity, or language
- Elderly and children with disabilities and their caregivers

Table X. Percent of Population Living with a Physical Disability*, Sacramento County, California, 2008-2012

	Percent	Total Population
Sacramento County	7%	1,301,428
California	6%	34,240,024

*Physical disability in this analysis is defined by U.S. Census Bureau as ambulatory disability (serious difficulty walking or climbing stairs) among noninstitutionalized persons ages 5 years or older.

This estimate is likely an underestimate since populations with other disabilities (such as hearing, vision, self-care, or independent living difficulties) are not included in this analysis but would also be vulnerable to the health impacts of climate change.

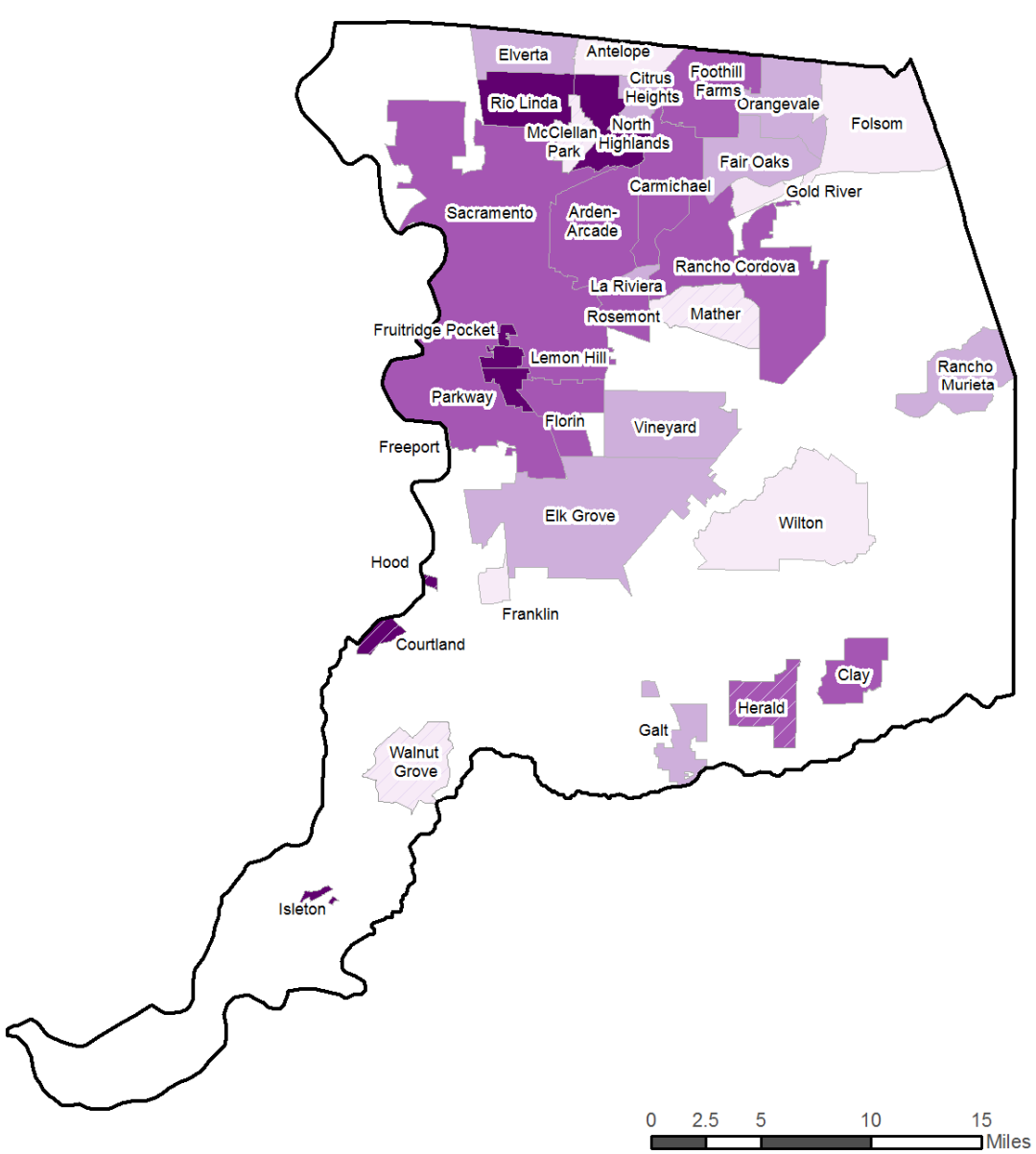
Source: U.S. Census Bureau, American Community Survey (ACS), 2008-2012

Physical Disability

Figure 20. Percent of population living with a physical disability*, by cities and towns, Sacramento County, California, 2008 - 2012

*Physical disability in this analysis is defined by U.S. Census Bureau as ambulatory disability (serious difficulty walking or climbing stairs) among noninstitutionalized persons ages 5 years or older.

This estimate is likely an underestimate since populations with other disabilities (such as hearing, vision, self-care, or independent living difficulties) are not included in this analysis but would also be vulnerable to the health impacts of climate change.



0% - 5%
6% - 7%
8% - 9%
10% - 29%
Unreliable Data (RSE >30)

Source: U.S. Census Bureau, American Community Survey (ACS), 2008-2012

Mental Disability

What is the challenge?

Climate change will bring more frequent, long lasting and severe adverse weather events and these changes can affect the severity and incidence of mental disabilities and mental health problems.

Why is this important to health?

Climate change may affect mental health in several ways leading to serious mental health problems and possible increased suicide rates as these vary with weather and rising temperatures. Following disasters, mental health problems increase, among both people with no history of mental illness or disability, and those with pre-existing risk. Climate change may affect people with mental health disabilities directly by exposing people to trauma or by affecting their physical health. The major impacts of climate change factors on mental health are likely to be associated with the stress and shock of storms, droughts, floods, and other weather extremes. Persons with severe mental illness, such as schizophrenia, are at risk because their medications may interfere with self-regulation of body temperature. There are direct physiological effects of heat strain that can reduce the ability to work at full capacity and to carry out various daily activities. Additionally, potential mental health impacts include the distress associated with environmental degradation or becoming displaced, and the knowledge of climate change may lead to anxiety and despair in some people.

Who is most impacted?

- Long-term mental health services are needed for low-income disaster survivors, especially those who experience disaster-related stressors.
- People with previous traumas or compounded losses may have longer recovery periods.
- There is concern in Australia that droughts substantially increase the incidence of suicide in rural populations, particularly among male farmers and their families.
- Increasing heat exposure can also worsen the clinical condition of people with pre-existing chronic diseases and mental health problems.
- Pre-existing dementia is a risk factor for hospitalization and death during heat waves.

Table X. Percent of Population Living with a Mental Disability*, Sacramento County, California, 2008-2012

	Percent	Total Population
Sacramento County	6%	1,301,428
California	4%	34,240,024

*Mental disability in this analysis is defined as cognitive disability (having difficulty remembering, concentrating, or making decisions (DREM) because of a physical, mental, or emotional problem) among noninstitutionalized persons ages 5 years or older.

This estimate is likely an underestimate since populations with mental health conditions or other disabilities (such as self-care, or independent living difficulties) are not included in this analysis but would also be vulnerable to the health impacts of climate change.

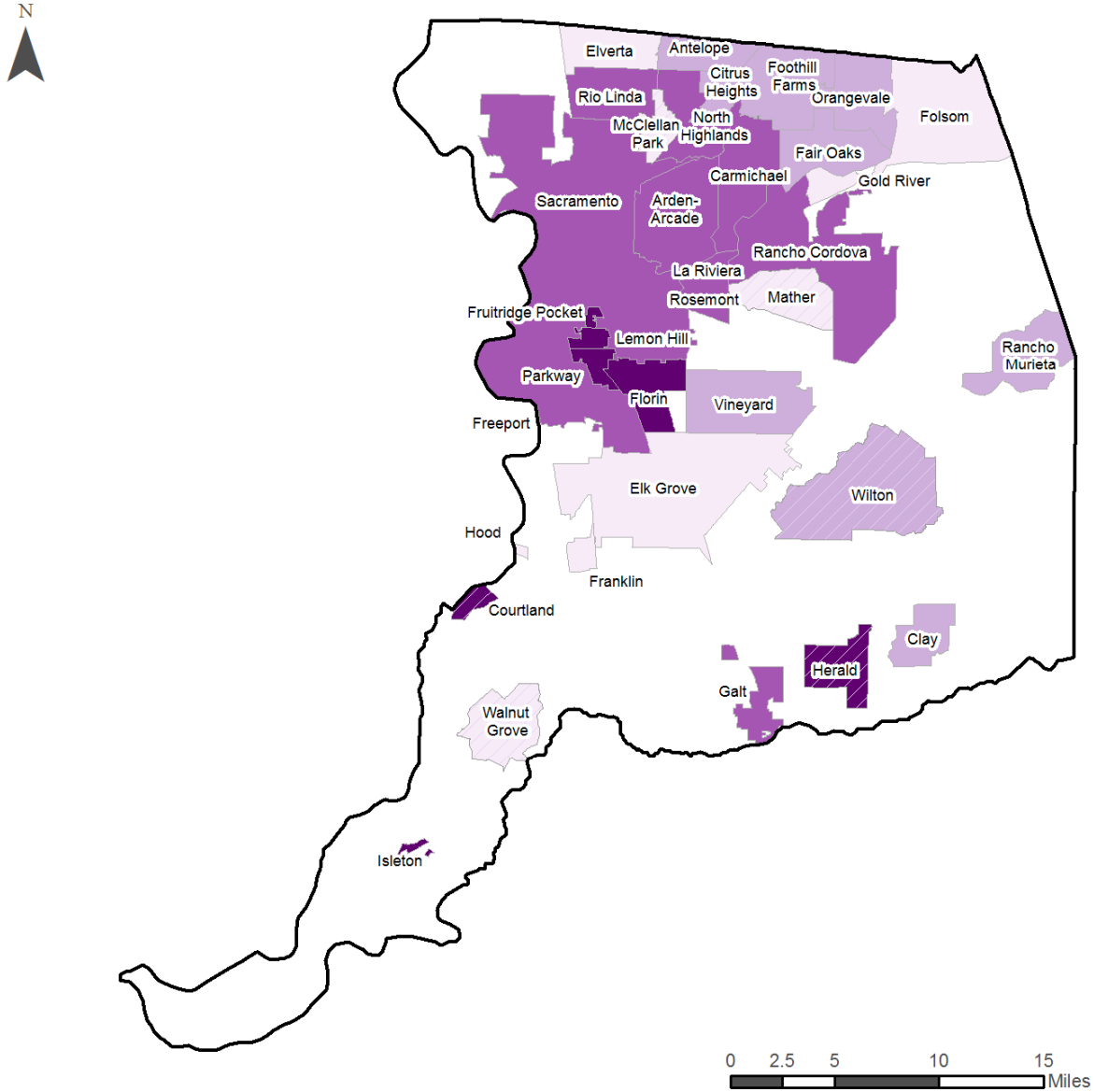
Source: U.S. Census Bureau, American Community Survey (ACS), 2008-2012

