DEVELOPING ADAPTATION STRATEGIES FOR SAN LUIS OBISPO COUNTY:

Preliminary Climate Change Vulnerability Assessment for Social Systems

A White Paper from the California Energy Commission's California Climate Change Center

Prepared for: California Energy Commission

Prepared by: Susanne Moser Research & Consulting, Santa Cruz

University of California, Berkeley

JULY 2012

CEC-500-2012-054

Susanne C. Moser

Susanne Moser Research & Consulting, Santa Cruz, California

Julia Ekstrom

University of California, Berkeley, California

ACKNOWLEDGEMENTS

This report was previously released as a foundational document for a participatory adaptation planning workshop with key stakeholders in San Luis Obispo. Prior to that process, an earlier version of this document and a shorter summary were reviewed by the following individuals (in alphabetical order): Dr. Marni Koopman, Jan Marx, Jim Patterson, and Tammy Seale. Since then, the California Energy Commission's PIER Program generously agreed to organize an additional scientific peer review of the document to enable its inclusion in the CEC's submission of technical input into the National Climate Assessment. We gratefully acknowledge the additional comments received from three anonymous reviewers. Christopher Burton generously helped with the data and methods underlying the social vulnerability analysis. The preparation of this report was supported through a grant from the Kresge Foundation to the Local Government Commission. Responsibility for the final content of this report remains solely with the authors.

ABSTRACT

San Luis Obispo faces a variety of risks from climate change, including extreme heat, a generally drier climate, increases in extreme weather events, and sea-level rise. Important vulnerabilities are apparent for water supplies, in agriculture (especially for wine and cattle ranchers) and related tourism, for fishing, coastal tourism, coastal development and infrastructure, and for community services. Certain county populations may face disproportionate risks including the elderly, those already affected by diseases, and outdoor and migrant workers from extreme heat, people living in coastal and inland floodplains, those living at the wildland-urban interface, the student population, institutionalized individuals (especially the state hospital), and those members of the community that tend to be somewhat disenfranchised from public decision-making, such as non-English speaking individuals and those who can't afford to take off from work to attend public meetings. The county is wise to begin planning and building its adaptive capacity at this time before climate change impacts become more severe, and before there may be greater competition for state and federal financial support for adaptation planning and implementation.

Keywords: regional climate studies, San Luis Obispo, climate vulnerability

Please use the following citation for this paper:

Moser, Susanne C., Julia Ekstrom. (Susanne Moser Research & Consulting, Santa Cruz and University of California, Berkeley). 2012. ***DEVELOPING ADAPTATION STRATEGIES FOR SAN LUIS OBISPO COUNTY: Preliminary Climate Change Vulnerability Assessment for Social Systems.*** California Energy Commission. Publication number: CEC-500-2012-054.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Unless otherwise noted, all figures and tables are provided by the authors.

Section 1: Introduction

1.1 Purpose & Organization of the Report

San Luis Obispo County is home to a growing population with a vibrant economy and stunning natural resources. Climate change is expected to have varied effects on both the socioeconomic and natural systems of the county. This report describes the social systems of San Luis Obispo County (its people, economic sectors, and critical infrastructure and community services) and explores their potential vulnerabilities to the impacts of climate change. This report was written as background information for a workshop involving county leaders and experts as they begin to develop strategies for climate change adaptation.

A previous report and workshop, organized by the National Center for Conservation Science and Policy (NCCSP), now the Geos Institute, focused on potential climate change impacts and adaptation options for the county's natural ecosystems and conservation areas.[i,ii] Details on climate change projections and their implications of ecosystems, species, and natural resources can be found there and are not repeated or summarized in great detail here. However, a functional and healthy natural environment is considered a critical foundation for San Luis Obispo County's economy, quality of life, and the health and well-being of its residents. Ecosystems services, such as water filtration, flood abatement, carbon storage, pollination, and many others, are essential for a strong local economy and health communities. Climate change is expected to stress ecosystems and the services they provide to society. Thus, strategies are needed to reduce stresses from climate change and other sources in a cohesive manner, and to create more resilient natural and social systems.

To fully understand what climate change will actually mean for local communities, science-based projections of potential changes in the physical climate (given selected greenhouse gas emissions scenarios) are essential, but not enough. What is equally necessary to complement these scenarios of future climate (i.e., changes in temperature, rainfall, extreme events, and sea-level rise) is a better understanding of the current (and future) conditions of the potentially affected natural and social systems. While climate change projections offer a glimpse of the physical risks that may arise from global warming, or that a community may be exposed to, an assessment of the current condition of affected systems provides insights about the community's "on-the-ground" vulnerabilities. In this

report, we focus primarily, though not exclusively, on these on-the-ground vulnerabilities and how these vulnerabilities interact with climate change to produce impacts on social systems. They will help identify adaptation actions that could be considered no- or low regrets options, not because they are necessarily no- or low-cost or easy to implement, but because they can yield benefits to the environment, economy and to people regardless of precisely how climate change will unfold. The stakeholder workshop, for which this report was prepared, aimed to stimulate an extended discussion of adaptation options, and a full assessment of promising options will require fuller analysis than can be offered here.

Thus, in this report we will offer a broader perspective than just climate-scenario dependent projections of climate change impacts on the county's people and economy. Instead, we will summarize what is known about these potential impacts, but primarily examine available information about

- demographics (wealth, race, education, special populations, etc.),
- locally important economic sectors (tourism, agriculture, fishing, etc.), and
- important infrastructure and community services (water supplies, transportation, and emergency management, etc.)

to better understand how the region and communities within the county are vulnerable to climate change.

The report draws on publicly available reports, plans, and data repositories available from local (municipal and county), state, and federal sources as well as on peer-reviewed research papers. For the social vulnerability assessment, original research was conducted to assess differential vulnerabilities among San Luis Obispo's population. Other assessments of vulnerability rest on the critical assessment of current conditions as ascertained from the existing information.

To present such a diversity of background information, this report is organized as follows. First, we will introduce a few concepts that are central to thinking about vulnerability and developing adaptation strategies. Key concepts include: vulnerability, exposure, sensitivity, adaptive capacity, coping, adaptation, and resilience. The use of these terms here is generally consistent with how they are being used in the California Climate Adaptation Strategy.[iii] Second, we will present a summary of modeled climate change projections (biophysical impacts – temperature, rainfall, sea-level rise, etc.) for the region to remind readers of the potential risks the county may be exposed to. At the time of the writing on this report (prior to the social systems climate vulnerability workshop on May 20, 2010 in SLO County put on by the Local Government Commission), the available information for San Luis Obispo was restricted to the report prepared by Koopman et al. Since then, additional down-scaled climate change projections have become available and can be found at the state's interactive climate information portal, cal-adapt.[iv] Finally, the core of the report will present information about the population, economic sectors, water, and infrastructure and supporting services (Figure 1). This information will be related to the concepts introduced earlier to illustrate how certain demographic, socio-economic and other factors make San Luis Obispo's residents and economic activities more or less vulnerable to climate change. They will also indicate what capacities the county already has to draw on and could leverage to begin the process of adaptation.

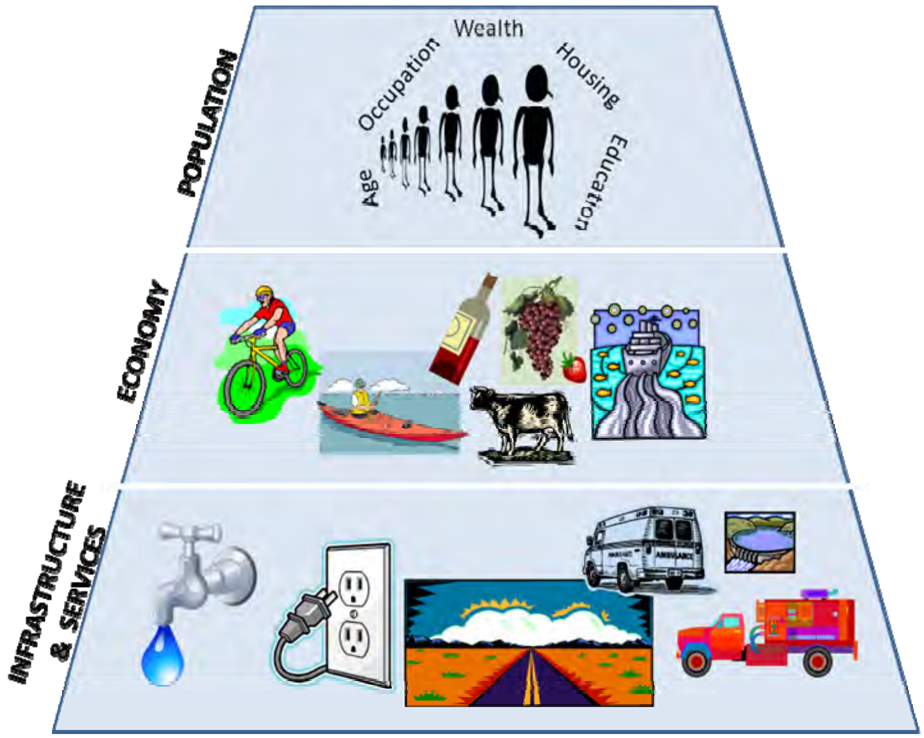


Figure 1: Main elements of the report: Population, economic sectors, and infrastructure and supporting services

1.2 Vulnerability and Adaptation: Introduction of Key Concepts

The effects of climate change in San Luis Obispo County, the State of California and around the world will differ widely. The changes will produce very different local impacts in part because of the regional differences in the nature of expected climate change (whether it is sea-level rise, higher temperatures, or patterns of extreme events) and because of the regionally varying conditions of the affected systems. Together, the physical changes in climate, and the condition of the interacting natural and human systems will determine the potential impacts, while actions to reduce the causes of global climate change and actions to minimize local impacts will determine the ultimate impacts.

For the purposes of this report, we employ the terminology used in the State of California's first Climate Adaptation Strategy.[v] We first distinguish climate change impacts from vulnerabilities. A ***climate change impact*** is an effect of climate change on the structure or function of a system. Potential impacts are those that may occur without considering adaptation. By contrast, ***vulnerability*** – in the most general sense – describes a system's susceptibility to harm or change. Vulnerability is the combined result of exposure, sensitivity, and adaptive or response capacity and as such a function of the character, magnitude, and rate of climate change to which a system is exposed, as well as of non-climatic (social and environmental) characteristics of the system, which determine its sensitivity and adaptive capacity.

First, ***exposure*** is the nature and degree to which a system experiences a stress or hazard.[vi] Examples of stresses that are familiar to some or all parts of the county include heat waves, water shortages, wildfires, coastal flooding from storms, dam failure, and large scale power outages during heat waves and other high-demand periods. Many of these may be exacerbated by climate change. The levels of exposure from a stressor often are not distributed evenly across a geographic space or across populations (e.g., coastal areas will experience storms more, but extreme heat less than those inland; individuals working in office buildings will experience the same heat wave less than outdoor workers). It is also important to note that climatic hazards can be one-time extreme events or slow creeping problems that are more chronic in nature, which – if not addressed – can eventually lead to a disastrous situation (e.g., an acute heat wave versus chronic water shortage). Thus, how exposure is distributed across space and populations, and the nature of the climate perturbation, are important for understanding local level vulnerability. The section on climate change projections summarizes the best available science at present on what climate changes and perturbations the county may be exposed to in the future.

The second dimension of vulnerability is ***sensitivity***, which refers to the degree to which the system is impacted by a given stressor, change or disturbance.[vii] The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).[viii] The sensitivity of a system is not just the result of climate-stresses, however, but also influenced by unrelated non-climatic stresses. For example, the elderly and frail are generally found to be more sensitive to extreme heat than healthy adults. People already under significant amounts of stress for health, economic, or psychosocial reasons may be more susceptible to climate-related health stresses.

The third dimension of vulnerability is ***adaptive capacity***. We use this short-hand here to include the ability to cope with extreme events, to make adaptive changes, or to transform more deeply, including the ability to moderate potential damages (negative consequences) and to take advantage of opportunities (beneficial consequences). While there are a number of ways to measure and evaluate adaptive capacity (and the scientific community does not agree on just one), this concept relates to the degree to which the system can adapt in order to deal with a stressor or change. Adaptive capacity can be assessed on any level of organization, from the individual to the national or international level. In this report and for this workshop we focus on the individual and community (i.e. municipality, special population and economic sector) levels. The factors that tend to increase adaptive capacity include economic resources, highly functional institutions, adequate infrastructure, availability of technological options and capacities, sufficient information and high levels of education and skill among decision-makers and stakeholders, significant social capital among stakeholders, and equity in the access to these resources and capacities. These definitions of exposure, sensitivity and adaptive capacity illustrate why in this report we focus extensively on the social characteristics of the county's population and economic sectors (Figure 2)[ix].

Adaptation is frequently defined as any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.[x] Strictly speaking, this broad definition includes mitigation actions, i.e., actions to reduce the causes of climate change. Many experts indeed view mitigation as the ultimate adaptation. Many others view them as separate sets of actions but both as an equally necessary and complementary to each other. Mitigation thus limits the pace and ultimate degree of climate change, ultimately making it possible for natural and social systems to adapt, while adaptation addresses the consequences of change that could not be avoided. For individuals familiar with disaster preparedness and management, "mitigating" potential impacts from disasters are among the actions one might take to prepare for and adapt to climate change. To avoid unnecessary confusion, in this report, we will refer to adaptation as all those adjustments one might make in a system to prepare for and deal with the impacts of climate change.

Finally, ***resilience*** is the ability of a system to absorb some amount of change, including shocks from extreme events, bounce back and recover from them, and, if necessary, transform itself in order to continue to be able to function and provide essential services and amenities that it has evolved or been designed to provide.[xi] In light of the potential risks from climate change, resilience has become a highly desirable outcome of adaptation for many.[xii] If adaptive actions can help a system be better prepared, able to bounce back faster and better from an extreme event, or deal with relative ease with changing conditions, continue to learn from such events and adjust over time, and provide the goods and services, the functions and amenities that are desirable, then adaptation may be considered successful.

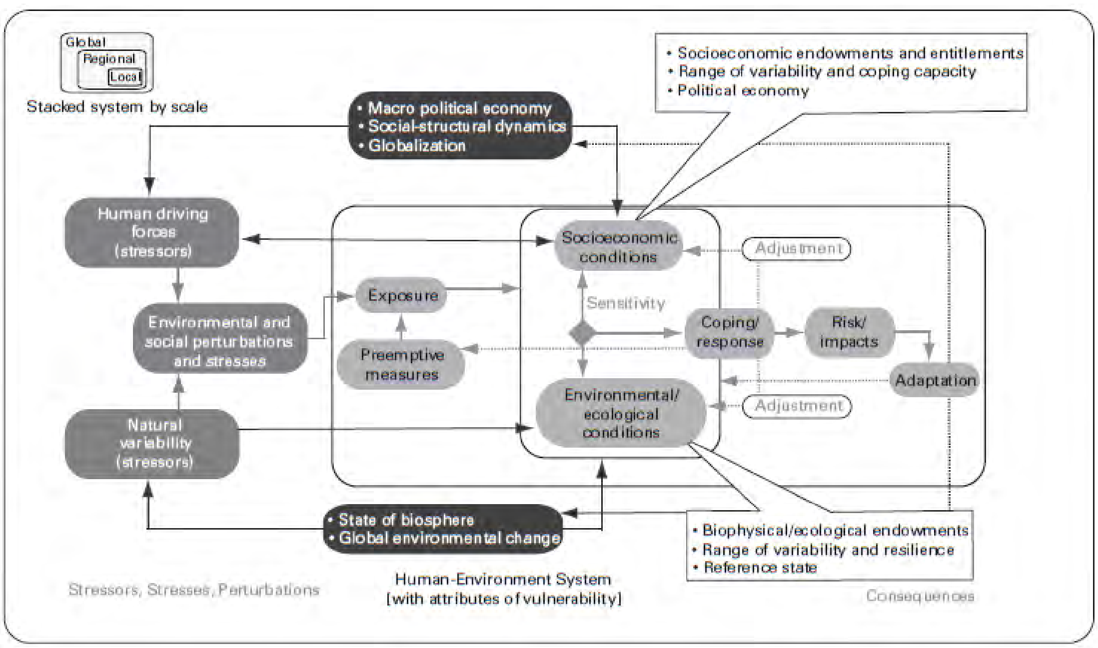


Figure 2: Vulnerability of coupled human-natural systems

(Source: Kasperson, Kasperson and Turner 2009)

1.3 Geography and Climate Change Projections for San Luis Obispo

San Luis Obispo County is located along the south central coast of California, bordered by Monterey County to the north, Santa Barbara County to the south, and Kern County directly to the east (Figure 3). The county has a land area of 3,304 square miles and a low population density of about 75 persons per square mile (compared to the State's average of over 217 people per square mile). The San Lucia Mountains run through the middle of the county from north to south, which prevent the moist cool coastal climate from reaching inland where it is hot and dry. The region's topography and coastal exposure create many microclimates where temperatures can vary dramatically over short distances (e.g., the beach and near-coastal areas could be foggy and cool, while inland areas are hot and dry).[xiii] These conditions create the particular quality of life that residents enjoy but also just the right conditions for the region's dominant agricultural product: wine. Variations in local conditions will also result in geographic differences in exposure to the effects of climate change. Figure 4 depicts the microclimates of the county, reflecting some of this detail, based on precipitation averages from 1961-1990.[xiv]

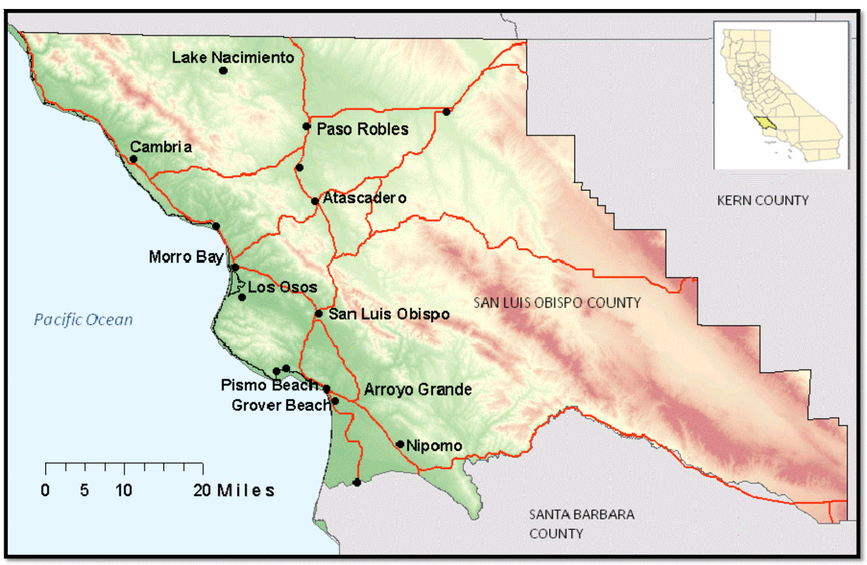


Figure 3: Map of San Luis Obispo County showing topography in green (low), yellow, and red (high elevation) and the main highways as red lines.

(Source: Map constructed by authors with topographic data from SLO County and UCSB Bren School and roads data from California Department of Transportation)

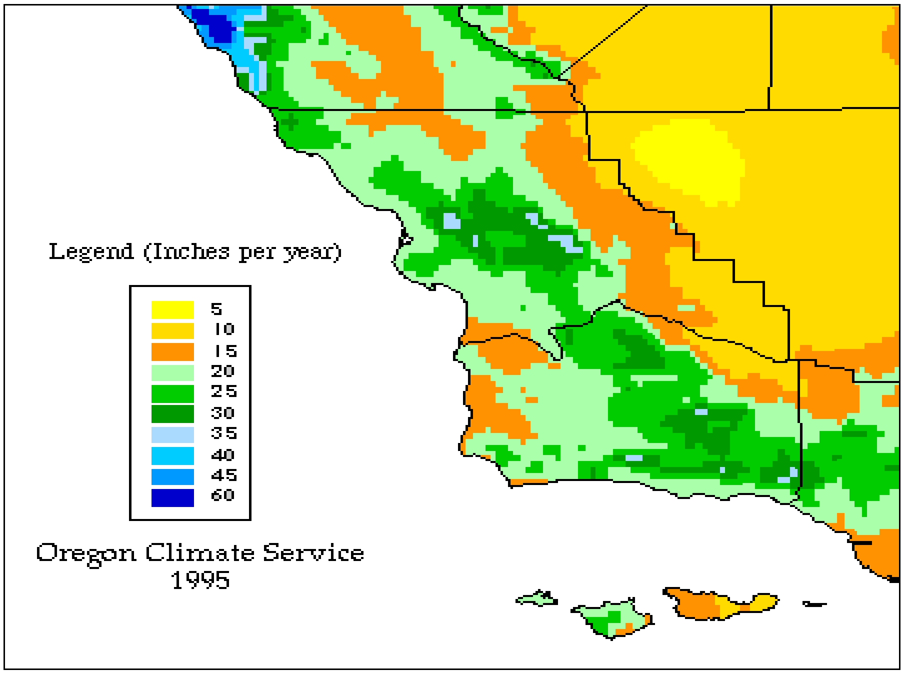


Figure 4: Annual average precipitation (Inches), San Luis Obispo, Period 1961-1990, as an indication of the many microclimates in the county

(Source: Desert Research Institute)

Several studies conducted for the State of California provide a first-order indication of the potential climatic changes that San Luis Obispo County may expect in the future. In addition, the National Center for Conservation Science and Policy (now, the Geos Institute) compiled a report, entitled *Projected Future Climatic and Ecological Conditions in San Luis Obispo County*, on climate change impacts specific to the county, projecting changes in temperature, precipitation, vegetation, wildfire, and sea level. In short, climate change could lead to the following potential changes in the county:

- Increase in inland temperature, including increase in the number of extreme heat days
- Increasing droughts
- Increasing severity of storms/rainfall events (resulting in intense runoff events and inland flooding)
- Change in the number of fog days along the coast (potential for decrease or increase)
- Increase of area burned annually by wildfires
- Increased risk of landslides (due to increased occurrences of wildfires and intense rainfall events)
- Sea-level rise along coast (resulting in more coastal flooding and coastal erosion)

The following information is summarized from the statewide studies and projections reported for the county in a report by the National Center on Conservation and Science Policy (NCCSP).[xv] This NCCSP report presents projections based on the output of three global climate models (CSIRO, MIROC, and HADCM) using the IPCC's A2 (higher) greenhouse gas emissions scenario.

