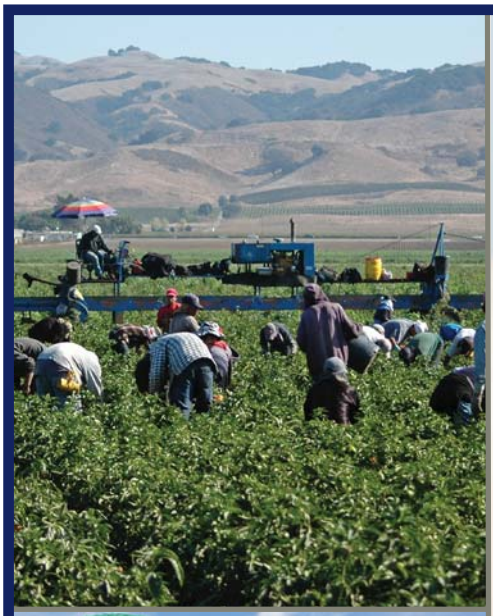

Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies

Report No. 1:

Heat-Related Illness and Mortality

Information for the Public Health Network in California

Climate Change Public Health Impacts Assessment and Response Collaborative
California Department of Public Health and the Public Health Institute

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PublicHealth

Table of Contents

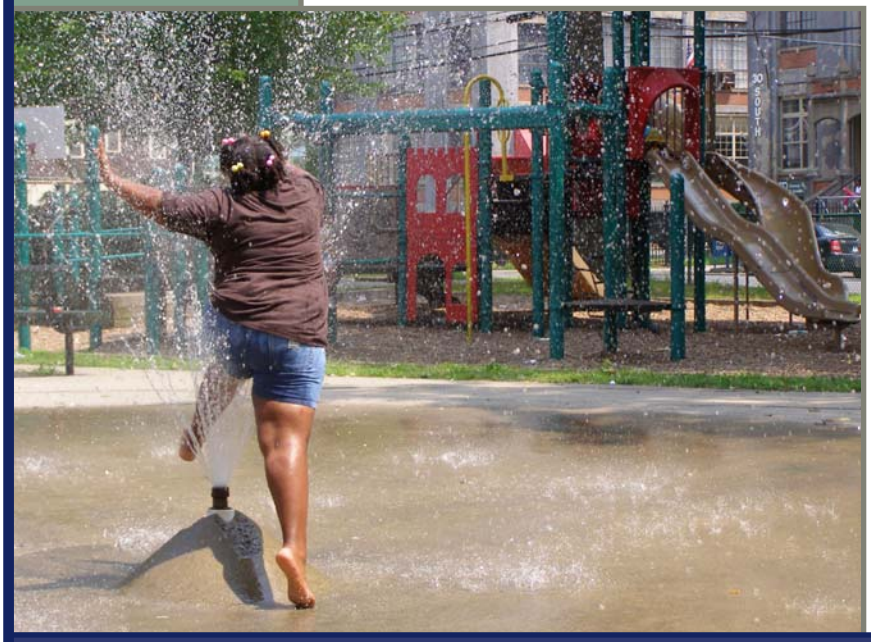
List of Figures and Tables

The primary objective of this community vulnerability assessment, the first in a series, is to identify locations and/or populations with high risk for heat-related illness.

Executive Summary

Climate change is a major cross-cutting public health issue that will significantly increase disease burden in California. Some health impacts will be direct, such as injuries that occur during floods, and others will arise from ecological shifts and environmental degradation, such as emergent infectious diseases or exacerbation of chronic respiratory diseases due to air pollution. In this report, we focus on heat-related illness and mortality.

The public health risks associated with extreme heat events vary across California's communities, and among the individuals within communities. Vulnerabilities and capacities change over time. To ensure the State's public health infrastructure has the capacity to withstand the challenges to health posed by climate change and heat, it is essential to know which communities or populations are most vulnerable and then identify strategies and resources to diminish their risk. Advance planning and intervention will be central in order to prevent illness and death.



The primary objective of this community vulnerability assessment, the first in a series, is to identify locations and/or populations with high risk for heat-related illness. To develop a model of community vulnerability we evaluated: (1) past heat waves and published literature to identify risk factors for heat-related illness; (2) a selected set of environmental, health, and demographic "indicators" of risk; and (3) readily available data sources, such as U.S. Census data or other survey data, for demographic risk factors. We used a Geographic Information System (GIS) framework to evaluate patterns of geographic distributions of overlapping indicators.

The results of this assessment include the following public health implications of increases in heat related to climate change:

- **California appears to be slowly warming, with temperatures increasing most rapidly in Southern California and in urban centers. Minimum temperatures at night are increasing more rapidly than daytime temperatures, limiting the body's ability to cool overnight during heat waves. The influence of "heat islands" (geographic areas that are warmer than surrounding areas and form as cities replace natural land cover with pavement, buildings, and other infrastructure) plays a large role in elevated nighttime temperatures. The number and duration of extreme heat events are expected to increase with concomitant increases in heat-related illnesses and deaths.**

- **Heat-related illness is a broad spectrum of disease, from mild heat cramps to the most severe – life threatening heat stroke. Virtually all heat-related illness and death is preventable if the appropriate prevention**

strategies are adopted and implemented by communities and individuals. Specific policies should be implemented at the local level in preparation for heat waves, including establishment and availability of transportation for vulnerable populations to cooling centers, education of social contacts of at-risk populations regarding symptoms of heat illness, and education regarding personal cooling strategies and first aid for heat illness.

- California counties have varying and unique indicators of risk, including high proportions of elderly, socially isolated populations, children, outdoor workers, the poor, the chronically ill, and the medically under served. County and local health officials are urged to identify vulnerable communities within their jurisdiction. Simple methods can be used such as targeting all ZIP codes where more than 20% of the residents live under the U.S. poverty level, for example. The urban areas of California such as Los Angeles, San Diego, and the San Francisco Bay Area, have the largest absolute numbers of people vulnerable to heat such as children and the elderly. Yet, other areas of the State, which are away from the major urban centers, especially counties with lower socioeconomic status, have high proportions of populations of socially isolated elderly and elderly living in nursing homes.

- Future heat waves may change geographic risk in California, due to lack of historic physiologic adaptability and capacity to cool. It is recommended that local health officials must focus efforts to prepare areas of the state not historically accustomed to heat. Foothill and mountainous communities throughout the State may be particularly subject to respiratory and heat stress due to lack of historic adaptability, higher ozone levels, higher elevations, and increasing temperatures. Further degradation of air quality due to climate change will amplify occurrence and severity of known air pollution-related adverse health effects.

- City and land-use planners are advised to work with public health officials to minimize the heat island effect. Increased development of impervious areas in urban locations contribute to the heat island effect. Policies and procedures should be established that require land-use planners and public health officials to work together to minimize the creation of more urban heat islands, and reduce the effects of current ones.

- Strategic planning and resources are needed to build public health response and surveillance infrastructure, including heat warning systems, and heat-related disease surveillance systems.

Virtually all heat-related illness and death is preventable if the appropriate prevention strategies are adopted and implemented by communities and individuals.

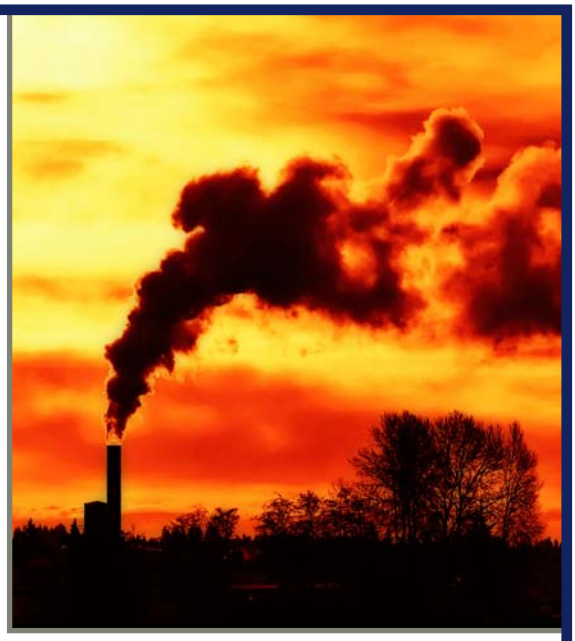
As the number and duration of extreme heat events increase, there will be a concomitant increase in heat-related illnesses and deaths.

I. Introduction

A. Our Changing Climate and Impacts on Public Health in California

There is international consensus that over the last 50 years human activities have altered the natural climatic balance. Excess production of greenhouse gases and changes in ecological characteristics (such as altered land surface via deforestation) that regulate climatic conditions at the global, regional and local scales are leading to global warming.[1] The Intergovernmental Panel on Climate Change (IPCC) concluded that changes in exposures due to global warming-related climate change "are likely to affect the health status of millions of people, particularly those with low adaptive capacity" (IPCC 2007). (Adaptive capacity is the ability to respond to the impacts of climate change on the environment or on public health and welfare.)

Public health in California will be affected by global warming, both because of greater climate variability as well as more-gradual shifts in climate (IPCC 2001; Haines et al 2006; Watson et al 2005; Epstein 2005; CEC 2006). Climate change can affect weather conditions (e.g., extremes in temperature or precipitation), water availability and quality, air quality, agricultural conditions and practices, and distributions of infectious disease pathogens (e.g., viruses, bacteria), vectors (e.g., mosquitoes, ticks), and hosts (e.g., rodents, deer). Climate change is expected to increase the number and duration of extreme heat events and decrease the number of extreme cold events (IPCC 2007). As the number and duration of extreme heat events increase, there will be a concomitant increase in heat-related illnesses and deaths.



B. California's Actions to Address Climate Change

California's agencies responsible for ensuring environmental quality are statutorily mandated to address the root cause of climate change by implementing policies that control greenhouse gas emissions (AB 32, Statutes of 2006). Our success will depend upon coordination with actions of other states and countries because this is a global problem. In the meantime, California's public health organizations and health care providers need to be prepared to address the

1 The earth's temperature equilibrium is regulated by the "greenhouse effect" in which naturally occurring "greenhouse" gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), as well as water vapor, absorb heat radiated from the earth's surface; this heat is radiated back to the earth's surface. Integral to maintenance of the equilibrium is sea surface/subsurface temperatures, which influence and are influenced by meteorological conditions.

imminent health consequences associated with those changes, such as short-term emergency situations (e.g., heat waves or floods) or longer-term climate-change-related shifts in infectious and chronic disease prevalence and patterns.

The Climate Change Public Health Impacts Assessment and Response Collaborative is a group of public health scientists, physicians, and health educators, centered at the California Department of Public Health. The purpose of the collaborative was to develop the requisite knowledge to prepare for, prevent, and reduce the health impacts of climate change in California and to facilitate translation of that knowledge into effective adaptive strategies. A key part of this effort is to focus on identifying locations and populations at highest risk of specific health impacts. To accomplish this, the collaborative will conduct a "community vulnerability assessment" for each health risk posed by climate change and summarize the findings in a report. The reports are not intended to be exhaustive references, but rather to provide information and tools that can be used to guide identification of county- and community-specific risks and vulnerabilities, priorities, and prevention actions.

California's public health system (e.g., state, county and local health departments and health-care and social service providers) in conjunction with the State's emergency response network will ultimately be responsible for development and implementation of health-related policies and guidelines designed to protect the public from the medical consequences of climate change. Therefore the primary audiences for the reports are those organizations and individuals that are responsible for ensuring the health of populations and individuals in their jurisdictions or under their care. The reports also target other organizations that can play an important role in the protection of public health, such as county supervisors and city managers who make decisions that affect the capacity of the public health infrastructure and the built environment. This document, which addresses Heat-Related Illness and Mortality, is the first in the series of reports. Others may include the health effects of flooding and emerging infectious diseases related climate change.

The purpose of the Climate Change Public Health Impacts Assessment and Response Collaborative was to develop the requisite knowledge to prepare for, prevent, and reduce the health impacts of climate change in California.

Climate Change Public Health Impacts Assessment and Response Collaborative
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In this report, we first review the clinical spectrum of heat-related illness (Section II), and then develop a model of population vulnerability to heat based on (1) historic heat data in California; (2) characteristics of the heat deaths in California in summer 2006; and (3) identification of demographic characteristics of population vulnerability to heat available from secondary data sources (Section III). In Section III, we also identify vulnerable geographic areas based on adaptive capacity (i.e., areas historically used to and not used to heat). In Section IV, we discuss prevention and mitigation strategies. Finally, in Section V, we present our short and long-term recommendations for responding to heat-related events in California.

II. Spectrum of Heat-Related Illness

A. Heat Stress

Any individual, regardless of age, sex, or health status can develop heat stress if engaged in intense physical activity and/or exposed to environmental heat (and humidity). Physiologic mechanisms maintain the core body temperature (i.e., the operating temperature of vital organs in the head or trunk) in a narrow optimum range around 37° C (98.6 °F). When core body temperature rises, the physiologic response is to sweat and circulate blood closer to the skin's surface to increase cooling. Over a period of one-to-two weeks, exposure to conditions that elevate body temperature -- physical activity and/or environmental heat -- results in a process of physiological adaptation, "acclimatization." When acclimated, the body produces more dilute sweat, and heart rate and body temperature increase less than when not acclimatized. Even when acclimatized, adequate hydration is critical to avoid development of heat-related illness.

If heat exposure exceeds the physiologic capacity to cool, and core body temperature rises, then a range of heat-related symptoms and conditions can develop. These are summarized in the following sections. It is beyond the scope of this report to discuss detailed medical protocols for treatment of heat-related illness, especially heat stroke or its complications; for the interested reader we refer them to the primary references identified in the American Medical Association's Report "Heat-related Illness During Extreme

Weather Emergencies" (AMA 1997), from which the information below was derived, and other authoritative medical texts. However, limited basic illness-avoidance and treatment information that can be applied by lay persons, as well as medical professionals, is included.

B. Heat Cramps, Heat Syncope, Heat Edema

Heat-related cramps, syncope, and edema are relatively minor readily treatable conditions; however, they should be used as important warning signs to immediately remove the affected individual from the exposure situation.

Heat cramps involve severe painful cramping of muscles in the legs or abdomen, and result from electrolyte disturbance, most notably when plasma sodium levels fall significantly below normal. Exertion, with profuse sweating, is a common cause of heat cramps, which often occur during cool-down after the activity has stopped. Exertion should be stopped if not already done and salted drinks (e.g., some sports drinks) provided to replenish fluid volume.

Heat edema, which is swelling in the legs due to the accumulation of fluids in the tissues, results from prolonged dilation of the small arteries in the legs. It can usually be treated by alternating between elevating the legs and gentle movement of the legs to increase circulation (venous return).

Heat syncope, characterized by a sudden loss of consciousness (fainting), results from orthostatic hypotension that is related to peripheral blood pooling. Light-headedness or weakness are initial warning signs of this condition; sitting or lying down at these first signs can prevent loss of consciousness.

C. Heat Exhaustion

Heat exhaustion is a consequence of extreme depletion of blood plasma volume, which may be coincident with low plasma levels as well as peripheral blood pooling. Heat exhaustion often does not present with definitive symptoms and may be misdiagnosed, often as an acute viral illness. Symptoms include mild disorientation, generalized malaise, weakness, nausea, vomiting, headache, tachycardia (rapid beating of the heart), and hypotension. Because untreated heat exhaustion can progress to heat stroke, the most serious form of heat-related illness, treatment should begin at the first signs of heat exhaustion.