Mental Disability

Figure 20. Percent of population living with a mental disability*, by cities and towns, Sacramento County, California, 2008 - 2012

*Mental disability in this analysis is defined as cognitive disability (having difficulty remembering, concentrating, or making decisions (DREM) because of a physical, mental, or emotional problem) among noninstitutionalized persons ages 5 years or older.

This estimate is likely an underestimate since populations with mental health conditions or other disabilities (such as self-care, or independent living difficulties) are not included in this analysis but would also be vulnerable to the health impacts of climate change.



0% - 4%
5% - 6%
7%
8% - 23%
Unreliable Data (RSE >30)

Source: U.S. Census Bureau, American Community Survey (ACS), 2008-2012

Health Insurance

What is the challenge?

Excessive heat exposures, elevated levels of air pollutants, and extreme weather conditions are expected to cause direct and indirect health impacts, particularly for vulnerable populations with limited or no access to health services. Health insurance enables access to care by connecting people to health care providers and by protecting persons against the high and often unexpected costs of medical care. A lack of health insurance among vulnerable populations that are exposed to the effects of climate changes may lead to greater health impacts.

Why is this important to health?

Insurance coverage is a key determinant of timely access and utilization of health services which is a fundamental pathway to improved health outcomes. A national study demonstrated an increased risk of mortality among the uninsured compared with the insured and estimated 44,789 annual deaths among Americans aged 18 to 54 associated with lack of health insurance. A systematic review of literature in 2008 found consistent evidence demonstrating that health insurance increases utilization and improves health. A national systematic review in 2010 found that patients who were uninsured were less likely to receive critical care services than those with insurance.

Who is most impacted?

- Low-income households
- Women: A study in Los Angeles County revealed lack of access to health care services as a significant barrier to health promotion and wellness, particularly for women and especially for women of Black, Latino, or Asian/Pacific Islander ethnicity.
- Displaced populations: A study among population displaced to shelters from Hurricane Katrina found lack of health insurance was a significant risk factor for lacking medications and arriving at the shelter needing immediate medical intervention.
- Undocumented immigrant populations, especially children

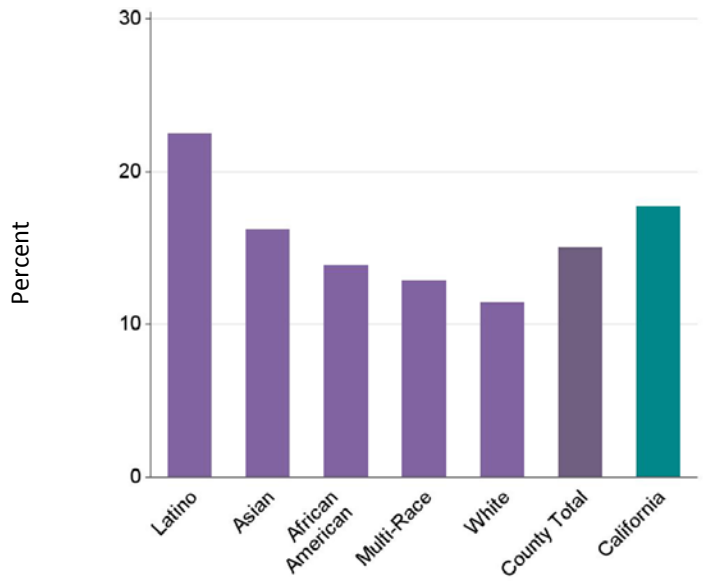
Table X. Percent of Population Without Health Insurance, Sacramento County, California, 2009-2013

	Percent	Total Population
Sacramento County	15%	**1,416,508**
California	18%	37,130,876

Sample population does not include active-duty military personnel and populations living in correctional facilities and nursing homes.

Source: U.S. Census Bureau, American Community Survey (ACS), 2009-2013

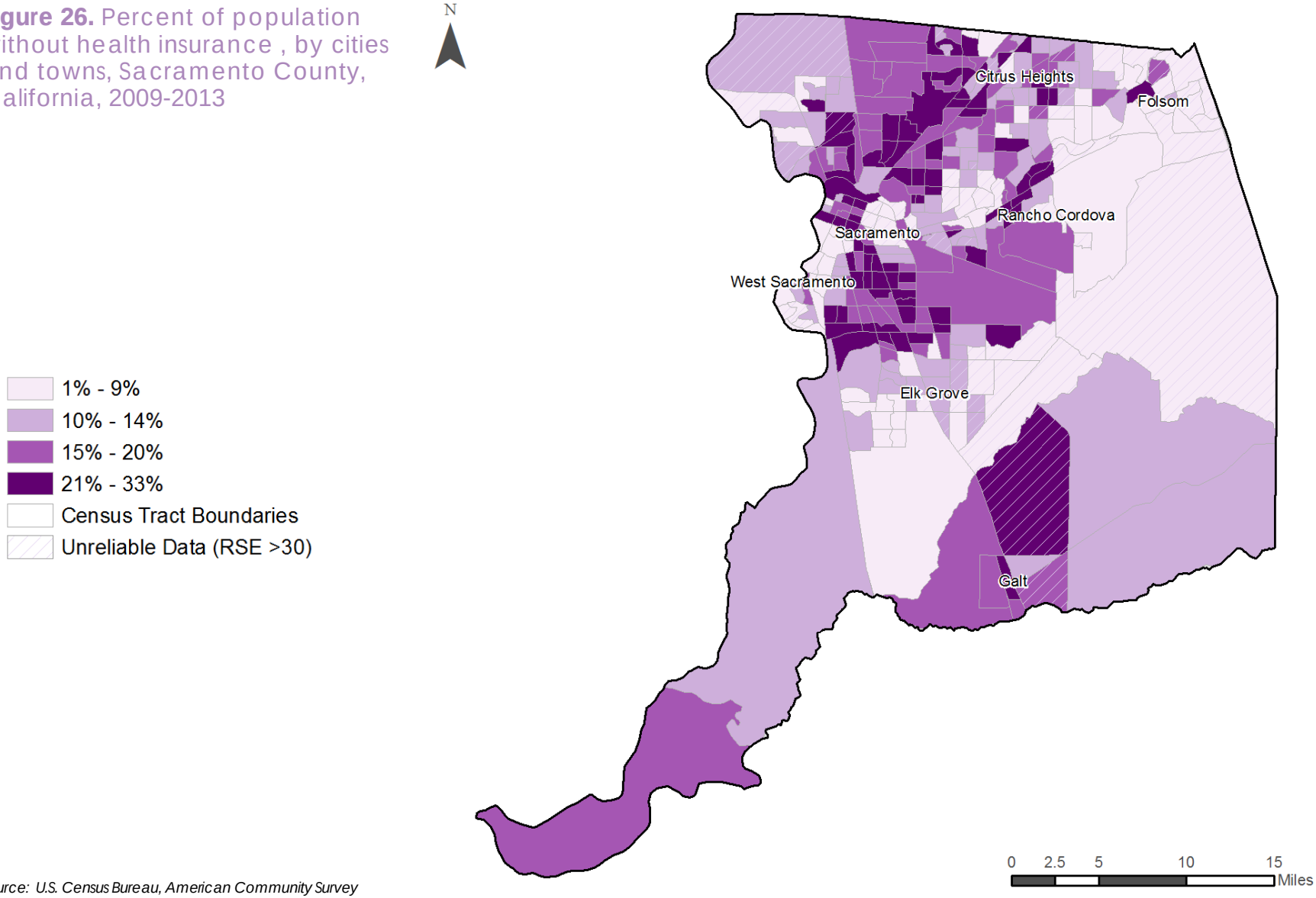
Figure 25. Percent of Population Without Health Insurance, by Race/Ethnicity Groups, Sacramento County, CA 2011-2013



Source: U.S. Census Bureau, American Community Survey (ACS), 2011-2013

Health Insurance

Figure 26. Percent of population without health insurance , by cities and towns, Sacramento County, California, 2009-2013



Source: U.S. Census Bureau, American Community Survey (ACS), 2009-2013

Violent Crimes

What is the challenge?

