ENVIRONMENTAL HEALTH AND EQUITY IMPACTS FROM CLIMATE CHANGE AND MITIGATION POLICIES IN CALIFORNIA: A REVIEW OF THE LITERATURE

A Paper From:
California Climate Change Center

Prepared By:
Seth B. Shonkoff, MPH
Rachel Morello-Frosch, Ph.D., MPH
Manuel Pastor, Ph.D.
James Sadd, Ph.D.

FINAL PAPER

DISCLAIMER

California Environmental Protection Agency
Air Resources Board

Arnold Schwarzenegger, *Governor*

August 2009
CEC-500-2009-038-F

Acknowledgments

Work for this project was supported by: the California Air Resources Board, the California Environmental Protection Agency, the Annenberg Foundation, the Energy Foundation, and the Hewlett Foundation.

Preface

The California Energy Commission's Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program conducts public interest research, development, and demonstration (RD&D) projects to benefit California's electricity and natural gas ratepayers. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts focus on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

In 2003, the California Energy Commission's PIER Program established the **California Climate Change Center** to document climate change research relevant to the states. This center is a virtual organization with core research activities at Scripps Institution of Oceanography and the University of California, Berkeley, complemented by efforts at other research institutions. Priority research areas defined in PIER's five-year Climate Change Research Plan are: monitoring, analysis, and modeling of climate; analysis of options to reduce greenhouse gas emissions; assessment of physical impacts and of adaptation strategies; and analysis of the economic consequences of both climate change impacts and the efforts designed to reduce emissions.

The California Climate Change Center Report Series details ongoing center-sponsored research. As interim project results, the information contained in these reports may change; authors should be contacted for the most recent project results. By providing ready access to this timely research, the center seeks to inform the public and expand dissemination of climate change information, thereby leveraging collaborative efforts and increasing the benefits of this research to California's citizens, environment, and economy.

For more information on the PIER Program, please visit the Energy Commission's website www.energy.ca.gov/pier/ or contract the Energy Commission at (916) 654-5164.

Table of Contents

List of Figures

List of Tables

Abstract

Climate change is an issue of great importance for human rights, public health, and social equity because of its profound consequences overall and its potentially disproportionate impact on vulnerable and socially marginalized populations. Community vulnerability to climate change is determined by its ability to anticipate, cope with, resist, and recover from the impact of major weather events. Climate change will affect industrial and agricultural sectors, as well as transportation, health, and energy infrastructure. These shifts will have significant health and economic consequences for diverse communities throughout California. Without proactive policies to address these equity concerns, climate change will likely reinforce and amplify current as well as future socioeconomic disparities leaving low-income, minority, and politically marginalized groups with fewer economic opportunities and more environmental and health burdens. This literature review explores disparities in the impacts of climate change and the abilities of different groups to adapt to it. Further, it investigates the costs and benefits of climate change mitigation strategies—some of which have been specified in the Scoping Plan for the implementation of the California Global Warming Solutions Act of 2006 (AB 32). Finally, knowledge gaps and future research questions are identified.

Keywords: Climate justice, environmental health, equity, vulnerability, environmental justice

1.0 Introduction—Climate Change: An Issue of Environmental Health and Social Equity

1.1. Background and Overview

Climate change is an issue of great importance for human rights, public health, and social equity because of its disproportionate impact on vulnerable and socially marginalized populations. Global climate change will affect diverse industrial and agricultural sectors, as well as transportation, health, and energy infrastructure. These shifts will have undeniable health and economic consequences for diverse communities throughout California. Without proactive policies to address these equity concerns, climate change will likely reinforce and amplify current as well as future socioeconomic disparities, leaving low-income, minority, and politically marginalized groups with fewer economic opportunities and more environmental and health burdens. The incidence of mortality (death) and morbidity (ill-health) associated with mounting physical and biological impacts and economic consequences will increase. Moreover, community vulnerability to climate change is also determined by the ability for a community to anticipate, cope with, resist, and recover from the impact of extreme weather events such as hurricanes, floods (Greenough and Kirsch 2005; Fothergill and Peek 2004; Frumkin et al. 2008a; Frumkin et al. 2008b; Blaikie et al. 1994), heat waves (English et al. 2007; Knowlton et al. 2009; Basu and Ostro 2008), air pollution (Bernard et al. 2001; Cifuentes et al. 2001; Jacobson 2008; O'Neill et al. 2008), and infectious diseases (Gage et al. 2008; Reiter 2001; Patz and Olson 2006). Therefore, to understand concerns regarding climate justice, it is critical to explore disparities in the costs and benefits of climate change, the abilities of different groups to adapt to it, and the mitigation strategies imposed to attenuate it in order to better inform future policy and regulatory action.

1.2. Project Objectives and Organization

This review of the literature focuses on the disparate impacts of climate change on groups of lower socioeconomic status (SES) in California.[1] The first section reviews the literature on the disproportionate health and economic impacts of climate change, and examines differences in the capacity of certain groups to adapt to direct and indirect effects such as extreme weather events, infrastructure impacts, or major economic shifts. Secondly, the review will examine the equity impacts of different climate change mitigation strategies, some of which have been specified in the Scoping Plan for the implementation of the California Global Warming Solutions Act of 2006 (AB 32). Finally, we will assess the implications of this wide-ranging body of literature for future policy-relevant research aimed at addressing equity concerns related to climate change.

[1] The term *socioeconomic status* or *socioeconomic position* (used synonymously) will refer to the position of an individual or group along the spectrum of access to the resources necessary to maintain their health and economic livelihoods. Socioeconomic status thus encompasses variables such as income level, inherited wealth, educational status, beneficial social networks, and race/ethnicity.

2.0 Methods

This project reviews the emerging literature on the disparate impacts of climate change and mitigation policies on low-SES groups in the United States that is relevant to the California context. Information in this review is drawn primarily from literature that addresses these issues directly. We have also secondarily drawn information from climate change policy, human health, and environmental justice literature that provides background and context for these issues. Our goal was to address the some of the prominent public health, equity, and regulatory issues that are pertinent to the policy deliberations surrounding AB 32.

3.0 Results

3.1. Environmental Health Inequities and Global Climate Change

3.1.1. Extreme Weather Events – Heat

Extreme weather events, such as heat-waves, droughts, and floods are expected to increase in their frequency and intensity in the next hundred years (IPCC 2007), which could amplify the risk of associated morbidity and mortality.

In a study on nine California counties from May through September of 1999–2003, Basu and Ostro (2008) found that for every 10°F (5.6°C) increase in ambient temperature, there is a 2.6% (95% confidence interval [CI]: 1.3, 3.9) increase in cardiovascular mortality with the greatest risk being found to be in ischemic heart disease[2] (Basu and Ostro 2008). Elevated risks were also found for persons at least 65 years of age (2.2%, 95% CI: 0.04, 4.0), infants one year of age or less (4.9%, 95% CI: -1.8, 11.6) (Figure 3-1), and African Americans (4.9%, 95% CI: 2.0, 7.9) (Basu and Ostro 2008) (Figure 3-2).

Many studies that look at heat-wave mortality have been done (Semenza, Rubin et al. 1996; Basu and Samet 2002; Naughton, Henderson et al. 2002; Donoghue, Nelson et al. 2003; Vandentorren, Suzan et al. 2004; Medina-Ramon, Zanobetti et al. 2006; Hajat, Armstrong et al. 2006; Kinney, O'Neill et al. 2008), however there are fewer studies on heat-wave morbidity.

Knowlton et al. (2009), in a study on the 2006 California heat wave (July 15–August 1, 2006) show that there were an estimated 16,166 excess emergency department visits and 1,182 excess hospitalizations statewide, compared with a temporally-proximate summer referent period (July 8–14, 2006, and August 12–22, 2006) with the same distribution of days of the week (Knowlton et al. 2009).

---

[2] Ischemic or ischemic heart disease (IHD), or myocardial ischemia, is a disease characterized by reduced blood supply to the heart muscle, usually due to coronary artery disease (atherosclerosis of the coronary arteries). Its risk increases with age, smoking, hypercholesterolaemia (high cholesterol levels), diabetes, and hypertension (high blood pressure).

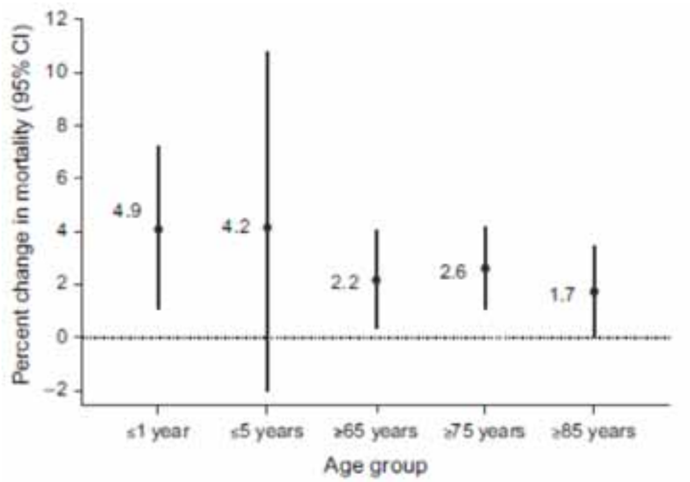

Figure 3-1. Estimated percent change associated with a 10°F (5.6°C) increase in mean daily apparent temperature* and non-accidental mortality (total mortality minus external causes) by age group in nine California counties, May through September, 1999–2003

*Apparent temperature: perceived outdoor temperature, composed by the combined effects of air temperature, relative humidity and wind speed.