A person showing signs of heat exhaustion should be moved to a cool environment and provided salted fluids – fluid and electrolyte replacement is essential. Active cooling of the affected individual may be necessary – measures such as loosening clothing, increasing air flow across the skin (e.g., with a fan)[1] while misting or wiping them down with cool water, or placing ice packs on their extremities. Massage of extremities is recommended to mitigate vasoconstriction associated with use of cold water or ice.

Because untreated heat exhaustion can progress to heat stroke, the most serious form of heat-related illness, treatment should begin at the first signs of heat exhaustion.

1 Use of fans to prevent a person from becoming overheated is not recommended under certain conditions of high humidity (greater than about 33%) and high temperatures (at or higher than 90°F (32.3°C)); when temperatures are above 100°F (37.8°C) fans may actually contribute to heat stress and subsequent illness (CDC 1995). However, the use of a fan in conjunction with wetting-down the skin of an affected person, as described above, may help the cooling process.

D. Heat Stroke

Heat stroke is an extreme medical emergency that if untreated can result in death or permanent neurological impairment.

Heat stroke is an extreme medical emergency that if untreated can result in death or permanent neurological impairment. Heat stroke occurs when a person's core body temperature rises above 40°C (104°F) as a result of impaired thermoregulation. High core body temperature and disseminated intravascular coagulation results in cell damage in vital organs, such as the brain, liver, and kidneys, which can lead to serious illness and death. Death may occur rapidly due to cardiac failure or hypoxia, or it can occur days later as a result of renal failure due to dehydration and/or rhabdomyolysis (i.e., the breakdown of muscle fibers with release into the circulation of muscle fiber contents, some of which are toxic to the kidney and can cause kidney damage).

The first signs of the neurologic impacts of heat stroke include headache, dizziness, and weakness, which can be followed by confusion or euphoria and a sudden loss of consciousness. Persons suffering neurologic complications of heat stroke, may present with hallucinations and be combative, or they may become comatose. Unconscious patients may suffer seizures and develop status epilepticus (i.e., when there is recurrent or continuous seizure activity lasting longer than 30 minutes, with permanent brain damage). Although consciousness may be regained within a few hours of treatment with cooling, neurologic symptoms may recur intermittently for weeks or never fully resolve.

The more quickly the heat stroke victim receives treatment to bring down the core body temperature to 39ºC (102º F) or below, and supportive therapies such as to replace blood volume and electrolytes, the less likely are severe complications and the better the prognosis.

Heat stroke is typically divided into two types. The two types are in general clinically the same, except that the individuals/population groups affected require medical interventions specific to their unique physiology and medical status. "Exertional Heat Stroke," as the name implies, involves strenuous physical activity under high temperature conditions to which the heat stroke victim was not acclimatized, and usually affects healthy young adults, such as athletes, outdoor laborers and soldiers. "Classic" heat stroke, by definition does not involve exertion, and usually affects susceptible individuals, such as infants and young children, the elderly, or people with chronic illness.

Because heat stroke, even if treated, can have a death rate as high as 33%, and up to 17% of heat stroke survivors suffer permanent neurologic damage (CDC 2001), it is imperative that measures be taken to prevent heat-related illness, especially among vulnerable populations.

III. Community Vulnerability to Heat-Related Morbidity and Mortality

A community's overall vulnerability reflects that of its constituent populations, as well as the capacity of its public health and emergency response infrastructure. In the scientific and lay literature there are different uses of the term "vulnerable" when applied to populations or individuals. For this report, population or individual vulnerability is defined as the level of potential risk of suffering the adverse effects of heat due to:

(a) Factors that increase biologic sensitivity or reduce resilience to heat (such as age, pre-existing disease, or genetics), and/or

(b) Determinants of greater potential for exposure, either due to personal behavior patterns, the built environment or more extreme environmental conditions in locations where time is spent (community, home, work, school), and/or

(c) The social and economic factors that may influence both biologic response and exposure.

A. Identification of Indicators of Risk

Indicators and measures of indicators are useful tools that can be used to identify populations at risk, and to direct scarce public health resources. We used three categories to guide our development of indicators of risk of community vulnerability to heat-related morbidity and mortality. They included information on (1) elevated temperatures or means to adapt to elevated temperatures (i.e., air conditioning) in California; (2) lessons learned about population vulnerabilities from an analysis of coroners' reports of the deaths from the 2006 heat wave in California; and (3) a literature review of other heat waves in the U.S. and abroad to identify demographic risk factors for heat illness and death.

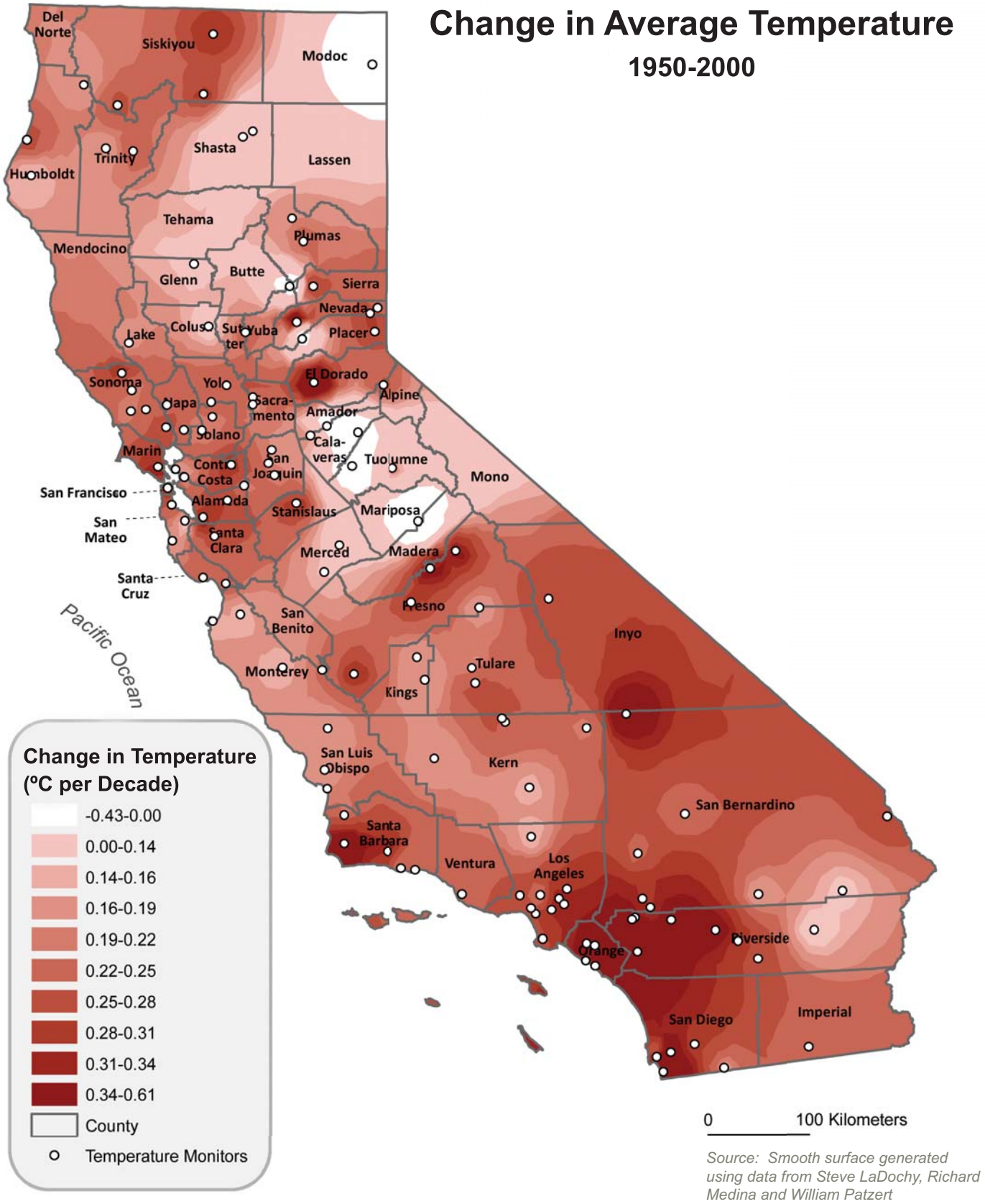
1. Historic Heat Waves, Heat Islands, and Air Conditioner Ownership in California

Historic Heat Waves and Temperature Trends in California

California has been identified as one of the states in the West showing the most extreme rise in the frequency of heat stress events (defined as periods of extremely high temperatures and humidity) from 1949 to 1995 (NOAA 1999). Heat waves regularly occur in many regions of California. The National Weather Service (NWS) defines heat waves differently for different regions. For example, in the California counties that had heat-related deaths in 2006, the NWS defines heat waves as three or more consecutive days with temperatures equaling or exceeding 100ºF. California appears to be slowly warming, as found in a study of temperatures from 1950 – 2000 in California (LaDochy et al 2007). The trends in warming appear be increasing more rapidly in California's urban centers and in southern California. Figure 1 shows temperature increase in ºC per decade over the State, showing the primary increases in Southern

A community's overall vulnerability reflects that of its constituent populations, as well as the capacity of its public health and emergency response infrastructure.

Figure 1:



Source: Smooth surface generated using data from Steve LaDochy, Richard Medina and William Patzert

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California.[1] Interestingly, minimum temperatures have been increasing more than average or maximum temperatures, leading to narrower temperature ranges and limiting residence cooling and subsequently affecting the body's ability to cool overnight during heat waves. According to LaDochy et al, the increases in nighttime temperatures were attributed primarily to increased urban development in California. Heat islands play a major role in this warming effect in urban areas.

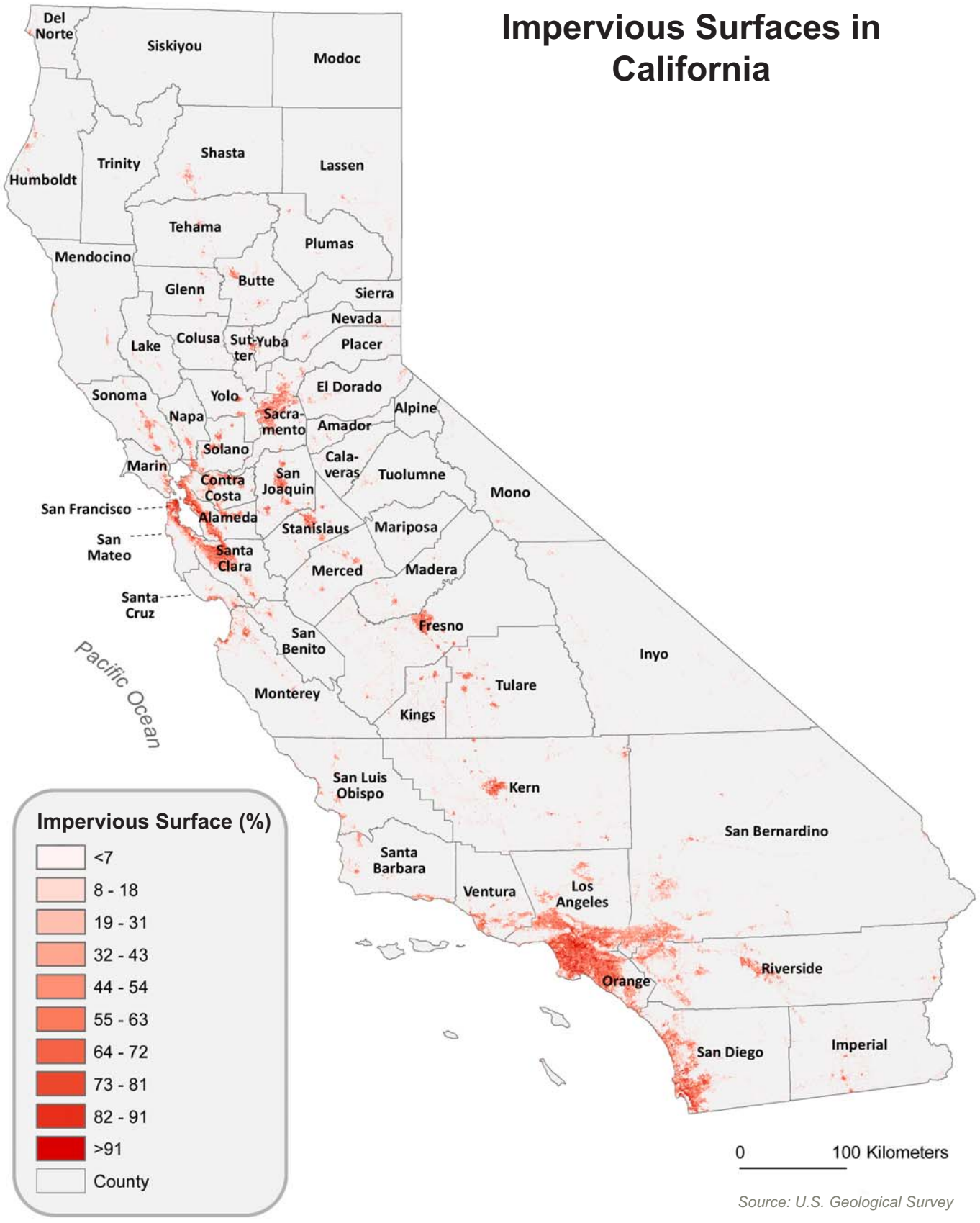
Heat Islands

For millions of Californians living in and around cities, the urban-heat-island effect increases their vulnerability to extended heat waves. Heat islands are geographic areas that form as cities replace natural land cover with pavement, buildings, and other infrastructure. Heat islands contribute to higher urban temperatures through a number of processes including (i) loss of natural cooling from shade and evapotranspiration as trees and vegetation coverage are removed, (ii) trapping of air and reduction of air flow by tall buildings and narrow streets, and (iii) waste heat from vehicles, factories, and air conditioners. In addition to these factors, the intensities of heat islands depend on an area's weather and climate, proximity to water bodies, and topography. The concept of a heat-island effect is derived from the observation that urban and suburban temperatures are 1 to 6°C hotter than nearby rural areas. Elevated temperatures can impact communities by increasing air pollution levels and health impacts by exacerbating heat-related illness and mortality.

Heat islands can occur year-round during the day or night. Urban-rural temperature differences are often largest during calm, clear evenings. This is because rural areas cool off faster at night than cities, which retain much of

1 Temperature change data from weather stations from LaDochy et al were interpolated over the State using inverse distance weighted interpolation.

Figure 2:


Impervious Surfaces in California
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Nevada
Lake
Colusa
Sut-ter
Yuba
Placer
Sonoma
Yolo
El Dorado
Napa
Sacra-mento
Alpine
Amador
Solano
Cala-veras
Marin
San Joaquin
Tuolumne
Contra Costa
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Pacific Ocean
Monterey
Tulare
Kings
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Riverside
Orange
San Diego
Imperial
Impervious Surface (%)
<7
8 - 18
19 - 31
32 - 43
44 - 54
55 - 63
64 - 72
73 - 81
82 - 91
>91
County
0
100 Kilometers
Source: U.S. Geological Survey

the heat stored in roads, buildings, and other structures. Heat islands are difficult to measure directly without setting up detailed temperature monitoring networks.