Natural disasters worsened by climate change increase the displacement of victims, which in turn increase population densities and tensions over resources. Increased population densities and decreased resources, whether factual or perceived, are likely to further violent crime.

Why is this important to health?

Safe neighborhoods that are free of crime and violence are an integral component of healthy neighborhoods. Injuries — both physical and mental — from violence and crime contribute greatly to the overall burden of disease and death. Post-traumatic stress in victims, families, and community members add significantly to mental health problems and are risk factors for chronic illnesses like cardiovascular disease. In addition to direct physical and mental impacts, fear of crime and violence inhibit the use of community assets and social interaction that promote health. These include stifling opportunities for physical exercise at nearby parks and playgrounds, or walking or bicycling as a way to commute to local destinations for basic needs. Furthermore, violence contributes to negative perceptions of neighborhoods and impacts real estate, housing, and economic development.

Who is most impacted?

- Communities of color: African Americans in California are 11 times more likely to die of assault and homicide than Whites.
- Young adults: Ten percent of all deaths in young California adults aged 15-44 years are related to assault and homicide.
- Women: In 2013, California law enforcement agencies reported 1,832 murders, 39,811 cases of violence against women, and over 109,000 aggravated assaults.

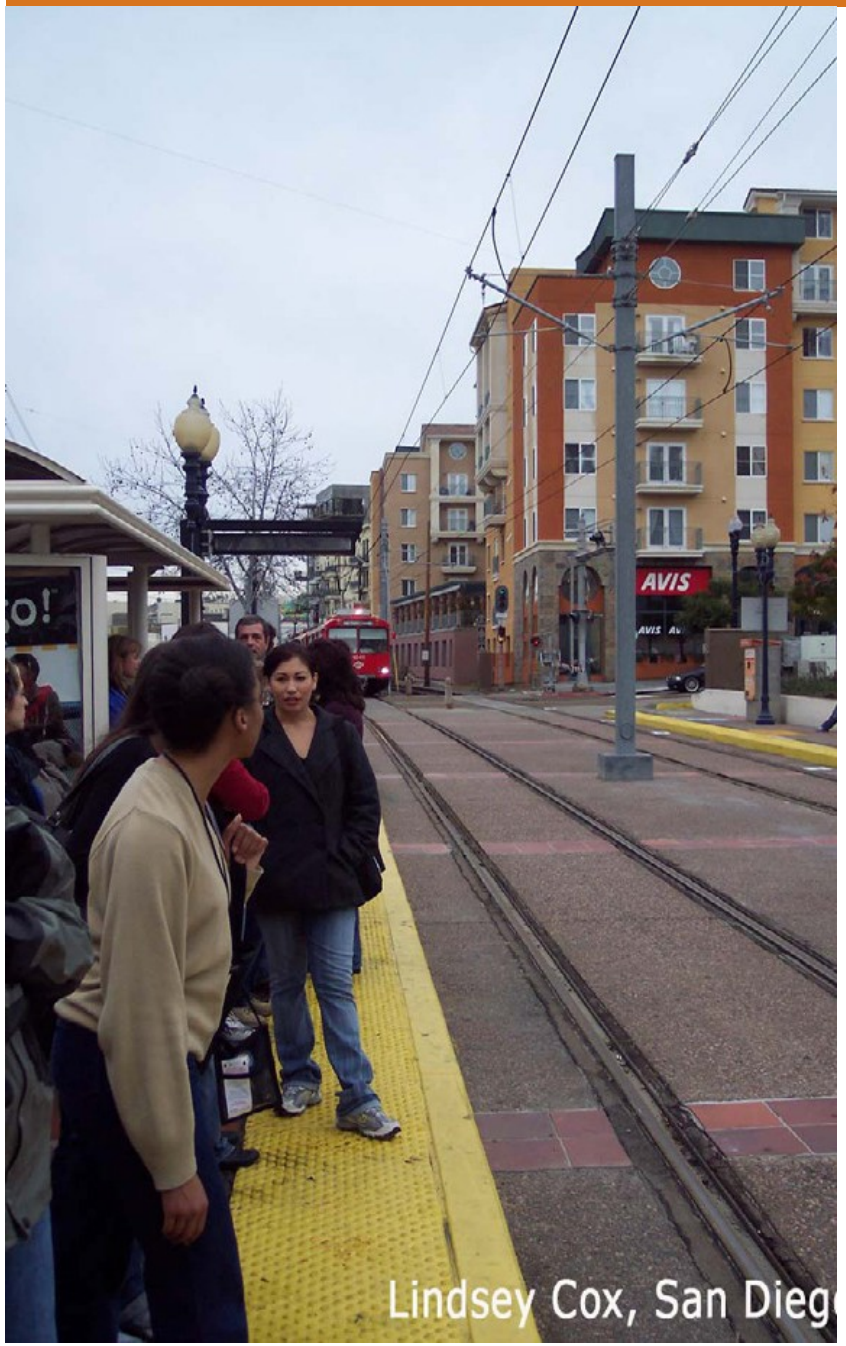
Table X. Number of Violent Crimes per 1,000 Residents, Sacramento County, California, 2010

	Crimes per 1,000 Residents	Total Population
Sacramento County	6	1,418,788
California	4	37,615,047

Data are based on incidents reported to law enforcement agencies. Violent crimes include murder and nonnegligent manslaughter, forcible rape, robbery, aggravated assault, simple assault, and intimidation. Because some crimes such as sexual assaults are underreported, crime data are not always accurate. Limitations in the use of these data are detailed at http://www.fbi.gov/about-us/cjis/ucr/ucr-statistics-theirproper-use.

Source: Uniform Crime Reports from Federal Bureau of Investigation, 2010.

Adaptive Capacity



Air Conditioning Ownership 41

Tree Canopy 42

Impervious Surfaces 43

Public Transit Access 45

Air Conditioning Ownership

What is the challenge?

Increasing temperatures and the risk of heat waves pose a serious public health concern. Air conditioning (AC) is an important protective factor against heat-related morbidity and mortality.

Why is this important to health?

In California, an estimated 65 percent of households have central or room AC; however, this varies greatly by income, the age of the house, and geographic location. Studies have shown that having working AC was the strongest protective factor against death during a heat wave, followed by access to an air-conditioned place for some time. Research specific to California found that a 10 percent increase in AC ownership would reduce heat-related mortality by 1.4 percent per 10°C change in temperature. A similar protective effect was found for the excess risk of hospitalizations.

Who is most impacted?

- Areas currently unaccustomed to heat waves, such as coastal communities, northern latitudes and higher elevations.
- Houses, schools, workplaces and older buildings (e.g., in older urban neighborhoods and in rural areas) generally do not have insulation or air conditioning.
- The cost of air conditioning can be a barrier to low income households. Even in households that have AC, using it may be limited by financial considerations.
- The elderly are also at an increased risk for mortality during heat waves, and children may be at increased risk for heat-related illnesses. One study found that more than one third of elderly people in the US restrict use of AC during hot weather due to financial burden.
- Communities of color have both higher heat-related morbidity and mortality and lower access to AC. One study found heat-associated mortality to be two times higher in Blacks than in Whites, and 64 percent of this disparity is attributable to central AC prevalence.

Figure 28. Statewide Percent of Households Without Air Conditioning, by Race/Ethnicity Groups, California, 2009

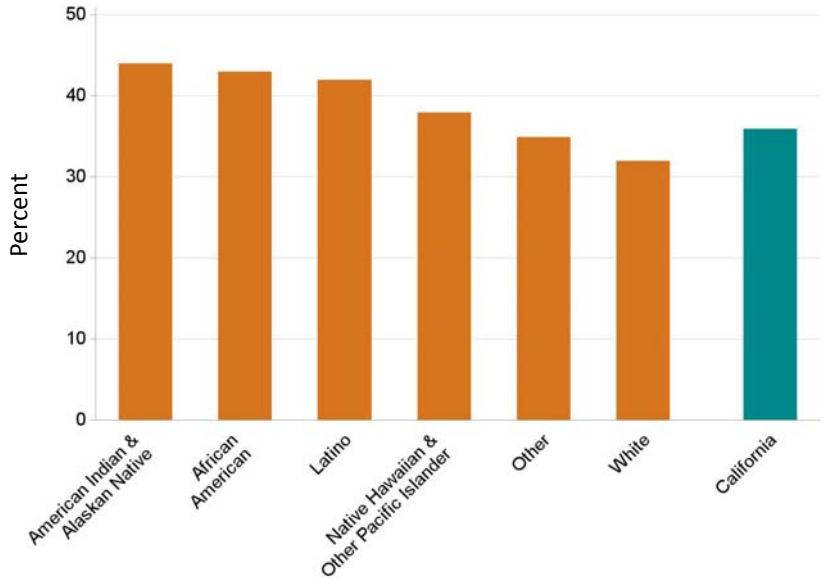


Table X. Percent of Households Without Air Conditioning , Sacramento County, California, 2009

	Percent	Total Households
Sacramento County	0%	2,339.00
California	36%	11,523,719

Source: Residential Appliance Saturation Study, 2009; U.S. Census Bureau, 2010. Analysis done by UC Davis and CDPH. Data only available at state level due to large error margins.