Source: Basu and Ostro 2008

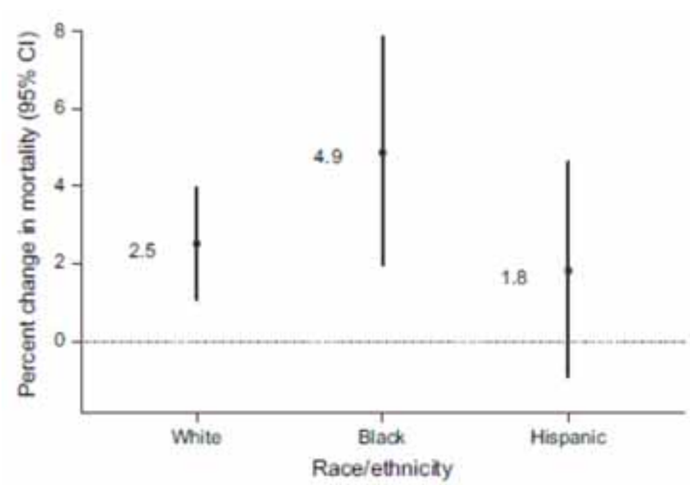

Figure 3-2. Estimated percent change associated with a 10°F (5.6°C) increase in mean daily apparent temperature and non-accidental mortality by race/ethnic group in nine California counties, May through September, 1999–2003

Source: Basu and Ostro 2008

Emergency department visits for heat-related causes increased across the state (relative risk [RR][3] 6.30; 95% CI 5.67– 7.01), especially in the Central Coast, which includes San Francisco. Further, emergency department visits showed statistically significant increases in acute renal failure, diabetes, cardiovascular diseases diabetes, electrolyte imbalance, and nephritis (Knowlton et al. 2009). Children (0–4 years of age), the elderly (≥ 65 years of age) (Knowlton et al. 2009), and low-income African Americans (Basu and Ostro 2008) were disproportionately affected by this event.

Although heat exposure alone can cause morbidity and mortality, physiological, social and economic factors are integral in explaining the uneven distribution of these adverse heat-specific health outcomes across diverse populations (Epstein and Rodgers 2004). Risk factors for heat-associated mortality and morbidity can be categorized as intrinsic (i.e., age, disability) or extrinsic (e.g., housing, access to cooling centers, transportation).

In terms of intrinsic factors, people suffering from chronic medical conditions have a greater risk of dying during heat waves (Epstein and Rodgers 2004; Kovats and Hajat 2008; Kilbourne 1997). In fact, a study on the heat-specific mortality during the 2003 heat wave in France reported that over 70% of the home victims had medical pre-conditions, particularly cardiovascular and / or psychological illness (Poumadere et al. 2005). Low SES groups are disproportionately affected by medical conditions due to their lack of access to technological, informational, and social resources to cope with these conditions (Phelan et al. 2004). Further, epidemiologic studies of heat-associated mortality show an increased risk among the elderly; especially among those older than ~50 years of age (Kovats and Hajat 2008).

In terms of extrinsic factors, low-income urban communities and communities of color are particularly vulnerable to increased frequency of heat waves and higher temperatures because they are often segregated in the inner city (Schultz et al. 2002; Williams and Collins 2001), which is more likely to experience the “heat-island” effect. The heat-island effect occurs in urban areas because dark-colored materials used to construct roads, buildings, and other structures absorb heat and do not allow it to dissipate at the same rate as soil, grass, forests, and other less-industrial materials (Oke 1973). In an unpublished analysis done by Morello-Frosch and Jesdale (2008) it was found that there is a positive dose-response relationship between the presence of impervious surfaces with increasing community poverty, and a negative dose-response relationship between the amount of tree cover and the level of community poverty in four California urban areas (Figure 3-3). This suggests the potential for a disproportionate burden of heat-island exposure to low-income populations compared with higher-income populations. Similarly, this trend is extended to the proportion of people of color that reside in a given neighborhood; there is a positive dose-response relationship between proportion of people of color and proportion of impervious surfaces and a negative dose-response relationship between proportion of people of color and amount of tree cover (Figure 3-4).

Further, in terms of technological adaptation as an extrinsic factor, studies have documented that lack of access to air conditioning is linked to the disproportionate risk of heat-related

[3] *Relative risk* is a ratio of the probability of the event occurring in an exposed group versus a non-exposed group. A relative risk of 1 means there is no difference in risk between the two groups. A relative risk less than 1 means the event is less likely to occur in the exposed group than in the control group. An relative risk greater than 1 means the event is more likely to occur in the exposed group than in the control group.

morbidity and mortality among low SES urban elderly in the United States (Kovats and Hajat 2008; Semenza et al. 1996).

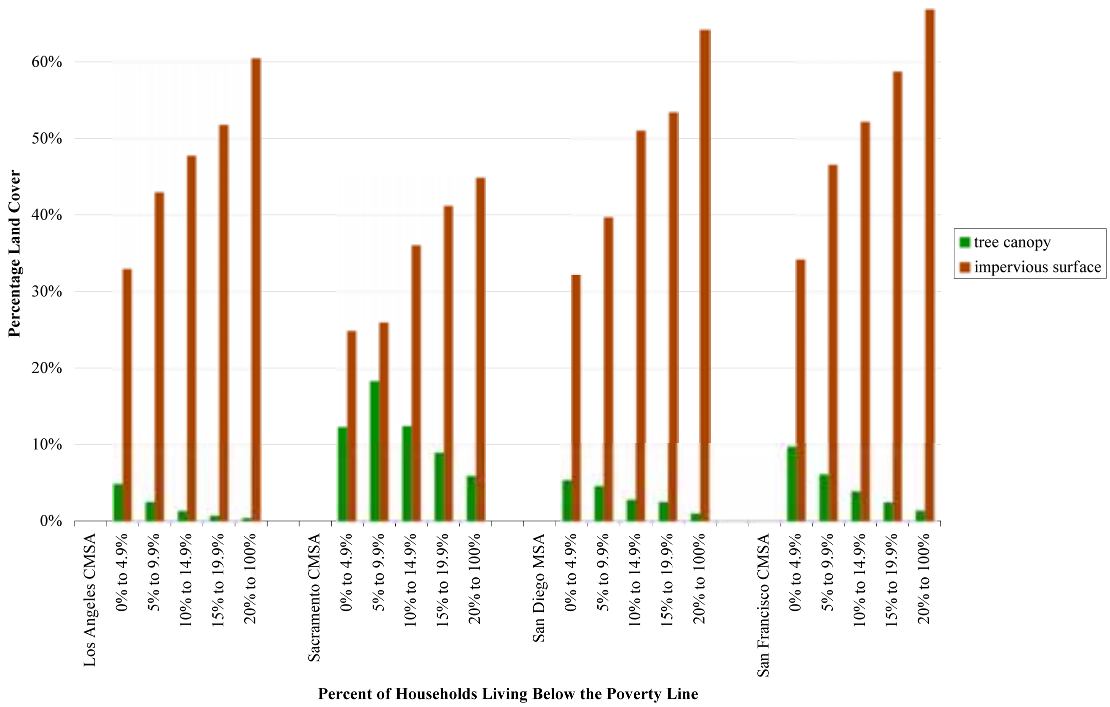

Figure 3-3. Land cover characteristics across comparable neighborhood poverty groups

Adapted from: Morello-Frosch and Jesdale 2008.

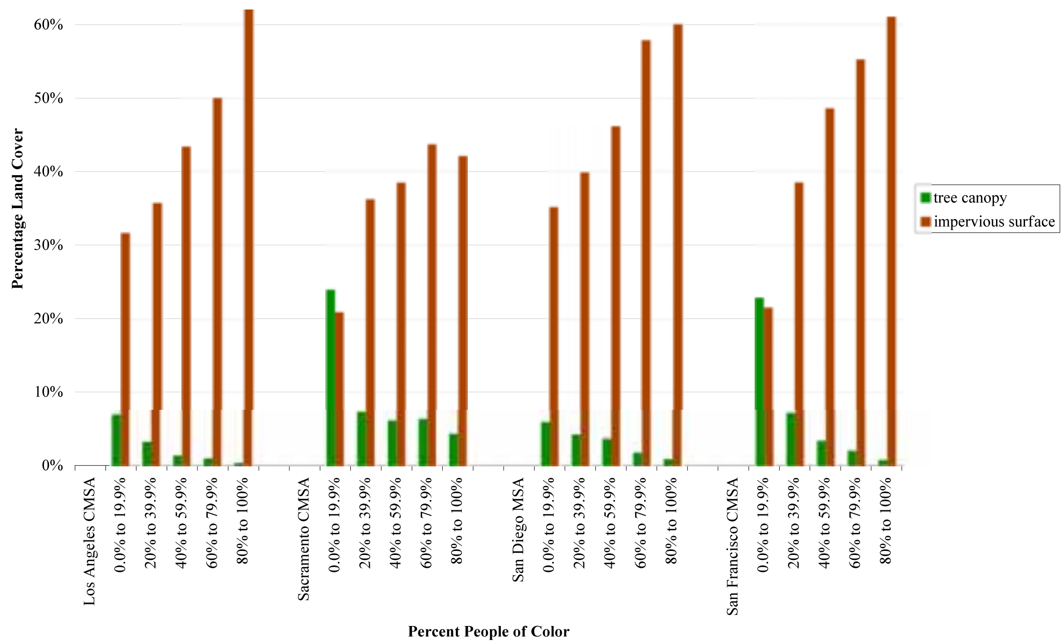

Figure 3-4. Land cover characteristics across comparable neighborhood racial/ethnic minority groups

Adapted From: Morello-Frosch and Jesdale 2008.