"Imperviousness" has been used as an indicator of heat-island potential because it is easier to quantify and measure remotely. Impervious surfaces are anthropogenic features that limit the ability of water to infiltrate the soil. They include roads, driveways, sidewalks, parking lots, and rooftops. Figure 2 shows the percent of urban impervious surface of California (from USGS National Land Cover Database through remote sensing). As can be seen from Figure 2, the highest percent of impervious areas are in the urban areas of Los Angeles, San Diego, and the San Francisco Bay Area, although impervious areas are growing in the Central Valley and outside of Los Angeles in the Riverside and San Bernardino County areas.

The 2006 Heat Wave

For the United States, July 2006 was the second hottest July on record (NOAA 2007). In mid-July, 2006, a heat wave of unusually long duration affected California and the rest of the nation. The summer 2006 heat wave can be conservatively bounded between July 15th and August 1st when California experienced record breaking daytime and nighttime temperatures. Nighttime temperatures surpassed the all-time high minimum temperatures at several reporting stations (Edwards et al 2006). In addition, this heat wave was of long duration with many areas experiencing over ten days of triple digit temperatures.

Figure 3 shows the average maximum temperatures in California for July 2006. The map shows high average maximum temperatures in the southern deserts, including Inyo, San Bernardino, Riverside, and Imperial Counties. Higher temperatures are also evident in the Central Valley. Incomplete data from 2006 (Table 1) shows that the highest maximum temperatures for July were in the southern California deserts/Inland Empire Areas (Imperial, Riverside, and Inyo) and the Central Valley (Kings, Tulare, Kern, Fresno, Yolo, and Colusa). Note that the highest maximum temperatures in 2006 in the Central Valley were higher in the southern part of the valley, reflecting the distribution of average maximum temperatures in Figure 3.

Impervious surfaces are anthropogenic features that limit the ability of water to infiltrate the soil.

Figure 3:

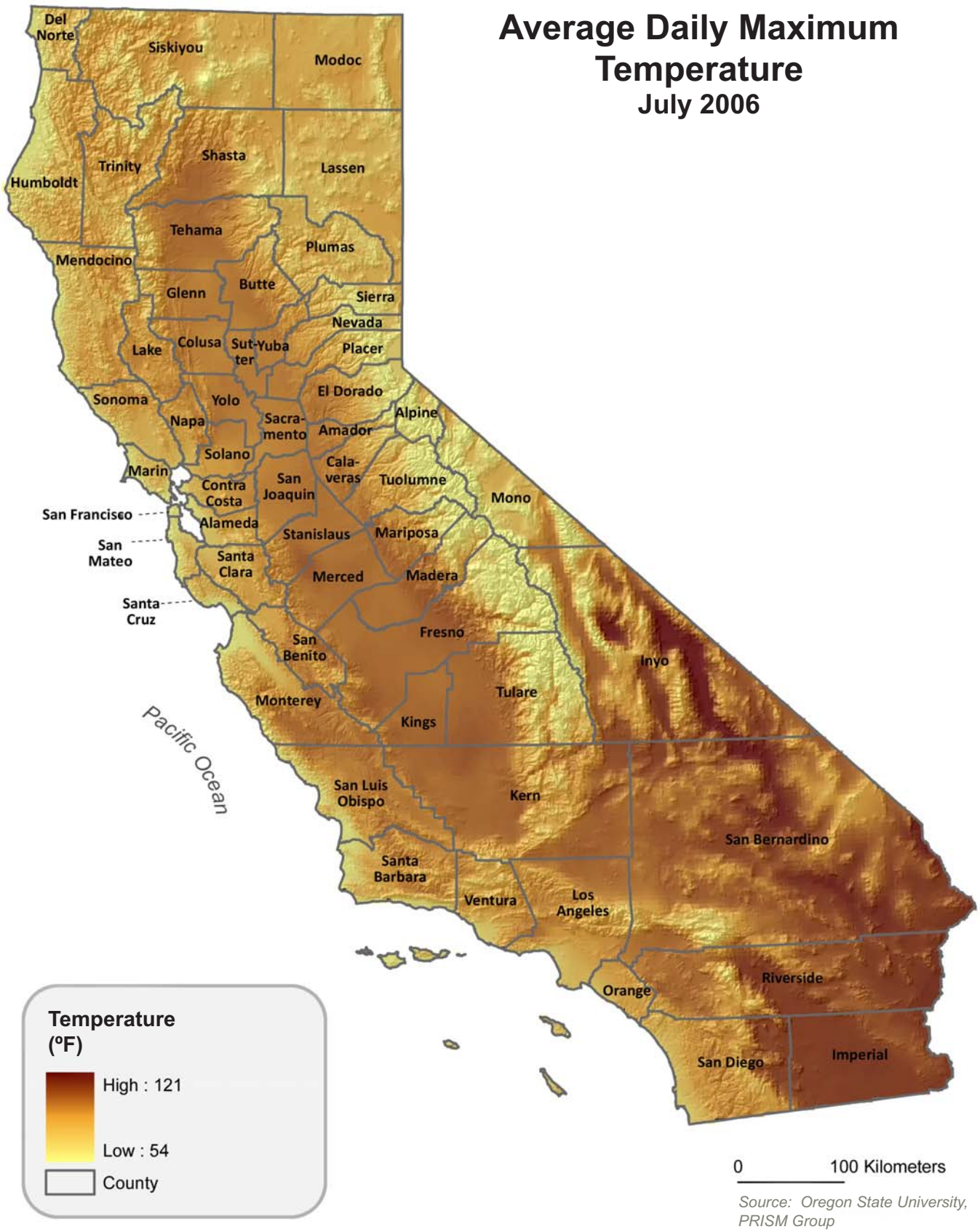

Average Daily Maximum Temperature
July 2006
Del Norte
Siskiyou
Modoc
Trinity
Shasta
Lassen
Humboldt
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Nevada
Lake
Colusa
Sut-Yuba ter
Placer
El Dorado
Sonoma
Yolo
Napa
Sacra-mento
Amador
Alpine
Solano
Cala-veras
Marin
Contra Costa
San Joaquin
Tuolumne
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Tulare
Monterey
Kings
Pacific Ocean
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Riverside
Orange
San Diego
Imperial
Temperature (ºF)
High : 121
Low : 54
County
0
100 Kilometers
Source: Oregon State University, PRISM Group

Table 1: Top 20 Counties by Average Daily Maximum and Minimum Temperatures (ºF) , July 2006

	County	Maximum Temperature	Minimum Temperature
1	Imperial	107.9	81.6
2	Riverside	102.2	73.3
3	Kings	100.6	68.5
4	Tulare	100.2	67.2
5	Fresno	99.0	65.7
6	Kern	98.2	66.6
7	Inyo	97.2	60.9
8	Colusa	97.0	62.9
9	Yolo	96.8	61.1
10	Merced	96.7	60.9
11	Glenn	96.3	63.0
12	Butte	95.8	62.2
13	Sacramento	95.8	62.2
14	Calaveras	94.9	61.6
15	San Bernardino	94.9	65.5
16	Mendocino	94.7	55.2
17	Solano	92.7	59.9
18	San Joaquin	92.7	59.0
19	Lake	92.5	54.7
20	Los Angeles	92.4	65.4

Source: University of California, IPM California Weather Database

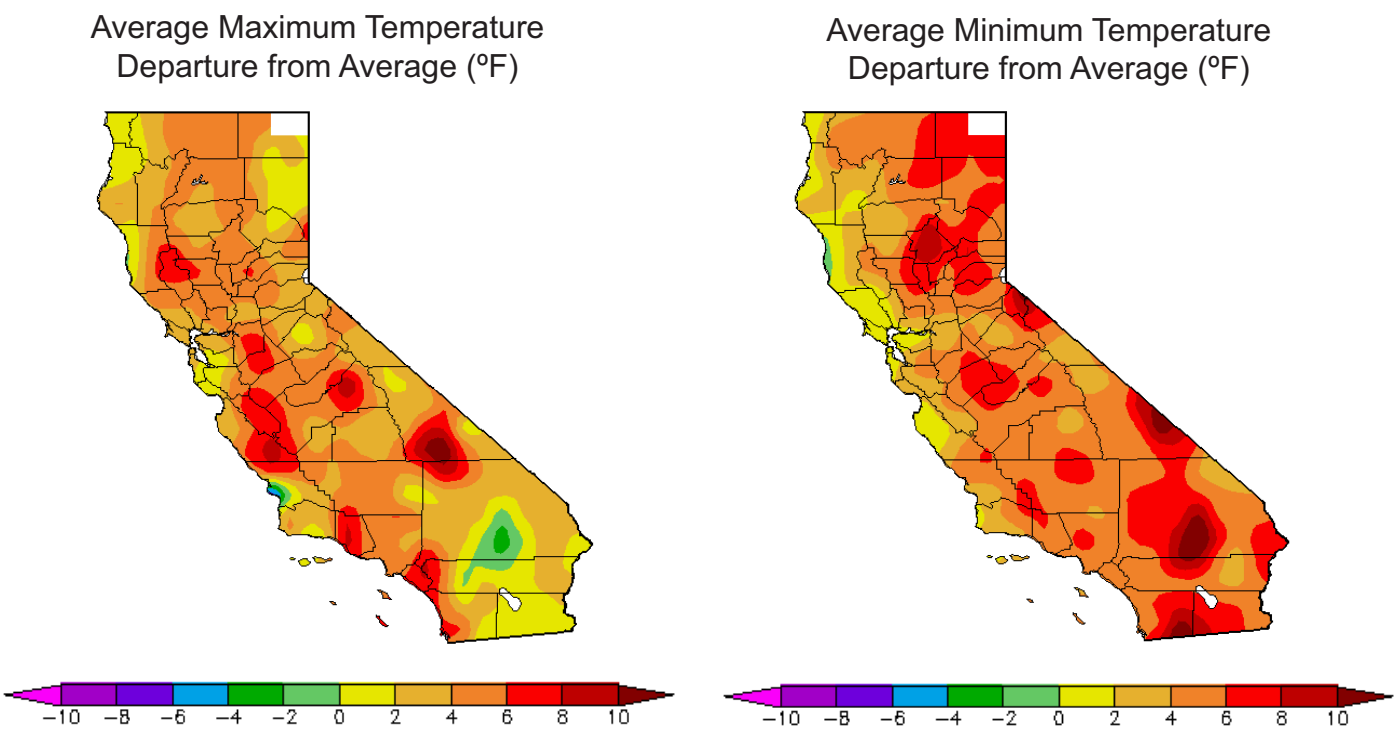
Even more revealing are the departures from average maximum and minimum temperatures for July 2006 (Figure 4). Previous average maximum temperatures were exceeded at times in coastal areas (e.g., San Diego, Orange, Ventura, and Monterey Counties). However, the areas with average minimum (nighttime) temperatures significantly above normal occurred in the Northern Central Valley and Imperial Valley. Elevated nighttime temperatures do not allow sufficient relief from daytime heat as mentioned above and are thought to be a risk factor in excess heat-related deaths (Patz et al 2001). In fact, these are locations where a number of heat deaths in California occurred in 2006, which will be discussed in Section III. A.2.

Air Conditioner Ownership in California

The capacity to adapt to elevated temperatures, through the use of cooling mechanisms such as air conditioning, is a component of vulnerability to heat morbidity and mortality. We used data from the California Energy Commission's Residential Appliance Saturation Study (RASS), which collected data from California energy utilities in 2003, to develop a map of air conditioner

The capacity to adapt to elevated temperatures, through the use of cooling mechanisms such as air conditioning, is a component of vulnerability to heat morbidity and mortality.

Figure 4: Departures from Average Maximum and Minimum Temperatures, California, July 2006



Source: Generated 8/1/2006 at the Western Regional Climate Center using provisional data. NOAA Regional Climate Centers.

ownership in California.[1,2] Data were collected by climate zone. Although several counties overlap multiple climate zones (e.g., Los Angeles) and precise county level rates are not available, it was possible to categorize counties by air conditioner ownership (Figure 5).[3] Counties were classified as: low (less than 52% of the population has air conditioning), medium (between 52 and 64% of population has air conditioning), and high (greater than 64% of population has air conditioning). As can be seen from Figure 5, low air conditioner ownership stretched along the coast from Sonoma to San Diego counties, while high air conditioner ownership is concentrated in the Central Valley and the eastern Inland Empire/desert counties (San Bernardino, Riverside, Imperial). The remaining counties were classified as medium air conditioner ownership.

Statewide, lower income households have been found to be less likely to have air conditioning in the home. Similarly, homes built before 1975 are significantly less likely to have air conditioning. Of those who have air conditioning, lower income households are more likely to have room air conditioners and evaporative coolers versus central air conditioning (CEC 2004). Evaporative coolers are not as effective as central air conditioning in reducing temperatures especially in cases of high humidity and/or high temperature.

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1 Air conditioning ownership includes: central air conditioning, room AC, and evaporative coolers.

2 The following counties were not included in the CEC survey: Del Norte, Siskiyou, Modoc, Sacramento, and Imperial. Air conditioner ownership for Sacramento County was provided by the Sacramento Municipal Utility District and estimated for Imperial County based on the neighboring climate zone as per the recommendation of a CEC representative.