Tree Canopy Coverage

What is the challenge?

Increasing temperatures and the risk of heat waves poses a serious public health concern. Increasing temperatures in urban areas can cause the urban heat island effect (a phenomenon in which urban areas are warmer than the surrounding non-urban areas).

Why is this important to health?

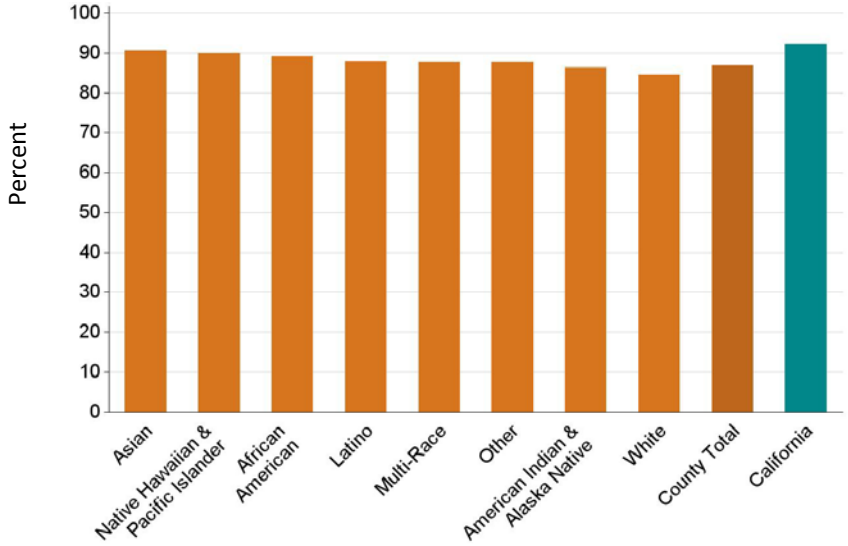
Evidence links tree cover to reducing air pollution from particulate matter, which in turn, reduces heart disease, respiratory illness, and lung cancer. Urban greening, such as parks and trees, may have a local cooling effect through shade and evapotranspiration. Tree canopy creates environments that reduce stress and neighborhood violence. Research has shown a positive effect from a natural, green environment on physical health, mental health, and longevity. Green spaces have also been shown to lessen flood risk and increase community safety, while simultaneously promoting active lifestyle and physical activity.

Who is most impacted?

The history of urban residential segregation and tree planting or removal may lead to some communities of color with less tree canopy and higher potential risks to heat exposure.

- Communities of color have both higher heat-related morbidity and mortality and lower access to air conditioning. Heat-associated mortality is two times higher in Blacks than in Whites, and 64 percent of this disparity is attributable to central AC prevalence.

Figure 30. Percent Without Tree Canopy Coverage weighted by population, by Race/Ethnicity Groups, Sacramento County, California, 2011



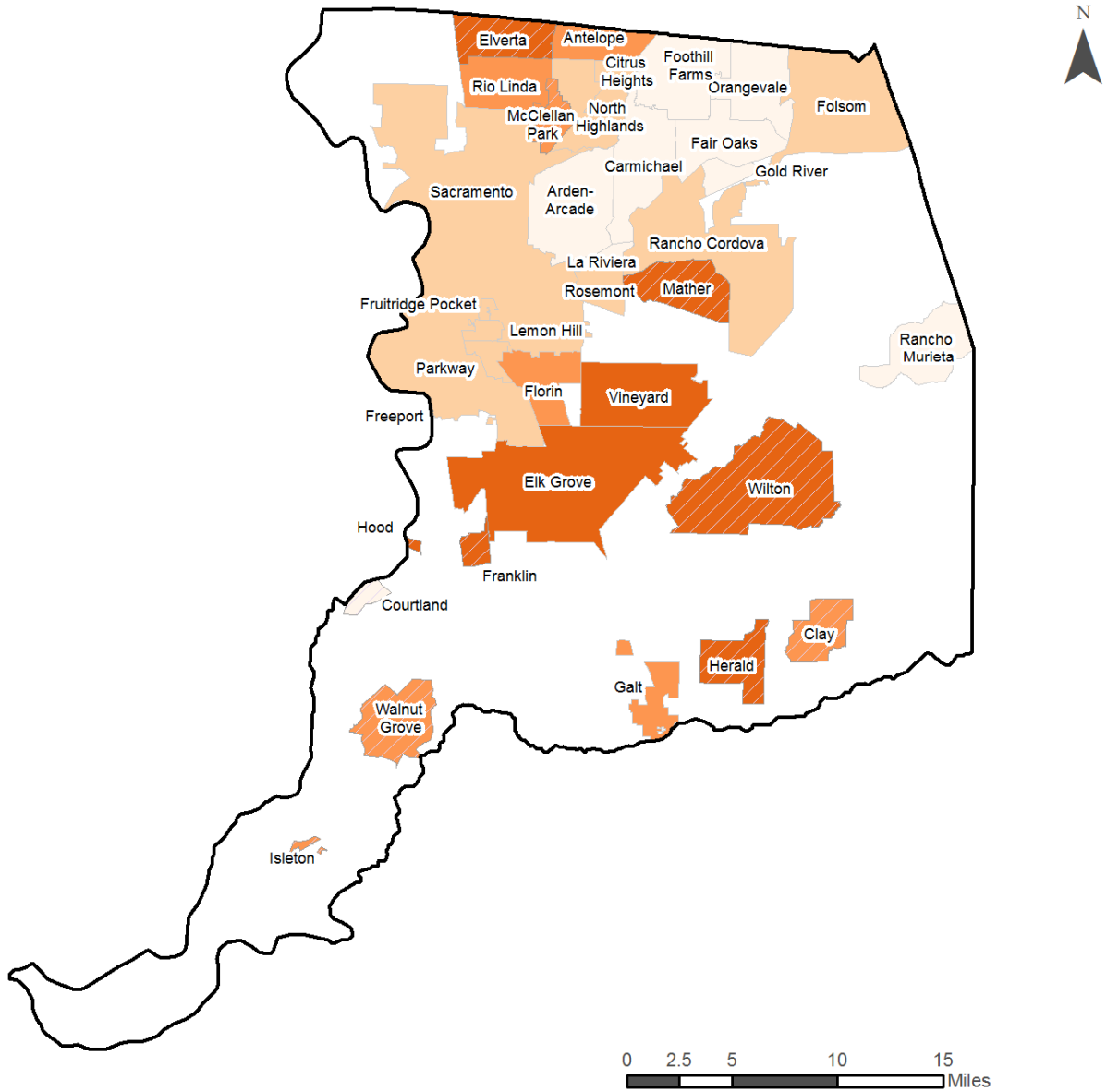
Tree Canopy Coverage

Figure 32. Percent without tree canopy coverage, weighted by population, by Census Places, Sacramento County, California, 2011

Data represents the percent of area not covered by tree canopy coverage. Data may be slightly underestimated at the local level

Source: 2011 National Land Cover Database; U.S. Census Bureau, 2010. Analysis done by UC Davis and CDPH.

- 71% - 84%
- 85% - 88%
- 89% - 93%
- 94% - 98%
- Unreliable Data (RSE >30)



Impervious Surfaces

What is the challenge?

Impervious surfaces are mainly artificial structures (including pavements, roads, sidewalks, parking lots) that are covered by materials in which water cannot pass through such as asphalt, concrete, and brick. Impervious surfaces retain heat and present barriers to absorption of water which can lead to the urban heat island effect, a phenomenon in which urban areas are warmer than the surrounding non-urban areas. Measures of impervious surfaces are important for assessing impacts from development of infrastructure and built environment on urban temperatures, precipitation runoff, and water quality.

Why is this important to health?

Increased heat exposure due to increasing temperatures over time and the risk of heat waves can lead to adverse health effects. Studies in United States cities as well as Montreal, Barcelona, Hong Kong, and Taiwan found associations between heat-related health effects and impervious surfaces. A New York City study found that extensive urban development has the potential to increase afternoon temperatures and decrease the amount of water in the air.

Who is most impacted?

- Communities of color are disproportionately represented in densely populated areas with more impervious surfaces which increases their risk of exposure to heat stress.
- Elderly: A study in New York City found significant positive association between impervious land cover and heat-related deaths among elderly persons.