Low SES groups are less likely to have access to air-conditioning (English et al. 2007). In the Los Angeles-Long Beach Metropolitan Area, for example, many more African-Americans do not have access to air conditioning compared to the general population. Similar trends hold for Latinos and communities living below the poverty line (UCSB 2004) (Table 3-1). Although these data do not explain the drivers of observed racial and SES disparities in air conditioner ownership, this inequity is important because some households may rely on air conditioning during poor air quality days when communities are instructed to stay indoors and avoid outdoor pollution exposures.

Table 3-1. Proportion of households without access to any air conditioning by race and SES – Los Angeles-Long Beach Metropolitan Area, California (2003)*

	Total Number of Households	Total Occupied Units	Black (Not Hispanic)	Hispanic	Elderly (65 years or older)	Below Poverty Level
All Occupied units	3,131,000	39.7%	58.5%	54.6%	37.5%	51.5%
Renters	1,608,900	48.1%	59.1%	58.4%	38.7%	56.3%
Homeowners	1,522,100	30.9%	57.4%	48.9%	36.8%	38.8%

* Percentages are likely an underestimate of the true value due to the fact that more than one category may apply to a single unit in the dataset.

Adapted from: American Housing Survey for the Los Angeles-Long Beach Metropolitan Area 2004 (USCB 2004).

Moreover, in the Los Angeles-Long Beach Metropolitan Area, compared to White households (7.9%), higher proportions of African-American (20%), Latino (17.1%), and Asian (9.8%) households do not have access to a car (UCSB 2004), thus restricting their capacity to move to cooler areas and government-sponsored cooling stations during extreme heat events. According to the American Community Survey (2007), nearly 84% of residents in this area rely on cars to get to work compared to 7% of residents who rely on public transportation. This paucity of public transit options makes residents extremely reliant on car ownership to meet basic transportation needs.[4]

Material and social deprivation, combined with a lack of access to the social networks central to protection from extreme heat conditions, especially in the inner city, is a strong determinant of heat-wave and heat-stroke mortality risk in the United States, including California (English et al. 2007; Kovats and Hajat 2008). For example, the heat wave in Phoenix, Arizona, in 2006 was responsible for thirteen heat-stroke-related deaths, eleven of which were homeless people who lack access to these types of resources (Kovats and Hajat 2008). It is also clear that African American groups may bear a disproportionate burden of heat-wave mortality because African American Los Angeles residents have a heat-wave-mortality rate that is nearly twice that of the Los Angeles average (Figure 3-5).

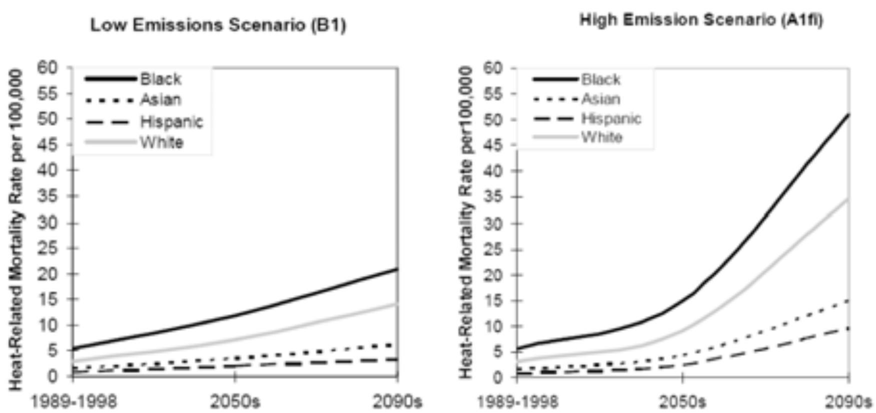

Figure 3-5. Relative heat-wave mortality rates by race/ethnicity for Los Angeles*

* Actual historical values (1989–1998) and projected future values (2050s and 2090s) for high-emissions (A1fi) and low-emissions (B1) scenarios. (HadCM3 projections only.)

Cited from: Cordova et al. (2006)

Moreover, in a meta-regression[5], using heat-wave data from Chicago, Detroit, Minneapolis, and Pittsburgh, O'Neil, Zanobetti et al. (2005) show that for each 10% increase in central air

---

[4] Since the 1930s when National City Lines, a holding company run by corporate partners in the automotive industry, bought and dismantled a considerable portion of the public transit infrastructure in Los Angeles, residents without a personal automobile in the Los Angeles-Long Beach Metropolitan Area have been at a severe disadvantage (Kunzli et al. 2003).

[5] A *meta-regression* is an extension of the meta-analysis and a generalization of subgroup analyses. They can be used to investigate heterogeneity of effects across studies. Meta-regressions examine the relationship between one or

conditioner (AC) prevalence, heat-associated mortality, pooled across these cities, decreased by 1.4% (95% CI = −0.1 to 2.9). The overall effect of heat on mortality (the effect of heat in a city with a 0% prevalence of central AC) was a 10.2% increase (95% CI = 4.5–16.2). African Americans were found to have a 5.3% higher prevalence of heat-related mortality than Whites and 64% of this disparity is potentially attributable to disparities in prevalence of central AC technologies (O'Neil, Zanobetti et al. 2005). This meta-regression is bolstered by a number of studies that have found associations between being African American and lack of AC as an indicator for vulnerability to heat-related poor health outcomes (Semenza et al. 1996; Rogot et al. 1992; O'Neill et al. 2003; Curriero et al. 2002; Greenberg et al. 1983.; Whitman et al. 1997). Unfortunately there is a paucity of such studies in California, and future research should be done to assess the impact of heat events on African American populations in the California context.

3.1.2. Heat, Health, SES, and Labor

California's agricultural and construction workers have experienced severe heat-related illness and death with data pointing towards possible increasing trends in recent years (English et al. 2007; MMWR 2008). The socioeconomic status of predominantly Mexican and Central American immigrants who come to California to work in the agricultural and construction sectors are particularly vulnerable because of the cumulative impacts of their long workdays under strenuous conditions, low capacity to protect their rights, and exposure to chemicals such as pesticides. Between the years 1992–2002, 40% of the crop-workers that died due to heat-associated complications were identified as Mexican or Central or South American (MMWR 2008) and 72% of these deaths were in adults aged 20–54 years, a population typically considered low-risk for heat illnesses (MMWR 2008). As heat-wave incidence and intensity increases, disparities will persist among those with high levels of material and social deprivation that characterize the context within which low-SES groups live.

3.1.3 Air Pollution

The literature suggests that the majority of the health effects due to air pollution are attributed to ozone (O_3) and particulate matter (PM) and thus, this literature review focuses on these two pollutants (Drechsler et al. 2006). It should be noted, however, that many other co-pollutants that are associated with greenhouse gases such as nitrogen dioxide, sulfur dioxide, and carbon monoxide affect the health of those that are exposed (Drechsler et al. 2006).

Five of the ten most ozone-polluted metropolitan areas in the United States (Los Angeles, Bakersfield, Visalia, Fresno, and Sacramento) are in California (Cordova et al. 2006; ALA 2008). Because of this, Californians suffer a relatively high disease burden due to air pollution. This burden includes 18,000 (95% CI: 5,600–32,000) premature deaths each year and tens of thousands of other illnesses (CARB 2008a). Primarily due to the combustion of fossil fuel in the mobile and the energy sectors, California's levels of nitrogen oxides (NOx), PM, O_3, and a myriad of other air pollutants are very high (ALA 2008). Of course, these sectors not only emit criteria air pollutants, but also emit greenhouse gases (GHGs) that lead to the increase in global climate change. Increasing temperatures interact with NO_x and sunlight that lead to increases in ambient ozone concentrations in urban areas (Jacobson 2008). In California, five of the

more study-level characteristics and the sizes of effect observed in the studies. The sizes of effects are the usual measures available for a meta-analysis, such as relative risks or differences in means.

smoggiest cities are also the locations with the highest projections of ambient ozone increases as well as the highest densities of people of color and low-income residents who also lack health insurance (Cordova et al. 2006). A lack of health insurance among vulnerable populations that are exposed to elevated levels of air pollutants may lead to greater complications arising from health impacts from air pollution than those who have health insurance. Moreover, a recent study by Jacobson (2008) found a dose-response relationship in which for each 1 degree Celsius (1°C) rise in temperature in the United States, there are an estimated 20–30 excess cancer cases, as well as approximately 1000 (CI: 350–1800) excess air-pollution-associated deaths Jacobson (2008). About 40% of the additional deaths may be due to ozone and the rest to particulate matter annually (Jacobson 2008; Bailey et al. 2008). Three hundred of these annual deaths are thought to occur in California (Bailey et al. 2008).

3.1.4 Infectious Diseases

Climate change has the potential to influence the distribution and prevalence of water-, food-, and insect vector-borne infectious diseases (Confalonieri et al. 2007). California, in comparison to other parts of the nation and many international regions, is not anticipating major increases in environmentally mediated infectious diseases, although some experts are nonetheless concerned (Reiter 2001; Patz and Olson 2006). However, increases in the prevalence of biological pathogens due to climate change have not been studied from an equity point of view. It is likely, however, that low-income households and people of color in California could be particularly at risk of adverse health effects of future disease outbreaks, should they arise, because of their lack of access to health care.