Temperature

Higher temperatures, as projected by the best available global climate models, can impact human health by increasing incidences of heat stress causing increases in morbidity and mortality. The inland portion of the county already has more extreme daily and seasonal temperature fluctuations than the coastal region where coastal fog dampens temperatures while inland temperatures are high.[xvi]

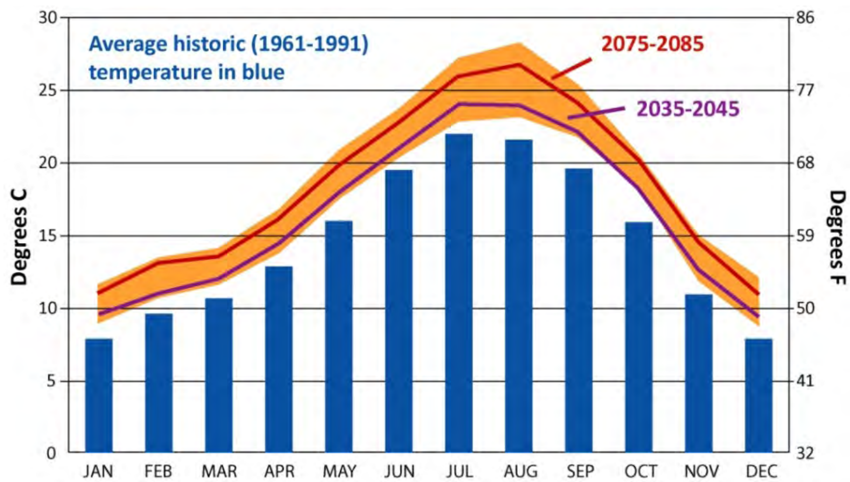


Figure 5: Temperatures are projected to increase significantly, especially in the summer. Dry periods will lengthen and precipitation is projected to decline.

(Source: Koopman et al. 2010)

Downscaled climate change projections reported by the NCCSP show that average temperatures are expected to increase countywide throughout this century. Average temperatures could increase by +2.1 to +3.9°F by 2035-45 and of +4.1 to +7.6°F by 2075-85, with summer temperature increases being larger than winter increases (Figure 5).[xvii] Some model projections for 2035-2045 show the most severe increase in January's average temperature. In addition, statewide studies project more frequent and severe extreme heat waves.[xviii] For example, using a different climate model (GFDL), but the same A2 emissions scenario, extreme heat days (days with maximum daily temperatures occurring on less than 2% of all extremely warm days) in the area around the city of San Luis Obispo (temperature threshold > 86 °F) have occurred historically on average four times per summer. By the end of the 21st century, there could be more than 65 such days each summer under this higher emissions scenario.[xix]

Inland populations are and will continue to be exposed to higher temperatures than those in the coastal region; however, climate change may also bring substantial increases to temperature for the coast (more recent model projections using different models can be viewed at cal-adapt). If coastal fog decreases, for example, as it already has along Northern California's coast[xx], the coast will experience more significant temperature increases especially in the summer, for which the region's communities may not be prepared. Besides the public health impacts, this could cause people to increase use of electricity and increase water use (residential, commercial, and agricultural). Alternatively, coastal fog may increase at times when inland areas are warmer. In either case, changes in the coastal fog season from climate change could bring dramatic temperature changes to the region.

Rainfall

Precipitation projections from the climate change models are less conclusive than temperature impacts. The MIROC model shows a trend of decreased precipitation in the winter and fall months compared the historic (1961-1990) monthly averages (Figure 6). The CSIRO model projects a slight decrease in precipitation in January, but an increase in rainfall in February, October, and November. The HADCM model projects the most substantial difference in rainfall countywide with an increase in average precipitation in January (by ~10mm), February (by ~30mm), and less so in March and April. The characteristic dry Mediterranean summers are expected to remain a dominant feature of future climate, regardless of the model used. The late-century projections (2075 -2085) in these models are inconclusive as to whether fall and winter months will become drier or wetter. However, more recent studies for the state show across all emission scenarios and all models a drying trend (reductions of 5-15% of total rainfall). Droughts may become more frequent, longer and more severe.[xxi] Increased temperatures, longer summer dry seasons and the resulting increased demand for water for ecosystem processes and human uses are likely to result in growing challenges to meet water supply needs in the state and county.

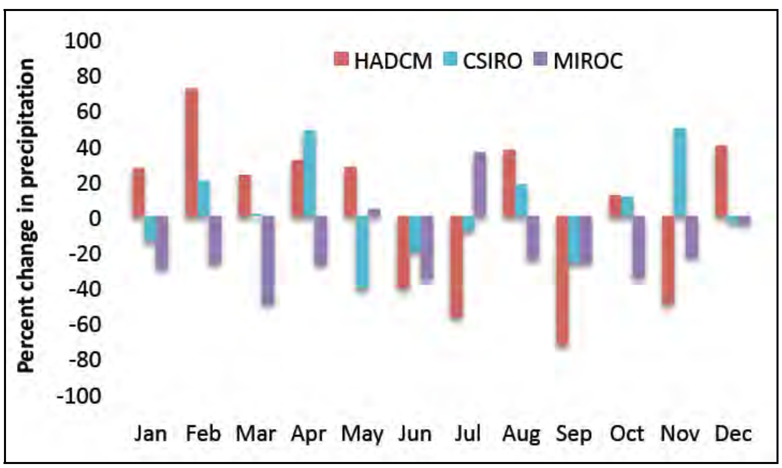


Figure 6: Total monthly percent change in precipitation for the time period of 2035-2045, as compared to the historic period (1961-1990).

(Source: Koopman et al. 2010)

Despite the overall drying trend in the long term, model projections suggest that whatever rainfall does occur may come in more extreme rainfall events.[xxii] Such rainfall events pose greater challenges with runoff (including affecting coastal water quality), sedimentation, limited soil water retention, and challenges for storage and flood management. As seen historically in southern and central California, extreme rainfall events that follow large wildfires that have removed vegetation, especially on steep slopes, can lead to severe soil erosion, landslides, and resulting sedimentation of reservoirs, roads, and valleys.[xxiii]

Wildfire

Climate change is projected to increase the annual acreage burned by wildfires statewide and in the county. Historically, the average area burned annually by wildfire has been 3.7% of the county land area, whereas the model projections show an increase to 6.8-7.3% of the county by 2035-45, or roughly a doubling in the area burned, and up to 8.5% by the end of the century.[xxiv] This increase in acreage burned could have significant implications for the demand on emergency services, water supply, air quality and associated public health, native species and ecosystems, and rural and urban establishments, including increased risk for residences at the wildland-urban interface.

Sea-level rise

Sea-level rise as a result of warming ocean waters (thermal expansion) and melting ice caps (especially Greenland and the West Antarctic Ice Sheet) are among the most certain consequences of climate change, yet accurate projections are currently hampered by the limits in scientists' ability to model ice sheet dynamics. Using the best available science, statewide studies conducted in 2009 projected that sea level could rise 12 to 16 inches by 2050 above current levels.[xxv] This is double the amount of increase California's coastline has experienced over the entire past century. By the end of the century, these studies project a total average sea-level rise of 3.3 - 4.6 feet (23 to 55 inches) above current levels. Some recent studies project even higher figures, but the slightly more moderate rates agreed upon for the statewide sea-level rise guidance are presented here.[xxvi] Studies are underway to improve global sea-level rise projections. Thus, while the exact amount of sea-level rise is still up for debate, a more rapid increase than historically experienced is virtually certain. Sea-level rise along the coast of San Luis Obispo could lead to the following impacts:

- Increased erosion of already retreating coastal bluffs and beaches, increasing the risk of cliff failures
- Coastal flooding with higher storm surges and flood elevations during coastal storms, potentially inundating valuable transportation, commercial, energy, wastewater, and residential infrastructure in low-lying areas
- Permanent inundation of coastal wetlands in the county
- Salt water intrusion into coastal freshwater wells that serve agriculture and local residents.

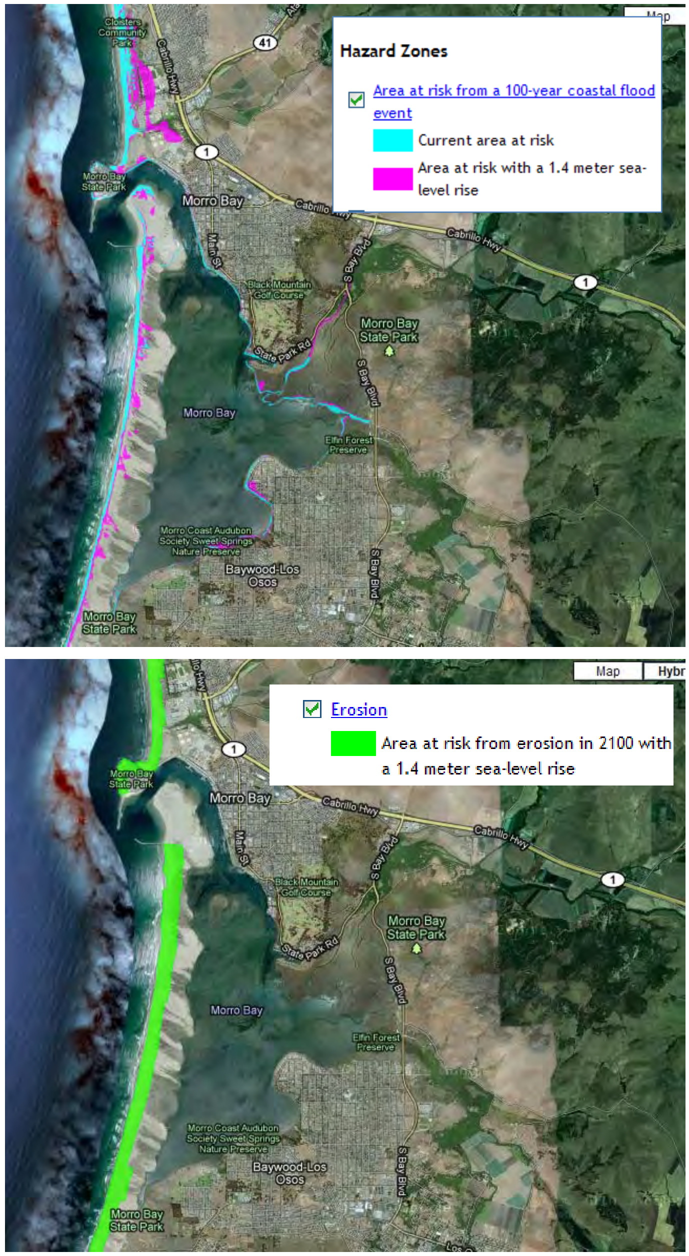


Figure 7: Areas at risk from sea-level rise related impacts: the current area inundated by a 100-year flood (light blue), and the area inundated by a 100-year flood after a 4.6 ft sea-level rise (pink) (top). The area at increased risk from coastal erosion is shown in green (bottom).

Maps produced using Google maps via the Pacific Institute website.

The Pacific Institute produced a series of potential flooding, erosion, and wetland migration maps based on these sea-level rise projections for the entire coast of California. These maps were a major contribution needed to assess the potential severity of impacts from sea-level rise; however, as expressed by coastal and marine nature resource experts who participated in the San Luis Obispo County Natural Resources Workshop[xxvii] in November 2009, sea-level rise and coastal erosion maps need to be produced with more accurate information for the county's coastline, including high resolution coastal geology (sediment types), bathymetry, and topography as well as existing barricades and practices that could prevent or allow coastal flooding. Figure 7 provides an example of the Pacific Institute's sea-level rise and coastal erosion findings for Morro Bay.

Even just these suggestive maps point to the importance of the potential impacts of sea-level rise and associated hazards for coastal residents, businesses and water-dependent uses. They also highlight the need for more accurate, high-resolution maps. For example, the flood and erosion risks appear to be mapped independently (Figure 7, upper and lower panel), but of course, in reality these hazards occur simultaneously. Thus, with erosion accounted for, there may be a much higher potential for sea- level rise related flooding during storms. Both processes need to be considered in developing improved maps that can be used for future coastal planning.

Sea-level rise and higher rates of coastal erosion could have major impacts for the region's beaches, roads (including State Highways 1 and 101 in some places), and commercial establishments built close to the coast. Additional concerns involve coastal wetlands. Maintaining the coastal wetlands ecosystem is especially of concern given:

- its importance as a habitat for many threatened and endangered fish, bird, and invertebrate species in California,
- its potential for accreting and possibly protecting coasts from sea-level rise related flooding,[xxviii] and
- its role in sequestering carbon from the atmosphere (and thus serving as a climate mitigation strategy).

Sea-level rise will force existing coastal wetlands to move inland if there is viable area for these habitats to migrate to, and if there are no barriers impeding this inland movement. The existing wetlands in the county (6.2 square miles) could migrate inland and occupy as much as 1.1 square miles of land that currently is not wetland.[xxix] Any development placed on the landward side of current wetlands could prevent this inland migration and result in a "wetland squeeze" and ultimate loss of these valuable habitats.

With this short summary of climate change projections and at least a qualitative assessment of potential physical and ecological impacts, we now turn to the potential impacts and vulnerabilities on the county's human residents and communities.

Section 2: Communities and Populations of San Luis Obispo

2.1 Differential Vulnerability among Populations

San Luis Obispo County is a predominantly rural county with several urban centers. Its population over the past few years has been growing at a moderate rate, and is expected to continue to do so. Most of this growth results from domestic immigration. Many new arrivals are retirees.[xxx] The profile of the existing population, the amount of growth, and the type of incoming new residents are important to consider with respect to their vulnerability to climate change.

Certain segments of the population commonly have higher than average sensitivity and exposure to climate variability and disasters. For example, elderly and infants tend to be physically more affected by extreme heat and extended heat periods (especially at night). Similarly, people working outdoors (agricultural, construction, and other kinds of outdoor and migrant workers) are more exposed to high temperatures and heat waves than indoor workers. Frequently, people residing along the coast live in houses lacking air conditioning; they are also not necessarily used to taking precaution to avoid excessive heat exposure. Residents living along low-lying coastal bluff or in fluvial floodplains areas are more exposed to sea-level rise and storm-related flooding than those living outside of flood zones, whereas other areas may be more susceptible to landslides or wildfires.

In this section we show how different segments of the population deemed more vulnerable to some climate change impacts are spatially distributed throughout the county. We also present the distribution of those population segments that tend to have lower response capacity than the average population. We begin this section by presenting some basic statistics about the general makeup of the county population to provide essential background, but then focus our discussion on the implications for various public health risks (especially heat and flooding risks).

2.1.1 Population Overview

According to the U.S. Census, the County of San Luis Obispo had an estimated population of 265,297 in 2008, a 7.5% rise since 2000, which was slightly lower than the statewide population increase.[xxxi] The largest municipality is the City of San Luis Obispo with 42,963 people in 2008 (**Figure 8**).[xxxii] There are six main population centers: San Luis Obispo, Arroyo Grande, Grover Beach, Paso Robles, Morro Bay, and Atascadero. Over 40% of the county's population lives in unincorporated areas (with government affairs overseen by the County). Main growth centers of the county include Nipomo, Templeton, San Miguel, Cambria, Shandon, Paso Robles, and Lake Nacimiento, while Los Osos slightly declined in population.[xxxiii]

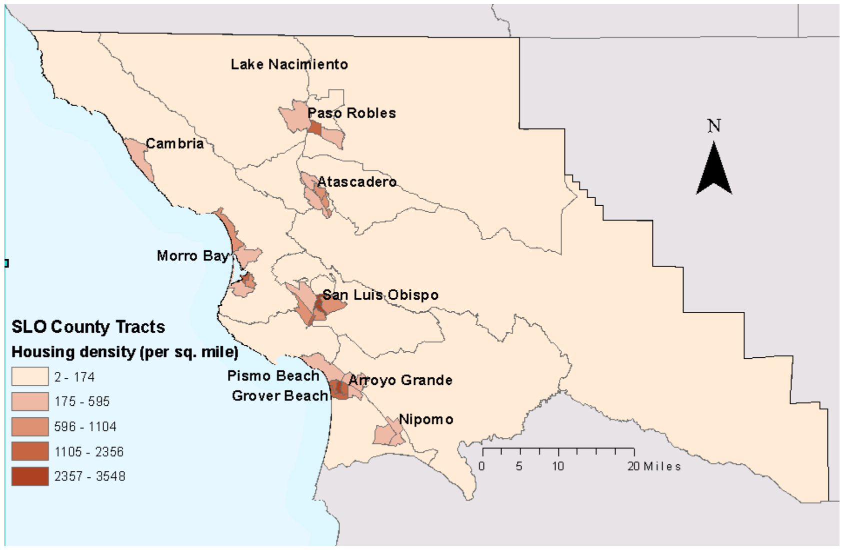


Figure 8: Housing density per square mile

(Source: Census 2000)

In general, the county's population is somewhat older than state average, with fewer children under 5 years, fewer youth under 18, and a greater proportion of the population over 65. The county population is also significantly less diverse than the state's with over 90% whites (nearly 20% identify as having Hispanic or Latino roots), 3% Asian, and 2% African Americans. While homeownership rates are slightly higher than state average, median household and per capita income are similar to state figures, and poverty levels are just slightly below the state average of 13%.[xxxiv] Below, we examine population characteristics more specifically with its implications for vulnerability to climate change impacts on public health.

2.1.2 Public Health

Climate change may have a substantial impact on human health in California through its impacts on environmental conditions (e.g., extreme weather events; changes in temperature and rainfall that decrease water supply; worsening air quality; increases in allergens and air pollutants; more wildfires).[xxxv] These increasing threats to public health can increase mortality and morbidity unless actions are taken to protect the population, especially those most vulnerable.[xxxvi] California's Adaptation Strategy highlights that the segments of population that will be the most at risk from climate change impacts are the "elderly, infants, individuals suffering from chronic heart or lung disease, persons with mental disabilities, the socially and/or economically disadvantaged, and those who work outdoors."[xxxvii] In terms of the three components of vulnerability, different population segments demonstrate greater vulnerability to these threats than others. We highlight several important examples (Table 1), but note that in reality, the three components have to be assessed for all groups in an integrated fashion to develop a comprehensive sense of vulnerability:

Table 1: Examples of Climate-Related Extreme Events Interacting with the Three Components of Vulnerability

Components of Vulnerability	Climate Change Risks	Population Particularly at Risk
Exposure	Floods Heat	Floodplain residents Outdoor and migrant workers
Sensitivity	Heat, Air pollution	Infants, populations with asthma and other respiratory illnesses, elderly
Adaptive Capacity	Heat, Floods	Institutionalized populations (e.g., persons with mental disabilities, prisoners) Socially excluded and economically marginalized groups

2.1.2.1 Exposure of Flood Plain Residents to Coastal and Inland Flooding

There are two types of flood risks that could be exacerbated by climate change in San Luis Obispo (Figure 9): sea-level rise related coastal flooding and inland flooding following extreme downpours or even dam failure at reservoirs due to increased severity of storms.

Figure 9: Higher risks in flood- plains

(Photo: MS Word Clipart)

The Pacific Institute's study on sea-level rise showed that there are 1,300 persons in San Luis Obispo County who reside in the areas that will be within the 100 year coastal flood zone with a 1.4 meter sea-level rise. Relative to other California coastal counties this number is low, and therefore, the county may not be one of the priority regions for the state, which makes it especially important for the county and cities within the county to prepare for these events, increase their flood emergency planning, and develop additional adaptation strategies to reduce floodplain residents' exposure to these risks. Coastal flooding is a periodic risk, which will become increasingly frequent and extensive the higher the sea level rises. Storm surges increase with the rise in the ocean's base elevation, coastal erosion during storm events will be exacerbated, and cliff failures become more likely. While more specific data on the exact changes in flood zones, flood frequency, and flood elevations are not available for the county at this time, existing flood and erosion related problems are likely to be exacerbated, affecting buildings in flood zones, along already retreating shorelines or near cliff edges most immediately and severely.

In addition to sea-level rise exacerbated coastal flooding, climate change is expected to lead to more extreme downpours and runoff, which can cause flooding along area creeks and rivers (e.g., the Salinas River), of roads, homes, and agricultural fields. If there are long-lasting rainfall periods (as is common in the winter) the capacity of streambeds and reservoirs could be overwhelmed, increasing the risk of dam failure and flooding. People living in low-lying areas, floodplains, and downstream of the Salinas Dam (e.g., Atascadero) and Lopez Dam (Arroyo Grande, Grover Beach, Halcyon, Oceano and Pismo Beach) are at particular risk.[xxxviii]

2.1.2.2 Exposure of Outdoor Workers to Extreme Heat

People who work outside are directly exposed to outdoor conditions, and they tend to have little choice about it. Exposure to temperature extremes is of particular concern for these individuals, especially those working in inland areas, far from the cooling ocean breeze. Examples of such populations are (migrant) agricultural field workers and gardeners for residential and commercial establishments, as well as road and building construction workers (Figure 10). Climate change-related temperature increases, especially increases in heat extremes, will put these workers even more at risk of heat exhaustion, sunstroke, dehydration, and other heat-related illnesses unless effective measures (i.e., mandated, implemented, and monitored) are put in place that allow outdoor workers to seek shade, cool off, and remain adequately hydrated.

Figure 10: Farm workers are highly exposed to extreme heat.