Figure 31. Percent Impervious Surfaces weighted by population, by Race/Ethnicity Groups, Sacramento County, California, 2011

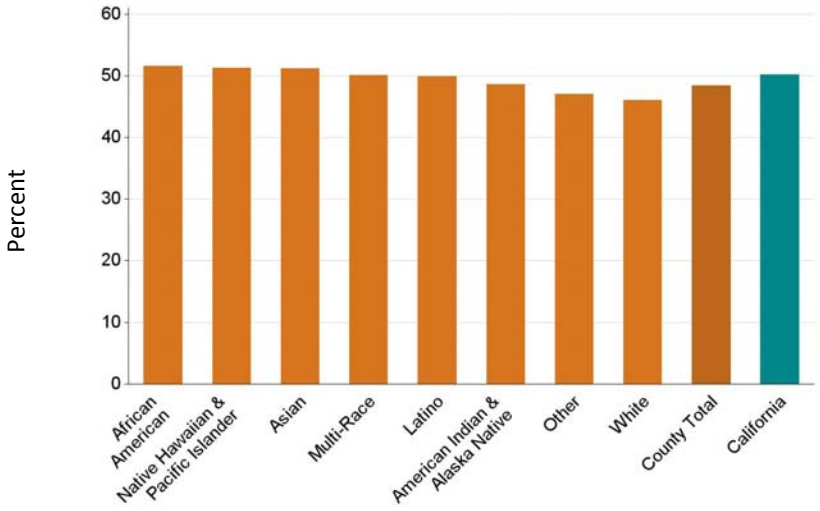


Table X. Cities and Towns (> 1,000 Population) With Highest Percent Impervious Surfaces weighted by population, Sacramento County, California, 2011

City/Town	Percent	Total Population
Rosemont	**56%**	**22,681**
North Highlands	55%	42,694
Foothill Farms	54%	33,121
Sacramento County	**48%**	1,426,490
California	50%	37,253,956

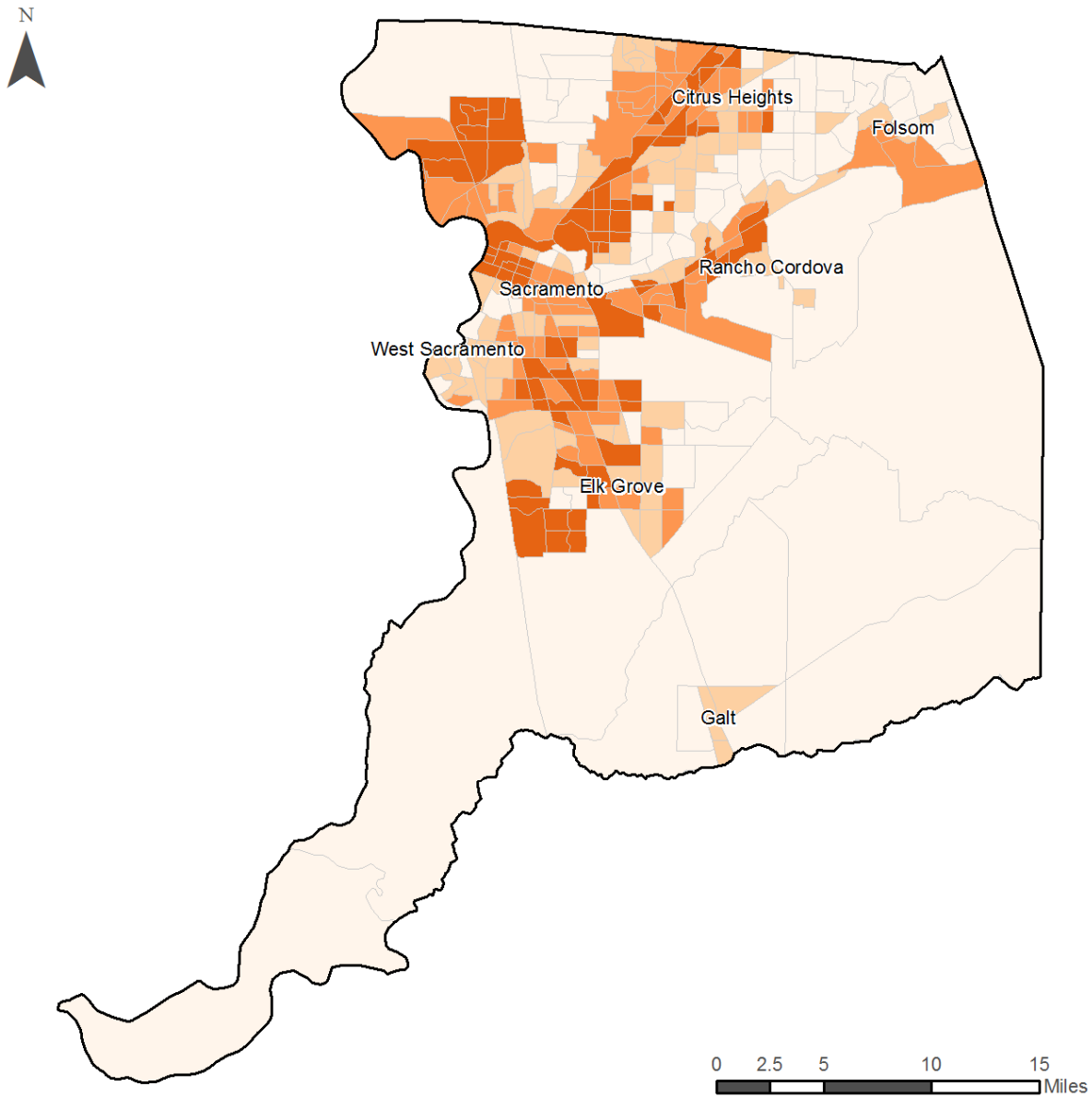
Source: 2011 National Land Cover Database; U.S. Census Bureau, 2010. Analysis done by UC Davis and CDPH.

Impervious Surfaces

Figure 32. Percent impervious surfaces, weighted by population, by Census Tracts, Sacramento County, California, 2011

Impervious surfaces retain heat and present barriers to water. Data represents the percent of area covered by impervious surfaces. Data may be slightly underestimated at the local level

Source: 2011 National Land Cover Database; U.S. Census Bureau, 2010. Analysis done by UC Davis and CDPH.



- 1% - 44%
- 45% - 50%
- 51% - 55%
- 56% - 76%
- Census Tract Boundaries

Public Transit Access

What is the challenge?

Limited access to public transit impedes ability to relocate to cooler spaces during extreme heat events or to evacuate during wildfires, flood events, or other natural disasters.

Why is this important to health?

A strong and sustainable transportation system supports safe, reliable, and affordable transportation opportunities for walking, bicycling, and public transit, and helps reduce health inequities by providing more opportunities for access to healthy food, jobs, health care, education, and other essential services. Active and public transportation promote health by enabling individuals to increase their level of physical activity, potentially reducing the risk of heart disease and obesity, improving mental health, and lowering blood pressure. Compared to public transit, a higher portion of trips by automobiles are associated with traffic accidents and increased air pollution, which are linked to increased rates of respiratory illness and heart disease.

Who is most impacted?

Individuals who live close to transit are more likely to be transit users and drive their cars less than people residing far from transit.

1: Public transit access is defined as residing within 1/2 mile of bus/rail/ferry stop with waiting time < 15 minutes during peak commute hours.

Data Sources: Sacramento Area Council of Governments (SACOG), 2008

Figure 33. Percent of Residents Without Access to High Quality Public Transit[1], by Race/Ethnicity Groups, Sacramento County, California, 2008