3.2. Disproportionate Economic Impacts of Climate Change

3.2.1. Price of Basic Necessities

The Natural Resources Defense Council (NRDC) estimates that under a business-as-usual scenario, between the years 2025 and 2100, the cost of providing water to the western states in the United States will increase from $200 billion to $950 billion dollars per year, representing an estimated 0.93%–1% of the United States' gross domestic product (GDP) (Ackerman and Stanton 2008). Further, it is predicted that under the same scenario annual U.S. energy expenditures (excluding transportation) will be $141 billion higher in 2100 than they would be if today's climate conditions continued throughout the century. This increase is equal to approximately 0.14% of the United State's GDP (Ackerman and Stanton 2008). Four climate change impacts—hurricane damage, energy costs, real estate losses, and water costs—alone are projected to cost 1.8% of the GDP of the United States, or, just under $1.9 trillion (2008 U.S. dollars [USD]) by the year 2100 (Ackerman and Stanton 2008). These price increases will disproportionately impact groups that spend the highest proportion of their income on these necessities (BLS 2002). There is nearly a three-fold difference in the proportion of the sum of expenses allocated to water between the lowest- and the highest-expenditure quintiles. Households in the lowest quintile use more than twice the proportion of their total expenditures on electricity than do those households in the highest quintile. Similarly, food, the commodity that represents the largest portion of total spending out of all the basic necessities in the expenditure quintiles, shows a two-fold discrepancy between the lowest and the highest quintiles (Figure 3-6) (Cordova et al. 2006). Because in the coming decades climate change impacts are projected to increase the prices of necessities (Ackerman and Stanton 2008) low-income people who already are paying a higher proportion of their income for necessities will potentially be subjected to increasingly disproportionate economic impacts of climate change. Current energy assistance programs could be extended and could also include summer air conditioner usage, which could help to decrease the gap between low-income household and higher-income household energy expenditure.

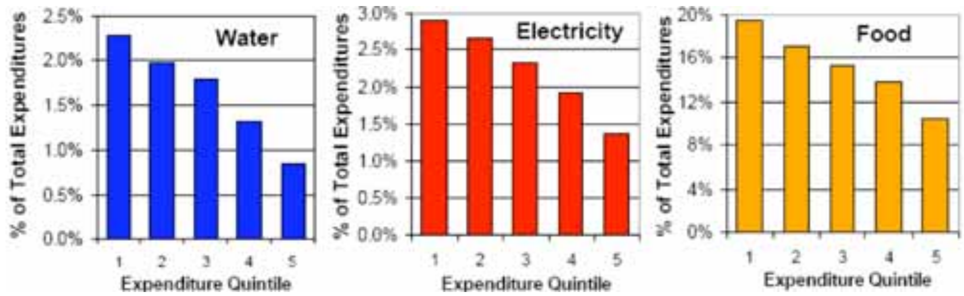

Figure 3-6. Household expenditures on water, electricity, and food by income group (as percentage of total expenditures)*

* Expenditure quintile is a proxy for income with quintile 1 representing the lowest-income households and quintile 5 representing the highest-income households.

Adapted From: BLS 2002; Cited in: Cordova et al. (2006)

3.2.2. Disproportionate Impact of Climate Change on Employment

The majority of jobs in sectors that will likely be significantly affected by climate change, such as agriculture and tourism, are held by low-income people of color (UCSB 2005; EDD 2004). These workers would be the first to lose their jobs in the event of an economic downturn due to climatic troubles.

Agriculture Sector

The literature suggests that climate change will affect employment within the agricultural sector in two main ways: (1) Increases in the frequency and the intensity of extreme weather events will expose agriculture to greater productivity risks and possible revenue losses that could lead to abrupt layoffs; and (2) changing weather and precipitation patterns could require expensive adaptation measures such as relocating crop cultivation, changing the composition or type of crops and increasing inputs such as pesticides to adapt to changes in ecological composition that lead to economic denigration and job loss (Cordova, Gelobter et al. 2006).

Climate change impacts on the agricultural sector hold major implications for equity issues in California. Latinos comprise 77% of the workforce and the majority of these men and women are also categorized as low-income (EDD 2004). In California, as of 2003, agriculture provided approximately 500,000 jobs with 315,000 of them being held by Latinos (EDD 2004). The majority of these jobs are seasonal, do not pay more than $7.50 per hour, and do not provide health insurance or job security. Because of the low wages and the seasonality of the work, agricultural counties are among the poorest in the state (Cordova, Gelobter et al. 2006). It is clear that as climate change adversely affects agricultural productivity in California, agricultural laborers will be increasingly affected by job loss. For example, the two highest-value agricultural products in California's $30 billion agriculture sector are dairy products (milk and cream, valued at $3.8 billion annually) and grapes ($3.2 billion annually) (CASS 2002). Climate change is expected to decrease dairy production by as much as 7%–10% under the B1 scenario and 11%–22% under the A1fi scenario by the end of the century (Pittock 2001). It is also expected to adversely affect the ripening of wine grapes, substantially reducing their market value (Hayhoe 2004). Communities in the Central Valley, where agriculture is most concentrated and low-income Latino communities are most common, would be the hardest hit by these climate change impacts.

Tourism Sector

Tourism is already quite vulnerable to market conditions because the ability to travel is heavily based on access to disposable income. Impacts are expected to be seen predominantly on sea-side destinations and mountainous regions of California (IPCC 2007; UNWTO 2007). Although there are no formal predictions of leisure travel that exist beyond the year 2020 (UNWTO 2007), and there is great uncertainty about shifts due to climate change in the tourism sector, there is concern that climate change may lead to jobs being retracted and downsized (Cordova et al. 2006; UNWTO 2007). Effects of climate change on the tourism industry could be seen in the form of shorter employment periods and lower wages as the industry struggles to deal with physical, temporal, economic, and climatic issues.

Because of shifts in the types of recreational opportunities that will likely remain available in California due to climatic changes, the jobs of the current tourism laborers may be at risk. In all of the major industries that have been generated by tourism—with the exception of the entertainment industry—people of color make up the majority of the workforce and could be vulnerable to layoff and decreased pay (Figure 3-7) (Cordova et al. 2006). The tourism employment category comprised of the greatest proportion of people of color is “traveler accommodations” which consists of hotel and motel workers. It is uncertain whether these same workers, or these same demographics in general, would be hired to work in new tourism activities if the industry shifts to other geographic locations or shrinks in size.

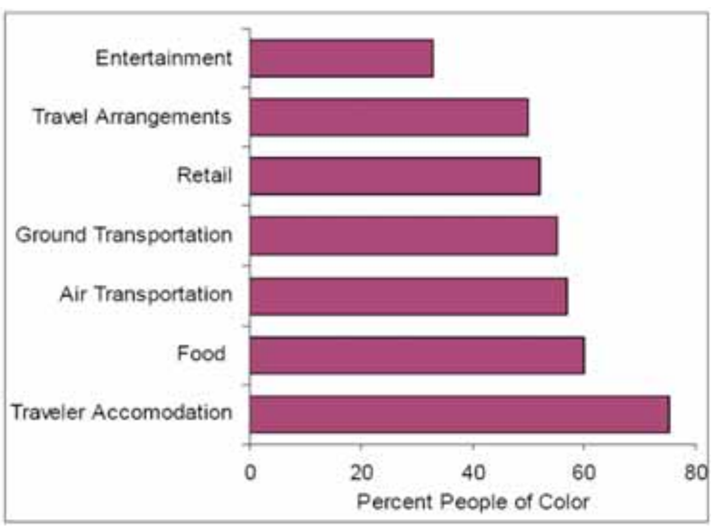

Figure 3-7. Percentage of people of color in tourism-generated jobs, by sector (2003)

Cited from: Cordova (2006) #3

3.2.3. Disparities in Infrastructure Impacts

As extreme weather events become more common and severe, California's infrastructure will be increasingly threatened and damaged. Although the issue of insurance is a large question and a detailed analysis is beyond the purview of this review, the literature shows that those in low socioeconomic positions are consistently underinsured (Fothergill and Peek 2004; Blaikie et al. 1994). Households that have home or renters' insurance can, relatively rapidly, recuperate and resume living much in the same way as prior to the disaster. In contrast, low-income communities—who are often under-insured—may spend the rest of their lives struggling to recover from property damage related to an extreme weather event (Fothergill and Peek 2004; Blaikie et al. 1994; Thomalla et al. 2006). Further, these increases in the frequency and intensity of extreme weather events due to climate change will increase the price of disaster insurance, making it prohibitively expensive for low-income people, decreasing their ability to cope with future losses. Swiss Re (2006) indicates that insurance losses have been on an upward trend since 1985. During the years 1987–2004 property insurance losses due to natural disasters averaged USD 23 billion per year and in 2005, losses rose to USD 83 billion, of which USD 60 billion was due to hurricanes (Katrina, Rita, and Wilma) alone (Swiss Re 2006). Increases in the price of disaster insurance will add insult to injury to those that are already disproportionately affected by these events.

Further, the disproportionate impact of extreme weather events on low-SES groups could exacerbate homelessness, especially in urban areas. This would be largely due to the lack of access to insurance and emergency credit, less savings, fewer personal resources, and disproportionate suffering from previous economic stress and problems (Fothergill and Peek 2004; Bolin and Bolton 1986; Tierney 1988). Moreover, increased governmental spending on infrastructure protection could directly affect low-income communities because funds may be diverted away from education, social programs, public transportation programs, health, and other economic sectors (CRAG 2002; Redefining Progress 2006).

3.3. Impacts of Climate Change Policies on Low-SES Groups

This section examines the equity impacts embedded in the most prominent climate change mitigation strategies, some of which have been specified in the Scoping Plan for the California Global Warming Solutions Act of 2006 (AB 32) (CARB 2008a). We discuss two overarching themes: (1) the economic implications of different climate change policies on low-SES households; and (2) positive and negative health impacts of different mitigation strategies on low-SES communities and households.

3.3.1. Economic Costs and Benefits of Different Climate Change Reduction Strategies

A major concern with regard to policies to reduce emissions is that they will be regressive; the burden of costs that arise from mitigation will fall disproportionately on lower-income households (Walls and Janson 1996; Hassett et al. 2008). For example, a study by the Congressional Budget Office (2007a) shows how a program implemented to cut carbon dioxide (CO_2) emissions by 15% would cost 3.3% of the average income of households in the lowest income quintile as opposed to only 1.7% of the average income of households in the top income quintile. Substantial equity issues are raised by how pollution credits are allocated to facilities as well as—in the case of policies that include fees on emissions or the auctioning of emission credits—how revenues generated from these programs are redistributed to society and individual consumers.