(Photo: Wikimedia Commons)

2.1.2.3 Sensitivity of Infants and Elderly to Extreme Heat and Air Pollution

Infants and those 65 years and older are physiologically more sensitive to high temperatures and also may be less able to protect themselves from extreme conditions.[xxxix] Long-lasting heat waves (over several days) and, in particular, very warm nights that do not allow people to cool off, are particularly challenging for human health.[xl] San Luis Obispo County has a relatively high population of persons 65 years and older and statewide this age group is growing rapidly and will continue to do so over at least the next two decades.[xli] Towns with relatively high older population include Avila Beach, Cambria, Cayucos, among others.[xlii]

According to the 2000 Census, the median age of the population is relatively lower in the City of San Luis Obispo (probably because of the large student population) and also lower than county average in Paso Robles (maybe because of a higher percentage of younger farm workers in vineyards or the service and accommodation industry) (Figure 11). By contrast, the median age is relatively higher in the coastal regions, including in Cambria, Morro Bay, Los Osos, Pismo Beach, and Grover Beach. To the extent the older segment of the population lives very near the ocean, these more sensitive individuals can benefit from the cool breezes off the Pacific. However, coastal housing stock generally lacks air conditioning.[xliii] By contrast, the elderly further inland do not have the benefit of a cooling ocean breeze. Close monitoring, effective early warning systems, and education of individuals and health care providers about effective protection measures, and social “buddy” systems have been used effectively to protect these vulnerable populations.[xliv] It is also important to note that between 2001 and 2004 the county had a relatively high percentage increase of workers aged 55 and older compared to the rest of the State of California. Thus, it is important to explore adaptive measures for the county’s *growing* aging population.[xlv]

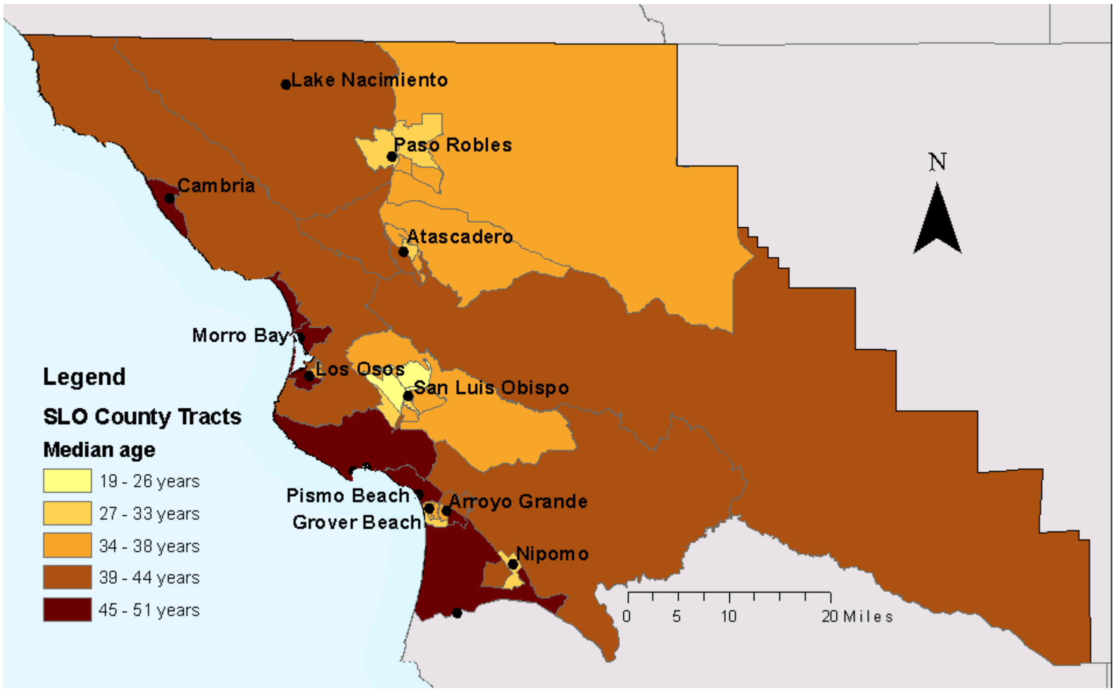


Figure 11: Median age by Census Tract

(Source: Census 2000)

Lacking heavy industry, the largest contributor to air pollution in the county is from transportation emissions.[xlvi] In addition, major contributor to air pollution problems in the county arise from ozone and small particulate matter (PM2.5) released during large wildfires.[xlvii] Current studies for California suggest that wildfires are likely to increase in severity and extent with climate change.[xlviii] In addition, climate change can increase the prevalence of allergens and – through higher temperatures – the formation of ground-level ozone. The risk of pulmonary health problems is increased particularly for children[xlix] and for those who have existing respiratory illnesses (such as asthma). One area already of particular concern in the county is Nipomo Mesa, which has particularly high values for PM10 airborne particular matter compared to the rest of the county and other California coastal regions. Historical monitoring records show that the concentration of PM10 in the air in Nipomo Mesa regularly exceeds State air quality standards, which can have particularly concerning long-term effects on children's health (e.g., reduced lung growth). A recent study found that this air pollution was an indirect result of the off-road vehicle activity, which removes vegetation and destabilizes the dune structure allowing winds to pick up sand particles "and carry them to the Mesa."[l] Thus, people living, working, recreating, playing and attending school in the Nipomo Mesa region are exposed to these elevated levels of air pollution, with children being particularly sensitive to such pollutants (Figure 12). The County Air Pollution Control District projects an increase in release of particulate matter over the next decade.[li] An increase in wildfire would add to this already existing risk and magnify the threat to the most sensitive populations.

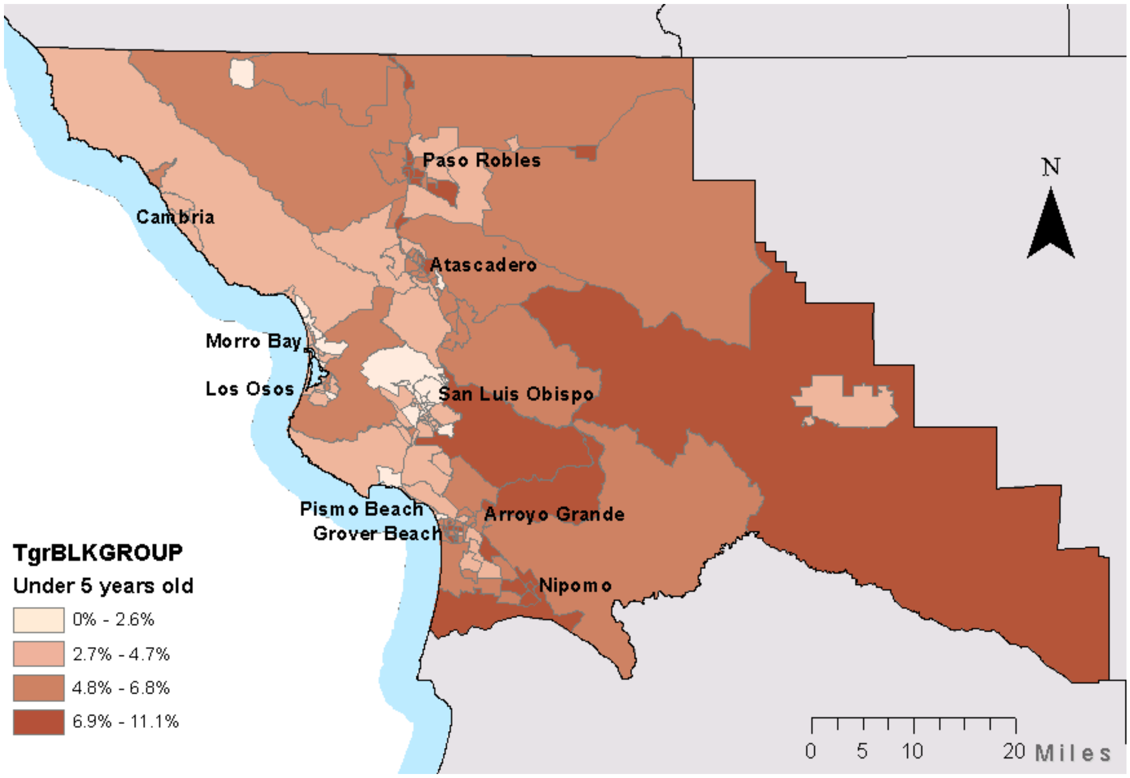


Figure 12: Children under 5 years old as percentage of total population

(Source: Census 2000)

In the next section we give some examples of populations that are more vulnerable to climate change impacts because of their lower adaptive capacity, i.e., their ability to cope with extreme events and to adapt to changing average conditions. Common characteristics of these segments of society include poverty and low income, age, lower educational attainment, race, linguistic isolation, university students, and females as head of households. [lii] These traits are unevenly distributed across the county.

2.1.2.4 Lower Income often Results in Lower Adaptive Capacity

Lower income often correlates with lower access to necessary resources to prepare for or evacuate in the case of a disaster, or to invest in actions required to adapt to climate change (e.g., insulating one's house, elevating one's house above a given flood elevation). Countywide median household income in 2000 was estimated to be $42,428 (median by census tract ranging from $7,171 to $70,000) and median family income countywide was $52,447.[liii] The southwest portion of the county has the highest per capita income (along with Cambria), while the City of San Luis Obispo (probably depressed because of the high student population) and areas around Atascadero and Paso Robles have the lowest average per capita income (Figure 13). In 2008, the Census estimated that 12.1% of the county's population was living below the federal poverty level.[liv] The Census 2005-2007 Survey shows that over 25% of the households countywide earn "Extremely Low Income" or "Very Low Income" when aligned with the SLO County income categorizations provided in the 2009 Housing Element (Figure 14). This percentage ranges from

1% in some areas up to 55.6% in others (Figure 15). As of December 2009, out of a total labor force of 138,800, approximately 9.4% (13,000) were unemployed.[lv]

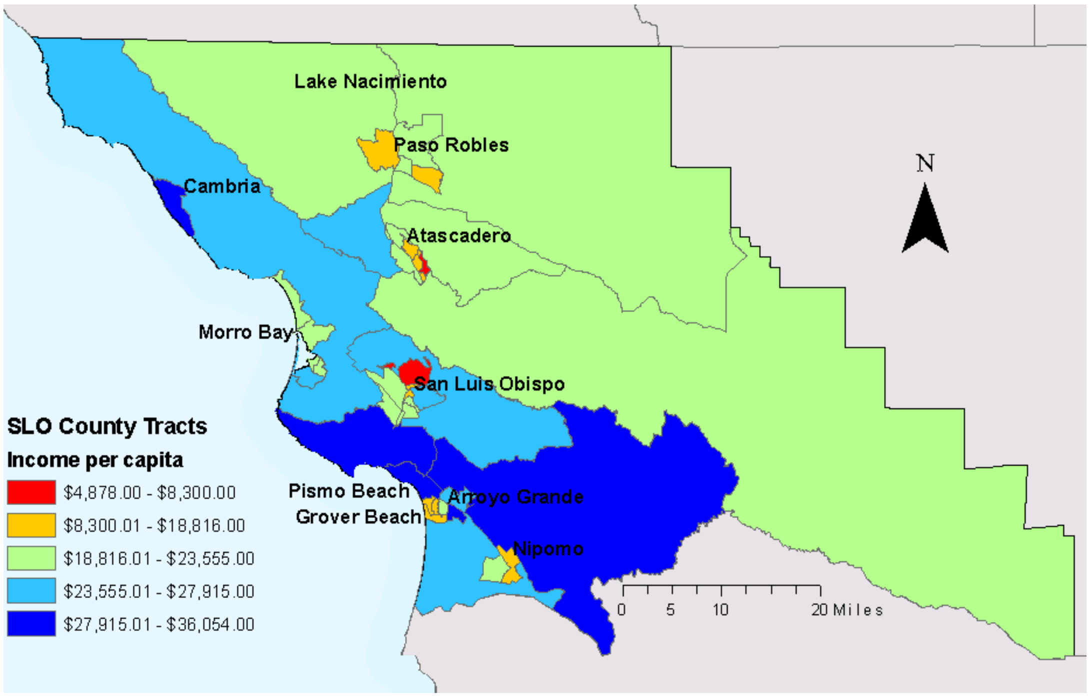


Figure 13: Per capita income by Census tract

(Source: Census 2000)

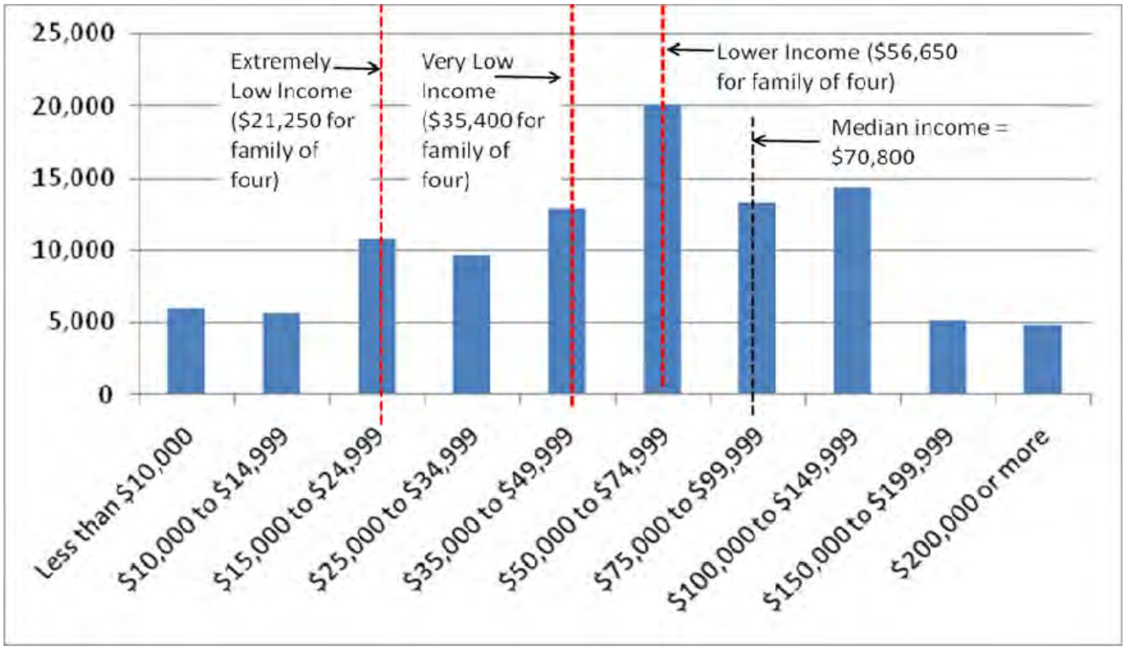


Figure 14: Countywide breakdown of household income with county-based income categories indicated with dotted lines

(Source: Income data from U.S. Census, American Community Survey 2005-2007[lvi]; income limit categories and median income defined in Housing Element of SLO County 2009 by County Planning and Building Department.[lvii])

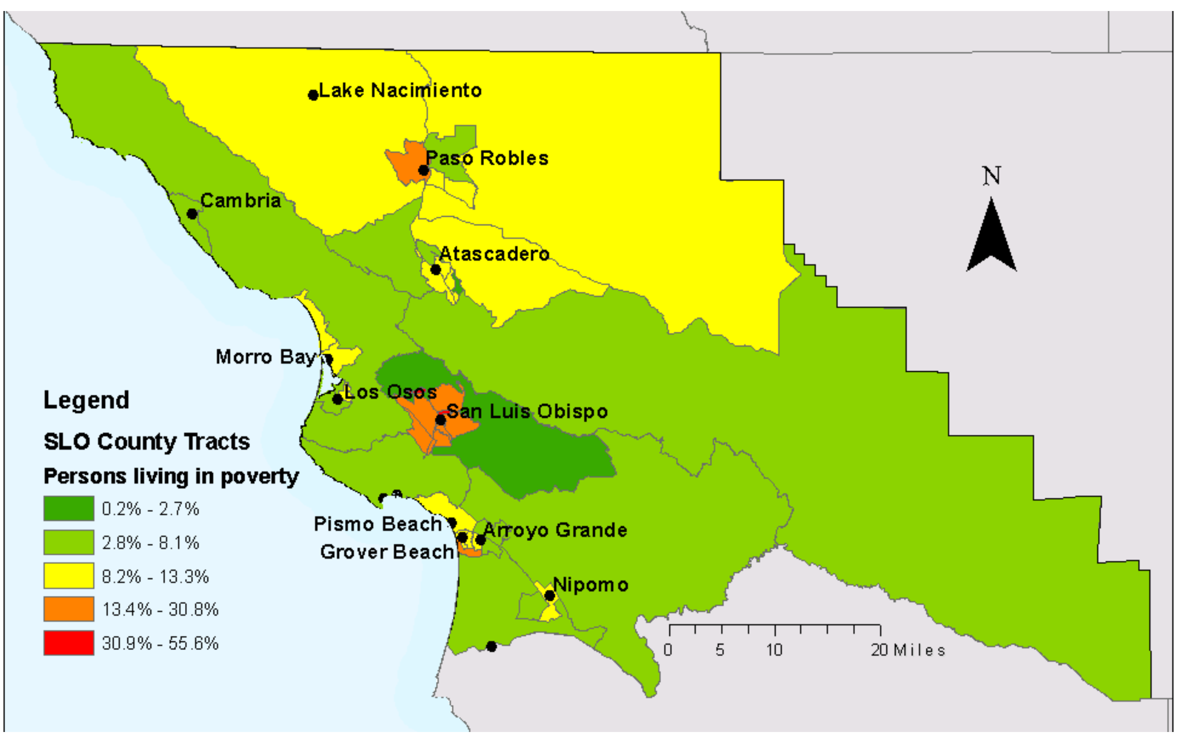


Figure 15: Percentage of persons living at or below the federally-defined poverty level by Census tract

($11,239 for a family of two; $17,603/year for a family of four for the year 2000) (Source: Census 2000)

What emerges from these two income-related maps is that the highest concentration of low income and poverty can be found in urban centers of the county, especially the City of San Luis Obispo. It is important to interpret these income data carefully however. According to the Housing Element for the City of San Luis Obispo (2009), "It is estimated that Cal Poly State University and Cuesta College students comprise more than one third of the City's population. As a result, students strongly influence the City's housing supply and demand. Although often grouped into low-income categories statistically, many students can spend more on housing than income data suggests because of parental support or larger household sizes. By pooling their housing funds, groups of students can often afford more expensive housing than non-student households. This contributes to higher rents in San Luis Obispo than in other parts of the County."[lviii] In addition to the large student population, low-wage labor in the service industry may be particularly prevalent around the city, followed by low-wage farm labor in the more rural inland census tracts. Income is one of the most important indicators of lower adaptive capacity, and can be addressed through special needs-related programs or by creating opportunities for low-income populations to make a better living (e.g., through education and training programs, providing a living wage, diversifying the economy).

2.1.2.5 Lower Education Can Undermine Adaptive Capacity

In some studies, lower educational attainment correlates with lower adaptive capacity to deal with extreme events. The possible connection between education and the ability to deal with disasters and change may involve a lower income, a lower capacity to obtain and understand emergency preparedness and response information, lack of access to health care, and various types of insurance, some degree of disenfranchisement from society, and so on. Figure 16 shows the distribution of individuals (by proportion) in each census tract over 25 years old that have not graduated from high school. In terms of education, 85.6% of the population 25 years and older as of 2000 were high school graduates (compared to 76.8% statewide) and 26.7% of this same age group had a bachelor's degree or higher (compared to 26.6% statewide) (Figure 17).[lix] People with less education thus require a different level of attention and assistance than those with greater resources of their own from public agencies.

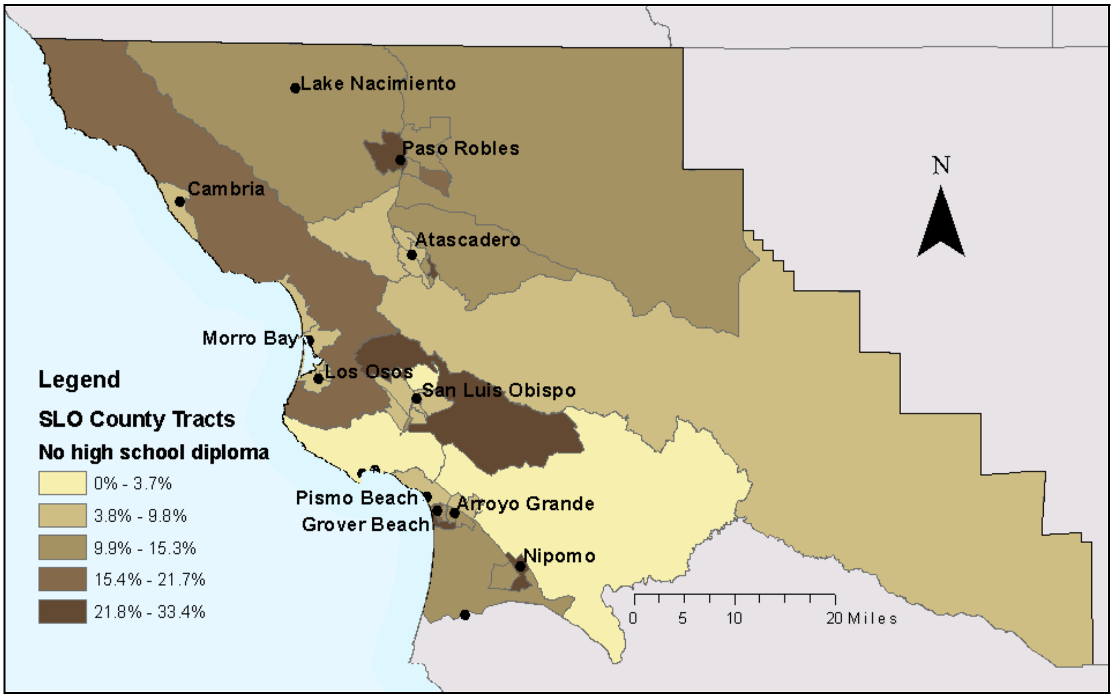


Figure 16: Percentage of people over 25 years old that have not graduated from high school

(Source: Census 2000)

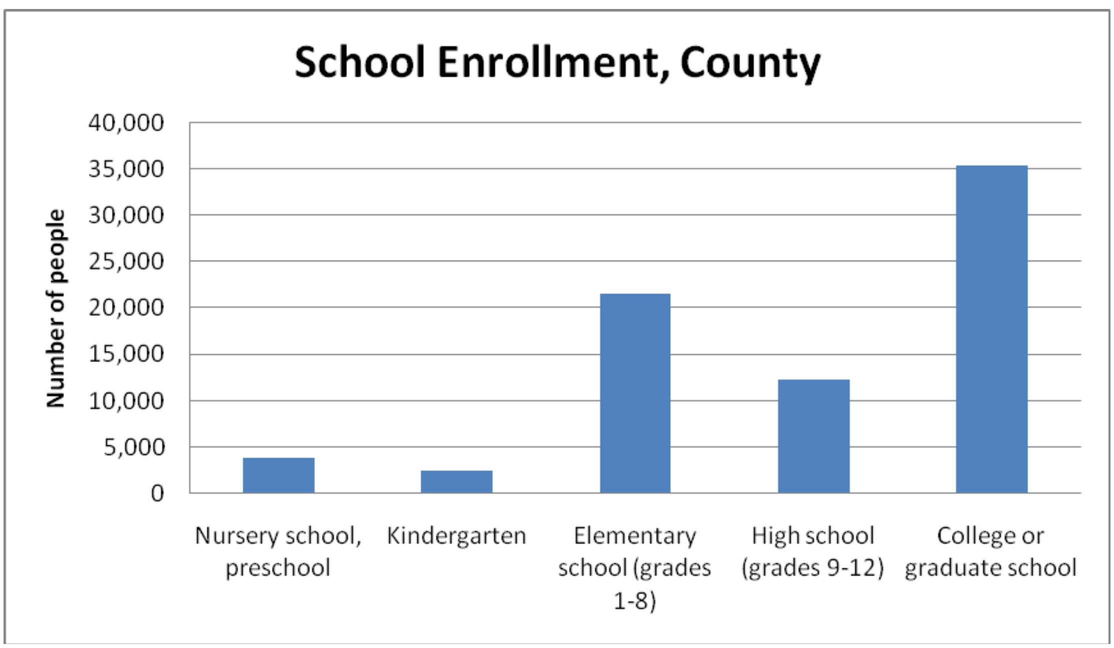


Figure 17: Number of people enrolled in school by grade level in San Luis Obispo County.