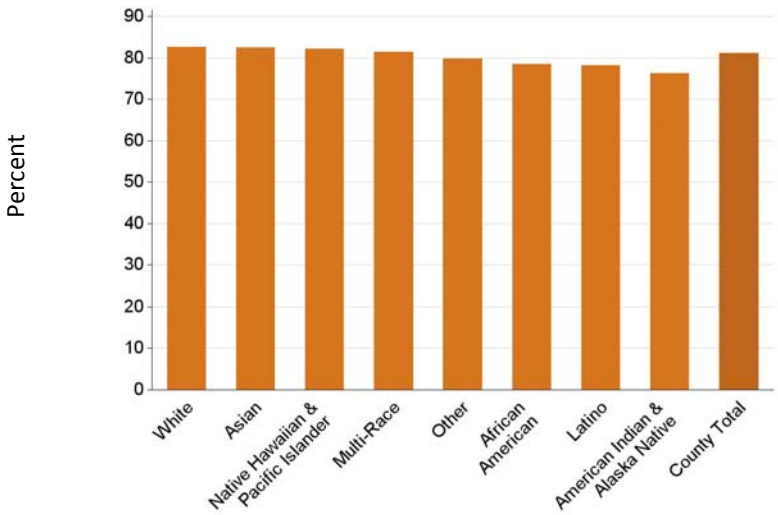


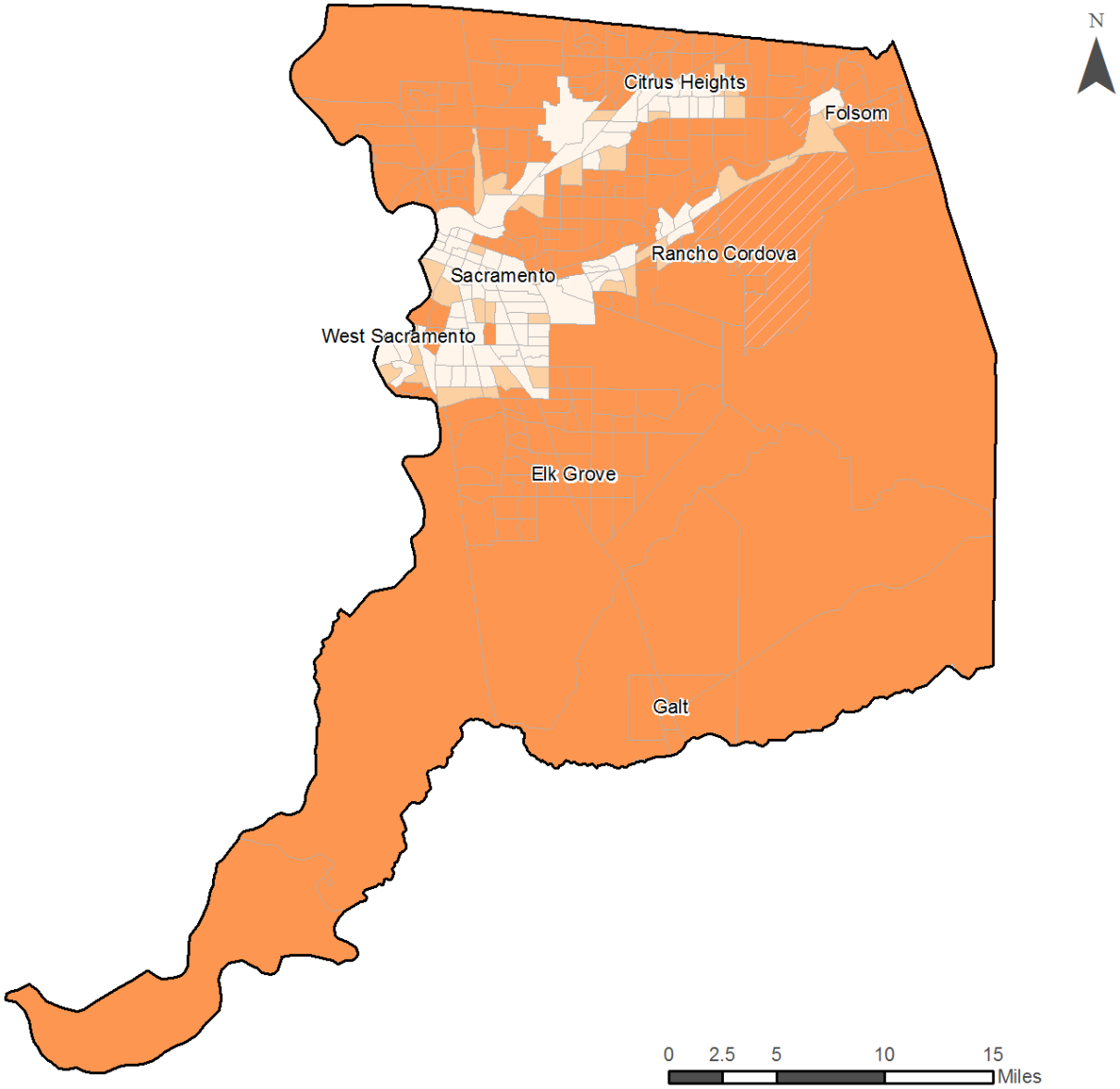
Table X. Cities and Towns (> 1,000 Population) With Highest Percent of Residents Without Access to High Quality Public Transit[1], Sacramento County, California, 2008

City/Town	Percent	Total Population
Antelope	**100%**	**45,770**
Clay	100%	1,195
Elk Grove city	100%	153,015
Sacramento County	81%	1,446,296
Sacramento Area Region	82%	1,999,270

Public Transit Access

Figure 32. Percent of residents within a half-mile of a major transit stop with less than a 15 minute wait at peak house, by Census Tracts, Sacramento County, California, 2008

Data may not reflect recent changes to transit stops and services. This indicator measures geographic access but does not capture impacts of other characteristics of public transit (such as affordability and personal safety) that can impact use.



- 0% - 60%
- 61% - 99%
- 100%
- Census Tract Boundaries
- Unreliable Data (RSE >30)

Data Limitations

The findings in this report should be interpreted within the context of the limitations discussed in this section. This report was created as a statewide assessment and may not capture local trends apparent in certain counties. This analysis does not include all factors that increase vulnerability to climate change and there may be certain subpopulations within a county that are not included in this statewide assessment. Although climate change affects the built environment and service delivery systems, these issues are not directly addressed in this report. This report is centered around 2010 where most indicator data was available.

Estimates are based on population figures as reported by the U.S. Census Bureau. Data on certain vulnerable population groups and vulnerable places may be limited, especially in areas with small populations. The U.S. Census Bureau American Community Survey (ACS) does not publish data when there are fewer than 3 unweighted occupied housing units in a geographic reporting area or when there are fewer than 50 unweighted respondents to survey questions. Data are not available for many small California cities and census tracts for race/ethnicity groups with relatively small numbers, generally American Indian/Alaska Native, Hawaiian Native and Other Pacific Islander, Other Race, and Multiple Races. The ACS collected data from persons regardless of their citizenship status; however, undocumented immigrants are less likely to respond to surveys, less likely to speak English, more likely to have informal or temporary living arrangements.

Stability and reliability of estimates decreased with more refined geographic scale. In general, small and rural populations do not lend itself to statistically reliable data. Some data available at refined geographic scale was excluded due to high instability of estimates where the estimate's relative standard error (RSE) was greater than 30%. Some census place level maps have high instability, but the majority of the population lives in census places with low instability.

Our analysis did not use population projections because these projections are not available below the county level. The actual rate and distribution of population growth, and social and economic change is expected to play a key role in shaping vulnerability to climate and health impacts in the future.

Climate projections tell us how weather conditions are likely to change on average, but they cannot predict the weather at a particular day and time. Climate model projections illustrate how the climate system is expected to behave under specific scenarios of greenhouse gas emissions. Since greenhouse gas emissions depend on a variety of different social, political, and economic factors, there is uncertainty concerning both the magnitude and direction of change. Therefore, projected climate data may not prove to be accurate if actual emissions pathways differ from the scenarios used to make the projections. In addition, some aspects of the climate system are less well understood than others. The Palmer Drought Severity Index does not identify future drought patterns and does not fully explain the impacts of drought due to California's extensive water management systems, variation in reliability of water supplies, and differences in economic dependence on water supplies.

More detailed information about indicator data methods and limitations is posted on the CalBRACE website as an appendix document.

Indicator Narrative References

Heat

Basu R. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. *Environmental Health* 2009;8:40.

Basu R, Feng W, Ostro BD. Characterizing Temperature and Mortality in Nine California Counties. *Epidemiology* 2009;19:138-145.

Hoshiko S, English P, Smith D, Trent R. A simple method for estimating excess mortality due to heat waves, as applied to the 2006 California heat wave. *International Journal of Public Health* 2010;55:133-137.

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits. *Environmental Health Perspectives* 2009;117:61-67.

Kovats RS, Hajat S. Heat Stress and Public Health: A Critical Review. *Annual Review of Public Health* 2008;29:41-55.

Kravchenko J, Abernathy AP, Fawzy M, Lyerly HK. Minimization of Heatwave Morbidity and Mortality. *American Journal of Preventative Medicine* 2013;44(3):274-282.

Ostro BD, Roth LA, Green RS, Basu R. Estimating the mortality effect of the July 2006 California heat wave. *Environmental Research* 2009;109:614-619.

Sheridan SC, Allen MJ, Lee CC, Kalkstein LS. Future heat vulnerability in California, Part II: projecting future heat-related mortality. *Climate Change* 2012.

Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL .IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Air Quality (Ozone)

Sujaritpong S, Dear K, Cope M, Walsh S, T K. Quantifying the health impacts of air pollution under a changing climate – a review of approaches and methodology. *International Journal of Biometeorology* 2013;58:149-160.

Drechsler D, Garcia C, Tran H, Mehadi A, Nystrom M, Propper R, et al. Review of the California Ambient Air Quality Standard For Ozone. Vol 4. Table B-5: California Annual Health Impacts of Current Ozone Concentrations Compared to the State 8-hour Ozone Standard of 0.070 ppm. Sacramento, CA: California Environmental Protection Agency, Air Resources Board; 2005. http://www.arb.ca.gov/carbis/research/aaqs/ozone-rs/rev-staff/vol4.pdf. Accessed on January 4, 2013.

Committee On Estimating Mortality Risk Reduction Benefits From Decreasing Tropospheric Ozone Exposure. Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution. Washington, DC: National Academy of Sciences; 2008. http://www.nap.edu/catalog/12198.html. Accessed on January 4, 2013.

Air Quality (Particulate Matter)

Sujaritpong S, Dear K, Cope M, Walsh S, T K. Quantifying the health impacts of air pollution under a changing climate – a review of approaches and methodology. *International Journal of Biometeorology* 2013;58:149-160.

Tran HT, Alvarado A, Garcia C, Motallebi N, Miyasato L, Vance W. Methodology for Estimating Premature Deaths Associated with Long-term Exposures to Fine Airborne Particulate Matter in California (Draft: Staff Report). Sacramento, CA: California Air Resources Board; 2009. www.arb.ca.gov/research/health/pm-mort/pm-mort_final.pdf. Accessed on 8/16/12.

Drechsler D, Garcia C, Tran H, Mehadi A, Nystrom M, Propper R, et al. Review of the California Ambient Air Quality Standard For Ozone. Vol 4. Table B-5: California Annual Health Impacts of Current Ozone Concentrations Compared to the State 8-hour Ozone Standard of 0.070 ppm.. Sacramento, CA: California Environmental Protection Agency, Air Resources Board; 2005. http://www.arb.ca.gov/carbis/research/aaqs/ozone-rs/rev-staff/vol4.pdf. Accessed on January 4, 2013.

Particulate Matter Integrated Science Assessment Project Team. Integrated Science Assessment for Particulate Matter. Research Triangle Park, NC: U.S. Environmental Protection Agency; 2009. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546#Download. Accessed on January 4, 2013.

Indicator Narrative References

Drought

Centers for Disease Control and Prevention, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Agency, and American Water Works Association. 2010. When every drop counts: protecting public health during drought conditions— a guide for public health professionals. Atlanta: U.S. Department of Health and Human Services

Stanke C, Kerac M, Prudhomme C, Medlock J, Murray V. Health Effects of Drought: a Systematic Review of the Evidence. PLOS Currents Disasters. 2013 Jun 5. Edition 1. doi: 10.1371/ currents.dis.7a2cee9e980f91ad7697b570bcc4b004.