3 The eastern portion of Lassen, Modoc, Plumas, Sierra and Placer Counties are not covered by this analysis.

Figure 5:

Source: California Energy Commission

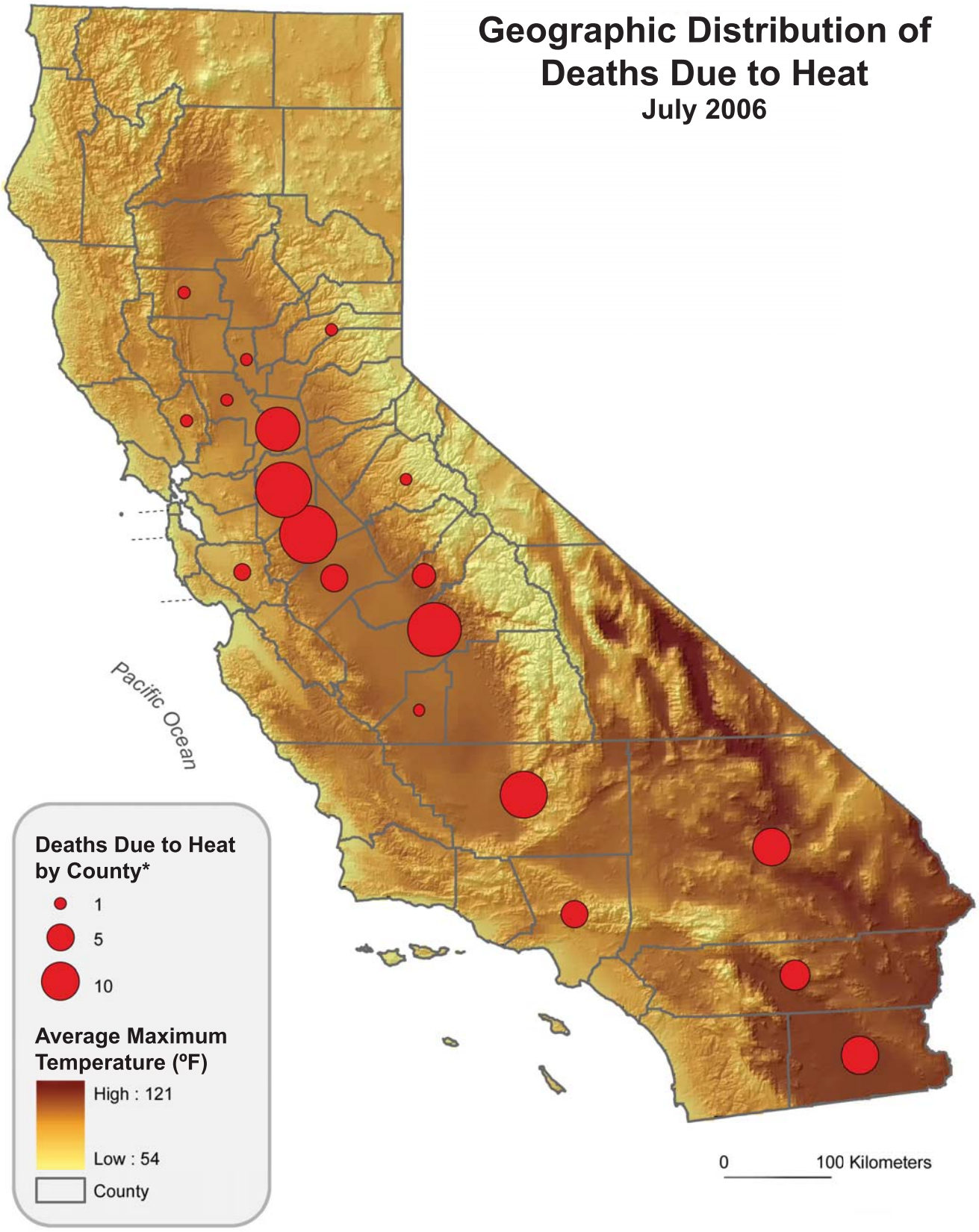
2. Heat-related Deaths in California from the Summer 2006 Heat Wave

Between July 15 and August 1, 2006, California coroners and medical examiners identified 140 deaths due to extreme heat (deaths with heat stroke, hyperthermia, heat stress, or related conditions listed as the underlying or contributing cause of death) (CDHS 2007). Heat likely contributed to many other deaths not seen by coroners or medical examiners, who generally do not investigate deaths of persons currently under a doctor's care. Studies of general death trends show increases in mortality during heat waves in addition to the deaths specifically identified by coroners as heat related (Basu and Samet 2002). Heat especially increases the vulnerability of persons with cardiovascular, respiratory, and/or cerebrovascular diseases even if do not show clear symptoms of heat stroke. Specific causes of death may include myocardial infarction or stroke. An analysis of temperatures during summers in several counties in California with no heat waves from 1999 to 2003 found a 3% increase in deaths in any given day for a 10º F increase in temperature (including humidity effects) (Basu et al unpublished manuscript). Therefore, the death toll documented in the California case series from summer 2006 is likely a significant underestimate of the true toll due to heat. Other planned studies will provide an estimate of the total mortality impact of the July 2006 heat wave.

In the two weeks of the 2006 heat wave, seven counties accounted for 80% of the reported deaths. These inland, low-lying counties are situated from Imperial County, through San Bernardino, and up through the San Joaquin Valley (Figure 6). Counties along the coasts, the Sierra, and north of Sacramento had few certifiable deaths due to heat.

Figure 7 shows the numbers of people who died due to extreme heat by day, along with the maximum local temperature in the Central Valley during the July 2006 Heat Wave. The graph indicates that heat-related deaths spiked sharply, but not immediately, after the increase in extreme temperatures, remaining elevated even after temperatures had begun to decline. This type of lag between the temperature increase and actual death is consistent with the pattern of heat-related death from other heat events (Basu and Samet 2002).

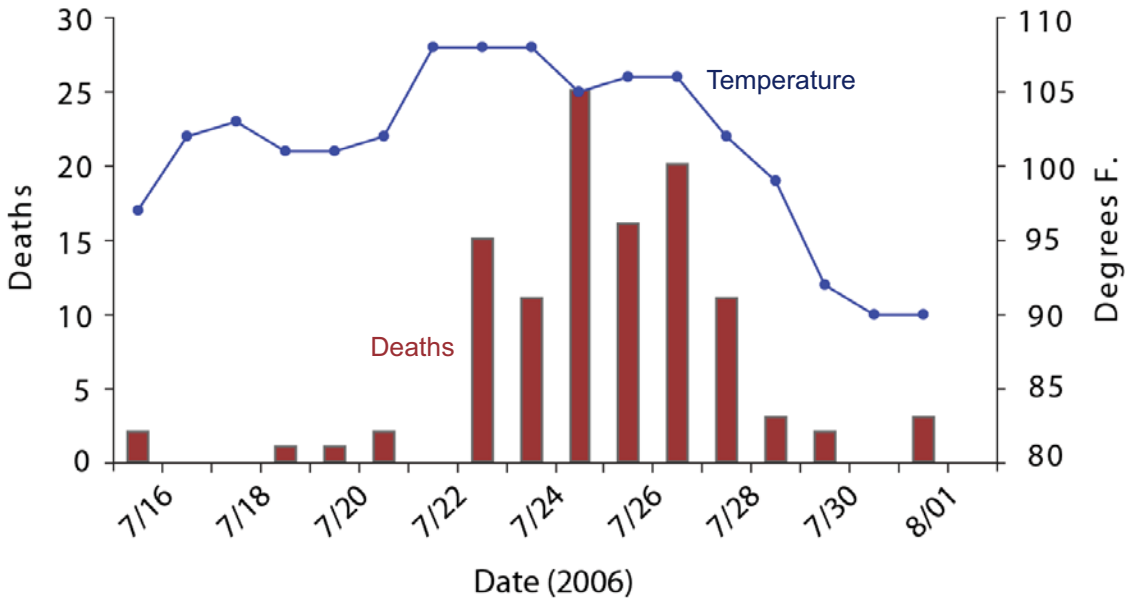
Figure 6:



*Note: Proportional circles representing the number of deaths per county have been placed at the counties' geographic centers.

Source: California Department of Public Health

Figure 7: Deaths due to Extreme Heat in California and Typical Central Valley Temperature*, July 15- August 1, 2006



Source: California Department of Public Health

*Maximum temperature from a weather station in the northern Central Valley region (Willows, CA) that was a typical pattern for most counties which experienced heat-related deaths.

The highest death rate occurred in Imperial County, although the largest number of deaths occurred in Stanislaus, San Joaquin, and Fresno Counties (Table 2). Other counties with significant numbers of deaths included Kern, Sacramento, and San Bernardino (Table 2). 64% of the heat-related death cases occurred in socioeconomically depressed areas (that is, in Zip codes where more than 20% of the residents earn less than the Federal Poverty Threshold).

The profile of these deaths from an analysis of coroner's reports showed that the victims were predominately male (66%), older adults (median age of 66 years), and had a history of chronic disease (73%). Only one decedent was known to have an air conditioner on in her home at the time of death. Inside temperatures (only noted in 36 of 140 cases) averaged 103.5ºF with a range of 85 to 140ºF. None of the decedents was known to have visited a cooling center.

Of all 140 heat death cases, 65, (46%), were known to have lived alone. Although 55% of those who died and lived alone had some regular social contact (such as a relative, neighbor, or friend who routinely checked on the person), only 19% were reported to have been contacted or seen by social contacts within 24 hours prior to death.

Table 2: Top Counties for Heat-Related Deaths, July 2006 Heat Wave

County	Number of Deaths	Death rate (per 100,000 population)
1 Stanislaus	23	4.6
2 San Joaquin	21	4.6
3 Fresno	20	2.3
4 Kern	15	2.0
5 Sacramento	13	0.9
6 San Bernardino	10	0.5
7 Imperial	10	6.4

Source: California Department of Public Health

3. Demographic Determinants of Vulnerability

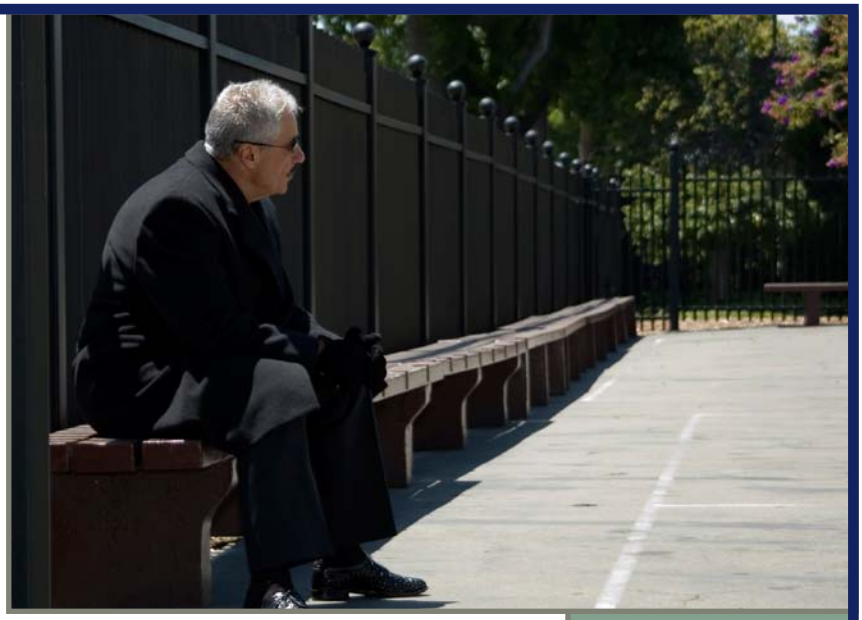
A) Vulnerable Populations

Elderly

The elderly are at higher risk due to reduced ability to acclimatize to changing temperatures and higher likelihood of pre-existing chronic health conditions (Health Canada 2006). Thermoregulatory mechanisms in older adults often do not function optimally, even when the individual is relatively healthy (Merck 2006). Impaired cognitive function in some older adults can affect decisions to avoid heat exposure, and intake fluids and food, or seek medical assistance. Social isolation and medication use (next page) are also factors that are not uncommon among the elderly that makes them more susceptible to the effects of heat.

Children

Children are physiologically and morphologically less able than adults to maintain an optimum core body temperature when exposed to environmental heat, especially when engaged in physical activity at ambient temperatures greater than 35º C (95º F). (AAFP 2005). There are three primary reasons for this: (1) they have a greater surface area-to-body mass ratio than adults leading to greater heat gain; (2) compared to adults they produce more metabolic heat per unit of mass when engaged in physical activity (regardless of intensity of activity); and (3) they have less physiologic capacity to sweat, thus reducing the efficacy of an important cooling mechanism (evaporation). In addition, children require more time to acclimatize than do adults. They



are also less likely to sense thirst and voluntarily replenish fluids that are lost during prolonged physical activity, thus increasing their risk of dehydration. The physiological differences combine with behavior pattern differences to amplify children's risk of heat-related illness. They tend to play outdoors more and engage in higher intensity activities.

Participants in Athletic Events

Individuals of any age who participate in athletic events in warm and/or humid environments to which they are not acclimatized may be at particular risk of heat stress and subsequent heat-related illness. More physically fit individuals are at lower risk than those who do not routinely train and engage in high intensity activities. For the reasons noted above, children are at special risk.

Event organizers, coaches, teachers, and athletes themselves must recognize the risk factors, signs and symptoms of heat stress and heat-related illness, and take the appropriate actions for prevention. These include allowing time to acclimatize when in a new or warmer environment, ensuring adequate fluid intake (avoiding alcohol), promoting

Social isolation and medication use are also factors that are not uncommon among the elderly that makes them more susceptible to the effects of heat.

California workers in agriculture and construction industries have experienced severe heat-related illness and death in recent years.

light-colored loose clothing, providing breaks from activities in a cooler location (e.g., shaded or indoor location) and if necessary curtailing activities altogether under extreme conditions of high temperatures and/or high humidity.

Outdoor Workers

Another group that is at risk for developing heat-related illness are workers laboring outdoors in hot environmental conditions to which they may not be fully acclimated. (Brown 1991; Morioka et al 2006). California workers in agriculture and construction industries have experienced severe heat-related illness and death in recent years. Between May and November 2005, Cal/OSHA conducted 25 investigations of occupational heat-related cases, 13 of which were deaths. Out of all cases investigated, 38% were agricultural workers, 29% were construction workers, and most (96%) involved some sort of outdoor work (Prudhomme et al 2006). During the July 15 – August 1, 2006 heat wave in California, eight workers were among the 140 confirmed heat-related deaths identified by coroners' reports. All but one of the work-related deaths were classified as 'outdoor' and the majority of these (71%) were agricultural (CDHS 2007).

Medically Compromised and Socially Isolated

There is often a confluence of age-related, medical and social factors that can place an individual at particular risk of heat-related illness. An exhaustive discussion of these factors is not provided in the context of this report; however, it is important that public health officials, emergency response personnel, and health care providers be cognizant of these factors. Briefly summarized here are those factors that represent the greatest risk and/or that affect the largest number of individuals.

- Medical conditions may predispose individuals to impaired thermoregulation and/or lead to dehydration.
- Medications, including common over the counter products as well as doctor-prescribed medications can increase the risk of dehydration or be associated with impaired thermoregulation. (Examples include: allergy medications (antihistamines), cough and cold medications (anticholinergics), blood pressure, heart, and prostate medicines (Alpha and Beta blockers, calcium channel blockers, diuretics), and diet pills (amphetamines), and laxatives.)
- Alcohol consumption, even in moderation, can lead to dehydration and impaired decisions about heat stress avoidance.
- Social isolation, which is not uncommon among the elderly, and which often accompanies mental illness, can contribute to risk both because individuals cannot or chose not to avoid heat exposure and because they do not have a social contact who can intervene on their behalf.

B) Demographic Analysis of California Counties

Risk factors for "classic" heat-related illness are well documented. These factors have been identified in studies of various health-related outcomes during heat waves, including all cause mortality, heat-related mortality, cardiovascular mortality, and hospital admissions. Our review of the published literature identified three main categories of host factors related to elevated risk for these outcomes: (1) social and behavioral factors (e.g., living alone); (2) demographics (e.g., age, socioeconomic status); and (3) health status. Housing has also been mentioned as a risk factor for heat exposure (e.g., living on the top story).

Using readily available secondary data sources we were able to identify the following risk factors from those identified above from the U.S. Census for which there were California county-level data for analysis: (1) Population less than five years of age; (2) Population 65 years of age and over ; (3) Population aged 65 and over living in a nursing home; (4) Population aged 65 years and over living alone (1-person household) ; and (5) Population with income (1999) below the U.S. poverty threshold.