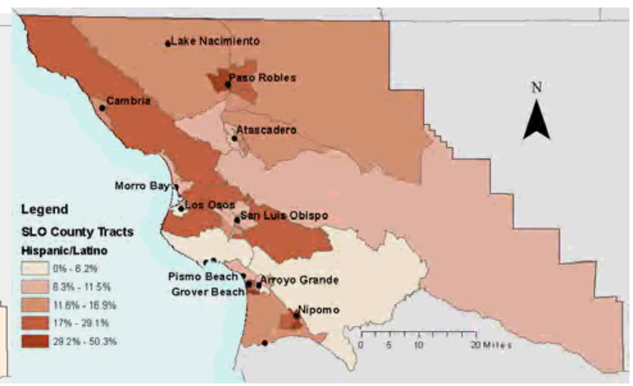
(Source: Census, American Community Survey 2006-2008)[lx]

2.1.2.6 Race and Environmental Injustice in Adaptive Capacity

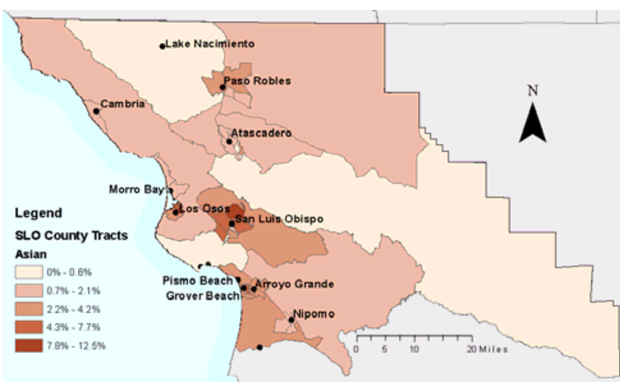
Studies of vulnerability to disasters repeatedly indicate that minority populations tend to have lower capacity for responding to disasters and adapting to climate change than non-Hispanic whites.[lxi] As indicated above, the countywide racial makeup in 2007 was predominantly white (90.9%), 2.1% African American, 3.2% Asian, 1.1% American Indian, and 19.1% of the population being of Hispanic or Latino origin.[lxii] Figure 18 shows the distribution of Hispanic, African American, and Asian segments of the population.

A. Percent African American

B. Percent Hispanic/Latino



C. Percent Asian



D. Percent Indian and Pacific Islander

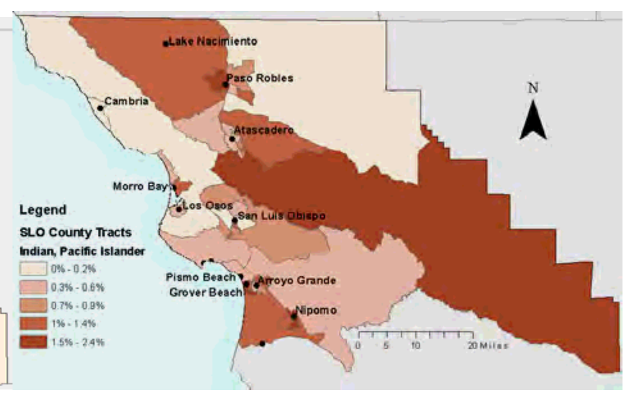


Figure 18: The geography of race in San Luis Obispo County by percentage of the total population

(Source: Census 2000).

The most likely reason for the correlation between race and lower adaptive capacity is the disproportionate amount of poverty and often lower incomes among African Americans and Hispanics compared to white segments of the population. In minority populations where English is not the first language spoken, linguistic proficiency can also play a role. Other factors, such as being tightly embedded in social networks, may compensate to some extent (see below).

According to the census, high Latino/Hispanic populations reside in Paso Robles, Nipomo, Grover Beach, and to a lesser extent along the coast north of Morro Bay.

2.1.2.7 Language and Cultural Isolation Reduce Adaptive Capacity

In some cases, immigrants born outside the United States and/or individuals not fluent in English may be culturally and linguistically isolated. Among other social and economic disadvantages, this cultural and linguistic isolation can make it difficult to access or receive important information for preparing for and responding to weather- and climate-related emergencies. In 2000, 8.9% of the county's population was foreign born compared to the State's 26.2%,[lxiii] but census estimates for 2008 suggest this percentage increased to 10.1% for the county (Figure 19). The census estimates show that of the foreign-born population, 78.1% entered before 2000 (i.e., they have been here for at least ten years, giving them time to get settled, learn the language, and build a community support network). Of the foreign-born population, 57.3% are not U.S. citizens.[lxiv] Of the population 5 years and over, the census estimates that in 2006-2008 there were 40,772 individuals that spoke a language other than English at home. Of these, 17,468 spoke English less than "very well." Most of them (14,919) were Spanish speakers.

Thus, it is important that adaptation planning not neglect these populations and provide them with necessary information, services, and engagement opportunities in their native language or with translators. For example during weather- and climate related disasters, these individuals may require essential information in the language most easily understandable to them; after disasters, non-native speakers may require special assistance working through difficult-to-understand disaster assistance applications and so on. Relatively new arrivals in the community may not yet be socially connected and thus be easily forgotten, not noticed, and they may not yet be familiar with available services.

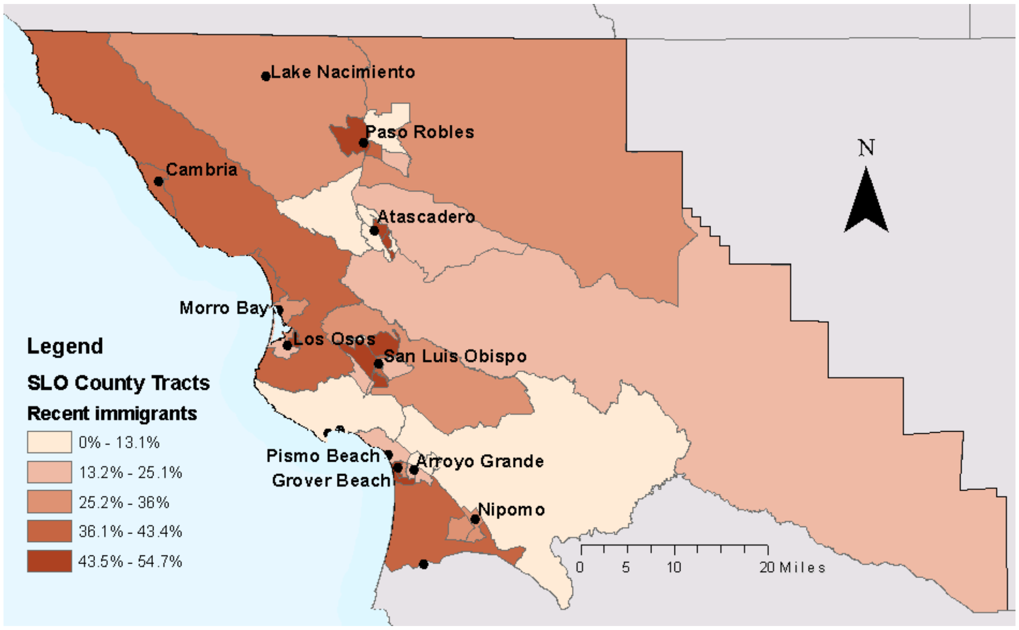


Figure 19: Percentage of the population (per Census tract) that is foreign born and has migrated from a foreign country between 1990 and 2000.

(Source: Census 2000)

2.1.2.8 Lower Adaptive Capacity: Limited Mobility of the Elderly in Disasters

Age can also play a role not just in sensitivity but also in adaptive capacity. For example, the elderly are considered to be more vulnerable in emergency situations because of possible mobility challenges.[lxv] As mentioned above, there are higher concentrations of elderly along the coast, especially Grover Beach, Pismo Beach, Avila Beach, Los Osos, Morro Bay and Cambria. When looking at the census block group, this age group ranges from nearly 0% up to 58% of the total population.[lxvi] Pismo Beach has the highest proportion of the 65 and older age group (58.4%). In California Valley (Figure 20, an outlier in the western part of the county), the 2000 US Census shows that more than 22% of the people living in this area were 65 years and older. This community may be of particular concern during climate- and weather-related disasters (e.g., wildfires) because it is relatively remote, emergency response times are long (see below) and individuals themselves may be less mobile without outside assistance.

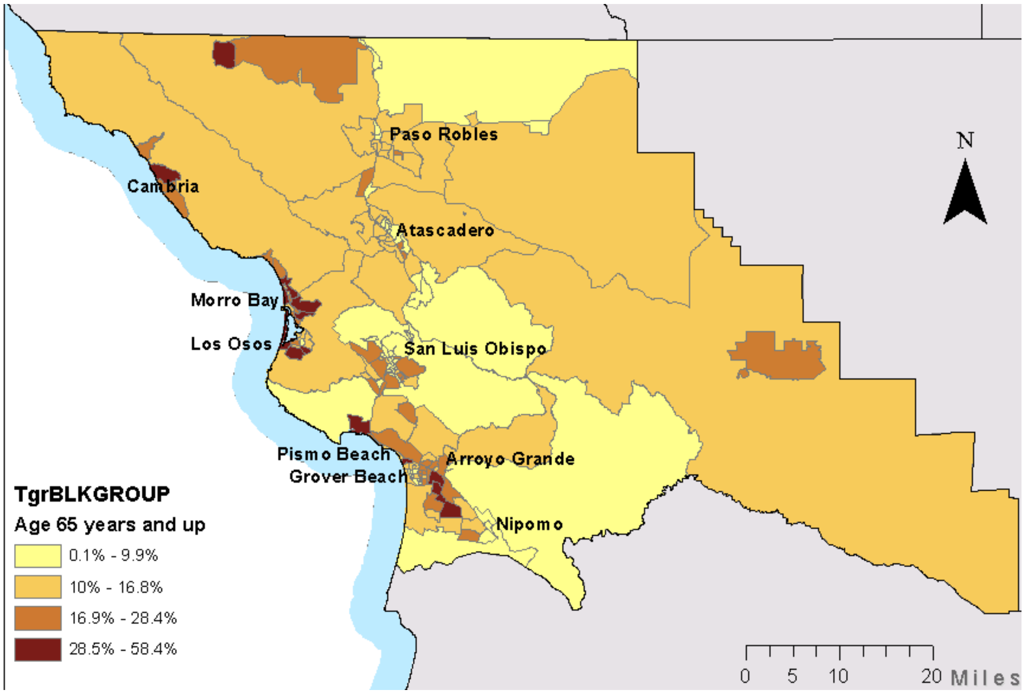


Figure 20: Percentage of population 65 years and older

(Source: Census 2000)

2.1.2.9 Housing and Control over the Living Situation

Housing also tends to be a factor in adaptive capacity. Home ownership versus renting indicates, again, income distribution. However, with regard to adaptive capacity, it also indicates how much control individuals have over their housing, e.g., to make structural adjustments to their home for flood protection or insulation from heat, or whether they are able to modify vegetation surrounding the house (a form of protection from wildfire).

In 2008, the census estimated that there were a total of 116,767 housing units in the county. The median price of a house sold in January 2010 was $372,500,[lxvii] although this varied considerably by place with higher prices typically found along the coast (**Error! Reference source not found.**). There were an estimated 40% renters countywide, albeit with considerable variation: just northwest of Atascadero, census tracts show only 11% renters, whereas in the area just north of the City of San Luis Obispo (where the university and college are) 99% of households rent. It is important to note, however, that while "Cal Poly State University and Cuesta College students are, on the average, relatively affluent, and many can afford housing that meets their needs"[lxviii], as renters they still have lower control over their housing than if they owned the property. Other concentrations of renters can be found in the more populated areas of Paso Robles, Atascadero, Morro Bay, Pismo Beach, and Grover Beach (**Error! Reference source not found.**Figure 22).

Another population that tends to have extremely low income is (migrant) farm workers. The San Luis Obispo City Housing Element (2009) notes that Edna Valley, just south of the City: "In the last decade, this area has experienced a rapid increase in wine grape production and has generated a need for additional farm worker housing."[lxix] This likely is not the only area where farm worker population has increased in the county.

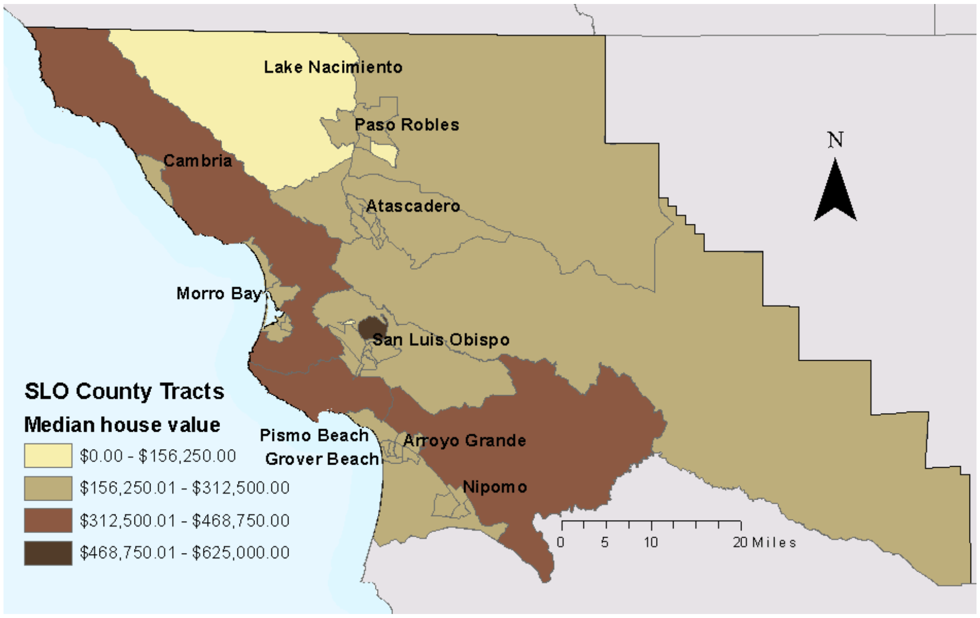


Figure 21: Median house value

(Source: Census 2000)

Of particular interest with regard to vulnerability is the homeless population. "The homeless population in San Luis Obispo appears to be increasing, possibly due to increased unemployment, continued high housing costs, statewide economic factors and changes in the make up of the homeless population. Historically, most homeless people were young or middle-aged men, often with little education or with alcohol or drug dependencies. However, in the last decade, homelessness in San Luis Obispo has become more visible. Steeply rising housing costs, reductions in public assistance and other economic changes have increased the number of homeless to include families with children and adults with disabilities or chronic health problems. The growing shortage of rental housing affordable to extremely low, very low and low income households further limits housing options for persons on the brink of homelessness."[lxx]

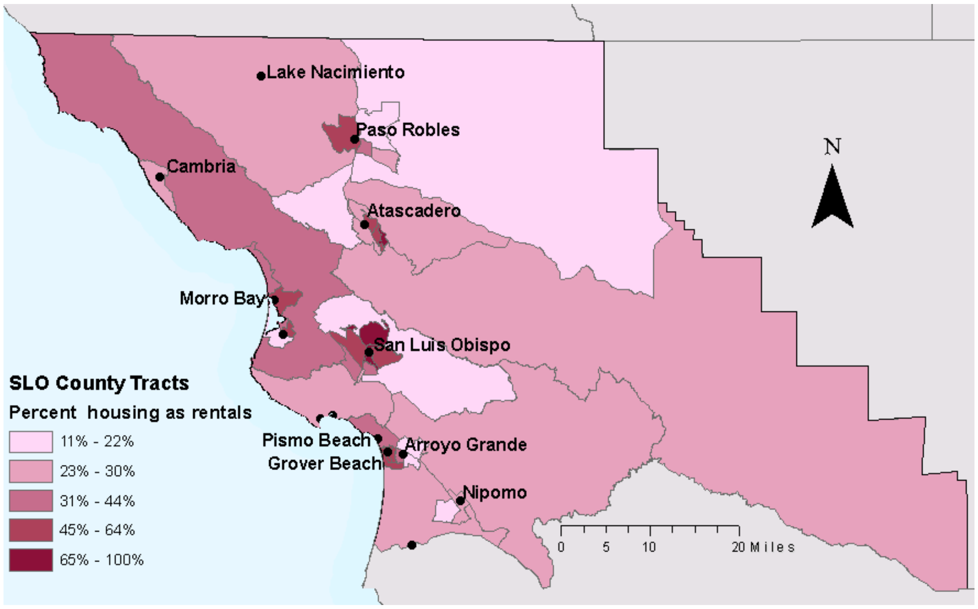


Figure 22: Percentage occupied housing units that are rented

(Source: Census 2000)

2.1.2.10 Of Special Concern: Students, Migrant Workers, and Institutionalized Populations

Two additional populations that are of special concern residing in SLO County are students and institutionalized populations.

In studies of disaster vulnerability, university students (as a unique category of the population that is transient and therefore someone disconnected from family ties) have been found to be at a particular disadvantage.[lxxi] This raises concerns about their capacity to respond to climate- and weather-related disasters expected with climate change. Students – often based far from home – tend to be disconnected from their families (especially foreign students) and from their resident community. In other ways students may be better connected during disasters because they are linked to a single institution that can easily inform them anf focus preparedness and disaster response operations. At the same time, they also may not have vehicles and may have a lower response rate to public warnings about emergencies. San Luis Obispo County has a high proportion of students enrolled in college or graduate school (Figure 17). As of fall 2009, 19,325 students were enrolled at the State University (Cal Poly) and the Junior College (Cuesta).[lxxii] While most Cal Poly students are from within California, only 9% are from San Luis Obispo County, or from the neighboring Santa Barbara or Monterey Counties,[lxxiii] leaving a high proportion of students to not have families within a few hours driving distance. The influence of isolation from family on student's low adaptive capacity is magnified by another factor: students tend to be renters and thus have lower control over their housing situation. On-campus housing at Cal Poly may require special evacuation and disaster preparedness plans to account for students' special situation.

Institutionalized populations are reliant on institutional provisions and the facility's response measures during times of disaster for support. There are two State establishments with high populations of institutionalized populations in the county: the California Men's Colony and

Atascadero State Hospital. California Men's Colony, located just north of the City of San Luis Obispo with a population of 7,000 minimum and medium security inmates, is close to a land slide risk zone marked as high potential. The Atascadero State Hospital, located on the south end of Atascadero along Highway 101 with a population of approximately 1,050, is in the flood zone of Salinas Dam.[lxxiv] Climate change studies for the state project an increasing severity of extreme rainfall events throughout California,[lxxv] increasing the risks for both institutions and demanding appropriate preparatory measures from these institutions to address the particular vulnerability of their residents to climate change-related extreme events.

2.1.2.11 Community Organizations and Social Capital: Enhancing Adaptive Capacity

Social groups can be important resources for communities in cases of emergency by providing resources and support as well as by helping to increase public awareness about what households and communities can do to cope with and adapt to impacts of climate change. Trustful social relations are among the most important immaterial resources during times of stress and change. For example, such community organizations (e.g., faith communities, civic organizations, neighborhood associations, social clubs) can distribute information and help educate each other by holding trainings, seminars, or informal gatherings. Through such events and dialogue social groups can develop strategies for helping individuals and families to become familiar with the risks, take actions to reduce their exposure, assisting targeted populations during emergencies (e.g., a social buddy system during heat waves), and support each other in the aftermath of disasters to rebuild and bounce back more quickly.

San Luis Obispo County is rich in social organizations, including clubs, interest-based associations, and religious communities. Some 43% of the population identifies as religious and over half the religious population is Catholic.[lxxvi] The county has 16 rapidly growing Catholic congregations with a total of 68,264 adherents.[lxxvii,lxxviii] The second most dominant religious affiliation is Evangelical Protestant with 22,321 adherents.[lxxix] Churches often serve as safe areas for evacuees in times of disasters, such as wildfires and flooding events. They provide emergency services and social and spiritual support. Some may also be particularly well positioned to reach into otherwise linguistically or culturally isolated segments of the population (e.g., especially Catholic churches with high Latino membership may be able to help get information about disaster preparedness and coping strategies to Spanish-speaking community members).

2.1.2.12 Summary

In summary then, we integrated 32 census variables commonly associated with low adaptive capacity and high sensitivity to climate-related disasters. The result is an integrated impression of social vulnerability across San Luis Obispo County (Figure 23).[lxxx] Based on this analysis, the most vulnerable populations are located in the more populated regions of the county. One benefit of the county's existing emergency preparedness structure is that each of these highly vulnerable populations are within regions in which emergency response time is fast (see Figure in Part III of this report). When considering additional exposures to climate change impacts, all coastal communities are exposed, but in light of sensitivities and adaptive capacities, we find that the communities of Morro Bay, Cambria and Grover Beach are most vulnerable to flooding-related inundation during storm events (yellow, orange and red in the map below). There are also medium-high to high vulnerability populations at risk from landslides (see Figure in PART III), including just north and east of the City of San Luis Obispo. Those vulnerable populations that are within or adjacent to high fire hazard severity zones (see Figure in Part III) include Atascadero, Nipomo, and Lake Nacimiento.