Introducing the National Drought Resilience Partnership. By Nancy Sutley. Accessed from https://www.whitehouse.gov/blog/2013/11/15/ introducing-national-drought-resilience-partnership on July 10, 2015.

Ledger ME, Harris R, Armitage PD, Milner AM. Climate Change Impacts on Community Resilience: Evidence from a Drought Disturbance Experiment. Advances in Ecological Research. 2012. (46); 211-253.

Friel S, Berry H, Dinh H, O'Brien L, Walls HL. The impact of drought on the association between food security and mental health in a nationally representative Australian sample. BMC Public Health. 2014 Oct 14. (14) doi: 10.1186/1471-2458-14-1102

Obrien LV, Berry HL, Coleman C, Hanigan IC. Drought as a mental health exposure. Environmental Research. 2014 January 20 (131) 181-187.

Hanak E, Mount J, Chappelle C. JUST THE FACTS. California's Latest Drought. 2015 January. Public Policy Institute of California. www.ppic.org

California Department of Water Resources. Climate Change in California. June 2007.Accessed from http://www.water.ca.gov/climatechange/docs/062807factsheet.pdf

2009 California Climate Adaptation Strategy: A Report to the Governor of the State of California in Response to Executive Order S-13-2008. California Natural Resources Agency. 2009. Accessed from http:// resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf

Wildfire

Finlay SE, Moffat A, Gazzard R, Baker D, and Murray V. Health Impacts of Wildfires. PLoS. 1:4. November 2012.

Westerling AL, Bryant BP. Climate change and wildfire in California. *Climatic Change* 2008;87 (Suppl 1):s231-s249.

Children

Zhang Y, Bi P, Hiller JE. 2007. Climate change and disability-adjusted life years. J Environ Health 70:32–36.

Ghosh JK, Wilhelm M, Su J, Goldberg D, Cockburn M, Jerrett M, Ritz B. Assessing the influence of traffic-related air pollution on risk of term low birth weight on the basis of land-use-based regression models and measures of air toxics. Am J Epidemiol. 2012 Jun 15;175(12):1262-74

Karr C., Lumley T., Schreuder A., Davis R., Larson T., Ritz B, Kaufman J. Effects of Subchronic and Chronic Exposure to Ambient Air Pollutants on Infant Bronchiolitis. Am J. Epidemiol. 2007 Mar 1;165(5):553-60.

Ritz B, Wilhelm M, Zhao Y. Air Pollution and Infant Death in Southern California, 1989–2000. Pediatrics. 2006 Aug;118(2):493-502.

Delfino RJ, Wu J, Tjoa T, Gullesserian SK, Nickerson B, Gillen DL. Asthma morbidity and ambient air pollution: effect modification by residential traffic-related air pollution. Epidemiology. 2014 Jan;25(1):48-57.

Delfino RJ, Brummel S, Wu J, Stern H, Ostro B, Lipsett M, Winer A, Street DH, Zhang L, Tjoa T, Gillen DL.The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003.Occup Environ Med. 2009 Mar;66(3):

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ Health Perspect. 2009 Jan;117(1):61-7.

Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL .IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Indicator Narrative References

Elderly

Gamble JL, Hurley BJ, Schultz PA, Jaglom WS, Krishnan N, Harris M. Climate Change and Older Americans: State of the Science. Environ Health Perspect. 2013; 121:15-22.

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environ Health Perspect. 2009 Jan;117(1):61-7.

Nitschke M, Hansen A, Bi P, Pisaniello D, Newbury J, Kitson A, Tucker G, Avery J, Dal Grande E. Risk factors, health effects and behaviour in older people during extreme heat: a survey in South Australia. Int J Environ Res Public Health. 2013 Dec 3;10(12):6721-33.

Delfino RJ, Brummel S, Wu J, Stern H, Ostro B, Lipsett M, Winer A, Street DH, Zhang L, Tjoa T, Gillen DL.The relationship of respiratory and cardiovascular hospital admissions to the southern California wildfires of 2003.Occup Environ Med. 2009 Mar;66(3):

California Department of Public Health. Epidemiologic Summaries of Selected General Communicable Diseases in California, 2001-2008. Available at http://www.cdph.ca.gov/programs/sss/Documents/Epi-Summaries-CA-2001-2008-083111.pdf#page=77. Last accessed on March 16, 2015.

Poverty

Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services. *National Healthcare Disparities Report 2012*. AHRQ Publication No. 13-0003, 2013.

Braveman P, Egerter S. *Overcoming Obstacles to Health: Report from the Robert Wood Johnson Foundation to the Commission to Build a Healthier America*. Robert Wood Johnson Foundation, 2008. Accessed July 16th, 2012.

Braveman PA, Cubbin C, Egerter S, Williams DR, Pamuk E. Socioeconomic disparities in health in the United States: what the patterns tell us. *Am J Public Health*. 2010; 100(S1): S186–S196.

Centers for Disease Control and Prevention. *Health Disparities and Inequalities Report - United States, 2011*. Morbidity and Mortality Weekly Report, 2011; 60: 1-113.

Galea S, Tracy M, Hoggatt KJ, DiMaggio C, Karpati A. Estimated deaths attributable to social factors in the United States. *Am J Public Health* 2011; 101(8):1456-1465.

Gennetian L, Ludwig J, McDade T, Sanbonmatsu L. Why Concentrated Poverty Matters. *Pathways Spring* 2013; 10-13. http://ssrn.com/abstract=2326579 Accessed November 4th 2013.

Kaplan G. *The Poor Pay More – Poverty's High Cost to Health*. The Robert Wood Johnson Foundation; 2009. Accessed Nov. 5th, 2013.

Kneebone E, Nadeau C, Berube A. *The Re-Emergence of Concentrated Poverty: Metropolitan Trends in the 2000s*. Metropolitan Policy Program, Brookings Institution, 2011. Accessed November 5th, 2012.

Murali V, Oyebode F. Poverty, social inequality and mental health. *Adv Psychiatr Treat* 2004; 10: 216-224.

Wilkinson R, Marmot M, eds. *Social Determinants of Health: The Solid Facts*. 2nd ed. Copenhagen, Denmark: WHO; 2003. Accessed July 12th, 2012.

Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL .IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Huang ZJ, Yu SM, Ledsky R. Health Status and Health Service Access and Use Among Children in U.S. Immigrant Families. American Journal of Public Health. 2006; 96(4); 634-640.

Education

Egerter S, Braveman P, Sadegh-Nobari T, Grossman-Kahn R, Dekker M. Issue Brief 6: Education and Health. Robert Wood Johnson Foundation Commission to Build a Healthier America. September 2009.

Galea S, Tracy M, Hoggatt KJ, DiMaggio C, Karpati A. Estimated deaths attributable to social factors in the United States. Am J Public Health 2011;101(8):1456-1465.

Dow W, Schoeni R. *Economic Value of Improving the Health of Disadvantaged Americans. Technical Report for Overcoming Obstacles to Health: Report from the Robert Wood Johnson Foundation to the Commission to Build a Healthier America*: Robert Wood Johnson Foundation 2008.

California Health Interview Survey. Public Use Datafiles. Los Angeles, CA: UCLA Center for Health Policy Research (http://healthpolicy.ucla.edu/contact/Pages/default.aspx, Accessed on February 4, 2013).

Indicator Narrative References

Race/Ethnicity

Braveman, P. Health Disparities and Health Equity: Concepts and Measurement. *Annu. Rev Public Health.* 2006; 27:167-194

English P, Richardson M, et al. Racial and Income Disparities in Relation to a Proposed Climate Change Vulnerability Screening Method for California. *The International Journal of Climate Change: Impacts and Responses.* Vol 4, 2013.

Gronlund, CJ. Racial and Socioeconomic Disparities in Heat-Related Health Effects and Their Mechanisms: a Review. *Curr Epidemiol Rep.* 2014; 1:165-173.

Jesdale BM, Morello-Frosh R, et al. The Racial/Ethnic Distribution of Heat Risk-Related Land Cover in Relation to Residential Segregation. *Environ Health Perspect.* 2013; 121:811-817.

O'Neill MS, Zanobetti A, et al. Disparities by race in heat-related mortality in four US cities: the role of air conditioning prevalence. *J Urban Health.* 2005;Jun;82(2):191-7.

Outdoor Workers

Centers for Disease Control and Prevention. Heat-related deaths among crop workers --- united states, 1992--2006. Atlanta, GA: Centers for Disease Control and Prevention; 2008.

CJ G. Racial and socioeconomic disparities in heat-related health effects and their mechanisms: A review. *Current Epidemiology Reports* 2014;1:165-173.

Morello-Frosch R, Pastor M, Sadd J, S S. The climate gap: Inequalities in how climate change hurts americans and how to close the gap; 2009.

Car Ownership

Brodie M, Weltzien E, Altman D, Blendon R, J B. Experiences of hurricane katrina evacuees in houston shelters: Implications for future planning. *American Journal of Public Health* 2006;96 (8):1402-1408.

Falanagan B, Gregory E, Hallisey E, Heitgerd J, B L. A social vulnerability index for disaster management. *Journal of Homeland Security and Emergency Management* 2011;8(1).

Morello-Frosch R, Pastor M, Sadd J, S S. The climate gap: Inequalities in how climate change hurts americans and how to close the gap; 2009.