With no revenue generated from cap-and-trade programs where emission credits are allocated for free, there is concern that these policies will be regressive (Dutzik et al. 2007). Alternatively, under the cap-and-auction or fee-based strategies, the sale of emission credits to polluters could generate sizable revenues that could be used to offset the regressive qualities of the program (Hepburn et al. 2006). Revenues could be distributed to the public through tax cuts, tax-shifting, investments in clean energy, high-value investments such as education, or through direct periodic dividends to consumers (CBO 2007a), assuaging the regressive impacts and creating a double-dividend (CBO 2007a.b; Dutzik et al. 2007; Boulder 1995; Boyce and Riddle 2007). A double-dividend occurs when a program reduces socio-environmental externalities and simultaneously reduces the distortionary costs and regressive qualities of the program (Goulder 1995).

Cap-and-auction reduces and fees eliminate the need for emissions trading in comparison to free-allocation programs because industry is likely to buy only what it needs (Hepburn et al. 2006). Auctioning credits also decreases financial incentives to keep old polluting facilities open by eliminating the grandfathering in of old facilities. It also decreases the problem of over-allocation and excessive banking and trading of emission credits. Over-allocation of credits, paired with excessive emission credit banking and trading, could possibly lead firms to not reduce local GHG emissions. This could lead to the under-achievement of significant co-pollutant benefits in communities that are currently highly impacted by multiple pollution sources. For example, a study of the Regional Clean Air Incentives Market (RECLAIM), an emission trading system employed to lower NO_x emissions in Southern California, indicates that the program may have increased NO_x emissions in Wilmington, California, while region-wide emission levels declined (Lejano and Hirose 2005). Further, under Rule 1610, licensed car scrappers could purchase old, polluting vehicles and destroy them, and in return receive emission credits by the South Coast Air Quality Monitoring District (SCAQMD) that could be sold to oil refineries (Drury et al. 1999). The majority of the emission credits were purchased by four oil companies: Unocal, Chevron, Ultramar, and GATX to avoid the cost of installing pollution-reduction technologies that would capture VOC gases forced out of oil tankers into the air when being loaded. These refineries are all located in close proximity to one another in the City of Wilmington and San Pedro except for the Chevron facility located in El Sugundo (Drury et al. 1999). In their analysis, Drury et al. (1999) indicate that this mobile-to-stationary trading program led to a situation where workers and local residents of these communities were unnecessarily exposed to benzene, a known human carcinogen, and other volatile organic compounds that were contained in the emissions; these emissions could have been remediated by pollution reduction technologies that were already in widespread use in similar operations along the West Coast.

3.3.2. Health Costs and Benefits of Different Climate Change Reduction Strategies

Since low-SES groups are disproportionately affected by climate change, they have relatively more to gain from sound climate change policies that are sensitive to the distribution of the co-pollutants of GHGs that may have localized impacts. While cap-and-trade, under certain circumstances, is efficient at reducing GHGs and their associated co-pollutants on a regional basis, the strategy makes no guarantee about these emissions from any one source (O'Neill 2004). Hence, low-SES communities are concerned about the persistence and potential exacerbation of co-pollutant hotspots at the local community level. The bundles of measures that CARB has proposed to use to reduce GHG emissions could also contribute to notable reductions in co-pollutants of those greenhouse gases such as NO_x, PM, ozone, and other contaminants (CARB 2008b). These measures could hold the most notable benefits for low-income groups and people of color who are disproportionately segregated in neighborhoods in close proximity to highways, ports, and other sections of the transportation and goods-movement corridors where air quality has been noted as poor (CARB 2006; CARB 2008c; Morello-Frosch and Jesdale 2006; Morello-Frosch and Lopez 2006).

Co-benefits of Proposed AB 32 Measures

Greenhouse gas reduction measures are predicted to reduce NO_x emissions, a precursor of ozone formation, by 86,000 tons by 2020, more than three-quarters of which will be achieved through regulatory requirements for cleaner cars and trucks (Bailey et al. 2008). For example, a review by CARB (2008c) indicates there is a 10% increase in number of premature deaths per 10 microgram per square meter (ug/m^3) increase in $PM_{2.5}$ exposure (CI: 3% to 20%). The California Air Resource Board (2008b) also estimates that diesel PM contributes to 3,500 (CI: 1,000 to 6,400) premature deaths, statewide, on an annual basis. The reduction of co-pollutants (i.e., PM) could bring the number of excess mortalities down.

Under AB 32, projected PM and NO_x reductions together are estimated to prevent approximately 780 premature deaths, 11,000 fewer cases of asthma-related and other lower respiratory symptoms, 980 fewer cases of acute bronchitis, and 77,000 fewer work days lost in California (CARB 2008b). These health benefits are projected to be valued at $1.4 billion to $2.3 billion in 2020 (Bailey et al. 2008). Moreover, actual health and economic benefits of these climate change policies may be underestimated because many emission reduction measures and public health benefits such as reduced cancer risks have not been accounted for (Bailey et al. 2008). Some known carcinogens that may be reduced by the implementation of GHG reduction measures are benzene, formaldehyde, and toluene predominantly produced directly and indirectly by mobile sources and by the refining and combustion of fossil fuels (EPA 2005). Reduction of air toxics may be important from an environmental justice perspective, as several studies indicate that communities of color and the poor bear a disproportionate burden of health risks associated with air toxics exposures (CARB 2008c; Morello-Frosch and Jesdale 2006; Morello-Frosch et al. 2002; Morello-Frosch and Shennasa 2006).

Co-Benefits of AB 32 Early Action and Other Mitigation Measures

The California Air Resources Board's plans for AB 32 will also include Early Action Measures (EAMs) that could be enforceable on or before 2010 (HSC §38560.5, Health and Safety Code Section 38560–38565). These EAMs include regulations affecting landfills, motor vehicle fuels, refrigerant in cars, port operations, and many other sources in 2007, including nine Discrete Early Action measures for which the CARB will adopt regulations by the end of 2009 (CARB 2007; CARB 2008b). It is estimated that if all EAMs were adopted together with the additional proposed measures, 52,000 tons of NO_x and PM pollution would be removed from the air, which would lead to a further decrease in exposure to unhealthy local pollution. It would also prevent an additional $1.1 billion to $1.8 billion in health costs in the year 2020 alone (Bailey et al. 2008). These measures would benefit low-SES groups that tend to be segregated in neighborhoods and that may be hosting significant industrial and transportation emission sources. It should be noted however that the Scoping Plan has notable shortcomings in terms of its lack of information and specifics regarding how and when cumulative impacts will be assessed. While co-benefits have been quantified at the state level, explanations of how these benefits (geographical and SES) will be distributed (geographically and across the SES strata) is not presented or explained. Further, the Scoping Plan does not explain how these benefits and their distribution will be characterized in the future.

Table 3-2 shows the reductions of NO_x and PM that could be expected if all of the potential AB 32 measures (Climate Action Team [CAT], EAMs, and additional measures) were implemented. Table 3-3 shows the health co-benefits of these actions.

Table 3-2. Statewide criteria pollutant emission reductions in 2020 from proposed scoping plan recommendation (tons per day)

Measure	NOx	PM2.5
Light-Duty Vehicle • Pavley I and Pavley II GHG Standards • Vehicle Efficiency Measures	1.6	1.4
Goods Movement Efficiency Measures	16.9	0.6
Medium and Heavy-Duty Vehicle GHG Emission Reduction • Aerodynamic Efficiency • Hybridization • Engine Efficiency	5.6	0.2
Local Government Actions and Regional Targets	8.7	1.4
Energy Efficiency and Conservation (Electricity)	7.0	4.0
Energy Efficiency and Conservation (Natural Gas)	10.4	0.8
Solar Water Heating	0.3	0.03
Million Solar Roofs	1.0	0.6
Renewables Portfolio Standard	9.8	5.6
Total	**61**	**15**

Note: This does not include the criteria pollutant co-benefits of additional greenhouse gas reductions that would be achieved from the proposed cap-and-trade regulation because we cannot predict in which sectors they would be achieved.

Cited from: CARB 2008c

Table 3-3. Estimates of statewide air quality-related health benefits in 2020

Health Endpoint	Health Benefits of Existing Measures and 2007 SIP *mean*	Health Benefits of Recommendations in the Proposed Scoping Plan *mean*
Avoided Premature Death	3,700	400
Avoided Hospital Admissions for Respiratory Causes	770	84
Avoided Hospital Admissions for Cardiovascular Causes	1,400	150
Avoided Asthma and Lower Respiratory Symptoms	110,000	11,000
Avoided Acute Bronchitis	8,700	910
Avoided Work Loss Days	620,000	67,000
Avoided Minor Restricted Activity Days	3,600,000	380,000

Cited from: CARB 2008c

Fuel Switching

The Low Carbon Fuel Standard (LCFS) is on the list of discrete EAMs in the AB 32 Scoping Plan (CARB 2008b). The goal of the LCFS is to reduce lifecycle GHG emissions from transportation by at least 10% (CARB 2008b). A large part of this discrete EAM involves transitioning from pure gasoline to partial or pure biofuels such as ethanol (CARB 2008b). However, studies suggest that biofuel refineries could negatively impact the health of adjacent communities by exposing them to chemical as well as microbial byproducts of the distillation processes necessary for fuel production (Madsen 2006).