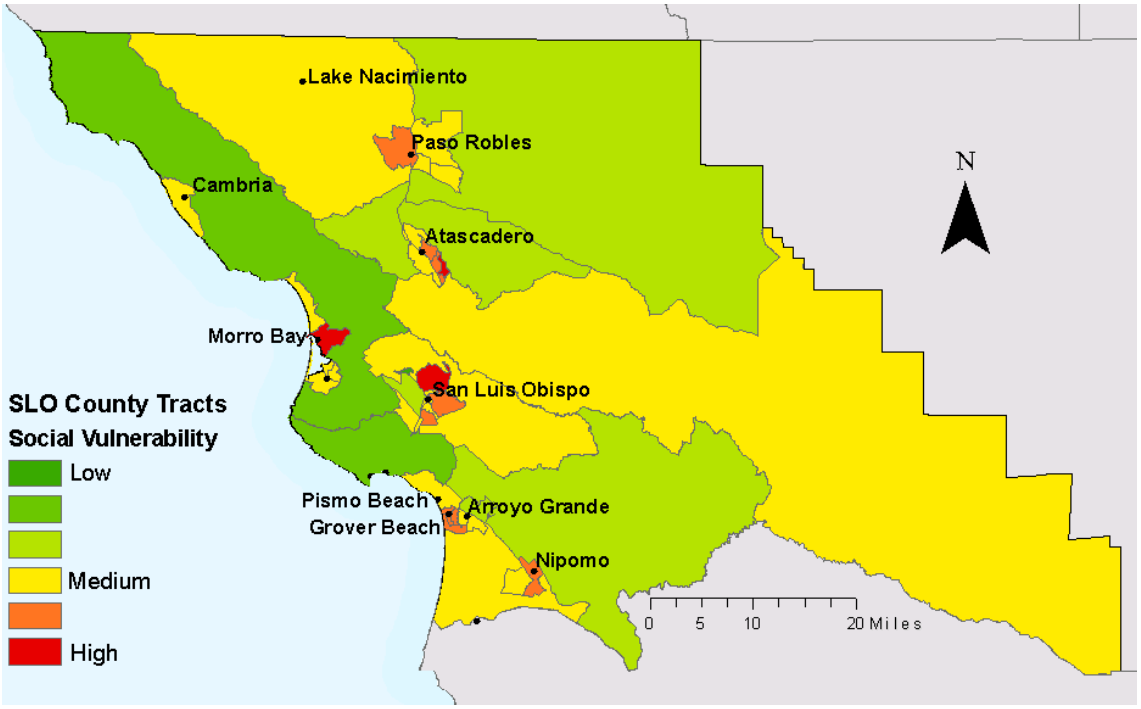


Figure 23: Social vulnerability map integrating 32 census variables commonly associated with low adaptive capacity and high sensitivity to climate-related disasters. Areas determined as most vulnerable include the most populated regions in the County: San Luis Obispo City, Nipomo, Grover Beach, Atascadero, Morro Bay, and Paso Robles. In addition, those unincorporated areas of the county shown to have medium vulnerability populations include the southwest, Cambria, the coastal region south of Grover Beach, and the area surrounding Lake Nacimiento in the north.

(Source: Map constructed with data compiled from Census 2000, using Cutter et al. 2003 methods)

Section 3: Economic Sectors and Activities of San Luis Obispo

3.1 Overview

The major economic industries in San Luis Obispo County by employment include tourism, retail, service industries, government and agriculture. Of these, tourism and agriculture are most directly dependent on services that are sensitive to climate change (e.g., sea-level rise and related hazards affecting beaches; temperature and water supply changes affecting agricultural crops and cattle). The county has predominantly a service economy (with significant employment in government, finance, insurance, real estate, education and health, leisure and hospitality, and business services). Again, among these, tourism is a major player, but indirect vulnerabilities also exist for insurance, real estate, and public health. Below, we provide a quick economic profile of the county and then discuss potential impacts and vulnerabilities to climate change to the most climate-sensitive economic sectors and activities. Employment figures by industry provide a first indicator of the county economy (Table 2).

Table 2: Employment by Economic Sector in San Luis Obispo County (2005-2007), Estimated Labor Force = 122,254 Persons

Economic Sector	Employment (% of total)
Educational services, and health care and social assistance	21%
Arts, entertainment, and recreation, and accommodation, and food services	13%
Retail trade	12%
Wholesale, information, and other services	11%
Construction	9%
Professional, scientific, and management, and administrative and waste management services	9%
Public administration	7%
Manufacturing	6%
Finance and insurance, real estate, rental and leasing	6%
Transportation and warehousing, and utilities	4%
Primary industries (agriculture, forestry, fishing, hunting and mining) (Note: SLO Chamber of Commerce[lxxxi] reports there are an estimated 4,388 people are employed in the agriculture sector)	3%

Source: Census, American Community Survey, 2005-2007[lxxxii]

The organizations employing the most people in the county include Cal Poly (with 2,693 staff), the County government (2,570 staff), Atascadero State Hospital (2,200 staff), California Men's Colony (2,000 staff), and PG&E (1,719 staff).[lxxxiii] The 2006-2008 Census estimates that 3,705 people work in agriculture, forestry, fishing and hunting, and mining (3% of the civilian employed population 16 years and over), most of which will be affected by climate change impacts because of their direct reliance on ecosystem goods and services (e.g., water, soils, terrestrial biodiversity, carbon storage, fish and shellfish). Jobs in the primary industries are most highly concentrated in the northern and south coastal portions of the county (Figure 24). According to the 2007 Economic Census, there were 1,262 retail trade commercial establishments, employing 14,652 people (with a total annual payroll of $353 million and sales, shipments and receipts valued at approximately $3.5 billion).[lxxxiv] The service and accommodation industry employment is predominantly concentrated along the middle and northern coast (Pismo Beach, Paso Robles and San Luis Obispo City), and less so in the region surrounding Atascadero (Figure 25).

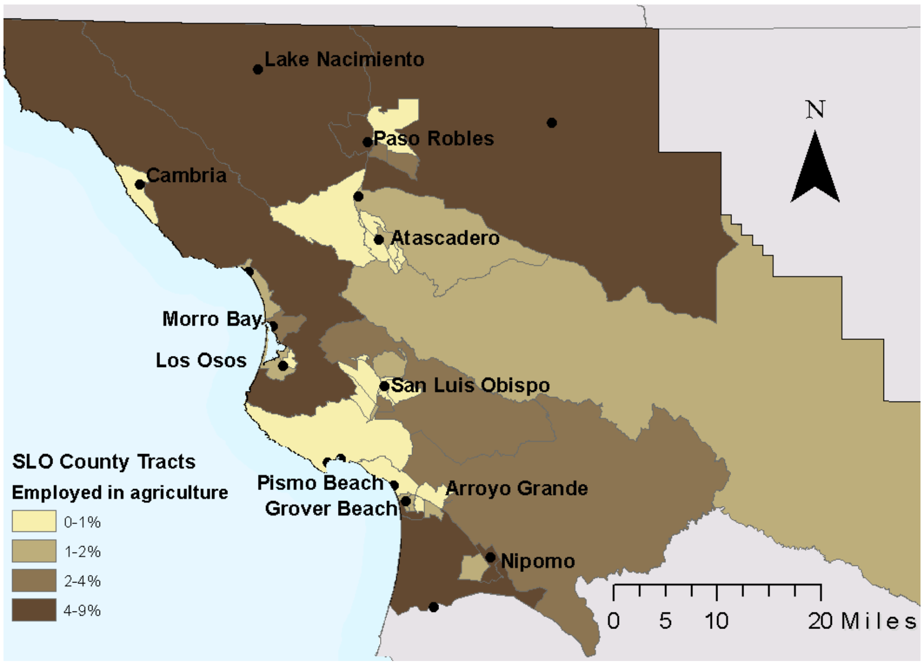


Figure 24: Percentage of labor force employed in the agricultural, mining, forestry, and fishing sector

(Source: Census 2000)

Figure 25: Percentage of labor force employed in service and accommodation Industry

(Source: Census 2000)

3.2 Agriculture

Agriculture employs relatively few individuals, but generates significant value for the county. It also is the predominant land use with over 55% of land zoned for agriculture (1,819 square miles out of the county's total land area of 3,304 square miles; 113,200 acres are harvested and 1,051,300 acres are pastureland).[lxxxv] The highest ranked crops by dollar amount are grapes (and wine), broccoli, strawberries, and cattle/calves (Table 3).

Climate change poses a serious threat to agriculture for the State of California and San Luis Obispo County. These threats include the following:

- higher temperatures, including extreme temperatures, can negatively affect plant growth during various stages of their development, as well as cattle health and reproduction; inland areas will be affected relatively more so by these temperature increases than coastal areas;
- reduced water availability as a result of (a) the projected decrease in snowpack as more precipitation falls as rain than as snow and (b) higher temperatures leading to higher evaporation from reservoirs and soils resulting in reduced reservoir storage, possibly lower recharge rates of groundwater reserves, and generally drier conditions; any decrease in total precipitation as projected by the latest climate change projections[lxxxvi] for the state would only exacerbate these declines in water supplies;
- more intense downpours can lead to fruit, vegetable and flower damage and increase the risk of soil erosion;

- water demand by plants and animals (for drinking and cooling) will increase as temperatures increase; and
- increased risk of pest infestations and spread of invasive plant species.[lxxxvii]

Many crops respond positively to elevated carbon dioxide under lower levels of warming, but this beneficial effect on growth and yields is limited quickly by higher levels of warming. A longer growing season, while potentially beneficial to farmers, may increase the overall demand for water. Finally, changes in coastal fog are still uncertain, but any reduction would lead to warmer coastal regions reducing the optimal growing conditions which some crops such as Chardonnay wine grapes depend. Decreased coastal fog could also lead to higher agricultural demand for water.[lxxxviii] Further discussion on water supply is provided in Section 4.2.

Table 3. San Luis Obispo County Leading Agriculture Production (in 2008 Dollars)

	2008 Ranking	Value	2007 Ranking
Grapes, wine	1	$124,126,000	1
Broccoli	2	$70,914,000	2
Strawberries	3	$65,481,000	3
Cattle, calves	4	$50,050,000	4
Vegetable transplants	5	$35,682,000	5
Cut flowers	6	$25,203,000	7
Head lettuce	7	$24,591,000	6
Indoor decoratives	8	$21,011,000	8
Carrots	9	$19,623,000	11
Oriental Vegetables	10	$13,090,000	Unranked

Source: San Luis Obispo Chamber of Commerce (2009)[lxxxix]

Farmers' ability to deal with these climatic changes depends on a number of factors. They reflect their exposure to climatic changes, their sensitivity to those changes, and their adaptive capacity, including:

- location (e.g., distance to coast, exposure, soils)
- types and diversity of crops grown and/or cattle raised

- current farming practices (e.g., soil and water conservation practices, organic/conventional farming) and willingness and ability to change these practices
- access to water resources, wells, and water rights
- existing stresses on water resources (e.g. groundwater overdraft)
- financial resources to invest in technologies such as irrigation, cooling and farm equipment required for growing new/different crops
- dependence on income solely from farming vs. several income sources
- access to flood and drought insurance
- participation in farming cooperatives
- access to and use of climate-related information for advance planning (e.g., through extension service, web-based sources)
- market, policy-related, or legal constraints on farming.

In general, smaller farmers with fewer financial, technological, and water resources, and farmers with fewer or less flexible response options, limited crop diversity, fewer risk sharing opportunities, and greater dependence on farm income tend to be more vulnerable to climate change. At the same time, smaller farms may be focused on growing high-value crops, which gives them financial incentives and means to innovate and adapt. In 2002, over 54% of farmers in the county owned 50 acres or less. Just over 25% owned 180 acres or more (Figure 26).

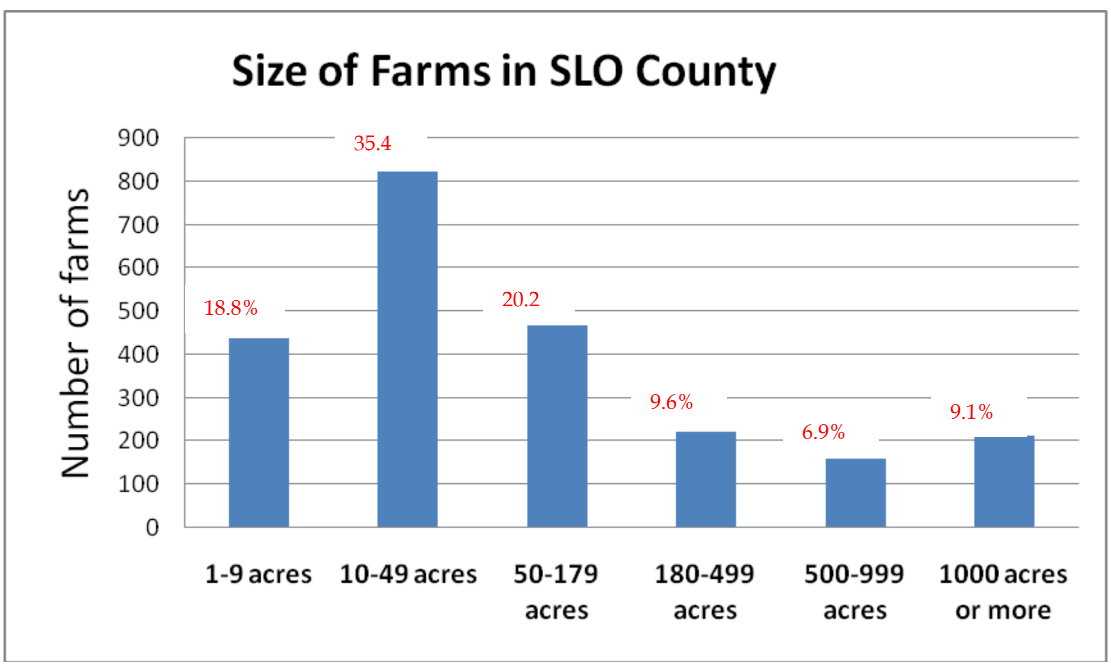


Figure 26: Farm Size Distribution in San Luis Obispo County

(Source: USDA, National Agricultural Statistics Service, 2002 data)[xc]

The county's agricultural sector exhibits existing sensitivity to three main types of climate-related extreme disturbances: drought, high temperatures, and sea-level rise in coastal areas. In October 2008, the USDA granted the County a disaster designation for losses caused by that year's drought and the extremely high temperatures experienced in June 2008, which allowed farmers and ranchers (with family-sized farming operations) to apply for emergency loans with low interest rates to cover losses that directly resulted from the designated disaster.[xci] That year, agriculture was especially hit hard by "unseasonable weather including a late April frost, a record breaking heat wave throughout the county in June, and the third consecutive year of less than average rainfall".[xcii] The county has experienced repeated weather-related losses in agriculture, including:

- consecutive days of warm temperatures in June 2008 reduced yields of most vegetable crops overall by 7%;[xciii]
- in 2007, low rainfall results in a 77% reduction in production of dry farm grain crops;[xciv]
- Hass avocado production in 2005 decreased 81% compared to 2004 due to record warm weather in April 2004 which caused blossoms of the 2005 crop to drop off trees;[xcv]

Below, with an eye toward projected increases in heat extremes and drier conditions, we highlight the most sensitive aspects of the agricultural sector in more detail.

GRAPES AND WINE

Among perennial crops, wine grapes have been one of the leading crops in California for years.[xcvi] In San Luis Obispo, too, the wine grape industry (including grape growing, wineries, and associated tourism and services) is a dominant economic sector. Its full economic impact in 2007 was estimated at $1.78 billion.[xcvii] Wine grape growing, production, wineries, and associated tourism employ over 8,000 people in the county.[xcviii] Grape growing is concentrated primarily in the northern portion of the county in and around Paso Robles and also smaller pockets in the southern coastal parts of the county (Figure 27). Wineries are concentrated in the north in and around Paso Robles and Templeton while fewer can be found around the City of San Luis Obispo, Avila Beach and Pismo Beach.[xcix] The grapes grown closer to the coast (needing the cooler summer temperatures and fog) tend to be white wines, while red wines are grown dominantly inland.[c]

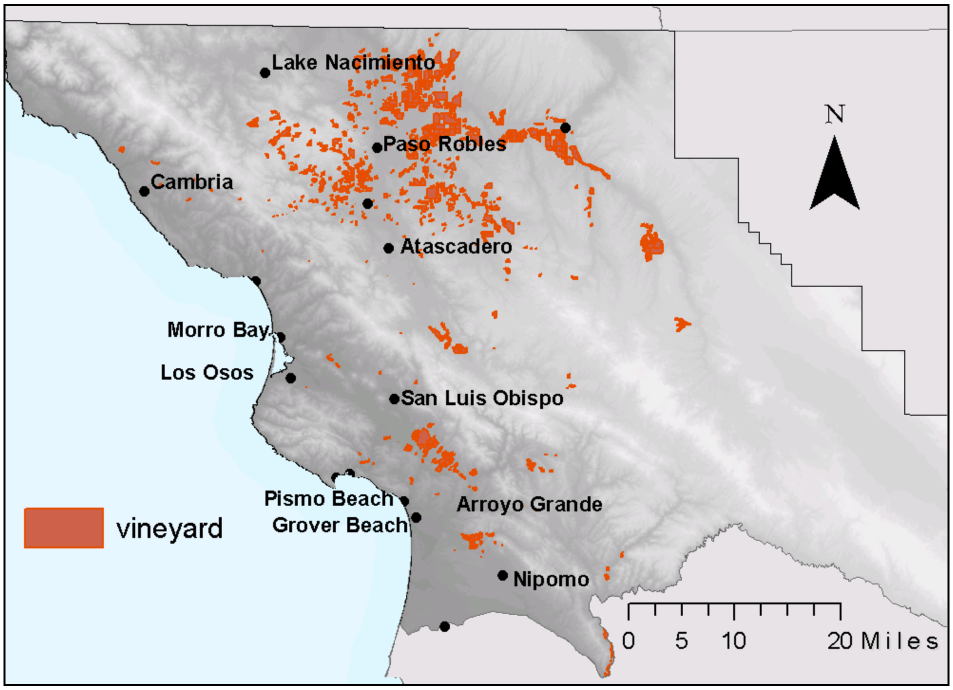


Figure 27. Distribution of vineyards in San Luis Obispo County in red showing the high density of activity around Paso Robles and the surrounding area and the small, but growing wine country in the south coast region.

(Source: SLO County Agriculture Commissioner Office 2008)[ci]

The quality of wine grapes in particular depends on certain climatic conditions, especially temperature, moderated by cool fog in summer months along the coast for certain varieties (e.g., Chardonnay grown mainly in the southern wine regions), and higher inland for other varieties (e.g. Cabernet Franc, Cabernet Sauvignon, and Zinfandel make up 80% of grapes grown in the region around Paso Robles[cii]). The all-important wine quality is thus susceptible to changes in climate. A small but growing number of scientific studies have begun to investigate the impacts of climate change on the premium wine growing regions of California and the industry.[ciii] While most of this research has focused broadly on California or specifically on Napa and Sonoma Counties, we can carefully extrapolate the findings from these studies to the extent they are relevant to San Luis Obispo County's wine production, tourism and grape growing industry.

Research has shown that the yields of wine grapes could decrease or potentially increase from changing seasonal temperatures from climate change. While reduced yields are a concern, the changing temperature patterns from climate change may have more considerable negative impacts on the wine *quality*. The possible reduction in wine quality could have a greater economic impact than yields in coastal counties where high quality wines are highly prized.[civ] According to a study conducted on wine in California, "in the Napa and Sonoma valleys, warmer winter and spring temperatures have resulted in a longer growing season and more favorable growing conditions. However, with the continuation of these warming trends, conditions will be too warm and no longer favorable for the production of certain grape varieties. This creates large financial risks for grape growers who must make significant upfront investments in crops which generally take many years to provide financial paybacks".[cv] At the same time, there are possibilities of grafting to speed up varietal changes, both in response to market and climatic conditions. Indeed, recent growing seasons are indicative of the industry's vulnerability to changing conditions: The value of wine grape production in the county declined by 12% between 2007 and 2008 for climate-related reasons.[cvi] However, a uniform increase in temperatures is less important than changes in certain months of the growing cycle. Interviews with Napa and Sonoma wine grape growers revealed, for example, that warm temperatures from April through June are important for the grapes to build the epicuticular wax; however, temperatures too warm during these months can damage young grapes.[cvii]

CATTLE

Cattle is a critically important component of the agricultural sector in San Luis Obispo, with annual sales valued at over $50 million.[cviii] Climate change poses direct threats to this industry through heat extremes and higher demands on water resources, but also through changes to the quantity and quality of forage. Cattle are at heightened risk of mortality from increased temperatures, especially prolonged periods of extreme heat, and possible decreases in reproductive success.[cix] To avoid these risks, farmers can choose a variety of ways to keep cattle cool, ranging from manual hosing off to increased shading and air conditioning, although these adaptation options typically are labor intensive and/or require substantial economic resources (both for the initial investment and ongoing operating expenses).

In general, fewer studies have examined the impacts of climate change on grassland species; moreover climate change impacts are complicated by pasture management practices.[cx] Higher temperatures, lengthened growing season, the fertilization effect on grass species, invasives, and the amount and timing of winter rains are among the key factors influencing the quality and quantity of forage. Statewide modeling studies suggest precipitation-driven declines of forage between 5% and 40% by the middle of the century, with resulting profit declines from livestock between $8 and $62 million. Inland areas of the county are among the hardest hit.[cxi] The cattle industry of San Luis Obispo has already experienced a recent decline due to low rainfall and water shortages, which reduce the available grass on pasture land. According to the 2008 county crop report, "Three consecutive years of below average rainfall reduced forage plants and grass available for grazing, causing an overall reduction of 10% in the value of the local animal industry. Approximately 7,000 fewer cattle were sold".[cxii] In addition, a statewide heat wave in 2006 and on-going drought resulted in a shortage of available grassland for cattle to forage.[cxiii] This shortage (along with high feed prices) forced cattle owners to sell calves 2-3 months early and under-weight. The below-average rainfall through 2008 continued to limit food and led to a substantial reduction in livestock industry in San Luis Obispo County.[cxiv]

FRUIT AND VEGETABLES

Strawberry and vegetable crops will experience a lengthening growing season, increases in temperatures, the general drying trend and related risk of water shortages, as well as higher flood risks in alluvial valleys. Crops grown in coastal areas will also be affected by sea-level rise driven land loss, flooding, and saltwater intrusion. Strawberries are among the most salt sensitive crops grown in California. A study contributing to the California Adaptation Strategy reports, for example, that the county's strawberry yield may decrease by 10-15% by 2030-2050 due to climate change,[cxv] but it is difficult to know whether this is due to water shortages or heat increase or the shortening of winter chill hours. (Common strawberry varieties require between 300-400 hours of temperatures between 32 and 59 °F).[cxvi] Only limited research is available to date on climate change impacts on strawberry crops, though it is fairly well understood that some varieties are heat-sensitive while others can withstand more heat, thus potentially offering county farmers the option of switching to alternative, more heat-tolerant varieties.