We used data from the 2000 U.S. Census to map these risk factors for California. Figure 8 shows the proportion of the population in California less than five years of age. The counties with the highest proportions of this population are centered in the southern Central Valley, with several counties, such as Fresno, Kern, and San Bernardino having heat deaths in 2006. The counties with the highest proportions of elderly population 65 years and over (Figure 9) are in some of the least populated eastern counties, such as those in the foothills or in the Sierra Nevada (e.g., Amador, Calaveras, Tuolumne, Mariposa).

It could be argued that not only the counties with high proportions of their populations with these characteristics are important, but also the counties with high absolute numbers. Ranked by absolute numbers of elderly and the number of children less than five years of age, the top ten counties are in the major metropolitan areas: Los Angeles, San Diego, Orange, Riverside, and Santa Clara, followed by Alameda, San Bernardino, Sacramento, San Francisco, and Contra Costa (Appendix 1).

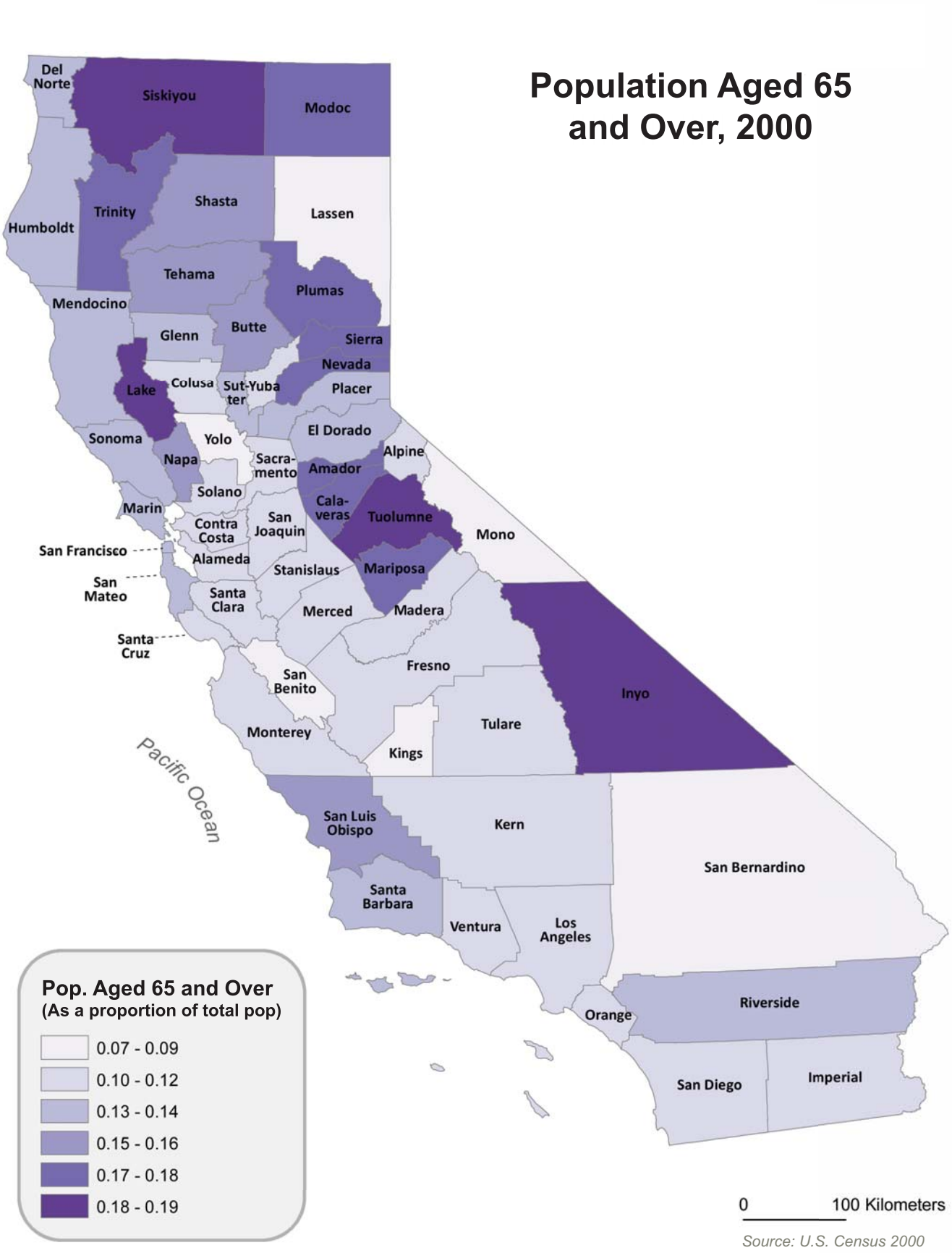
Sutter, Solano, Marin, and Santa Cruz counties stand out as counties having some of the highest proportions of populations of elderly living in nursing homes (Figure 10). Counties with the highest proportions of elderly living alone include some less populated counties such as Inyo and Modoc, but also some more populated counties along the northern coast such as San Francisco, Marin, Sonoma, and Mendocino (Figure 11). Figure 12 shows the counties with high proportions of poverty. Several counties with heat deaths in 2006, such as Imperial, Fresno, Merced, and Madera, are also ranked as high poverty counties.

Our review of the published literature identified three main categories of host factors related to elevated risk for these outcomes: (1) social and behavioral factors ; (2) demographics; and (3) health status.

Figure 8:

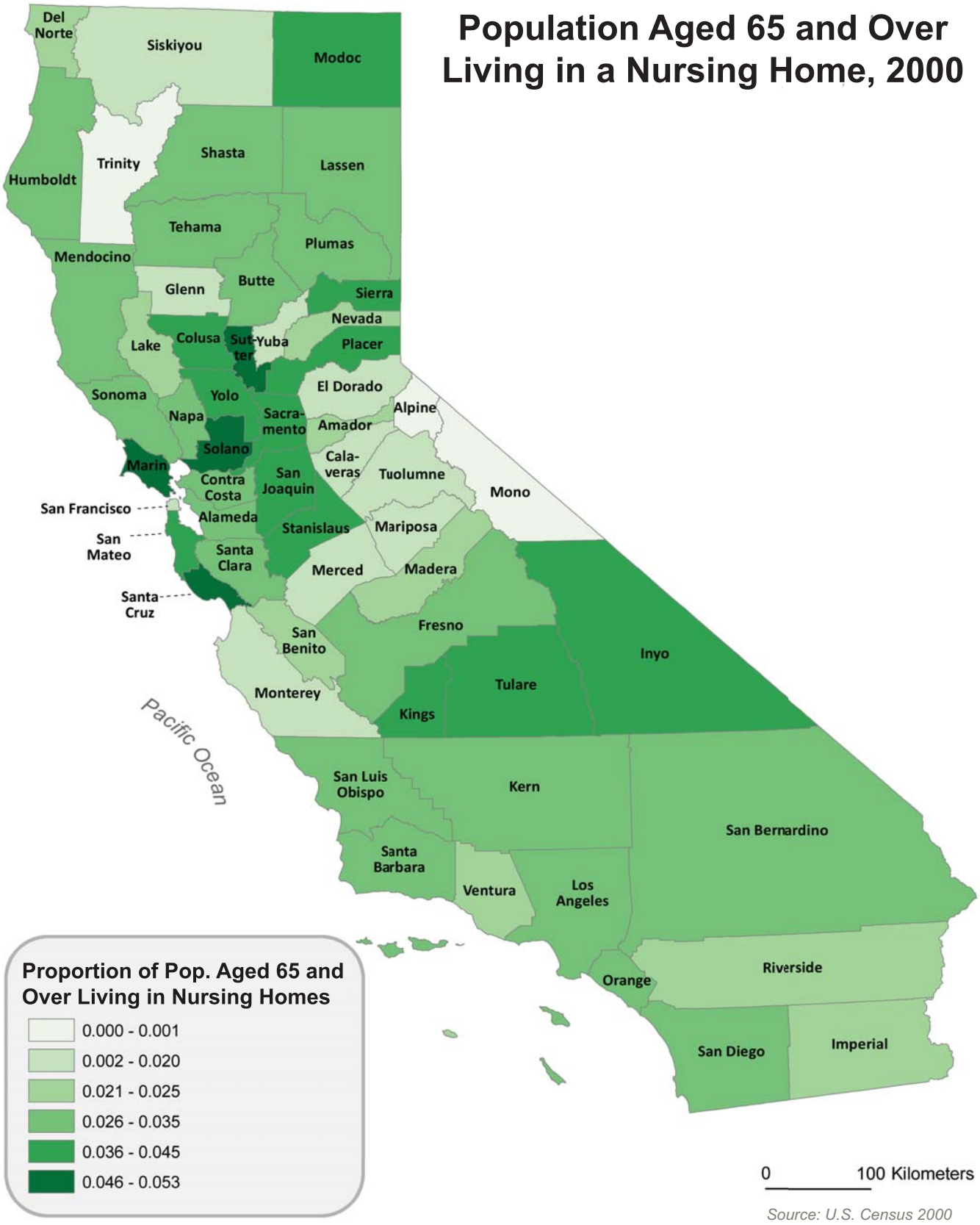

Population Less Than Five Years of Age, 2000
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Nevada
Colusa
Sut-ter
Yuba
Placer
Lake
El Dorado
Sonoma
Yolo
Napa
Sacra-mento
Alpine
Amador
Solano
Cala-veras
Tuolumne
Marin
Contra Costa
San Joaquin
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Tulare
Monterey
Kings
Pacific Ocean
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
Population Less Than Five
(As a proportion of total pop)
0.040 - 0.047
0.048 - 0.056
0.057 - 0.064
0.065 - 0.072
0.073 - 0.080
0.081 - 0.089
0
100 Kilometers
Source: U.S. Census 2000

Figure 9:



Climate Change Public Health Impacts Assessment and Response Collaborative
California Department of Public Health and the Public Health Institute

Figure 10:



Climate Change Public Health Impacts Assessment and Response Collaborative
California Department of Public Health and the Public Health Institute

Figure 11:

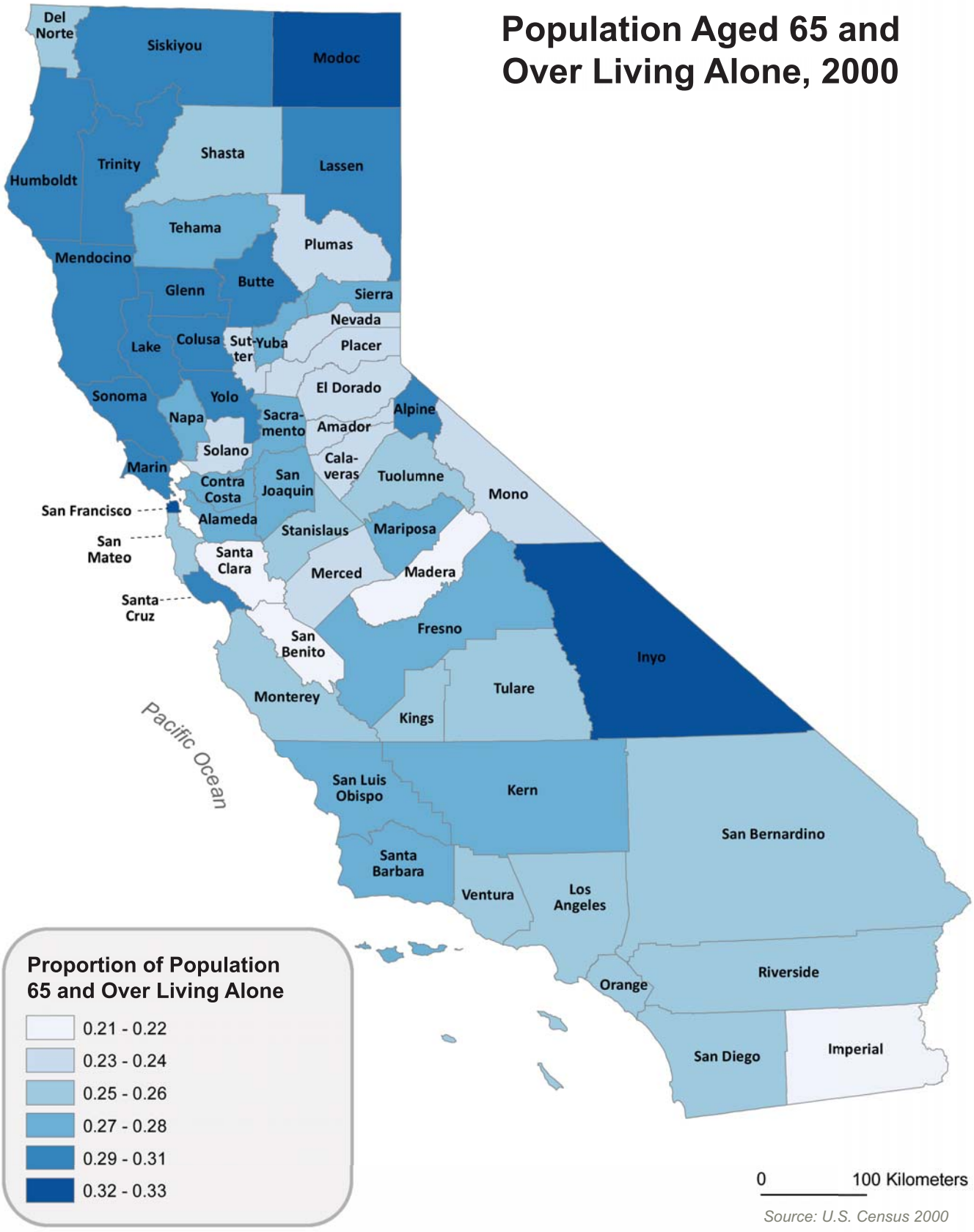
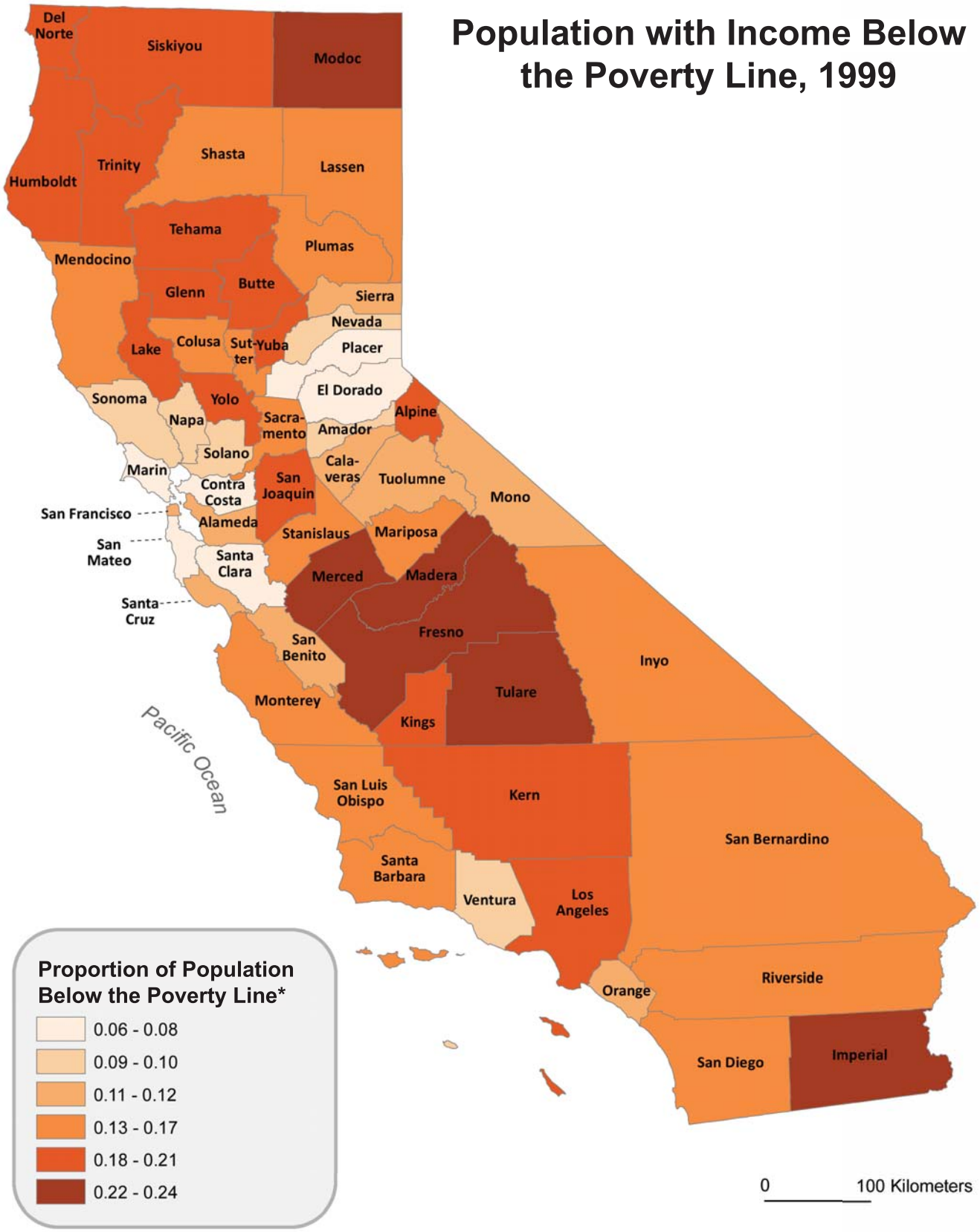