Further, Jacobson (2007) predicts that E85 (85% ethanol, 15% gasoline) may increase ozone-related mortality, hospitalization, and asthma by 9% in Los Angeles and 4% nationwide if used to power vehicles. In fact, E85 may prove to have as much or more of a public health impact than regular gasoline (Jacobson 2007). Moreover, low-income and minority communities that live disproportionately closer to highways and goods transport corridors could also bear disproportionate health burdens if these fuels prove to be more toxic than gasoline.

Lastly, it should be noted that growing crops for fuel will likely raise prices of crops used for food (Tenenbaum 2008). This could prove to be regressive, damaging socioeconomic prospects of low-income consumers and low-income agricultural laborers who are most vulnerable to job loss and hunger (Tenenbaum 2008).

4.0 Conclusions and Future Research Needs

4.1. Conclusions

Climate change is not only an environmental issue; it is also a human rights, public health, and social equity issue. Our review of the literature indicates that climate change will adversely affect the health of communities that are least likely to cope with, resist, and recover from the impacts of extreme weather events and potential increases in air pollution (Knowlton et al. 2004). Further, low-income and minority communities could be disparately affected by the economic shocks associated with climate change both in price increases for basic necessities (i.e., water, energy, and food) and by threats of job loss due to economic and climatic shifts that affect industries such as agriculture and tourism (Stern 2006). Without proactive climate change policies that are sensitive to their economically regressive potential and their distribution of benefits, climate change policies could potentially reinforce and amplify current as well as future socioeconomic and racial disparities

The consistency of racial and SES disparities as they relate to climate change has made these issues of mounting concern to regulators, policy-makers, researchers, and environmental justice advocates. However, research on climate equity—ranging from health effects to economic impacts—is in its infancy. Expanding this new line of work requires interdisciplinary approaches—spanning the fields of climate change science, industrial ecology, epidemiology, environmental health, sociology, economics, geographic information system (GIS) spatial analysis, and statistics—in order to understand the socioeconomic, cultural, and health effects of complex ecological, meteorological, and air pollution phenomena and to specify which policies and mitigation practices would best address climate justice.

Of course climate justice will not be achieved through scientific inquiry alone. It will also require significant resources to disseminate research in ways that are transparent to policy-makers, the regulatory community and the public to advance national, state, and local greenhouse gas reduction initiatives. This will help to shape efforts to move California and the nation toward a sustainable, equitable, low-carbon economy. With the passage of AB 32, the state is taking the lead in forging new and aggressive strategies to reduce greenhouse gas emissions. Although California is likely to be a model for the nation in terms of how to achieve reductions in ways that move our economy toward a stronger, and more sustainable direction, it will also be critical for decision-makers to ensure that climate justice is part of the equation.

4.2. Recommendations

Although this paper is a comprehensive review of the existing literature on climate change disparities within the United States, there are limitations in the available data. These limitations include issues regarding the generalizability of national data to California, as well as a paucity of research that explores mechanisms of inequity and other competing risk factors that could confound relationships between race, SES, and climate change impacts. Further research is needed to better understand relationships between climate change and equity in California.

4.2.1. Health Disparities Associated with Climate Change

More research is needed to look at the rates and impacts of climate change events that are projected to occur specifically in California. Identifying possible adaptation strategies that could be used to evade morbidity and mortality burdens from climate change impacts specifically in California are increasingly important foci for future analysis.

Because burdens of heat-related illness during extreme heat events are borne disproportionately by groups of older residents, children, and those of low socioeconomic status (Knowlton et al. 2009; English 2007; Basu and Ostro 2008), strategies to prevent heat-related illness should include messages and information that are disseminated and targeted toward parents and caregivers of young children, continual outreach to the elderly—especially to socially isolated populations, and geographically targeted messages about extreme heat exposure (Knowlton et al. 2009). Climate change adaptation interventions focused on vulnerable groups could attenuate their disproportionate burden of heat-related health effects during extreme heat weather events in California.

Differential exposures to the health-damaging impacts of climate change, such as excessive heat, extreme weather events, and infectious diseases could be examined from a geographical equity perspective by using GIS maps overlaid with vulnerability models and current socioeconomic, racial/ethnicity, and cultural group distributions in California. Interaction of these data layers should be taken into account when developing climate change policy (Elliott et al. 2005), so as to reduce the likelihood that future policies would create disproportionate burdens on vulnerable populations.

As discussed in Section 3.3 of this review, low-income communities and communities of color could disproportionately benefit from greenhouse gas reduction strategies because of the indirect reduction in co-pollutants such as NO_x, SO_x, PM, lead, and ozone. Efforts to model the reduction of co-pollutants associated with reductions of greenhouse gases are complicated by the need to rely on uncertain assumptions regarding baseline regulations and the policies used to address climate change. More careful studies should be conducted to assess which climate policies would hold the greatest benefits for communities that are most impacted by local air pollution (Elliott et al. 2005).

Additionally, research should aim to characterize patterns of population exposure resulting from local sources of pollution in a variety of settings, especially in urban areas. Although methodologically difficult to develop, this could include—under a cap-and-trade scheme—the building of analytical tools to track where carbon credits are being traded in order to assess the subsequent amounts of co-pollutant emissions that may increase or decrease on the local level.

Additionally, in the case of fuel innovations, epidemiologic studies can better assess the effects of exposure to new fuels (i.e., ethanol) and their externalities such as increased emissions of co-pollutants during combustion (Jacobson 2007) as well as production and distillation—for which there are currently no studies available. More studies must also focus on dangers of food shortages and food price increases associated with the production of ethanol and other biofuels (Tenenbaum 2008). Obtaining this information could illuminate uneven distribution of pollution, as well as display uneven impacts of food prices on the poor. This type of data could inform the policy-development process, leading to fairer policy outcomes.

Runaway climate change, where positive feedback loops drive warming irrespective of human mitigation actions, could occur and has, to date, received a dearth of attention (NRC 2002; Gjerde et al. 1999; Pizer 2003). Without the success of upstream state and federal level strategies to curb GHG emissions, more downstream adaptation strategies such as infrastructure protection, better air-cooling technologies, and possibly new medical treatments for emerging infectious diseases would most likely emerge. Attention should be paid to what these more downstream adaptation strategies could entail and the equity dimensions of their distributions across diverse populations. Without attention paid to the equity dimensions of severe adaptation needs, disparities between populations of differing socioeconomic status will likely increase.

Cumulative Impacts Screening Method to Guide Decision-making

Assembly Bill 32 requires that, prior to implementation, there be consideration and prevention of cumulative or additional impacts on already disproportionately impacted communities (CARB 2008b). However, no established method for identifying these communities exists. Researchers are developing environmental justice screening methods that employ GIS-based mapping that considers risk from both criteria and toxic pollutants, proximity to sources of pollution, and socioeconomic factors. Such tools could be used to evaluate community-level cumulative impacts. Research to expand upon this work could enable the development of a screening method that is consistent across air districts and cities, that would assure that all communities are assessed using similar metrics (Prasad 2008). Such screening tools could be valuable in the future for evaluating permitting, land-use, and growth pattern decisions made at local and regional scales (Prasad 2008) providing data for decision-makers to better predict the local impacts of regional policy choices.

Localized Impacts and Co-Pollutants

There is substantial argument over the scale at which measurements of localized impacts and co-pollutants must be evaluated in order to meet the intent and requirements of the AB 32 laws relating to vulnerable populations (Prasad 2008). In order to design proper policies and monitor the efficacy of those policies in regards to localized impacts, future research would be beneficial to: (1) explore how to characterize, quantify, and maximize co-benefits of pollution reductions in existing or new "toxic hotspots"; (2) determine the geographic scale at which these evaluations can take place given the data available; and (3) identify the data necessary to improve future evaluations.

4.2.2. Economic Disparities Associated with Climate Change

Because climate change will likely differentially affect certain economic sectors more than others, close studies of the equity dimensions of these impacts among diverse SES and racial/ethnic groups in California are imperative. Some important research questions are:

- Which source sectors hold the most pollution reduction promise without economic disruption, both in terms of overall emission reductions and environmental equity/health benefits (Prasad 2008)?
- How can we better anticipate and address inevitable job shifts and retraining needs to maximize opportunities for low-income communities and communities of color to successfully transition to and benefit from a low-carbon economy?

Answers to these questions could lead to the least economically regressive policy outcomes that do not concentrate the greatest economic burdens among populations of low socioeconomic status.

4.2.3. Equity Dimensions of Climate Change Strategies

Some important questions to investigate are:

- Recognizing the fact that climate impacts will continue and may even increase into the foreseeable future, how should resources be raised and allocated to adequately invest in adaptation measures that will assist the most impacted communities across the state (Prasad 2008)?
- In which ways and to what extent can revenue generated from a market-mechanism such as cap-and-trade be used to decrease the economic burden on low-income residents in California?

- How can we uniformly ascertain the social and economic equity impacts of different GHG emission reduction strategies being considered at different levels (i.e., local, regional, state, national, and international) (Prasad 2008)?
- How can the successes and detriments of a green economy be measured (scale, scope, and indicators), and who enjoys the benefits of this transition (Prasad 2008)?
- How should the associated disparities be mitigated, and how do affected communities play a role in these policy and regulatory deliberations?

Moreover, because climate change will likely differentially affect some populations more than others in California, it is important to capture the specific vulnerabilities of individual communities. Non-technical knowledge, such as local expertise, community experience, and other contextual information is important to supplement technical knowledge. Researchers hoping to generate climate change-impact knowledge that is sensitive to community-specific concerns should employ community-based participatory research methods in their studies (Morello-Frosch et al. 2005; Minkler and Wallerstein 2003). To proactively address climate equity and alleviate environmental health inequalities, agency officials and policy makers should ensure that vulnerable communities facing cumulative impacts from multiple pollution sources play a significant role in shaping future solutions to climate change in California (Elliott et al. 2005).