Almonds and other nuts and fruits also need a certain amount of winter chill hours, which are projected to decrease as the climate warms further.[cxvii] While chill requirements vary by variety, almonds require 100-500 chill hours, most peaches between 400-800 hours, and pistachios 600-1,500 hours.[cxviii] The higher these numbers, the greater the chance that the warming climate may restrict productive harvests. In addition, certain temperature ranges during particular months are critical for adequate development and ripening. Freestone peaches, for example, will benefit from winter warming – particularly at night – but be harmed by additional warming during the summer.[cxix] Almonds, by contrast, are particularly sensitive to nighttime warming in February (probably because low temperatures during the bloom season enhance pollination success). Thus, the projected warming between now and 2030 could result in a roughly 10% (statewide) loss in yields by 2030 of the no.1 perennial crop in California, unless farmers adapt (e.g., by switching to less heat-sensitive varieties, or assisting in pollination success).[cxx]

Vegetable crops such as lettuce and broccoli prefer cool temperatures and may be particularly sensitive to increases in temperature, particularly early in the year. For example, the June 2008 heat wave reduced yields of many vegetable crops by 7%,[cxxi] highlighting existing sensitivities to extreme weather events that will likely increase with climate change. To buffer against these increases, farmers may choose to only grow these crops in the immediate coastal areas where cool ocean breezes and fog prevail, or switch to different crop. In addition to climate change impacts, concurrent non-climate stresses such as fuel increases make it more difficult for crop growers to adapt to climate change.[cxxii]

3.3 Coastal and Marine Sectors

COMMERCIAL AND RECREATIONAL FISHERIES

Fisheries, harbors and coastal tourism make up other important economies of the county. In 2000, the county had the 10th highest value for commercial landings ($5.7 million) out of California's 19 coastal counties.[cxxiii] As with most other coastal counties in the state (and in fact much across the nation), employment in the fishing industry and landings have been decreasing for much of the first decade of the 21st century.[cxxiv,cxxv] Still, fishing remains an economically and culturally important part of coastal San Luis Obispo and could be significantly impacted by climate change.

Climate change will impact fish populations directly by warming ocean waters, changing currents (upwelling), affecting nutrient availability and the oceanic food web, and shifting habitats, and indirectly through impacts on fishing-related coastal infrastructure and inundation of critical nursery habitat (i.e., coastal wetlands) (Figure27). Changes in upwelling and higher ocean temperatures may have severe impacts on fish populations, but further research is necessary to understand how these factors impact species distributions and abundance, species physical health, and food web interactions. In addition to food web and habitat changes, ocean acidification is expected to severely impact ocean and shellfish fisheries as well as aquaculture.

Figure 28: Despite declining employment and landings, fishing remains an economically and culturally important part of coastal San Luis Obispo. Climate change will affect fish populations, nursery habitats and coastal infrastructure for commercial and recreational fisheries.

(Photo: Dwayne Oberhoff)

In addition to commercial fishing, recreational fishing is another component of the industry and people's way of life. Recreational fishing – just as commercial fisheries – could be directly impacted by climate-related habitat shifts but also indirectly by the loss of wetland, which provides important nursery habitat.[cxxvi] For example, the Morro Bay National Estuary protects an important wetland system that provides vital habitats of eelgrass beds and wetlands to migratory birds and nursery habitats for marine fish. Nearshore coastal fisheries could also be impacted by runoff from land. For example, extreme runoff events after heavy downpours can impact coastal water quality, unless buffered or treated prior to entering open waters.

The Community Fishing Profiles Project describes several communities that depend on fisheries in the county.[cxxvii] According to project reports for 2000, "43,399 resident sportfishing licenses, 40 nonresident sportfishing licenses, 52 sport salmon punch cards, and 30 abalone report cards were purchased in San Luis Obispo County."[cxxviii] Twelve sportfishing businesses (in 2000) operating out of the county serve sport fishermen and tourists. Morro Bay also has an aquaculture industry for farming Pacific oysters, mussels, and clams. Shellfish are particularly vulnerable to ocean acidification.[cxxix] Research to better understand the impacts on ocean biology of temperature and pH (acidity) changes are currently under investigation.[cxxx]

Until recently, San Luis Obispo County was one of California's major fishing ports, on par with Monterey Bay. As with most fisheries in California and worldwide, the reduction in fish populations along with regulations restricting spatial fish catch and gear type has had dramatic impacts on the local level fisheries. In reaction to and in the interest of improving fish populations and sustaining commercial fisheries off California's coast, The Nature Conservancy (TNC) has developed an experimental permit program, the Central Coast Groundfish Program, as way to simultaneously protect fish and support fisheries. In 2005 TNC purchased several trawl-fishing permits from commercial fishermen and has more recently started to lease these back to fishermen who use sustainable gear and practices and to those who agree to participate in a community fishermen's cooperative.[cxxxi] The example highlights how an industry can take creative and collaborative steps to endure major changes while sustaining commercial fishing in the region. The willingness to experiment with new approaches and ability to change reflect the industry's adaptive capacity and may position it well in anticipation of future changes.

HARBOR INFRASTRUCTURE

Coastal storms can cause severe coastal flooding of low-lying areas (e.g., inundating economically important infrastructure such as harbors and related building and infrastructure). While there still is scientific uncertainty regarding changes in the frequency and intensity of coastal storms,[cxxxii] a faster rate of sea-level rise will elevate the ocean baseline, leading to more frequent flooding and higher storm surges. The erosive impact of storms could also have severe impacts on coastal infrastructure and installations, thus requiring adaptive measures such as elevation, strengthening, flood protection, or even retreat.

3.4 Tourism

Besides government, education and health care, tourism is the dominant economic industry in San Luis Obispo County, attracting visitors for its beautiful natural environments (coast and beaches, cultural sites (three missions) and historical events, its picturesque wine country (especially around San Luis Obispo and Paso Robles), and its countless visitor attractions (Hearst Castle, Oceano Dunes, the Carizzo Plain) and opportunities for recreation (e.g., mountain biking, hiking, kayaking, fishing, whale watching) (Figure28).[cxxxiii] Travel spending in 2007 was $1.21 billion.[cxxxiv] Tourism accounts for over 16,500 jobs (for the years 2001 to 2007).[cxxxv] Many of the jobs are service-related and pay low wages considering the high cost of living in many of the coastal areas (see **Error! Reference source not found.** and Figure 25 above). Local government budgets depend heavily on tourism-related taxes, thus any potential declines in local tourism could have direct and indirect impacts on the regional economy. According to the 2008 Economic Vitality Corporation report on tourism, the county's tourism sector is in direct competition with its neighboring counties of Santa Barbara and Monterey, which offer similar attractions (natural and cultural resources, wine, and coastal tourism).

Figure 29: Hearst Castle, one of the countless tourist attractions of San Luis Obispo.

(Photo: Wikimedia Commons)

The county's coastal tourism first and foremost relies on clean and beautiful beaches, scenic vistas and drives, and birds, wildlife and fish for recreational fishing, bird and whale watching and other activities. But tourism also requires critical infrastructure, services and establishments (e.g., coastal roads, hotels, restaurants, guided tours) to support the industry. The county lists the top attractions as: Hearst Castle, Missions, beaches (Avila, Cayucos, Morro Strand, Oceano, Pismo, and San Simeon,[cxxxvi] all of which are coastal tourism destinations.

Both natural and built resources are to varying degrees vulnerable to climate change impacts. The direct physical impacts of climate change on the tourism industry in San Luis Obispo County relate to its reliance on transportation infrastructure, weather and the health of natural resources. The coastal region's tourism will be affected by climate change-driven sea-level rise and increasing beach erosion and risks related to coastal flooding and higher storm surges.[cxxxvii,cxxxviii] Declines in the perceived attractiveness and safety of tourism destinations and supporting infrastructure could have detrimental impacts on accommodations, restaurants, and other tourist related services (discussions of these potential impacts have arisen after analysis of climate change impacts on coastal tourism in Monterey and Santa Cruz counties[cxxxix]). A study estimated projections of climate change impacts on Southern California's beaches found that sea-level rise could cause "an overall reduction of economic value in beach going, but with some beaches experiencing increasing attendance and beach-related earnings while others lose attendance and earnings" depending on the degree of beach erosion and changing sediment movement along the coast.[cxl] To date, there have been no major documented beach nourishment projects in the county, except for small dredging projects.[cxli] However, further research on sea-level rise impacts may indicate erosion of highly valued beaches, in which case some communities may consider nourishment of their beaches as part of an adaptation strategy. Beaches that will witness increased erosion could trigger requests for stabilization or beach nourishment to sustain their current physical state. Implementing such adaptation strategies would depend on physical conditions, economic cost-benefit analysis, and regulatory requirements. While other options exist for adaptation in coastal areas (e.g., planned retreat, breakwaters, wetland restoration), and which are most applicable depend on shoreline characteristics, economic resources, legal options, and the social acceptability of the option at hand.

San Luis Obispo County's agriculturally-based – i.e., largely wine-related – tourism may suffer if climate change causes large enough shifts in the industry to diminish its importance and impact on the landscape's character. Visitors' perceptions of reduced attractiveness of the region (e.g., eroded beaches, reduced fishing opportunities, lower wine quality, wildfires) combined with broader, more remote socio-economic changes may be as or more important than the direct impacts.

Service employees in the tourism sector often earn relatively low wages, making them potentially more vulnerable to these changes and resulting in generally lower adaptive capacity than for better-earning individuals.[cxlii] Maintaining a diverse economy, diverse employment opportunities, safe and functional infrastructure, and healthy ecosystems will all be critical components to increasing the county's adaptive capacity.

Section 4: Community Services, Infrastructure & Supporting Activities of San Luis Obispo

4.1 Supporting Infrastructure and Services: Introduction

In support of people's daily life, well-being, safety, travel and participation in San Luis Obispo County's economic and recreational activities, the county provides a variety of infrastructure and community services. Many of them are susceptible to being affected by climate change, both directly and indirectly. First and foremost is the provision of the most essential resource for both urban and rural areas: water. Water quality and supply issue are already high on the public agenda, and climate change will assure that they remain there. In addition, we will discuss wastewater management, transportation, emergency preparedness and response systems, and energy. For the all-important conservation and management of ecosystems for the goods and services underlying much of San Luis Obispo County's economy and quality of life, please review the first adaptation workshop and resulting report.[cxliii]

4.2 Water Supply

Water supply shortages are a serious problem for many regions in San Luis Obispo County and under the modeled climate change impacts these shortages are projected to get worse. Several areas in the county already experience summertime shortages. Some areas have borrowed fresh water from emergency supplies that otherwise would remain on reserve for fighting fires.[cxliv] In addition, several communities rely on diminishing supplies of groundwater. The state provides only a very limited amount of the county's water through the State Water Project. Therefore, many economic and service sectors and communities rely on regional reservoirs and groundwater. Climate change projections summarized above suggest that the county will experience a longer dry summer season, and generally drying conditions, especially toward the end of the century. In addition, the region may see fewer but more severe rainfall events, resulting in intense run-off which may overwhelm sewer and treatment facilities, thus potentially negatively affecting stream and coastal water quality. Currently there is insufficient infrastructure to harness that momentary surplus of water. Higher temperatures and increasing wildfire risks (aside from population growth) suggest there will be a growing demand for water supplies while supplies are shrinking. The county is aware of the water shortage needs, especially in light of the growing demands (from increasing population and changes in agriculture). However, water also needs to be managed in consideration of the climate change impacts discussed above, as well as to account for increased demands from higher population in coming years and likely increased demands from existing users as a reactive adaptive response to higher temperatures. Therefore, the water system and current uses depending on scarce water supplies are highly exposed to the additional impacts of climate change. The County has developed a master water plan to assess the existing infrastructure and improve the emergency preparedness for its water systems.[cxlv] The County is in the process of updating this Master Water Plan, which will incorporate climate change concerns, including the recently release draft climate-related standard required by the State Integrated Regional Water Management Plan.

Table 4 lists the water supply regions and their current water challenges.

Table 4: Water supply-related challenges in San Luis Obispo County

City/town/area	Main water source	Current issues
Arroyo Grande	Lopez Lake (65%) and Groundwater (35%)[cxlvi]	Considering desalinization as additional water source for the future[cxlvii]
Atascadero	Groundwater and underflow of Salinas River, Nacimiento project water (expected Summer 2010)[cxlviii]	Unknown at time of report
Avila Beach	Lopez reservoir (41%) and state water project (59%)[cxlix]	Highest cost of water in the county.
California Valley	Small isolated water systems	Water quality and lack interties with other water sources
Cambria	Groundwater	Limited groundwater supply has led to no new development permitted
Diablo Canyon Power Plant	Desalinization plant[cl]	Is not linked to any other freshwater source
Grover Beach	Lopez Lake and groundwater[cli]	Unknown at the time of report
Los Osos	Groundwater (Los Osos Valley Groundwater Basin)	Required to build sewage treatment plant; saltwater and septic tank intrusion into groundwater threatening the potable water supply;[clii] reduction in recharge
Morro Bay	Groundwater (Morro and El Chorro Creek underflows), State water project, and desalinated sea water[cliii]	High cost of water
Nipomo	Groundwater	Complete dependency on groundwater, Water shortage, saltwater intrusion[cliv,clv]
Paso Robles	Groundwater (Paso Robles Basin)[clvi] and Nacimiento water project (expected Summer 2010)	Groundwater basin in state of rapid decline[clvii]
Pismo Beach	Lopez Lake, State water project, groundwater (Santa Maria Groundwater Basin) [clviii]	Unknown at the time of report
San Luis Obispo City	Santa Margarita Lake, Whale Rock Reservoir, Nacimiento project (expected Summer 2010), water recycling program	Unknown at the time of report
San Miguel	Groundwater from Paso Robles groundwater basin[clix]	Groundwater basin is in decline and population is expected to increase in the area
San Simeon	Groundwater	At the most critical level for several years and "no additional water supplies are readily available; no additional development is expected in the foreseeable future. A development moratorium is in place since 1991."[clx]

Shandon	Small isolated water systems, Nacimiento water project (expected Summer 2010)	Increasing agricultural demands (changed from dry farms to vineyards and may change to alfalfa). No alternative supplies.[clxi] Isolated water systems lack interties
Templeton	Majority from groundwater or underflow of Salinas river, but also recycled water, Nacimiento water project (expected Summer 2010)[clxii]	May need new water supplies to keep up with growing demands
Oceano	Lopez Reservoir, groundwater, and State Water project. [clxiii]	Unknown at the time of report

Sources: In addition to sources listed in the table, San Luis Obispo Water Supply Reports and County Water Master Plan.[clxiv,clxv,clxvi,clxvii]

The entire north county inland (i.e., San Miguel, Paso Robles, Templeton, Atascadero, Shandon, Creston and Santa Margarita) relies on groundwater extraction. Some of these areas show signs of water shortage already, and lack of monitoring inhibits better planning for the future. Scientific study of the impacts of climate change on groundwater resources is very limited to date, but higher evaporation rates, more intense rainfall events that cause higher runoff rather than recharge, and increasing use by agriculture and residential users can be expected to result in negative impacts. Thus, as higher temperatures may cause farmers to want to supplement with additional irrigation, already overdrawn water supplies and increasingly scarce water resources as the climate dries in the future suggest potential conflicts for limited resources and possibly unmet needs of natural ecosystems and resources.

Cambria's drinking water is pumped by the Cambria Community Services District Board (CCSD) Water Department from Santa Rosa Creek and San Simeon aquifers. As a result of that community's severe chronic water shortages, the CCSD has required – since 1986 – a waiting list for the development of any new water and sewer hookups. The waiting list for single families is currently over 600 people long.[clxviii] The current Water Master Plan (as of the time of this report) presents three options to deal with the increasing demands (and water shortages) in the future: seawater desalination, recycled water, and water demand management.

The City of Paso Robles also has endured major challenges related to water.[clxix] Although the city is expected to begin receiving water from the Nacimiento water project in Summer 2010, currently it relies on groundwater entirely, which has resulted in groundwater declines, reduced well production, and reduced water quality. The city reports that during the summer the extreme water shortages have led to the use of emergency supplies stored for fire emergencies to supply residents. In addition, water contamination is a growing concern, especially given the area's reliance on groundwater. Many home systems add water softeners, which increases concentrations of chloride, sulfate, and sodium into the groundwater. This use of the emergency supplies reduces the response capacity of communities in cases of wildfires. With climate change projected to increase temperatures and the frequency of extreme heat periods, extend the dry summer season, and increase wildfire risk in the county, demand for and decreased availability of water supply are likely problems in the future.[clxx]

The Cuyama, California Valley, Shandon and Creston areas have water service provided only by small isolated water systems. The lack of connectivity between water systems in these rural areas makes it difficult to assist these places during water shortages, as described in this excerpt of the County's Water Master Plan:

"Only about half of our community water systems share common boundaries or supply lines, such that an intertie could successfully be put into place within a matter of days. The Whale Rock, Lopez, Salinas, Chorro Valley, and State Water pipelines provide important connections among many communities. The north coast communities of San Simeon and Cambria are particularly isolated from neighboring systems. The same is the case with San Miguel, Creston, Shandon and California Valley. Purveyors in these communities, in particular, should provide sufficient water storage and back-up power to remain self-sufficient during the 72-hour disaster recovery period. Though there are many independent systems in the Nipomo Area, few are interconnected to each other and none have a turnout from the State Water System. An emergency connection to the State Water system would benefit this area which otherwise is wholly dependent upon ground water supplies."[clxxi]

In addition to this lack of connectivity, heavy reliance on groundwater wells also proves to be a liability. Communities in the northern portion of the county rely on wells for their water, which means that lengthy power outages (e.g., due to shut-down of the nuclear power plant, reduced electricity supplies from other sources, wildfire damage) could have severe impacts on these communities, especially given that the emergency storages of water may be needed for fire fighting.[clxxii]

In addition to water shortages, reports for other coastal areas of the state express concern for saltwater intrusion into water supplies due to sea-level rise. San Luis Obispo County already experiences saltwater intrusion as a result of groundwater overpumping. Sea-level rise-driven saltwater intrusion into coastal acquifers with shallow water tables, such as Los Osos, will worsen this problem. Water in the county needs to be managed in consideration of the range of climate change impacts described above, as well as to account for increased demands from higher population in coming years and likely increased demands from existing users as a reactive adaptive response to higher temperatures.

4.3 Wastewater

Climate change could impact wastewater treatment in two ways. First, as intense rainfall events are expected to increase, extreme runoff periods will also become more common. During such storms, the runoff could impede the proper functioning of the county's many onsite septic systems or overwhelm sewers and centralized sewage treatment plants. As a result untreated water with the full load of toxics and organic waste could enter streams and coastal waters.

Second, while the Pacific Institute determined that no wastewater treatment plant will be affected by a 100-year flood after 55 inches of sea-level rise,[clxxiii] leach fields and treatment ponds near the coast might be at flood risk. Such flooding could cause wastewater that is not completely treated to flow into coastal waters. Los Osos exemplifies this problem with a long challenging history with wastewater disposal due to its unique low-lying location along the coast and its shallow water table.[clxxiv] Groundwater contamination issues in that region are compounded by the fact that Los Osos obtains its drinking water from local groundwater aquifers.

4.4 Transportation

The main transportation infrastructure of the county – its roads, airport, and railway – is in various ways susceptible to the impacts from climate change. The major transportation arteries to, from, and within the county include Highways 1 and 101, north to south and Highways 41 and 46 running east to west (Figure 29). CalTrans District 5 is in charge of maintaining this infrastructure.[clxxv] Railways run through the county, with Amtrak stops at Grover Beach, Paso Robles, and the City of San Luis Obispo. There is a small county airport located at the south end of the City of San Luis Obispo, which has approximately 13 flights arriving and departing per day (to and from San Francisco, Los Angeles, and Phoenix).[clxxvi] In terms of public transportation, some towns have cable car systems and the SLO Regional Transit Authority provides several types of transportation services: fixed routes service is a public bus that runs throughout the county and the Runabout is the ADA (Americans with Disabilities Act) para-transit service.[clxxvii] Several communities also have their own transit service (Dial-A-Ride in Nipomo, Templeton, Shandon/Paso; Trolley in Avila Beach and Cambria).

Figure 30: Sea-level rise may increase flooding of Highway 1 along the northern portion of the county. This map shows one proposed idea for relocating the highway in response to such risks.

(Source: CA DOT)

Transportation routes in the county are exposed to several climate change impacts, including sea- level rise and related erosion and cliff failures, heat extremes, flooding/inundation, and increased wildfire and associated problems with soil erosion, sedimentation, and landslides.

Increased severity of storms could increase flooding of important transportation routes during intense rainfall and runoff events, by causing dam failure of reservoirs, or from coastal and stream flooding. Increased severity of heat extremes may damage existing roadways and railways.[clxxviii] In the past wildfires have led to closures of important evacuation routes and climate change is projected to result in more fires in the region. Post-fire soil erosion, sedimentation, and landslides can damage roadways and other infrastructure (e.g., culverts).

Transportation infrastructure is particularly sensitive to climate-related disasters. There are very few routes in and out of the county, and if one gets cut off due to fire, landslide risks, or flooding alternative evacuation routes need to be provided and communicated to the public. The Pacific Institute estimated 28 miles of roads in the county (26% of which are highways, the highest proportion of highway at risk in any of California's counties) would be affected by sea-level rise.[clxxix] Areas of particular exposure to sea-level rise (and associated storms/waves) are Highway 1 and possibly 101 at Pismo Beach, and Highway 1 at Cayucos and several areas of the same highway in and north of Cambria and San Simeon. Several of the latter portions of highway are already vulnerable to flooding, but this would be exacerbated by sea-level rise unless the road is realigned (a proposal of such relocation and realignment is depicted in Figure 30).[clxxx]

Frequently, to protect critical infrastructures such as roads and rails from coastal flooding and erosion, state and local agencies resort to building seawalls and other physical protection or stabilization. Pacific Institute reports estimated economic costs of building protective structures as an adaptation strategy to sea-level rise. This study estimates that SLO County will need 7.4 miles of new levee and 5.4 miles of new seawall (for a total of 13 miles) to guard against flooding from a 1.4 m sea level rise. While the initial capital cost is estimated at $210 million for these coastal defenses, the Pacific Institute estimates operation and maintenance of such structures would cost about $21 million per year.[clxxxi] The cost of building new seawalls in California can run anywhere from $2,600 to $4,800 per linear foot. However, other experts have estimated that small scale seawalls can cost $3,000 or more per linear foot and larger ones (such as one in San Francisco) costing up to $7,000 per foot).[clxxxii] The actual cost will vary by needs and physical situation. Other adaptation options – albeit dependent on physical location and feasible alternatives, is the relocation of transportation infrastructure. Costs of such relation have not been assessed to date on a state- or countywide basis.