Population Aged 65 and Over Living Alone, 2000
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Nevada
Lake
Colusa
Sut-ter
Yuba
Placer
El Dorado
Sonoma
Yolo
Napa
Sacra-mento
Amador
Alpine
Solano
Cala-veras
Marin
Contra Costa
San Joaquin
Tuolumne
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Monterey
Tulare
Kings
Pacific Ocean
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
Proportion of Population 65 and Over Living Alone
0.21 - 0.22
0.23 - 0.24
0.25 - 0.26
0.27 - 0.28
0.29 - 0.31
0.32 - 0.33
0
100 Kilometers
Source: U.S. Census 2000

Figure 12:



*Population for whom poverty status is determined (1999)

Source: U.S. Census 2000

4) Influence of Adaptive Capacity

Often, evaluations of heat-related morbidity or mortality focus on locations that tend to be warmer and routinely reach higher maximum temperatures, with the assumption that absolute temperature is the strongest determinant of risk. With global warming, prolonged heat events are likely to impact areas currently not often affected by heat waves such as communities in more northern latitudes or at higher elevations. Populations in cooler areas in California may ultimately be at greater risk of excess heat-related illness and mortality because (a) people in these areas have less physiological adaptive capacity, (b) they are less aware of the risk or protective behaviors (e.g., reduce activity level, go to an air conditioned location, and drink fluids), and (c) the built environment is not designed for warmer conditions (e.g., homes and institutions are less often equipped with air conditioning or they are inadequate for extreme or prolonged heat episodes) (Haines and Patz 2004; Haines et al 2006; Kalkstein and Greene 1997; Chestnut et al 1998). In addition, communities in these locations, unaware of the risk, may not have plans or capacity for emergency mitigation measures.

These reasons in part account for results from a study of the effects of weather changes on hospitalizations for cardiovascular diseases and stroke in Los Angeles, Sacramento and San Francisco, between 1983 and 1998, which found the effect of weather varied by region, age, and gender (Ebi et al 2004). In this study, temperature changes were associated with small changes in hospitalizations in Los Angeles, whereas in San Francisco temperature changes were associated with a larger increase (6-13%) in hospitalizations for most health outcomes among men and women 70 years of age or older.

To examine how adaptive capacity may influence population vulnerabilities to heat, we conducted an analysis of demographic determinants of risk for counties by air conditioner ownership and a geographic analysis of increased temperatures, elevation, and ozone levels.

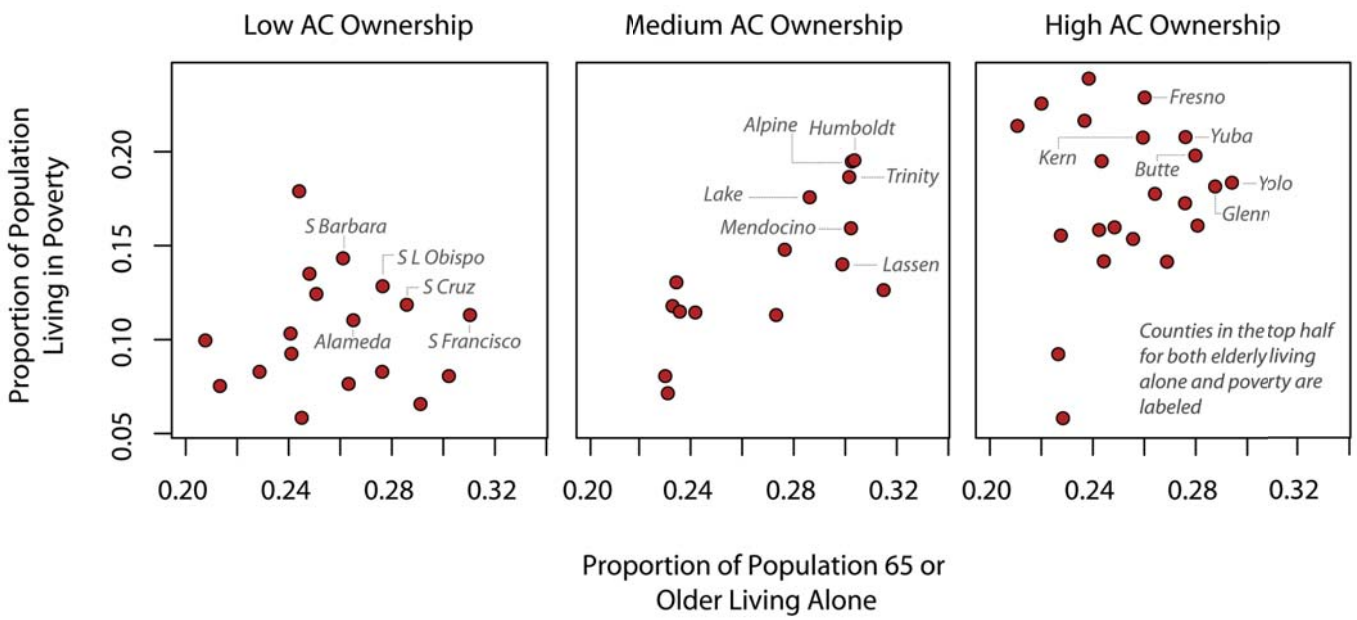
A. Air Conditioner Ownership and Demographic Determinants of Vulnerability by County

Analysis of vulnerability to heat morbidity and mortality must account for adaptation to elevated temperature, and air conditioner ownership is a key aspect of this capacity. We stratified the joint distribution of poverty and social isolation in each California county by the three categories of air conditioner ownership to identify the most vulnerable counties. We identified counties that ranked in the top 50% of both poverty and social isolation (elderly living alone) measures.

Figure 13 shows the joint distribution of elderly living alone and the proportion of the population living in poverty by

Analysis of vulnerability to heat morbidity and mortality must account for adaptation to elevated temperature, and air conditioner ownership is a key aspect of this capacity.

Figure 13: Poverty and Social Isolation in California Counties Categorized by Air Conditioner Ownership



Source: California Energy Commission, U.S. Census 2000

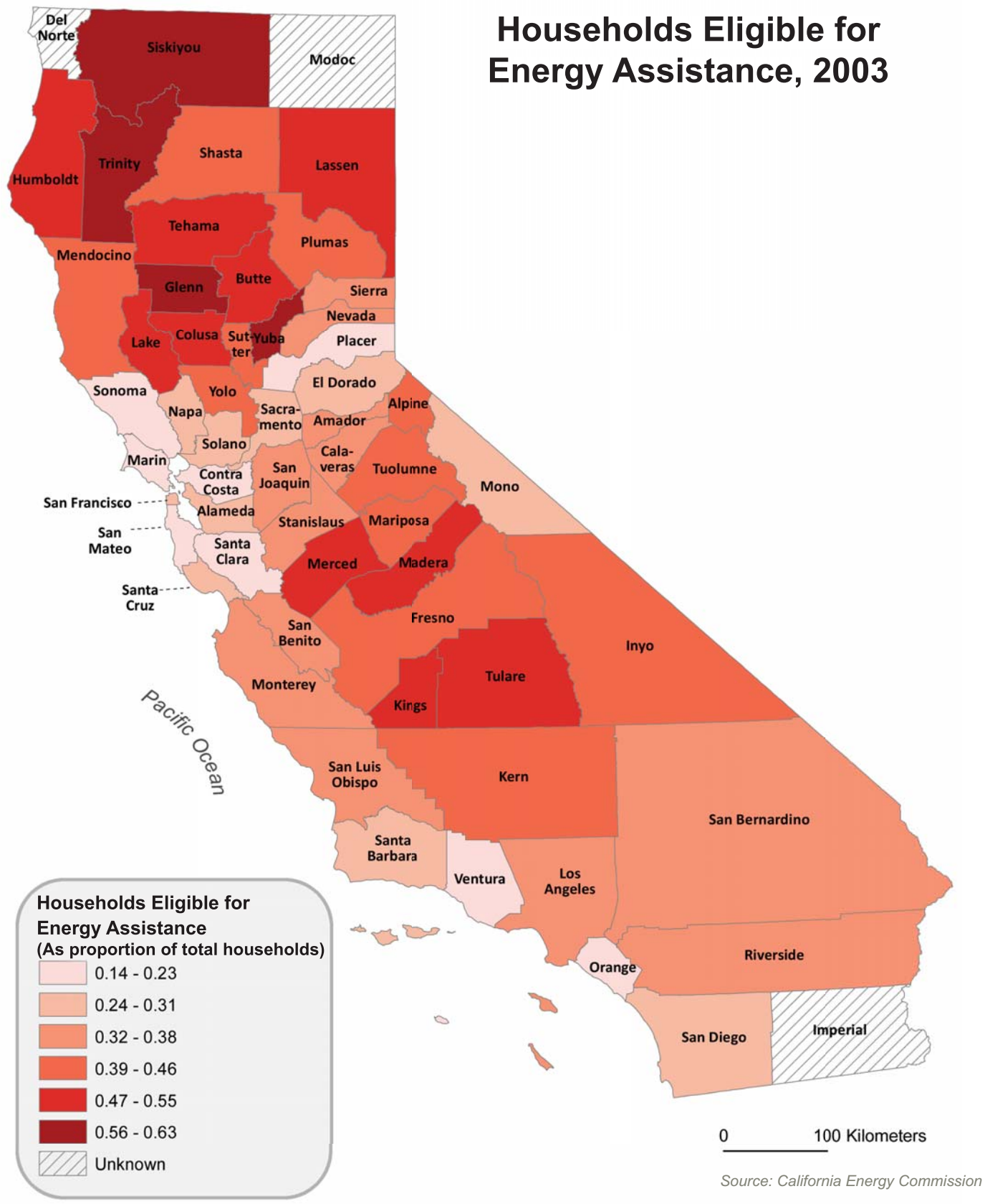
Note: Del Norte, Modoc, and Siskiyou counties were not included in the CEC survey as they are serviced by out of state electricity providers and therefore no AC data are available.

air conditioner ownership. For the high air conditioner ownership counties, Fresno, Yolo, Yuba, Butte, Kern, and Glenn counties showed the greatest vulnerability. Fresno, Yolo, Kern, and Glenn counties experienced at least one certifiable heat death in 2006. Among the counties with medium levels of air conditioning ownership, Trinity, Humboldt, Mendocino, Lake, Lassen and Alpine counties were identified as higher vulnerability in this grouping. Finally, for the low air conditioner ownership counties, Santa Barbara, San Luis Obispo, Santa Cruz, San Francisco, and Alameda counties show the highest vulnerability in this grouping.

Households eligible for energy utility financial assistance programs may be more at risk of not utilizing cooling appliances, such as air conditioning, due to associated energy costs. Estimates of the proportion of the population eligible for assistance with energy costs in each service are based on income and household size criteria and county level census data.[1] Figure 14 shows the distribution of population by county with some of the interior northernmost counties – Siskiyou, Trinity, Glenn, and Yuba, having the highest proportion of population eligible for energy assistance (56-63%). Several other counties in the north: Lassen, Tehama, Butte, Colusa, and Lake in the interior and Humboldt on the coast; and in the central interior: Merced, Madera, Kings, and Tulare, also have moderately higher proportions of populations eligible (47-55%).

1 Data from local energy companies.

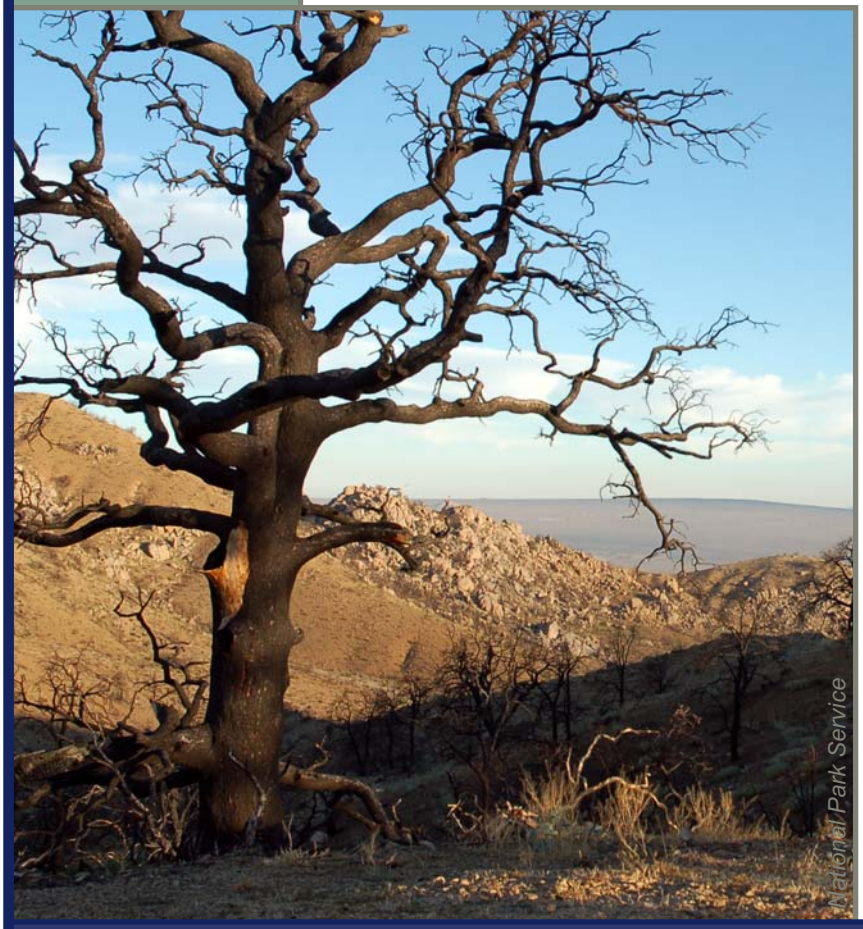
Figure 14:


Households Eligible for Energy Assistance, 2003
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Mendocino
Glenn
Butte
Sierra
Nevada
Lake
Colusa
Sut-ter
Yuba
Placer
Sonoma
Yolo
El Dorado
Napa
Sacra-mento
Alpine
Amador
Solano
Cala-veras
Marin
Contra Costa
San Joaquin
Tuolumne
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Tulare
Monterey
Kings
Pacific Ocean
San Luis Obispo
Kern
San Bernardino
Santa Barbara
Ventura
Los Angeles
Riverside
Orange
San Diego
Imperial
Households Eligible for Energy Assistance
(As proportion of total households)
0.14 - 0.23
0.24 - 0.31
0.32 - 0.38
0.39 - 0.46
0.47 - 0.55
0.56 - 0.63
Unknown
0
100 Kilometers
Source: California Energy Commission

Poor air quality can affect the health of a large portion of Californians, with a disproportionate effect on children, the elderly, those with pre-existing chronic diseases, and those in lower socioeconomic strata.