5.0 References

Ackerman, F., and E. Stanton. 2008. *The Cost of Climate Change: What We'll Pay if Global Warming Continues Unchecked.* NRDC: New York, New York.

ALA (American Lung Association). 2008. State of the Air: 2008. American Lung Association: New York.

American Community Survey. 2007. 2007 American Community Survey 1-Year Estimates. Washington, D.C.

Bailey, D., K. Knowlton, and M. Rotkin-Ellman. 2008. *Boosting the Benefits: Improving air quality and health by reducing global warming pollution in California.* Natural Resources Defense Council: New York, New York.

Basu, R., and B. D. Ostro. 2008. "A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California." *Am J Epidemiol* 168(6): 632–637.

Basu, R., and J. M. Samet. 2002. "Relation between elevated ambient temperature and mortality: A review of the epidemiologic evidence." *Epidemiol Rev* 24(2): 190–202.

Bernard, S. M., J. M. Samet, A. Grambsch, K. L. Ebi, and I. Romieu. 2001. "The potential impacts of climate variability and change on air pollution-related health effects in the United States." *Environ Health Perspect* 109 Suppl 2: 199–209.

Blaikie, P., T. Cannon, I. Davis, and B. Wisner. 1994. *At Risk: Natural Hazards, People's Vulnerability, and Disasters.* Routledge, New York.

BLS (Bureau of Labor Statistics). 2002. Consumer expenditure survey. Washington D.C.

Bolin, R., and P. Bolton. 1986. *Race, religion, and ethnicity in disaster recovery, program on environment and behavior.* University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center: Boulder, Colorado.

Boyce, J., and M. Riddle. 2007. *Cap and Dividend: How to Curb Global Warming While Protecting the Incomes of American Families.* Political Economy Research Institute.

CARB (California Air Resources Board). 2006. Quantification of the Health Impacts and Economic Valuation of Air Pollution from Ports and Goods Movement in California. Appendix A in Emission Reduction Plan for Ports and Goods Movement (GMERP).

CARB. 2007. Expanded list of early action measures to reduce greenhouse gas emissions in California recommended for board consideration. California Air Resources Board. Sacramento, California.

CARB. 2008a. *Methodology for Estimating Premature Deaths Associated with Long-term Exposure to Fine Airborne Particulate Matter in California.* California Air Resources Board. Sacramento, California.

CARB. 2008b. *Climate change proposed scoping plan: A framework for change.* California Air Resources Board. Sacramento, California.

CARB. 2008c. *Diesel particulate matter health risk assessment for the West Oakland community: Preliminary summary of results.* California Environmental Protection Agency, Air Resources Board, Sacramento, California.

CASS. 2002. California agriculture statistical review. Sacramento, California. California Agriculture Statistics Service.

CBO (Congressional Budget Office). 2007a. *Trade-offs in allocating allowances for* CO_2 *emissions.* Washington, D.C.

CBO. 2007b. Trade-offs in allocating allowances for CO_2 emissions, in *A series of Issue Summaries.* Congressional Budget Office. Congressional Budget Office: Washington, D.C.

Cifuentes. L., V. H. Borja-Aburto, N. Gouveia, G. Thurston, and D. L. Davis. 2001. “Assessing the health benefits of urban air pollution reductions associated with climate change mitigation (2000–2020): Santiago, Sao Paulo, Mexico City, and New York City.” *Environ Health Perspect* 109(Suppl 3): 419–425.

Confalonieri, U., and B. Menne. 2007. Human health. Climate Change 2007. *Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, O. F. C. M. L. Parry, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, eds. Cambridge, UK.: Cambridge University Press 391–431.

Cordova, R., M. Gelobter, A. Hoerner, J. R. Love, A. Miller, C. Saenger, and D. Zaidi. 2006. *Climate change in California: Health, Economic and Equity Impacts.* Redefining Progress: Oakland, California.

CRAG (California Regional Assessment Group). 2002. *Preparing for a changing climate: The potential consequences of climate variability and change for California.* Washington, D.C.: U.S. Global Change Research Program.

Donoghue, E., M. Nelson, G. Rudis, R. I. Sabogal, J. T. Watson, and G. Huhn. 2003. "Heat-related deaths - Chicago, Illinois, 1996–2001, and United States, 1979–1999." *MMWR Morb Mortal Wkly Rep* 52: 610–613.

Curriero, F. C., K. S. Heiner, J. M. Samet, S. L. Zeger, L. Strug, and J. A. Patz. 2002. "Temperature and mortality in 11 cities of the eastern United States." *Am J Epidemiol* 155(1): 80–87.

Drechsler, D., N. Motallebi, M. Kleema, D. Cayan, K. Hayhoe, L. S. Kalkstein, N. Miller, S. C. Sheridan, J. Jin, and R. A. VanCuren. 2006. *Public health-related impacts of climate change in California.* California Energy Commission.

Dutzik, T., R. Sargent, and F. Figdor. 2007. *Cleaner, cheaper, smarter: The case for auctioning pollution allowances in a global warming cap-and-trade program.* U.S. PIRG Education Fund.

Drury R., M. Belliveau, J. Kuhn, and S. Bansal. 1999. "Pollution trading and environmental injustice: Los Angeles' failed experiment in air quality." *Duke Environmental Law and Policy Forum* 9:231–289.

EDD (California Employment Development Department). 2004. Occupational Employment (2002) and Wage (2003) Data, Occupational Employment Statistics Survey Results. Sacramento, California.

EDD. 2004. "Occupational Employment (2002) and Wage (2003) Data, Occupational Employment Statistics Survey Results." 2004, from (www.calmis.cahwnet.gov/file/occup$/oeswages/Cal$oes2003.htm.

Elliott, M., C. Saenger, and A. Hoerner. 2005. *Latinos and climate change: A scoping report.* Redefining Progress: Oakland, California.

English, P., K. Fitzsimmons, S. Hoshiko, T. Kim, H. G. Margolis, T. E. McKone, M. Rotkin-Ellman, G. Solomon, R. Trent, and Z. Ross. 2007. *Public health impacts of climate change in California: Community vulnerability assessments and adaptation strategies.* Climate Change Public Health Impacts Assessment and Response Collaborative, California Department of Public Health Institute, Richmond, California.

EPA. 2005. *Toxics release inventory (TRI) basis of OSHA carcinogens.* United States Environmental Protection Agency, Washington, D.C.

Epstein, P., and C. Rodgers. 2004. *Inside the greenhouse: The impacts of CO_2 and climate change on public health in the inner city.* Center for Health and the Global Environment: Boston, Massachusetts.

Hajat, S., B. Armstrong, M. Baccini, A. Biggeri, L. Bisanti, and A. Russo. 2006. "Impact of high temperature on mortality: Is there an added heat wave effect?" *Epidemiology* 17: 632–638.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. “Emissions pathways, climate change, and impacts on California.” *Proc Natl Acad Sci U S A* 101(34): 12422–12427.

Fothergill, A., and L. Peek. 2004. “Poverty and disasters in the United States: A review of recent sociological findings.” *Natural Hazards Journal* 32(1): 89–110.

Frumkin, H., A. J. McMichael, and J. J. Hess. 2008a. “Climate change and the health of the public.” *Am J Prev Med* 35(5): 401–402.

Frumkin H., J. Hess, G. Luber, J. Malilay, and M. McGeehin. 2008b. “Climate change: The public health response.” *Am J Public Health* 98(3): 435–445.

Gage, K. L., T. R. Burkot, R. J. Eisen, and E. B. Hayes. 2008. “Climate and vectorborne diseases.” *Am J Prev Med* 35(5): 436–450.

Gjerde, J., S. Grepperud, and S. Kverndokk. 1999. “Optimal climate policy under the probability of a catastrophe.” *Resource and Energy Economics* 21: 289–317.

Goulder, L. 1995. “Environmental taxation and the double dividend: A reader's guide.” *International Tax and Public Finance* 2:157–183.

Greenberg, J. H., J. Bromberg, C. M. Reed, T. L. Gustafson, and R. A. Beauchamp. 1983. “The epidemiology of heat-related deaths, Texas—1950, 1970–79, and 1980.” *Am J Public Health* 73(7): 805–807.

Greenough, P. G., and T. D. Kirsch. 2005. “Hurricane Katrina. Public health response—assessing needs.” *N Engl J Med* 353(15): 1544–1546.

Hassett, K., A. Mathur, and G. Metcalf. 2008. *The incidence of a U.S. carbon tax: A lifetime and regional analysis.* Cambridge, Massachusetts: American Enterprise Institute for Public Policy Research.

Hepburn, C., M. Grubb, K. Neuhoff, F. Matthes, and M. Tse. 2006. “Auctioning of EU ETS phase II allowances: How and why?” *Climate Policy* 6(1): 137–160.

HSC §38560.5, Health and Safety Code Section 38560–38565: Sacramento, California.

IPCC (Intergovernmental Panel on Climate Change). 2007. *Working Group I Report: The Physical Science Basis.*

Jacobson, M. Z. 2007. “Effects of ethanol (E85) versus gasoline vehicles on cancer and mortality in the United States.” *Environ Sci Technol* 41(11): 4150–4157.

Jacobson, M. 2008. “On the causal link between carbon dioxide and air pollution mortality.” *Geophys Res. Let.* 35(L03809).

Kilbourne, E. 1997. Heat waves and hot environments. In *The Public Health Consequences of Disasters.* E. Noji, Editor. New York, New York: Oxford University Press.

Kinney, P. L., M. S. O'Neill, M. L. Bell, and J. Schwartz. 2008. "Approaches for estimating effects of climate change on heat-related deaths: Challenges and opportunities." *EnvironmentalScience & Policy* 11(87–96).