One major obstacle for San Luis Obispo's adaptation efforts for its transportation infrastructure is the fact that the county currently is <u>not</u> marked as one of the State's priority regions for infrastructure protection from climate change impacts.[clxxxiii] While this non-priority status means that the county's transportation infrastructure is not as vulnerable to climate change impacts as other regions in California, it could have major implications in terms of receiving State funding and other support for adaptation of this infrastructure.

Good maintenance of road infrastructure, however, is integral to, and essential for, the county's ability to provide emergency services to its residents. Thus failure to adapt transportation infrastructure will undermine the preparedness and ability to respond effectively to disasters.

4.5 Emergency Preparedness and Services: Natural Hazards

Well functioning emergency planning, preparedness, and services are critical in times of disaster. Climate change-driven impacts are likely to lead to an increase in the number of climate-related disasters, increasing the demand for emergency services. Over time, this implies a need for increasing budgets or contingency planning to continue to be able to respond effectively.

The current emergency response time and facilities cross the have been mapped (Figure 0); the map shows that response time is fast for highly populated regions yet over 20 minutes in the more isolated rural regions, creating geographic differences in response capacities and thus in vulnerability. Big institutions such as Cal Poly or the State Hospital have their own (albeit coordinated) emergency response plans.[clxxxiv]

The County Office of Emergency Services (OES) offers educational materials to individuals on how to respond to heat and cold waves, storms, flooding, hazardous materials, wildfires, earthquakes, and tsunamis.[clxxxv] Currently, OES's information does not mention climate change, thus does not use its position and the opportunity of weather-related disasters to educate county residents about the growing risks from climate change.

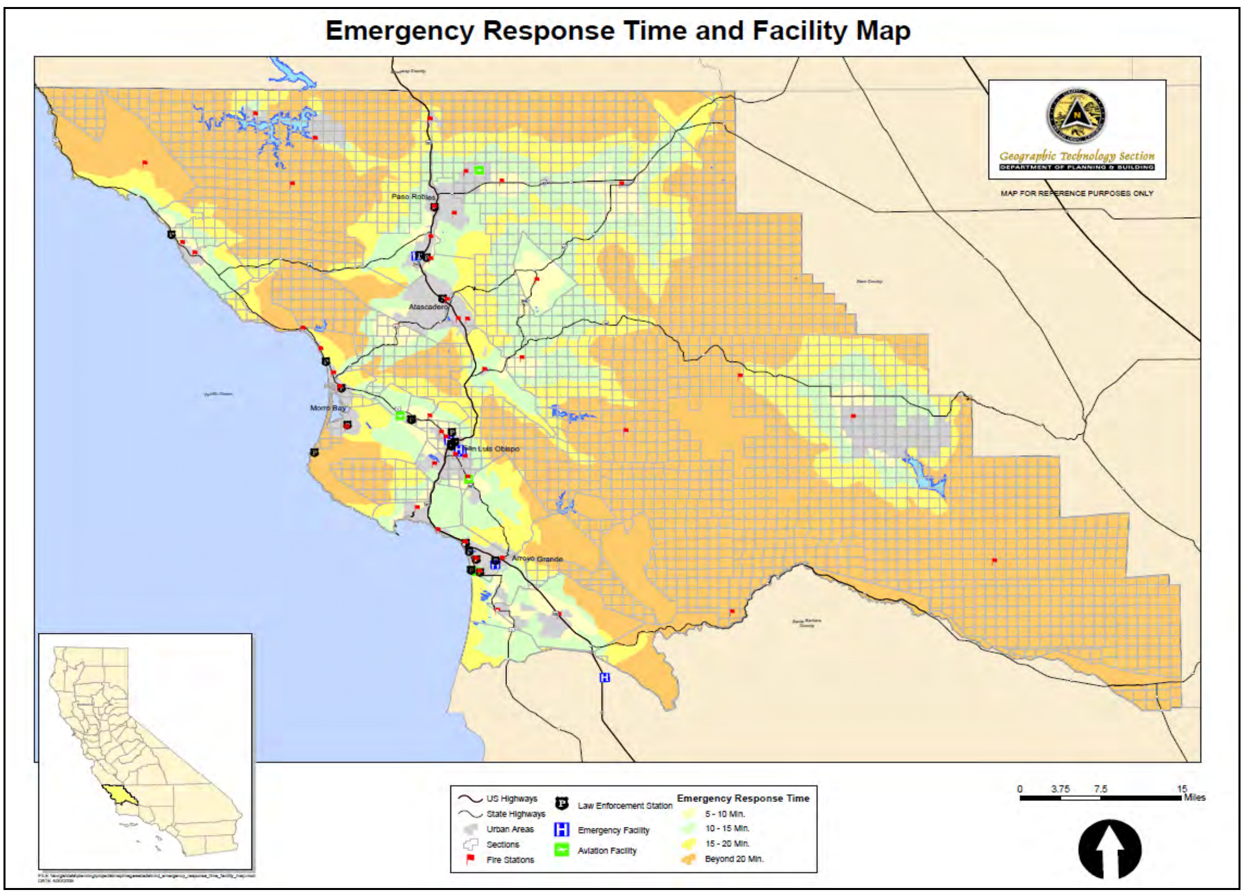


Figure 31: San Luis Obispo County emergency response time and facility map shows slower response time to more remote/rural areas of the county

(Source: SLO County for CDF 2000)[clxxxvi]

Given the growing risk of climate-related disasters, below we explore emergency preparedness plans and specific geographic vulnerabilities for specific types of natural disasters.

Flooding and Levee Failure

Climate change is projected to intensify the hydrological cycle and thus lead to an increase in intense downpours in California, even if the overall amount of precipitation changes little or decreases somewhat toward the end of the century.[clxxxvii] Historically, flooding in the county has been the direct result of high rainfall events. While this is currently considered a medium hazard risk based on the county's 2005 risk assessment,[clxxxviii] climate change is expected to increase the vulnerability if it increases the severity of such events. San Luis Obispo County has developed a Dam and Levee Failure Evacuation Plan highlighting the existing vulnerabilities and response plan in the case of flooding from dam failure.[clxxxix] This report was revised in July 2008 and the first portion of the report contains detailed descriptions of flood risks from each dam and levee and infrastructure (roads, railways, and special facilities, such as waste water treatment plants) that would be flooded. The report notes specifically that the Santa Maria River Levee did not receive certification in 2006 by the Army Corps of Engineers, meaning that assessments show that it is not likely to withstand a 100-year flood. Not receiving certification means that the structure does not provide the expected level of safety (e.g. against a 100-year flood). According to the USACE:

"Following the Hurricane Katrina disaster the Army Corps of Engineers began a systematic assessment of flood control structures and facilities throughout the United States to measure their risk of potential failure. After their assessment of the Santa Maria River Levee, in March 2006, the Army Corps of Engineers placed the Santa Maria River Levee on the nationwide list of levees at risk of failure and declined to certify that it could withstand a 100-year flood. The Flood Control District of the county of Santa Barbara is the lead agency responsible for the levee."[cxc]

Given that Santa Barbara County is responsible for the levee, this flood risk raises the need for San Luis Obispo County to work with neighboring counties in order to develop adaptation strategies that adequately protect its residents. Another option, involving difficult trade-offs, was recently proposed by the county flood control agency when it decided to allow selected farmland to flood in the case of an emergency in order to protect more urbanized areas from being inundated. [cxci]

The County Dam and Levee Failure Evacuation Plan describes the existing flood vulnerabilities from potential dam breaks. Even without more refined climate projections for rainfall in the region, statewide studies anticipate more extreme/severe rainfall from storms; therefore, management could expect an increased risk of dam breaks. There are two potential dam ruptures that would have major impact to life and property, according to the County's Evacuation Plan. First, the breaking of Lopez Dam would have "potential major impact to life and property in the communities of Arroyo Grande, Grover Beach, Halcyon, Oceano and Pismo Beach".[cxcii] The evaluation plan notes that between 10,000 and 12,000 people could be affected if the dam broke while the reservoir was at full capacity, flooding Highway 1 and facilities such as a hospital, elementary schools, and elder care facilities. In addition, if Whale Rock Dam were to rupture while the reservoir were at full capacity, it could affect approximately 1,500 people and a water treatment plant, while flooding portions of the main artery, Highway 1. A rupture of this dam is considered in the plan to have potentially "major impact to life and property to approximately one third of the community of Cayucos".[cxciii]

Complete dam failure of the Salinas Dam (owned by the U.S. Army Corps of Engineers, but operated by San Luis Obispo County Flood Control) would impact approximately 1,000-2,000 residents and business occupants, as well as rail lines and major transportation routes of Highways 101, 41, 46, and 58. This would also put the Atascadero State Hospital within the flood zone.[cxciv]

Landslides

Landslides often follow heavy rains, especially in areas previously affected by wildfires and in mountainous terrain where soil is exposed. Given that both wildfires and the severity of heavy rains may increase with climate change, landslide risks may also increase. Figure 31 below shows the degree of landslide risk based on current conditions. Those areas that are red or orange are areas that are especially at high risk (exposure). The map suggests that major sections of Highway 1, 101, 41, 46, and 166 (the latter runs along the southern edge of the county) are in high landslide risk zones, thus affecting transportation infrastructure, major traffic arteries, and the county's emergency response capability.

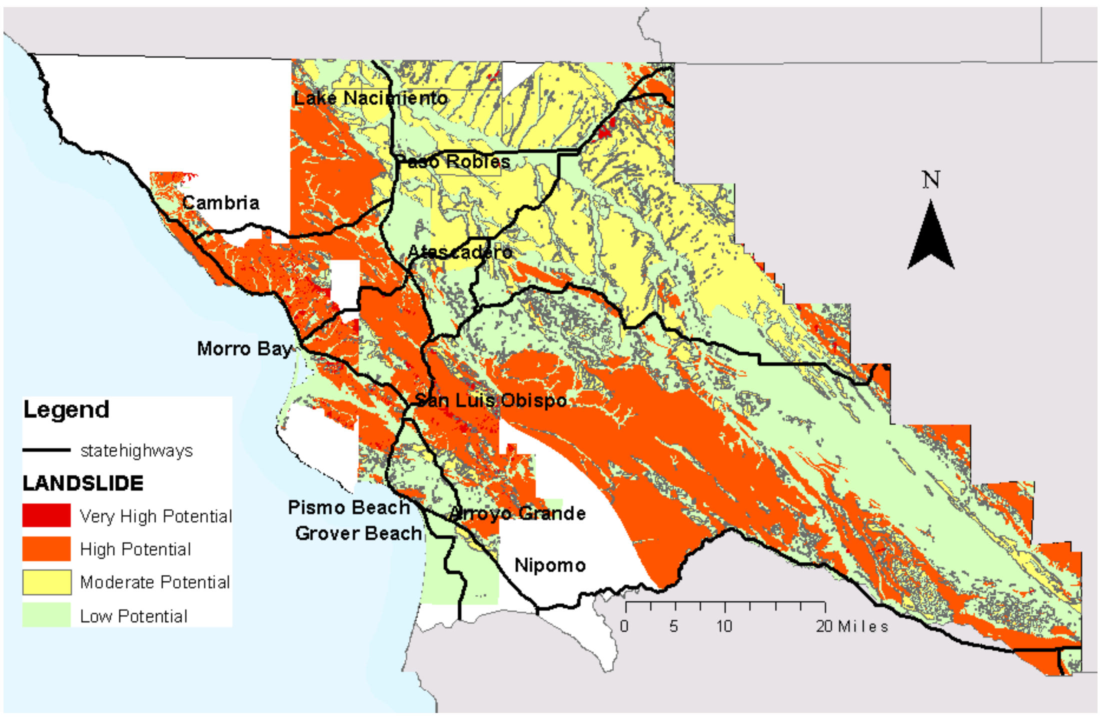


Figure 32: Landslide risk across San Luis Obispo County

(Source: data from San Luis Obispo County, Department of Planning and Building 2001)

Wildfire

Wildfires are a hazard of major concern in San Luis Obispo County given that the region is "one of the worst fire environments in the State of California for large damaging wildfires".[cxcv] The County's 2005 Local Hazard Mitigation Plan lists wildfires of high to very high severity as having a high to very high probability of occurring. The risk of fires is highest in the late summer and fall, making this the historical "fire season." Not only do wildfires require a large amount of financial, water and human resources to fight (Figure2), they also put important infrastructure as well as species, ecosystems and the goods and services they supply at risk. The Highway 41 Fire in 1994, for example, shut down two major highways, caused power outages, and destroyed radio and TV communication towers, cutting off communication to residents, and even hampering some fire fighting communication.

Figure 33: Wildfire is projected to increase in SLO County as temperatures increase, extremely hot days become more frequent, and the vegetation and soils dry out more readily

(Photo: U.S. Forest Service)

Wildfires can cause harm to people, housing, commercial and industrial structures, and agriculture (burning crops, harming soil and water).[cxcvi] According to state maps showing fire hazard severity zones, San Luis Obispo County has several high hazard zones along the coast and in inland mountain ranges, while the northwestern part of the county and some southern portions experience no to low fire hazards (Figure 34).[cxcvii]

The California Department of Forestry and Fire Protection (Cal Fire) together with San Luis Obispo County Fire provide fire protection and services to 1.5 million of the 2.1 million acres in the county.[cxcviii] Their service area includes the unincorporated portions of the county, State Responsibility Areas, and the City of Pismo Beach, Los Osos, and the town of Avila Beach.[cxcix] Important infrastructure that is located within this service area includes Diablo Canyon Nuclear Power Plant, the county airport, Hearst Castle, and Tosco Oil Refinery, the pier at Avila Beach, and Camp San Luis Obispo. Cal Fire in San Luis Obispo County has developed "pre-plans", i.e., ready-made plans for how to respond to fires in certain areas.[cc] Cal Fire/County Fire update their Fire Management Plan annually, which provides frequent opportunity to incorporate changing climatic, vegetation, and land use conditions. And indeed, according to the California statewide adaptation strategy, "state fire fighting agencies should begin immediately to include cc impact info into fire program planning to inform future planning efforts."[cci]

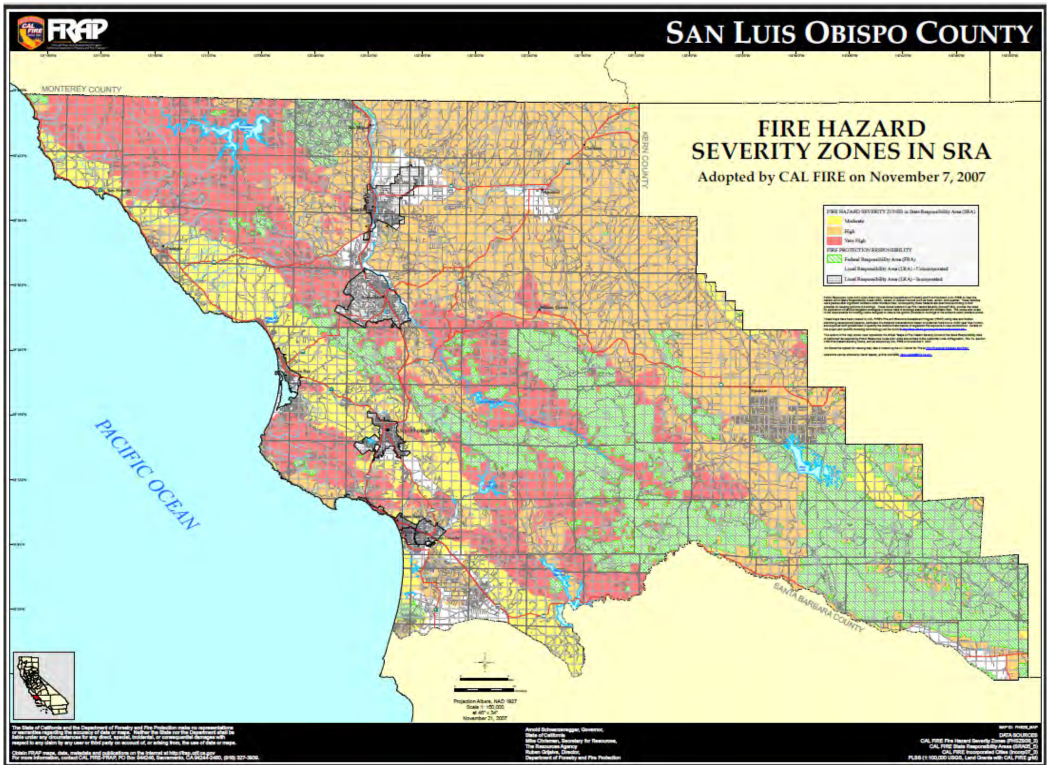


Figure 34: Fire hazard severity zones. Very high severity of fire hazard is in pink, high is in orange, and moderate is in yellow. Areas under federal responsibility are green. Those areas with gray and/or white are the responsibility of the local jurisdiction.

(Source: Cal Fire)[ccii]

Most of the areas designated as very high severity hazard for fire are in the Santa Lucia Mountains and also include the region surrounding Atascadero (Figure33 and Figure 34). These areas contain the hazardous combination of vegetation fuel, topography (steep slopes make fires burn faster), and human proximity.[cciii] Interestingly, fire stations are unevenly distributed across the county, and some high-hazard fire areas have no or only very few fire stations (Figure).

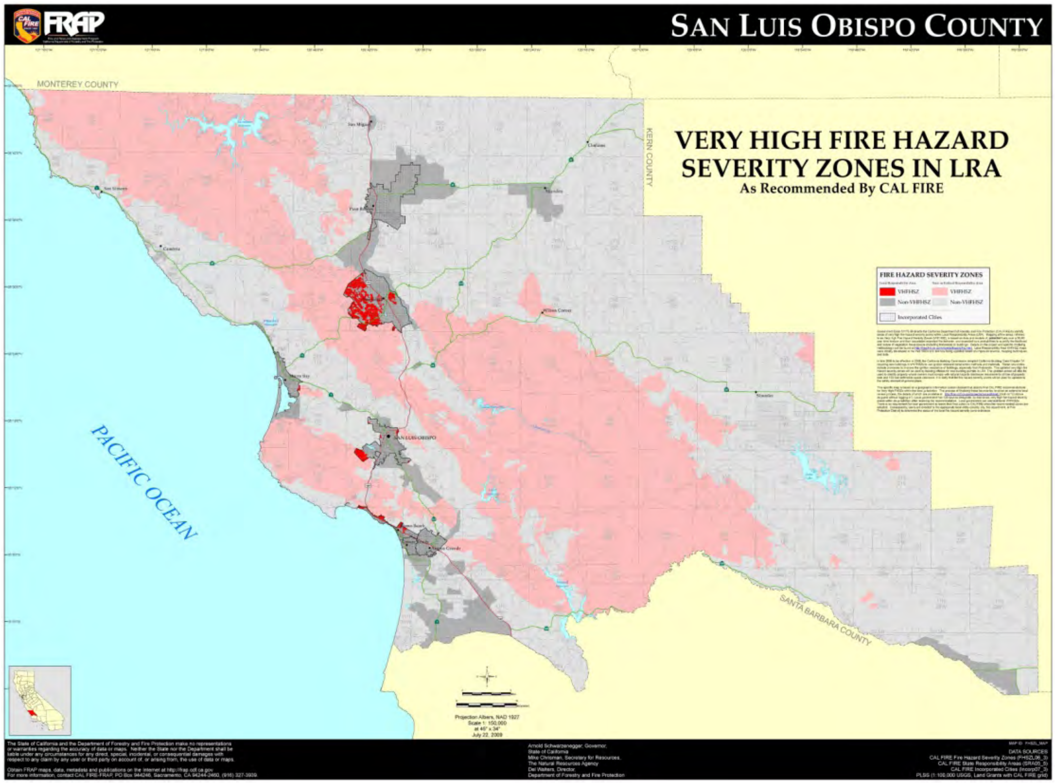


Figure 35: Map of areas designated as high fire hazards in the county

(Source: Cal Fire)[cciv]

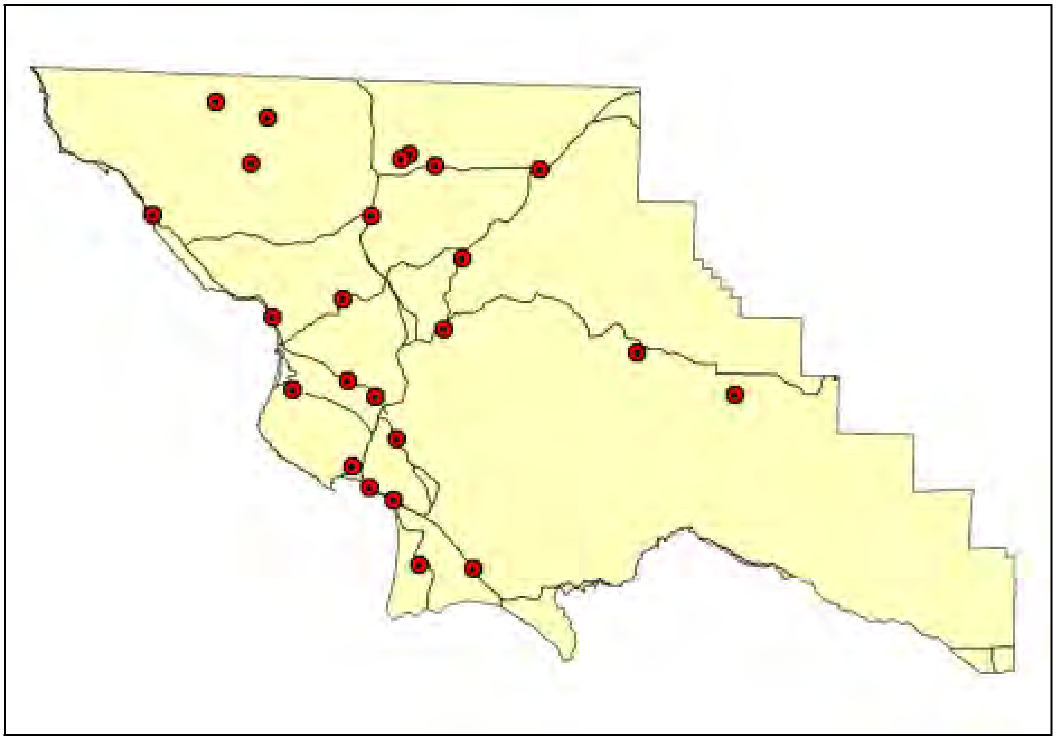


Figure 36: Location of fire stations in San Luis Obispo County. There are few fire stations in the south inland region which is designated as a high fire hazard severity zone in Figure.