B. Geographic Analysis of Increased Temperatures, Elevation, and Ozone Levels

A climate change-related factor that will worsen the health hazards from heat is degradation of air quality. Climate-related atmospheric changes (higher temperatures and greater penetration of ultraviolet [solar] radiation towards the earth's surface) favor the formation of ground-level ozone and other air pollutants. Poor air quality can affect the health of a large portion of Californians, with a disproportionate effect on children, the elderly, those with pre-existing chronic diseases (e.g., asthma, cardiovascular disease, diabetes), and those in lower socioeconomic strata. The increased occurrence of extreme heat episodes also will likely bring increased demand for electric power generation, which may contribute to further degradation of air quality despite efforts to control power plant emissions.

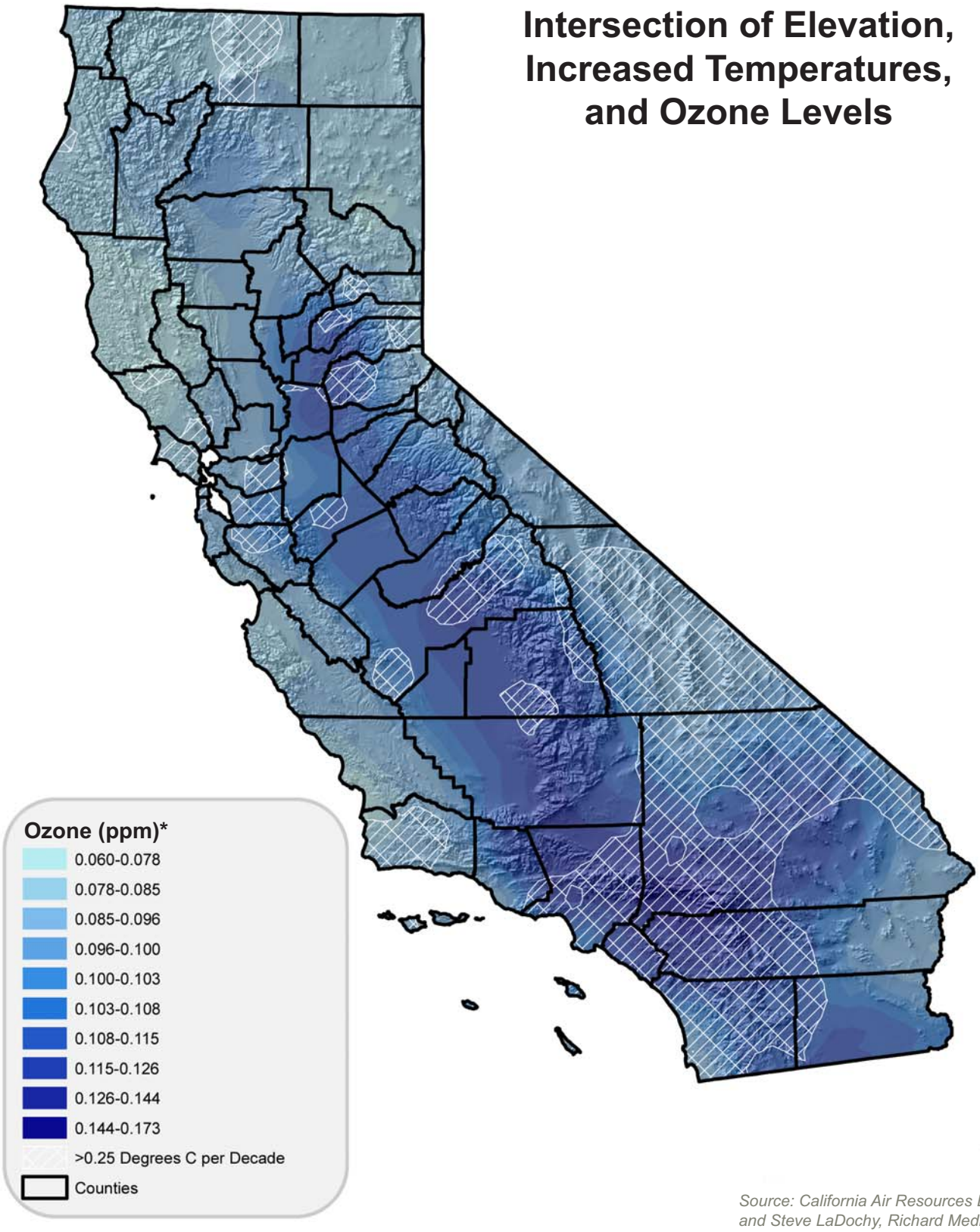


Some areas in California at higher altitudes, which historically have had cooler temperatures, also often have higher ozone levels due to air mass transport of pollutants. The populations in these areas may be particularly vulnerable to the effects of heat due to their lack of acclimatization and due to the interaction of increased heat and higher ozone levels on respiratory health. To help identify these areas, we statistically interpolated the ozone levels for the State based on data from 241 air monitoring stations from the California Air Resources Board. The resulting surface was overlaid on a digital elevation surface, and then the geographic areas of the State were marked to show the areas which experienced greater than 0.25ºC increase per decade[1] (Figure 15).

The resulting map shows several areas of interest where higher levels of ozone, elevation, and increasing temperatures intersect. In the north, the foothills outside of the Sacramento area (e.g., Placerville, Auburn, Grass Valley) show vulnerability. Moving further south, the foothill area outside of Fresno also show higher ozone levels and increased temperatures (e.g., south of Oakhurst). Between Fresno and Bakersfield, the foothill communities below Sequoia National Forest (e.g., Springville) may be affected. In the south, a large area (the mountainous communities in the Los Angeles area national forests, stretching from Santa Clarita to the west to Big Bear in the east) shows the combination of increased historical temperatures, and high ozone levels.

1 Using data obtained from LaDochy et al

Figure 15:



*Ozone 2005: 8-hr, 3-yr 4th max

Source: California Air Resources Board and Steve LaDochy, Richard Medina, and William Patzert

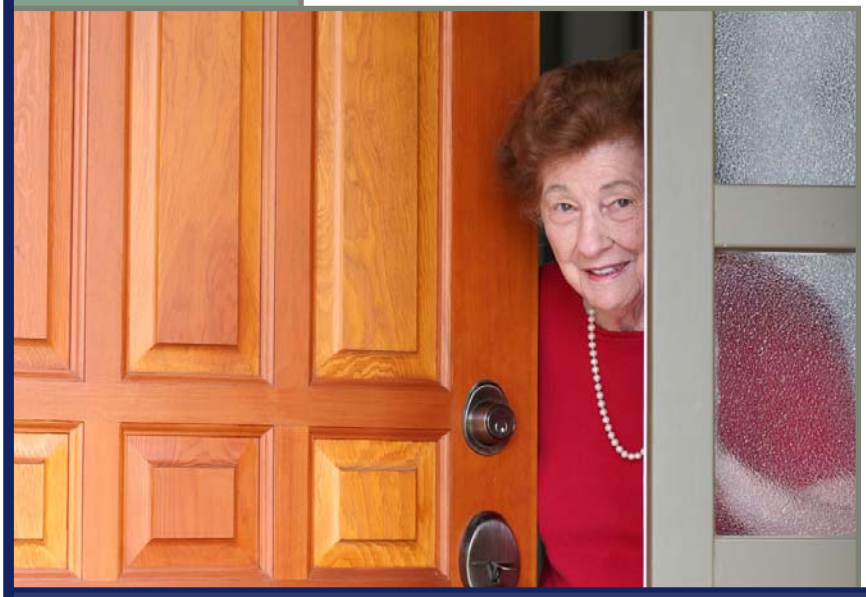
IV. Prevention, Adaptation, and Mitigation

A. Prevention Strategies

1. Cooling Centers

A commonly recommended "adaptive" strategy to prevent heat-related illnesses is to establish cooling centers in communities/ neighborhoods for persons without access to an air conditioned location. Establishment of "cooling centers" must be accompanied by plans and resources to identify and provide assistance to individuals requiring transportation to the cooling centers. In addition, these centers must be prepared to accommodate companion animals in order to ensure that vulnerable residents with pets will utilize the facilities.

Staying at a cooling center for long periods could be complicated by power outages, transportation problems, personal mobility limitations, and other medical issues, so alternatives also need to be considered.



Cooling strategies for persons exposed to risk of exertional heat illness (people engaged in outdoor work, recreation, or other strenuous activities) should also be identified.

2. Public Education and Outreach

Mobilization of Social Contacts of Vulnerable Individuals

As previously mentioned, of all the cases who died in California due to heat in 2006, 46% lived alone. Of those heat death cases that lived alone and had a social contact, only 19% were "checked on" within 24 hours prior to death. It is unknown from the 2006 California heat wave if social contacts of people at risk of classic heat stroke were able to identify symptoms or respond appropriately. Public service announcements (PSAs) and other targeted outreach campaigns need to be initiated to inform social contacts that they must move vulnerable individuals without air conditioning to an air conditioned location, such as a cooling center, as soon as heat wave is predicted or a heat emergency is declared whether or not they show any symptoms of heat-related illness.

Education Regarding Personal Cooling Strategies

PSAs and other targeted outreach efforts (using appropriate language and competency levels) must also educate the public about heat-illness prevention strategies. These include the necessity of proper hydration during heat events, staying in public buildings during the hottest part of the day, and first aid for heat illness. Personal cooling strategies should be promoted, including reducing

temperatures with cool baths, using appropriate cold beverages such as cool water rather than alcoholic or caffeinated drinks, or using cold packs or ice to promote body cooling. Proper hydration is especially important regardless of age. Children and older adults (especially if they are taking certain medications such as some common anti-hypertensives) are at special risk of dehydration.

There was little evidence from the 2006 summer heat wave that those individuals who died attempted to use effective personal cooling strategies. Inappropriate use of fans was mentioned. The CDHS Fact Sheet "Preventing Summer Heat Injuries" (see Appendix 2) should be widely disseminated.

B. Strategies for Mitigation of Effects of Heat Islands

The U.S. EPA has developed a series of recommendations for mitigation of the effects of heat islands (U.S. EPA 2007). They include:

- Installation of cool reflective roofs on buildings (there is up to a 70 degree F reduction in maximum temperatures on cool compared to traditional roofs) (U.S. EPA 2007).
- Planting of trees and vegetation (up to 25% of a household's energy consumption can be saved by planting trees properly near buildings) (National Renewable Energy Laboratory 1995).
- Use of cool paving materials in sidewalks and roads.

C. Strategic Implementation Plans and Emergency Response/Heat Warning Plans

Sufficient experience and scientific knowledge exists to plan for and effectively respond to heat events, thereby reducing heat-related morbidity and mortality. The single strongest message that has come from evaluation of prior deadly heat waves is the need for all communities to have emergency response plans in place. Many small communities in locations with historically relatively cooler climates may face heat-related public health challenges often ascribed only to major urban centers in warmer climates.

Early and accurate heat warning systems are important to develop and can save lives. These warning systems forecast heat threshold conditions and then can issue heat advisories to the public. The California State Warning Center serves as a pass-through for heat warning information from the National Weather Service, and is forwarded to other parties including the media through the Emergency Digital Information Service (EDIS), the statewide emergency news service, operated by the Governor's Office of Emergency Services. Local County Health Departments, such as Los Angeles in the 2006 heat wave, used EDIS to issue heat alerts and to notify residents where cooling centers were open and where to receive additional information.

More robust and standardized approaches to conduct surveillance on heat deaths in California need to be developed. To acquire immediate information on heat deaths as they begin, systems could be developed to report sentinel cases of heat-related illness presented at selected emergency departments or heat stroke deaths encountered by coroners and medical examiners.

The single strongest message that has come from evaluation of prior deadly heat waves is the need for all communities to have emergency response plans in place.

California will be confronted with heat emergencies for the foreseeable future and they will be increasing in frequency. Weather changes related to climate change will only compound the risks to human health due to heat.

V. Recommendations for Short-term and Long-term Strategies

Short-term strategies

California will be confronted with heat emergencies for the foreseeable future and they will be increasing in frequency. Weather changes related to climate change will only compound the risks to human health due to heat. In the short-term, we have the following recommendations to reduce illness and death due to heat:

- County and local health officials are urged to identify vulnerable communities within their jurisdiction. These include children, the elderly, the chronically ill, outdoor workers, and the poor and medically under served. Since most of the 2006 heat deaths occurred in Zip codes where more than 20% of the residents live under the Poverty threshold, we recommend that populations in these areas be given targeted attention by local health officials. The elderly who live alone without social contacts are at highest risk. Health officials should assess strategies specific to communicating and providing services to these populations and conduct appropriate outreach, education, and mitigation activities (see below).

- It is recommended that specific policies should be implemented in preparation for the next heat wave event:
  - Establishment and availability of transportation to cooling centers should be a local priority for vulnerable populations in each county. Cooling strategies for persons exposed to risk of exertional heat illness (people engaged in outdoor work, recreation, or other strenuous activities) should also be considered.
  - Education of social contacts of at-risk populations is needed. PSAs and other targeted outreach campaigns need to be initiated to inform social contacts that they must move vulnerable individuals without air conditioning to cooling centers as soon as a heat wave is predicted or a heat emergency is declared whether or not they show any symptoms of heat-related illness.
  - Education of personal cooling strategies and first aid for heat illness is recommended. PSAs and other targeted outreach efforts need to be made to individuals at risk and social contacts on personal cooling strategies (such as the necessity of proper hydration during heat events and

staying in public buildings during the hottest part of the day) and first aid for heat illness. To further develop recommendations for personal cooling strategies and to provide advice to social contacts of persons at risk, we recommend that the State convene a panel composed of physicians experienced in heat-related illness, health educators, public health officials, and representatives of caretakers/ social contacts of vulnerable populations.