Knowlton, K., J. E. Rosenthal, C. Hogrefe, B. Lynn, S. Gaffin, R. Goldberg, C. Rosenzweig, K. Civerolo, J. Y. Ku, and P. L. Kinney. 2004. "Assessing ozone-related health impacts under a changing climate." *Environ Health Perspect* 112(15): 1557–1563.

Knowlton, K., M. Rotkin-Ellman, G. King, H. G. Margolis, D. Smith, G. Solomon, R. Trent, and P. English. 2009. The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits. *Environ Health Perspect* 117(1): 61–67.

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

Kunzli, N., R. McConnell, D. Bates, T. Bastain, A. Hricko, F. Lurmann, E. Avol, F. Gilliland, and J. Peters. 2003. "Breathless in Los Angeles: The exhausting search for clean air." *Am J Public Health* 93(9): 1494–1499.

Lejano, R., and R. Hirose. 2005. "Testing the assumptions behind emissions trading in non-market goods: The RECLAIM program in Southern California." *Environmental Science & Policy* 8:367–377.

Madsen, A. M. 2006. "Exposure to airborne microbial components in autumn and spring during work at Danish biofuel plants." *Ann Occup Hyg* 50(8): 821–831.

Medina-Ramon, M., A. Zanobetti, D. P. Cavanagh, and J. Schwartz. 2006. "Extreme temperature and mortality: Assessing effect modification by personal characteristics and specific cause of death in a multi-city case only analysis." *Environ Health Perspect* 114:1331–1336.

Minkler, M., and N. Wallerstein. 2003. *Community-based Participatory Research for Health.* San Francisco, California: Jossey-Bass.

MMWR (Morbidity and Mortality Weekly Report). 2008. "Heat-related deaths among crop workers - United States, 1992–2006." *MMWR* 57(24): 649–653.

Morello-Frosch, R. A., and B. Jesdale. 2006. "Separate and Unequal: Residential Segregation and Estimated Cancer Risks Associated with Ambient Air Toxics in U.S. Metropolitan Areas." *Environmental Health Perspectives* 114(3): 386–393.

Morello-Frosch, R., and B. Jesdale. 2008. Unpublished impervious surface and tree cover data. Data for this analysis was derived from: U.S. Geological Survey's National Land Cover Dataset 2001. www.mrlc.gov/nlcd.php, accessed on June 20, 2007; and ESRI's ArcMap census boundary files www.census.gov/geo/www/cob/bdy_files.html, accessed June 6, 2008.

Morello-Frosch, R., and R. Lopez. 2006. "The riskscape and the color line: Examining the role of segregation in environmental health disparities." *Environmental Research* 102: 181–196.

Morello-Frosch, R., and E. Shennasa. 2006. "The Environmental 'Riskscape' and Social Inequality: Implications for Explaining Maternal and Child Health Disparities." *Environmental Health Perspectives* 114(8): 1150–1153.

Morello-Frosch, R., M. Pastor Jr., C. Porras, and J. Sadd. 2002. "Environmental Justice and Regional Inequality in Southern California: Implications for Future Research." *Environmental Health Perspectives* 110(supplement 2): 149–154.

Morello-Frosch, R., M. Pastor, J. Sadd, C. Porras, and M. Prichard. 2005. Citizens, Science, and Data Judo: Leveraging Community-based Participatory Research to Build a Regional Collaborative for Environmental Justice in Southern California. In *Methods for Conducting Community-Based Participatory Research in Public Health*, B. Israel, et al., editors. University of Michigan, Jossey-Bass Press.

Naughton, M. P., A. Henderson, M. C. Mirabelli, R. Kaiser, J. L. Wilhelm, S. M. Kieszak, C. H. Rubin, and M. A. McGeehin. 2002. "Heat-related mortality during a 1999 heat wave in Chicago." *Am J Prev Med* 22(4): 221–227.

NRC (National Research Council). *Abrupt Climate Change: Inevitable Surprises.* Committee on Abrupt Climate Change. Washington, D.C.: National Academy Press.

Oke, T. 1973. "City size and the urban heat island." *Atmos. Environ.* 7:769–779.

O'Neill, C. 2004. "Mercury, risk and justice." *ELR News and Analysis* 34: 11070–11115.

O'Neill, M. S., P. L. Kinney, and A. J. Cohen. 2008. "Environmental equity in air quality management: Local and international implications for human health and climate change." *J Toxicol Environ Health A* 71(9-10): 570–577.

O'Neill, M. S., A. Zanobetti, and J. Schwartz. 2003. "Modifiers of the temperature and mortality association in seven US cities." *Am J Epidemiol* 157(12): 1074–1082.

O'Neill, M. S., A. Zanobetti, and J. Schwartz. 2005. "Disparities by race in heat-related mortality in four US cities: The role of air conditioning prevalence." *J Urban Health* 82(2): 191–197.

Patz, J. A., and S. H. Olson. 2006. "Climate change and health: Global to local influences on disease risk." *Ann Trop Med Parasitol* 100(5-6): 535–549.

Poumadere, M., C. Mays, S. Le Mer, and R. Blong. 2005. "The 2003 heat wave in France: Dangerous climate change here and now." *Risk Anal* 25(6): 1483–1494.

Phelan, J. C., B. G. Link, A. Diez-Roux, I. Kawachi, and B. Levin. 2004. "'Fundamental causes' of social inequalities in mortality: A test of the theory." *J Health Soc Behav* 45(3): 265–285.

Pittock, B., D. Wratt, R. Basher, B. Bates, M. Finlayson, H. Gitay, A. Woodward, A. Arthington, P. Beets, B. Biggs, et al. 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Cambridge, U.K.: Cambridge University Press.

Pizer, W. 2003. Climate change catastrophes. Resources for the Future Discussion Paper.

Prasad, S. 2008. Environmental justice: Draft CEC PIER-EA Discussion Paper. California Energy Commission, Public Interest Energy Research: Sacramento, California.

Redefining Progress. 2006. *Climate change in California: Health, Economic and Equity Impacts.*

Reiter, P. 2001. “Climate change and mosquito-borne disease.” *Environ Health Perspect* 109(Suppl 1): 141–161.

Rogot, E., P. D. Sorlie, and E. Backlund. 1992. “Air-conditioning and mortality in hot weather.” *Am J Epidemiol* 136(1): 106–116.

Schulz, A. J., D. R. Williams, B. A. Israel, and L. B. Lempert. 2002. “Racial and spatial relations as fundamental determinants of health in Detroit.” *The Milbank Quarterly* 80(4): 677–707.

Semenza, J. C., C. H. Rubin, K. H. Falter, J. D. Selanikio, W. D. Flanders, H. L. Howe, and J. L. Wilhelm. 1996. “Heat-related deaths during the July 1995 heat wave in Chicago.” *N Engl J Med* 335(2): 84–90.

Stern, N. 2006. *Stern Review on the Economics of Climate Change.* London.

Swiss Re. 2006. *Natural catastrophes and man-made disasters 2005: High earthquake casualties, new dimension in windstorm losses.*

Tenenbaum, D. 2008. “Food vs. fuel: Diversion of crops could cause more hunger.” *Environ Health Perspect* 116(6): A254–A257.

Thomalla, F., and T. Downing, E. Spanger-Siegfried, G. Han, and J. Rockström. 2006. “Reducing hazard vulnerability: Towards a common approach between disaster risk reduction and climate adaptation.” *Disasters* 30(1): 39–48.

Tierney, K. 1988. “The Whittier Narrows, California earthquake of October 1, 1987 – Social aspects.” *Earthquake Spectra* 4(1): 11–23.

UNWTO (United Nations World Tourism Organization). 2007. Climate Change and Tourism: Proceedings of the 1st International Conference on Climate Change and Tourism, Djerba, Tunisia, 9–11 April 2003.

USCB (U.S. Census Bureau). 2004. Current Housing Reports, American Housing Survey for the Los Angeles-Long Beach Metropolitan Area: 2003.

USCB. 2005. California — County. Percent of People Below Poverty Level in the Past 12 Months (For Whom Poverty Status is Determined). Washington, D.C.: United States Census Bureau.

Vandentorren, S., F. Suzan, S. Medina, M. Pascal, A. Maulpoix, J. C. Cohen, and M. Ledrans. 2004. “Mortality in 13 French cities during the August 2003 heat wave.” *Am J Public Health* 94(9): 1518–1520.

Walls, M., and J. Hanson. 1996. Distributional Impacts of an Environmental Tax Shift: The Case of Motor Vehicle Emissions Taxes. Resources for the Future: Washington, D.C.

Whitman, S., G. Good, E. R. Donoghue, N. Benbow, W. Shou, and S. Mou. 1997. “Mortality in Chicago attributed to the July 1995 heat wave.” *Am J Public Health* 87(9): 1515–1518.

Williams, D. R., and C. A. Collins. 2001. “Racial residential segregation: A fundamental cause of racial disparities in health.” *Public Health Reports* 116: 404–416.

6.0 Glossary

AB 32	Assembly Bill No. 32: California Global Warming Solutions Act of 2006
AC	Air Conditioning
CARB	California Air Resources Board
CAT	Climate Action Team
CI	Confidence interval
CEC	California Energy Commission
EAMs	Early Action Measures
GHG	Greenhouse gas
LCFS	Low Carbon Fuel Standard
MMT	Million metric tons
$MMTCO_2e$	Million metric tons of carbon dioxide equivalent
NO_x	Nitrous oxides
NRDC	Natural Resources Defense Counsel
PM	Particulate Matter
O_3	Ozone
RECLAIM	Regional Clean Air Management program
SES	Socioeconomic status / socioeconomic position
SO_x	Sulfur Oxides