San Francisco Department of Public Health. Healthy development measuring tool (hdmt). IR. San Francisco, CA: San Francisco Department of Public Health; 2011.

Noji EK. The public health consequences of disasters. New York: National Center for Environmental Health Centers for Disease Control and Prevention; 1997.

Linguistic Isolation

DeAnne K, Messias H, Barrington C, Lacy E. Latino social network dynamics and the Hurricane Katrina disaster. Disasters, Volume 36, Issue 1; 2011.

Hansen A, Bi P, Saniotis A, Nitschke M, Benson J, Tan Y, Smyth V, Wilson L, Han GS. Extreme heat and climate change: Adaptation in culturally and linguistically diverse (CALD) communities. National Climate Change Adaptation Research Facility; 2013.

Kessler RC. Hurricane Katrina's Impact on the Care of Survivors with Chronic Medical Conditions. Department of Health Care Policy, Harvard Medical School. July 2007.

Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. Health Effects of Coastal Storms and Flooding in Urban Areas: A Review and Vulnerability Assessment. Journal of Environmental and Public Health. May 30, 2013.

Uejio CK, Wilhelmi OV, Golden JS, Mills DM, Gulino SP, Samenow JP. Intra-urban societal vulnerability to extreme heat: The role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health & Place* 2011.

Indicator Narrative References

Mental Disability

Berry HL, Kelly BJ, Hanigan IC, Coates JH, McMichael AJ, Welsh JA, Kjellstrom T. Rural mental health impacts of climate change: Commissioned report for the Garnaut Climate Change Review. 2008.

Berry HL, Bowen K, Kjellstrom T. Climate change and mental health: a causal pathways framework. International Journal of Public Health, 2010; Volume 55, Issue 2, 123-132

Fussell E, Waters M, Paxson C, Rouse CE, Rhodes J. Chan C. The Impact of Hurricane Katrina on the Mental and Physical Health of Low-Income Parents in New Orleans. American Journal of Orthopsychiatry 2010; 80(2): 237–247.

Hanigan IC, Butler CD, Kokic PN, Hutchinsond MF. Suicide and drought in New South Wales, Australia, 1970–2007. Proceedings of the National Academy of Sciences of the United States of America 2012 Aug 28; 109(35): 13950–13955.

Centre for Health and Development, World Health Organization. Climate change exposures, chronic diseases and mental health in urban populations - a threat to health security, particularly for the poor and disadvantaged. 2009.

Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL .IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Physical Disability

Boon H, Brown L, Clarks P, Pagliano K, Tsey K, Usher K. Schools, Climate change and health promotion: a vital alliance. Health Promotion Journal of Australia 2011;22:S68-S71.

Brown O. Migration and climate change. International Organization for Migration: IOM Migration Research Series 2008;31.

Foroni M, Salvioli G., Rielli R, Goldoni CA, Orlandi G, Zauli Sajani S, et al. A retrospective study on heat-related mortality in an elderly population during the 2003 heat wave in modena, italy: The argento project. J Gerontol A Biol Sci Med Sci 2007;62(6):647-651.

Lewis D, and Ballard K. Disability and Climate Change: Understanding vulnerability and building resilience in a changing world, Development Bulletin, No.74, June 2011.

Smith D, Notaro S. Personal emergency preparedness for people with disabilities from the 2006-2007 behavioral risk factor surveillance system. Disability and Health Journal 2009;2:86-94.

The Global Partnership for Disability & Development (GPDD), The World Bank. The impact of climate change on people with disabilities. 2009.

White GW, Fox MH, Rooney C, Rowland J. Final report findings of the nobody left behind: Preparedness for persons with mobility impairments research project. Research and Training Center on Independent Living 2007.

World report on disability, World Health Organization, 2011.

Indicator Narrative References

Insurance

Wilper AP, Woolhandler S, Lasser KE, McCormick D, Bor DH, DU H. Health insurance and mortality in us adults. *Research American Journal of Public Health* 2009;99(12).

Freeman JD, Kadiyala S, Bell JF, Martin DP. The causal effect of health insurance on utilization and outcomes in adults: A systematic review of us studies. *Med Care* 2008;46(10):1023-32.

Kjellstrom T, McMichael A. Climate change threats to population health and well-being: The imperative of protective solutions that will last. SI. Sweden: Global Health Action; 2013.

Los Angeles County Department of Public Health. Health indicators for women in Los Angeles county: Highlighting disparities by ethnicity and poverty level. IR. Los Angeles, CA: Los Angeles County Department of Public Health Office of Women's Health and Office of Health Assessment & Epidemiology; 2010.

Fowler RA, Noyahr L, Thornton D, Pinto R, Kahn J, Adhikari NKJ, et al. An official American thoracic society systematic review: The association between health insurance status and access, care delivery, and outcomes for patients who are critically ill. *American Journal of Respiratory and Critical Care Medicine* 2010;181:1003-1011.

Greenough PG, Lappi MD, Hsu EB, Fink S, Hsieh YH, Vu A, et al. Burden of disease and health status among hurricane Katrina-displaced persons in shelters: A population-based cluster sample. *Annals of Emergency Medicine* 2008;4:426-32.

Chung YK, Leigh JP. Medicaid use by documented and undocumented farm workers. Journal

Huang ZJ, Yu SM, Ledsky R. Health Status and Health Service Access and Use Among Children in U.S. Immigrant Families. American Journal of Public Health. 2006; 96(4); 634-640.

Stevens GD, West-Wright, Tsai K. Health Insurance and Access to Care for Families with Young Children in California, 2001-2005: Differences by Immigration Status. Journal of Immigrant and Minority Health. June 2010. 12(3); 273-281.

Violent Crimes

Fowler PJ *et. al.* Community violence: A meta-analysis on the effect of exposure and mental health outcomes of children and adolescents. Dev Psychopathol 2009; 21(1): 227-259.

Rudolph L, Gould S, Berko J. Climate Change, Health, and Equity: Opportunities for Action. Public Health Institute. 2015. Accessed May 30th, 2015.

Takagi D, Ken'ichi I, Kawachi I. Neighborhood social capital and crime victimization: Comparison of spatial regression analysis. Soc Sci Med 2012.

EpiCenter: California Injury Data Online. Assault/Homicide. Sacramento, CA: California Department of Public Health. http://epicenter.cdph.ca.gov/ReportMenus/InjuryDataByTopic.aspx. Accessed on June 24th, 2015.

Indicator Narrative References

Air Conditioning Ownership

Bouchama A, Dehbi M, Mohamed G, Matthies F, Shoukri M, Menne B. Prognostic factors in heat wave-related deaths: A meta-analysis. *Archives of Internal Medicine.* 2007; 167: 2170-2176.

O'Neill MS, Zanobetti A, Schwartz J. Disparities by race in heat-related mortality in four US cities: The role of air conditioning. *Journal of Urban Health.* 2005; 82: 191-197.

Ostro B, Rauch S, Green R, Malig B, Basu R. The effects of temperature and use of air conditioning on hospitalizations. *American Journal of Epidemiology.* 2010; 172: 1053-1061.

Ostro B, Rauch S, Green S. Quantifying the health impacts of future changes in temperature in California. *Environmental Research.* 2011; 111: 1258-1264.

Reid CE, O'Neill MS, Gronlund CJ, et al. Mapping community determinants of heat vulnerability. *Environmental Health Perspectives.* 2009; 117: 1730-1736.

Impervious Surfaces

Civerolo K, Hogrefe C, Lynn B, Rosenthal J, Ku J, Solecki W, et al. Estimating the effects of increased urbanization on surface meteorology and ozone concentrations in the new york city metropolitan region. *Atmospheric Environment* 2007;41:1803-1818.

CJ G. Racial and socioeconomic disparities in heat-related health effects and their mechanisms: A review. *Current Epidemiology Reports* 2014;1:165-173.

Jesdale B M, Morello-Frosch R, L C. The racial/ethnic distrbution of heat risk -related land cover in relation to residential segregation. *Environmental Health Perspectives* 2013;121(7):811-817.

Rosenthal J K, Kinney P L, B MK. Intra-urban vulnerability to heat-related mortality in new york city, 1997-2006. *Health & Place* 2014;30:45-60.

Tree Canopy Coverage

Martineau C. Public health benefits of urban trees. *Canopy* 2011.

San Francisco Department of Public Health. Healthy development measuring tool (hdmt). IR. San Francisco, CA: San Francisco Department of Public Health; 2011.

Sherer PM. Why america needs more city parks and open space: The benefits of parks. EV. San Francisco, CA: The Trust for Public Lands; 2006.

Stair P, Wooten H, Raimi M. How to create and implement healthy general plans: A toolkit for building healthy, vibrant communities through land use policy change. IR. Oakland, CA: Public Health Law & Policy; 2012.

Tzoulas K, Korpela K, Venn S, Yli-Pelonen V, Kazmierczak A, Niemela J, et al. Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning* 2007;81:167-178.

Public Transit Access

Ewing R, Cervero R. Travel and the built environment: A meta-analysis. *JAPA* 2010; 76(3): 265-294.

Frank LD, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med* 2004; 27(2): 87-96.

Besser LM, Dannenberg AL. Walking to public transit: Steps to help meet physical activity recommendations. *Am J Prev Med* 2005; 29(4): 273-280.

Centers for Disease Control and Prevention. *CDC Recommendations for Improving Health through Transportation Policy*. National Center for Environmental Health. 2008.