Long-term strategies

From historic data, it is apparent that California's urban centers, and Southern California in particular, are warming more rapidly than other parts of the State. Much of this temperature increase is related to urban development, and the coincident growth in impervious areas and heat islands. These factors have in turn contributed to higher temperatures at night, which interferes with the body's ability to recover from high daytime temperatures.

Although household air conditioning may be practical for a short-term solution to decrease heat-related morbidity and mortality, in the long-term, it will only exacerbate the global warming problem by increasing energy demand, unless more of California's energy can come from renewable sources. Other options could include strategies to reduce nighttime temperatures, such as ameliorating the heat island effect associated with urban development.

To reduce long-term population risks for extreme heat events:

- It is advised that attention be given to areas of the State not historically exposed to and less prepared for extreme heat events. Future heat waves may change geographic risk in California, due to lack of historic physiologic adaptability and capacity to cool. Seven inland counties accounted for 80 of the deaths in the 2006 heat wave. However, future increases in temperature due to climate change may affect other populations in the State due to lack of air conditioning, lack of historic adaptability to heat, and/or respiratory effects due to high heat and poor air quality.
  - For example, Humboldt County has only medium air conditioner ownership (60-65% of the population), a high proportion of poor elderly living alone, and a moderately high proportion of its population is eligible for assistance on energy bills, thereby making the county more vulnerable to the public health consequences of long-term increases in temperatures and heat waves.
  - Foothill and mountainous communities throughout the State (e.g., foothill communities outside of Sacramento) may be

...in the long-term household air conditioning will only exacerbate the global warming problem by increasing energy demand, unless more of California's energy can come from renewable sources.

particularly subject to respiratory and heat stress due to lack of historic adaptability, higher ozone levels, higher elevations, and increasing temperatures.

- Land use and city planners are advised to work with public health officials to minimize the heat island effect. According to recent studies, increases in both minimum and maximum temperatures in California are likely related not only to global warming, but to land use decisions. Increased development of impervious areas in urban locations contribute to the heat island effect, which contribute to elevated minimum temperatures at night and hinder the body's ability to cool off during heat waves. Policies and procedures should be established that require land use planners and public health officials to work together to minimize the creation of more urban heat islands, and reduce the effects of current ones.

- Strategic Planning is needed to build public health response and surveillance infrastructure.
  - Early and accurate heat warning systems should be developed based on enhancements and support to existing systems, such as the California State Warning Center, the National Weather Service, the Emergency Digital Information Service (EDIS), the statewide emergency news service and the Governor's Office of Emergency Services. These systems can be deployed to issue heat alerts and to notify residents where cooling centers are open and where to receive additional information.
  - Surveillance systems should be developed to allow rapid tracking of sentinel cases of heat-related illness presented at selected emergency departments or heat stroke deaths encountered by coroners and medical examiners.

- There is a critical public health need for coordinated planning and action to prepare for climate change-related increases in temperature. With strategic planning, sparse resources can be adequate to begin the urgent tasks required to reduce heat-related illness and mortality.

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Inset images provided by istockphoto.com

Appendix 1: Table: California Counties: Population Vulnerability Data

	Total	Under 5 Years		65 and Older		Living Alone 65 and Up		Under Poverty Level		Energy Assistance	Age 65 Up Nursing Home
County	*Population*	*Population*	*Proportion*	*Population*	*Proportion*	*Pop. 65 Alone*	*Per. 65 Alone*	*Population*	*Proportion*	*Proportion*	*Proportion*
Alameda County	1,443,741	97,075	0.067	147,663	0.102	39,159	0.265	156,804	0.110	0.248	0.032
Alpine County	1,208	61	0.050	119	0.099	36	0.303	232	0.195	0.429	0.000
Amador County	35,100	1,410	0.040	6,348	0.181	1,439	0.227	2,808	0.092	0.356	0.021
Butte County	203,171	11,667	0.057	31,966	0.157	8,946	0.280	39,148	0.198	0.503	0.030
Calaveras County	40,554	1,723	0.042	7,309	0.180	1,703	0.233	4,704	0.118	0.367	0.013
Colusa County	18,804	1,529	0.081	2,062	0.110	579	0.281	2,964	0.161	0.506	0.039
Contra Costa County	948,816	65,054	0.069	106,904	0.113	28,140	0.263	71,575	0.076	0.198	0.026
Del Norte County	27,507	1,481	0.054	3,470	0.126	872	0.251	4,765	0.202	NA	0.021
El Dorado County	156,299	8,931	0.057	19,508	0.125	4,508	0.231	11,079	0.071	0.257	0.012
Fresno County	799,407	66,985	0.084	78,999	0.099	20,565	0.260	179,085	0.229	0.454	0.035
Glenn County	26,453	1,994	0.075	3,388	0.128	975	0.288	4,729	0.181	0.565	0.018
Humboldt County	126,518	7,095	0.056	15,904	0.126	4,829	0.304	24,059	0.195	0.524	0.029
Imperial County	142,361	10,831	0.076	14,516	0.102	3,196	0.220	29,681	0.226	NA	0.021
Inyo County	17,945	983	0.055	3,467	0.193	1,092	0.315	2,244	0.126	0.408	0.040
Kern County	661,645	55,012	0.083	62,175	0.094	16,135	0.260	130,949	0.208	0.440	0.026
Kings County	129,461	10,205	0.079	9,689	0.075	2,361	0.244	21,307	0.195	0.520	0.035
Lake County	58,309	3,054	0.052	11,332	0.194	3,245	0.286	10,081	0.176	0.533	0.021
Lassen County	33,828	1,643	0.049	3,053	0.090	913	0.299	3,484	0.140	0.545	0.032
Los Angeles County	9,519,338	728,242	0.077	926,970	0.097	226,278	0.244	1,674,599	0.179	0.337	0.033
Madera County	123,109	9,387	0.076	13,210	0.107	2,786	0.211	24,514	0.214	0.513	0.022
Marin County	247,289	13,281	0.054	33,457	0.135	9,742	0.291	15,601	0.066	0.192	0.049
Mariposa County	17,130	819	0.048	2,915	0.170	806	0.277	2,489	0.148	0.446	0.010
Mendocino County	86,265	5,190	0.060	11,690	0.136	3,533	0.302	13,505	0.159	0.447	0.025
Merced County	210,554	18,295	0.087	19,824	0.094	4,698	0.237	45,059	0.217	0.516	0.020
Modoc County	9,449	509	0.054	1,632	0.173	539	0.330	1,962	0.215	0.000	0.044
Mono County	12,853	756	0.059	941	0.073	222	0.236	1,456	0.115	0.283	0.001
Monterey County	401,762	30,812	0.077	40,181	0.100	9,964	0.248	51,692	0.135	0.321	0.019
Napa County	124,279	7,484	0.060	19,006	0.153	5,251	0.276	9,913	0.083	0.306	0.029
Nevada County	92,033	4,220	0.046	16,112	0.175	3,708	0.230	7,332	0.081	0.366	0.023
Orange County	2,846,289	213,881	0.075	278,805	0.098	67,137	0.241	289,475	0.103	0.135	0.026
Placer County	248,399	15,720	0.063	32,577	0.131	7,444	0.229	14,272	0.058	0.206	0.039

Plumas County	20,824	971	0.047	3,723	0.179	873	0.234	2,686	0.131	0.447	0.034
Riverside County	1,545,387	119,460	0.077	194,833	0.126	47,625	0.244	214,084	0.142	0.336	0.021
Sacramento County	1,223,499	87,449	0.071	135,503	0.111	36,442	0.269	169,784	0.141	0.244	0.035
San Benito County	53,234	4,611	0.087	4,217	0.079	876	0.208	5,241	0.100	0.316	0.024
San Bernardino County	1,709,434	140,709	0.082	145,447	0.085	35,296	0.243	263,412	0.158	0.364	0.028
San Diego County	2,813,833	196,115	0.070	313,702	0.111	78,687	0.251	338,399	0.124	0.292	0.028
San Francisco County	776,733	31,083	0.040	106,958	0.138	33,197	0.310	86,585	0.113	0.246	0.015
San Joaquin County	563,598	44,153	0.078	59,482	0.106	15,718	0.264	97,105	0.177	0.368	0.042
San Luis Obispo County	246,681	12,157	0.049	35,679	0.145	9,863	0.276	29,775	0.128	0.318	0.026
San Mateo County	707,161	44,652	0.063	88,240	0.125	21,622	0.245	40,692	0.058	0.169	0.035
Santa Barbara County	399,347	25,485	0.064	50,550	0.127	13,195	0.261	55,086	0.143	0.300	0.027
Santa Clara County	1,682,585	118,517	0.070	159,263	0.095	33,975	0.213	124,470	0.075	0.170	0.031
Santa Cruz County	255,602	15,369	0.060	25,308	0.099	7,236	0.286	29,383	0.119	0.266	0.049
Shasta County	163,256	9,672	0.059	24,766	0.152	6,335	0.256	24,556	0.154	0.451	0.026
Sierra County	3,555	146	0.041	615	0.173	168	0.273	397	0.113	0.372	0.040
Siskiyou County	44,301	2,273	0.051	8,079	0.182	2,344	0.290	8,109	0.186	0.597	0.016
Solano County	394,542	28,240	0.072	37,371	0.095	8,549	0.229	31,344	0.083	0.239	0.047
Sonoma County	458,614	27,034	0.059	57,518	0.125	17,380	0.302	36,349	0.081	0.232	0.026
Stanislaus County	446,997	35,164	0.079	46,519	0.104	11,563	0.249	70,406	0.160	0.353	0.040
Sutter County	78,930	5,664	0.072	9,538	0.121	2,172	0.228	12,031	0.155	0.440	0.053
Tehama County	56,039	3,553	0.063	8,930	0.159	2,464	0.276	9,503	0.173	0.530	0.027
Trinity County	13,022	528	0.041	2,182	0.168	658	0.302	2,372	0.187	0.630	0.000
Tulare County	368,021	32,626	0.089	35,775	0.097	8,536	0.239	86,572	0.239	0.500	0.038
Tuolumne County	54,501	2,536	0.047	10,076	0.185	2,436	0.242	5,690	0.114	0.408	0.017
Ventura County	753,197	55,830	0.074	75,582	0.100	18,214	0.241	68,540	0.092	0.225	0.024
Yolo County	168,660	10,868	0.064	15,575	0.092	4,582	0.294	29,787	0.184	0.412	0.043
Yuba County	60,219	4,825	0.080	6,171	0.102	1,704	0.276	12,205	0.208	0.568	0.012

Preventing Summer Heat Illness

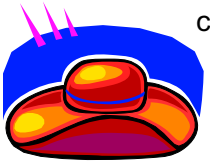
Summer heat waves can be dangerous. A very high body temperature can damage the brain and other vital organs. Some health conditions can make it harder for the body to stay cool in hot weather. These include old age, obesity, fever, dehydration, heart disease, poor circulation, sunburn and drug and alcohol use. To protect your health when temperatures are very high:

Get Plenty to Drink

Sweating removes needed salt and minerals from the body. When it is hot, drink more water, juice and sports drinks. Avoid drinks with caffeine (tea, coffee, and cola) and alcohol. Be sure to eat regularly.

Wear Light Clothing and Sunscreen

Wear as little clothing as possible when you are at home. Choose lightweight, light-colored, loose-fitting clothing.



In the hot sun, a wide-brimmed hat will keep the head cool.

If you will be in direct sun, use a sunscreen with a sun protection factor (SPF) of 15 or higher and follow package directions. Reapply every 2 hours while in the sun.

Warning: If your doctor limits the amount of fluid you drink or if you take water pills, ask him or her how much you should drink when the weather is hot. If you are on a low-salt diet, talk with your doctor before drinking a sports beverage.

Stay Cool Indoors

The best way to beat the heat is to stay in an air conditioned area. If you don't have an air conditioner, go to a shopping mall or public building for a few hours. A cool shower or bath is also a good way to cool off.

Schedule Outdoor Activities Carefully

Try to be less active during the hottest part of the day, late afternoon. If you must be out in the heat, plan your activities so that you are outdoors either before noon or in the evening. While outdoors, rest often in a shady area. Never leave kids or pets in a parked car.

Pace Yourself

If you are not used to working or exercising in hot weather, start slowly and pick up the pace gradually. Take frequent, regularly scheduled breaks. If activity in the heat makes your heart pound or leaves you gasping for breath, stop activity, get into a cool or shady area, and rest. Especially if you become lightheaded, confused, weak or feel faint.

Use a Buddy System

During a heat wave, check on your friends and family and have someone do the same for you. If you know someone who is elderly or has a health condition, check on them twice a day during a heat wave. Watch for signs of heat exhaustion or heat stroke.

High temperatures can cause serious health problems. Know the symptoms of heat-related illness and be ready to help.

California Department of Public Health – July 2007

Treating Summer Heat Illness

Heat stroke happens when the body can no longer control its temperature. The body's temperature rises fast. The body cannot sweat and is unable to cool itself. Warning signs include red, hot, dry skin; very high body temperature, dizziness, nausea, confusion, strange behavior or unconsciousness, rapid pulse or throbbing headache. Heat stroke can cause death or disability if treatment is not given. What to do:

- Get medical help quickly.
- Get the victim to a shady area.
- Cool the person off with a cool shower, garden hose, etc.
- Do not give the victim fluids to drink.
- If emergency medical personnel are delayed, call the hospital for further instructions.

Heat exhaustion is a milder illness that happens when the body has lost too much water and salt in sweat. Warning signs include heavy sweating, cramps, headache, nausea or vomiting, tiredness, weakness, dizziness and fainting. If heat exhaustion is not treated, it can turn into heat stroke. Get medical help if the symptoms are severe or if the victim has heart problems or high blood pressure. Help the victim cool off with:

- Cool, nonalcoholic beverages,
- Rest, lying down,
- Cool shower, bath or sponge bath,
- Air-conditioning,
- Lightweight clothing.

Heat cramps are muscle pains and spasms due to heavy activity. They usually involve the stomach muscles or the legs. It is generally thought that the loss of water and salt from heavy sweating causes the cramps. If you have heart problems or are on a low-sodium diet, get medical attention for heat cramps. What to do:

- Stop. Sit quietly in a cool place.
- Drink clear juice or a sports beverage.
- Rest for a few hours to avoid heat exhaustion or heat stroke.
- Get medical help if heat cramps do not stop after one hour.

Sunburn is when skin becomes red, painful and unusually warm after being in the sun. Sunburn should be avoided because it damages the skin and could lead to more serious illness. What to do:

- See a doctor if the sunburn affects an infant younger than one year old or if the victim has fever, blisters or severe pain.
- Stay out of the sun.
- Bathe the sunburned area with cool water.
- Use moisturizing lotion on sunburn, do not use salve, butter or ointment.
- Do not break blisters.

For more information…
Call CDC for info in English or Spanish:
800-CDC-INFO (800-232-4636)
888-232-6348 (TTY)
Or visit: www.cdc.gov
www.bepreparedcalifornia.ca.gov

California Department of Public Health – July 2007