(Sources: SLO County, Cal Poly, and Fugro 2000)[ccv]

Model projections show that climate change will increase the frequency and size of wildfires in the western United States in general and in many regions across California as well.[ccvi] The county's existing vulnerabilities to wildfires thus are likely be exacerbated by climate change by increasing the length of the dry summer and thus fire season, and related changes in vegetation. As pines are replaced by oaks and grassland, for example, fire is likely to speed the conversion. Confounding factors that increase vulnerabilities of certain areas (such as the City of San Luis Obispo) include the following:

- Urban areas are taking water stored away for fire emergencies to use in residential areas (see water supply section above).
- Some areas have longer response times than others, including Diablo Canyon, which includes critical electrical grid infrastructure surrounded by dense vegetation (high fuel potential).
- Moreover, the County's Local Hazard Mitigation Plan (2005) discusses concern that population growth in the county could increase ignition risks and make fuel conditions more dangerous, which in combination with climate change could lead to a significant increase in wildfires.[ccvii]

By contrast, some areas in the county have demonstrated lower risk to wildfires than others based not only on their microclimate (the coastal region tends to be cooler with more moisture, creating lower risk), but also from the density of development and type of vegetation that surrounds the developed areas. Cayucos and Oceano, for example, are less vulnerable to wildfires because "the low-growing native grasses and shrubs found in these communities present a minimal vegetative fuel source and [have] a corresponding low wildfire risk".[ccviii]

San Luis Obispo County already takes a number of steps to reduce its vulnerability to fire, but wildfires are inevitable in the region given its exposure and sensitivity derived from the climate, topography, and vegetation. Wildfire is also a vital component of the county's natural ecosystems. Strategies for preparing for increasing fires in the future is presented in the County's Local Mitigation Hazard Plan: communities should design buffer zones surrounding areas to reduce fuel adjacent to high population centers, provide sufficient emergency water supply (although this presents a critically limiting factor as climate change continues); and build and remodel existing structures to be more fire resistant. Prescribed burning that supports natural systems while preventing catastrophic fire is another important tool.

4.6 Energy: Nuclear Power Plant and Electricity Transmission

Energy-related infrastructure is another important lifeline for the county. Maybe of foremost interest and importance is the Diablo Canyon Nuclear Power Plant. It is located directly along the shoreline and uses seawater intake for cooling. While highly fortified by seawalls, the facility itself and the infrastructure upon which it depends is directly exposed to the onslaught from coastal storms, flooding and erosion. As discussed previously, erosion and flooding (storm surges) will be exacerbated by sea-level rise. To maintain the current level of protection, the utility will need to invest in more frequent maintenance and upgrade as sea-level rise accelerates. At the time of this report, no information could be found, whether the utility has already begun reviewing its preparedness and protection plans.

The Fukushima Daiichi nuclear accident following the earthquake and tsunami in Japan in March 2011 illustrated the enormous vulnerability of coastal nuclear power plants to known, but unpredictable hazards. Following the event, the Diablo Canyon power plant's emergency response measures and systems were inspected and found adequate (after several adjustments were made).[ccix] As sea-level continues to rise, and at increasing rates, the safety margins for less severe coastal storm events, and potentially catastrophic events such as large tsunamis need to be frequently reviewed. The adequate protection of such facilities will get more difficult the higher sea level rises, and relocation would be enormously expensive and difficult; thus the Diablo Canyon power plant will need to remain a high priority risk management focus for the county (and beyond).

In preparation for potential problems from the power plant, the county provides a series of emergency evacuation route maps showing the roads emergency planning relies on (Hwy 1 going north, 41 going east, and 101 going south) (Figure36).[ccx] The county also provides public information about evacuation routes.[ccxi] At this time, this information makes no mention of sea-level rise and how the power plant intends to adapt its emergency response plan for growing risks of flood-related interruptions or problems due to climate change.

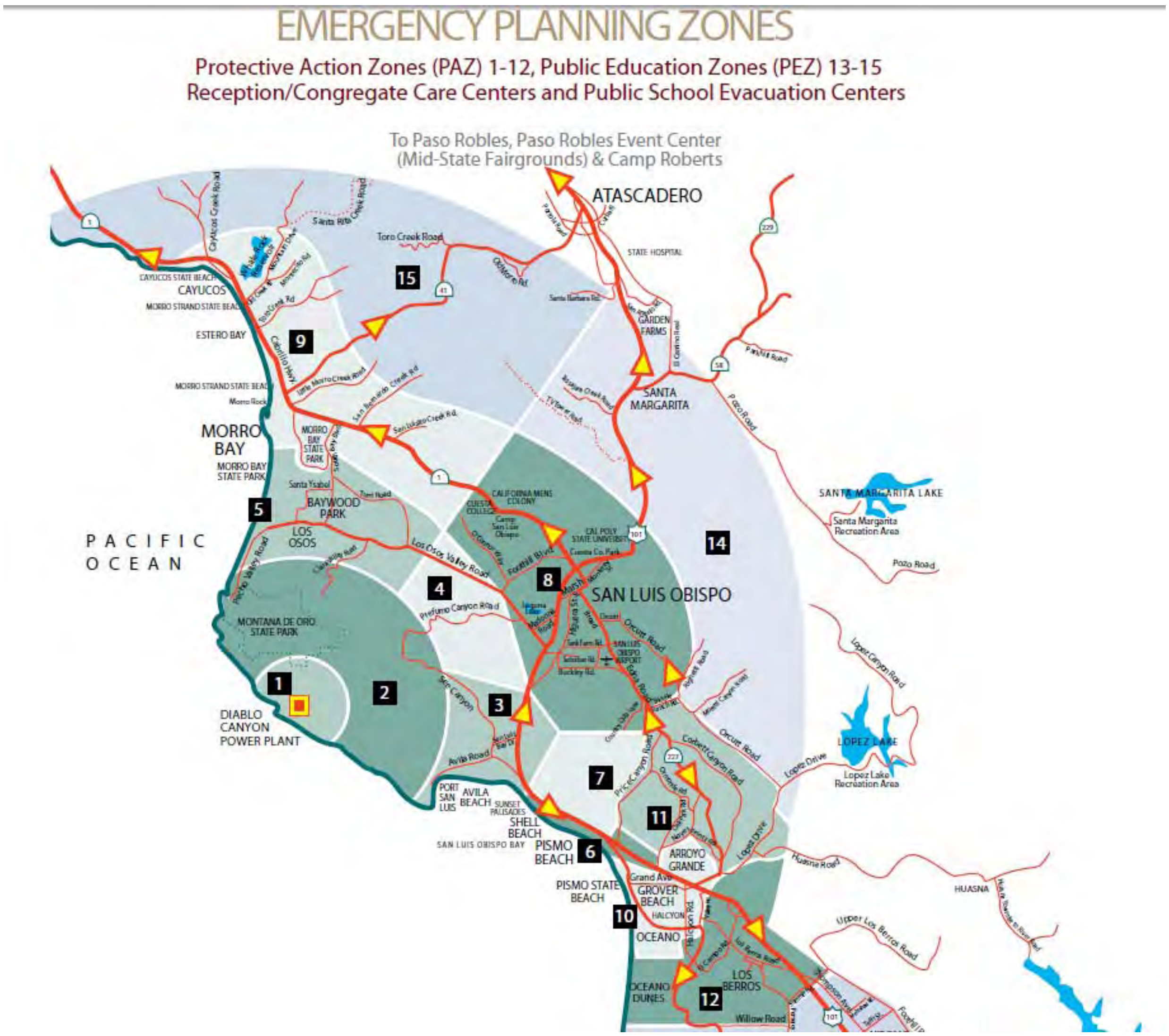


Figure 37: Map of emergency planning routes in case of emergency at the Diablo Canyon Power Plant. Red lines indicate escape routes and yellows are direction of route.

(Source: San Luis Obispo County)[ccxii]

Power plants also depend on adequate water supplies and safe electricity transmission lines. With direct access to cold coastal waters, water is not an issue at Diablo, but transmission lines may be vulnerable to the impacts of extreme events such as storms fires and landslides. As Figure 31 shows, inland from the Diablo plant, landslide hazards are high; similarly – as shown in Figure 34 – transmission lines from the plant inland cross through high-hazard fire zones. Thus, with both risks potentially increasing, the risk of cutting off critical electricity supplies is a significant, and potentially costly issue for the county.

Section 5: Conclusions

Climate change will impact San Luis Obispo in a variety of ways, some potentially severe, with direct impacts on its people, economic sectors, its supporting infrastructure and services, as well as the natural environment on which much of the county's economy, rural character, and quality of life depends. The discussion in Section 2 (Communities), 3 (Economic Sectors) and 4 (Infrastructure and Community Services) have detailed, to the extent available, current vulnerabilities to weather- and climate-related changes and extreme events in San Luis Obispo, and how climate change may exacerbate or change them in the decades ahead. While most climate change-risks are not fundamentally new or different, most climate-related risks are expected to increase in the future, thus placing additional strains on scarce public preparedness and response monies. The impacts to these sectors will differ based on current and future vulnerabilities to weather- and climate-related changes and extreme events in San Luis Obispo County.

The critical vulnerabilities that emerged from this initial assessment include the following:

- Differential social vulnerabilities, with the elderly, infants, already ill individuals, socially and culturally isolated individuals, and outdoor (migrant) workers – especially in the hotter inland areas – experiencing relatively greater exposure, sensitivity and/or lower adaptive capacity. These social vulnerabilities matter more or less with regard to different climate-related hazards. A growing and ageing population will create increasing challenges in the future, whereas economic prosperity and dense social networks could reduce future vulnerabilities.
- Several institutionalized populations are of special concern due to their location in flood zones or landslide and fire risk zones (hospital, college, prison etc.), and the challenge of evacuating large numbers of people in short periods.
- Important regional agriculture – particularly wine and cattle – through its dependence on scarce water resources and sensitivity to heat is highly vulnerable to climate change, especially smaller farmers, with less diverse crops and limited resources to invest in adaptive technologies.
- Coastal residents along eroding beaches and cliffs and in low-lying areas are particularly vulnerable to sea-level rise and related hazards such as flooding, erosion and cliff failure. While many coastal residents are wealthy, many are also elderly and depend on coastal transportation (and evacuation) routes that are at risk from multiple climate-sensitive hazards (erosion, flooding, wildfires, and landslides).
- Coastal areas and the agricultural rural landscape are keys to the county's tourism industry. While impacts on tourism are mostly indirect and difficult to predict because changing visitors' perceptions about the attractiveness and safety of the region may be as important as the climate change impacts on agriculture and coastal areas themselves, it is reasonable to assume that tourism may be negatively impacted in agriculture and coastal areas are. Socioeconomic impacts are likely most challenging for low-income earners and small establishments.

- Crucial supporting infrastructure and services will experience greater demands or challenges as climate change-related risks grow, including for already scarce water supplies, transportation and energy infrastructure, and emergency preparedness and services. A number of climate-related hazards (such as landslides and fire) may interrupt these critical services more frequently than in the past.

Clearly, the county faces many challenges, albeit surmountable ones with timely and adequate planning and preparation. While difficult choices will need to be made, City and County governments are in the advantageous position of beginning their adaptation efforts early.[ccxiii] Adaptation efforts carefully vetted against other policy goals, including greenhouse gas mitigation efforts, pose an important opportunity to move San Luis Obispo County toward greater long-term environmental, social, and economic sustainability.

Appendix A:

Social Vulnerability Index Analysis

The Social Vulnerability Index (SoVI) is a well-established index method applied in natural disaster research to provide an objective snapshot of relative social vulnerability for a specified region. The social vulnerability index (SoVI) uses 32 variables of Census data to capture generic indicators of sensitivity, adaptive capacity, and social exposure. These variables are statistically integrated to create a single vulnerability score for a given census unit (census tract, block group, county, etc, depending on research needs and data availability). The standard deviations of the resulting scores are displayed visually using GIS mapping, showing patterns of how and where vulnerability ranges within a given region. The following provides a summary of steps used to produce the map (for a more detailed statement of methods, refer to 'The SoVI Recipe', as described on the Hazards & Vulnerability Research Institute: http://webra.cas.sc.edu/hvri/docs/SoVIRecipe.pdf).

In the study of San Luis Obispo County, the analysis was conducted for a single county using US Census tract-level data. The 32 variables collected for this study came from the US Census (Data Ferret *beta* database) from the year 2000. Principal Components Analysis was conducted on the normalized data, resulting in a set of factors. Each factor is 'composed' of a set of one or more variables that highly correlate to it (dominant variables listed in Table 1). Socio-economic status, to which seven of the variables were highly correlated, was the largest contributor to vulnerability for this county. This factor explains 24% of the variation within the dataset analyzed, and Factors 1-6 explain 75% of the variation in the dataset. Table 1 shows which variables were most highly correlated to each factor and the degree to which each factor explains the variation in the dataset.

Factor	**Name (representing dominant variables)**	**Dominant variables**	**Percent variance explained**
1	**Socio-economic status**	• Per capita income • % earning >$100K • % renters • number of physicians per 100K people • % employed in transportation industry • % living below federal poverty level • % female	**23.7**
2	**Race/ethnicity and age**	% Native American population % Hispanic/Latino pop. % pop <5 years	**17.0**

		Median rent % population over 25 that has not graduated from high school	
3	**Race and gender**	% African American population	**11.1**
4	**Population structure and housing**	% population 65+ years Median age % housing as mobile % >65 collecting social security # people per household	**9.2**
5	**Labor**	% employed in service industry % population immigrated within past 10 years % labor force female	**8.4**
6	**Rural and agriculture**	% area in rural farm % population working in agriculture % land designated as urban	**5.6**
7	**House value and unemployment**	Median house value % labor force unemployed % Asian decent	**3.9**
8	**Nursing home residents**	% nursing home residents	**3.3**

References

[i] Koopman, M. E., R. S. Nauman and J. L. Leonard. 2010. Projected Future Climatic and Ecological Conditions in San Luis Obispo County. National Center for Conservation Science and Policy Report. 33 pages.

[ii] Koopman, M. E., R. S. Nauman and J. L. Leonard. 2010. Projected Future Climatic and Ecological Conditions in San Luis Obispo County. National Center for Conservation Science and Policy Report. 33 pages.

[iii] California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[iv] Go to www.cal-adapt.org and enter the county name, a city, or a zipcode to optain finer-scaled information for higher and lower emissions trajectories.

[v] http://www.climatechange.ca.gov/adaptation/; see in particular the Appendix in which key concepts are defined. The State's terminology reflects common understanding in the scientific literature, especially the (social scientific) climate change literature.

[vi] Romero Lankao, P. and JL. Tribbia. 2009. Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the Fifth Urban Research Symposium 2009: page 4.

[vii] Romero Lankao, P. and JL. Tribbia. 2009. Assessing patterns of vulnerability, adaptive capacity and resilience across urban centers. Paper presented at the Fifth Urban Research Symposium 2009: page 4.

[viii] California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[ix] Kasperson, J.X. , R.E. Kasperson, and B.L. Turner II. 2009. Vulnerability of coupled human-ecological systems to global environmental change. In: *Human Footprints on the Global Environment: Threats to Sustainability*, eds. E.A. Rosa, A. Diekmann, T. Dietz, and C.C Jaeger, 231-294, Cambridge, MA: The MIT Press.

[x] California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[xi] California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF; Appendix.

[xii] Miller, F., H. Osbahr, E. Boyd, F. Thomalla, S. Bharwani, G. Ziervogel, B. Walker, J. Birkmann, S. Van der Leeuw, J. Rockström, J. Hinkel, T. Downing, C. Folke, and D. Nelson 2010. Resilience and

vulnerability: complementary or conflicting concepts?. *Ecology and Society* **15**(3): 11. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art11/

[xiii] San Luis Obispo Council of Governments. *2004 Regional Profile*. Accessed online February 2010 at http://library.slocog.org/PDFs/Census/RegionalProfile/Chap%201%20Introduction.pdf.

[xiv] Additional, more specific, or frequently updated climate information can be obtained from the Western Regional Climate Center at: http://www.wrcc.dri.edu/index.html.

[xv] The NCCSP Report by Koopman, Nauman, and Leonard (2010) presents maps of temperature, precipitation, and wildfire changes based on downscaled modeled outputs produced by the Pacific Northwest Research Station of the USDA. The MAPPS Team used the IPCC's A2 scenario (referred to as "business as usual" meaning that carbon emissions would continue to increase at the same rate from the year 2000) and produced output of this scenario from three global atmospheric-ocean interaction models: CSIRO, MIROC, and HADCM (Hadley model from the UK). The modeled output also includes projections for vegetation and wildfire, which were devised using the MAPSS team vegetation model (MCI). http://nccsp.org/climate-change/preparing-local-communities-and-ecosystems-for-climate-change

[xvi] SLO County Board of Supervisors. 2007. San Luis Obispo County Hazard Mitigation Plan. County Report. (http://www.slocountyoes.com/lhmp_bos.pdf, page 12, accessed last April 10, 2010)

[xvii] Koopman, M. E., R. S. Nauman and J. L. Leonard. 2010. Projected Future Climatic and Ecological Conditions in San Luis Obispo County. National Center for Conservation Science and Policy Report. 33 pages.

[xviii] Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, Miller NL, Moser SC, Schneider SH, Cahill KN, Cleland EE, Dale L, Drapek R, Hanemann RM, Kalkstein LS, Lenihan J,Lunch CK, Neilson RP, Sheridan SC, Verville JH. 2004. Emissions pathways, climate change, and impacts on California. *Proceedings of the National Academy of Science*, 101(34):12422-7 (http://www.ncbi.nlm.nih.gov/pubmed/15314227).

See also more recent studies, none of which however specifically focus on SLO:

Sheridan, and L. Kalkstein. 2011. A Spatial Synoptic Classification Approach to Projected Heat Vulnerability In California Under Future Climate Change Scenarios. Research report prepared for the California Air Resources Board and the California Environmental Protection Agency. Sacramento, CA.

[xix] This projection was not originally included in the Koopman et al. report. The information is based on data generated with the extreme heat tool for the city of San Luis Obispo, at www.cal-adapt.org.

[xx] Johnstone, J. A. and Dawson, T. E. 2010. Climatic context and ecological implications of summer fog decline in the coast redwood region. *Proceedings of the National Academy of Sciences, 107*(10): 4533-4538.

[xxi] Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California 2008 Climate Change Scenarios Assessment. California Climate Change Center. CEC- 500-2009-014-F.

[xxii] Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California 2008 Climate Change Scenarios Assessment. California Climate Change Center. CEC- 500-2009-014-F.

Dettinger, M., H. Hidalgo, T. Das, D. Cayan, N. Knowles. 2009. Projections of Potential Flood Regime Changes in California – Final Report. PIER Report (CEC-500-2009-050-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-050-F.

[xxiii] Westerling, A. L., B. P. Bryant, H. K. Preisler, T. P. Holmes, H. G. Hidalgo, T. Das, and S. R. Shrestha. 2009. Climate Change, Growth, and California Wildfire. California Climate Change Center. CEC-500-2009-046-F.

[xxiv] Koopman, M. E., R. S. Nauman and J. L. Leonard. 2010. Projected Future Climatic and Ecological Conditions in San Luis Obispo County. National Center for Conservation Science and Policy Report. 33 pages.

[xxv] Cayan, D., M. Tyree, M. Dettinger, H. Hidalgo, T. Das, E. Maurer, P. Bromirski, N. Graham, and R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California 2008 Climate Change Scenarios Assessment. California Climate Change Center. CEC- 500-2009-014-F.

[xxvi] Sea-Level Rise Task Force. 2010. "State of California Sea-Level Rise Interim Guidance Report." (California: Coastal and Ocean Working Group of the California Action Team and Ocean Protection Council, October 2010).

[xxvii] Workshop was organized by the NCCSP/The Geos Institute.

[xxviii] The natural ability of wetlands to accumulate soil and organic matter may allow them to keep up with the rise in sea level. The greater the rate of sea-level rise, the faster the natural vertical growth of wetlands would have to be to keep up. . When the rate of sea-level rise exceeds the rate of vertical growth, wetlands begin to drownFor further discussion on this topic, see the following literature:

Morris, James T., P. V. Sundareshwar, Christopher T. Nietch, Björn Kjerfve, and D. R. Cahoon. 2002. Responses of coastal wetlands to rising sea level. *Ecology* 83:2869–2877.

Reed, D.J., D.A. Bishara, D.R. Cahoon, J. Donnelly, M. Kearney, A.S. Kolker, L.L. Leonard, R.A. Orson, and J.C. Stevenson. 2008. Site-Specific Scenarios for Wetlands Accretion as Sea Level Rises in the Mid-Atlantic Region. Section 2.1 in: Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1, J.G. Titus and E.M. Strange (eds.). EPA 430R07004. U.S. EPA, Washington, DC (available at http://www.epa.gov/climatechange/effects/downloads/section2_1.pdf).

[xxix] Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore, 2009. Roadways vulnerable to a 100-year coastal flood with a 1.4 meter sea level-rise (map), In *The Impacts of Sea-Level Rise on the California Coast*. A Paper from the California Climate Change Center (CEC-500-2009-024-F).

[xxx] San Luis Obispo Council of Governments. *2004 Regional Profile*. Accessed online February 2010 at http://library.slocog.org/PDFs/Census/RegionalProfile/Chap%201%20Introduction.pdf.

[xxxi] Fedstats website. Available at http://www.fedstats.gov/qf/states/06/06079.html.

[xxxii] US Census Bureau, available at: http://quickfacts.census.gov/qfd/states/06/0668154.html.

[xxxiii] SLO County Department of Planning and Building. 2009. Housing Element 2009-2014: County of San Luis Obispo General Plan. Amended December 8, 2009. Available at http://www.slocounty.ca.gov/Assets/PL/Elements/Housing+Element.pdf

[xxxiv] US Census Bureau, available at: http://quickfacts.census.gov/qfd/states/06/06079.html.

[xxxv] Basu, Rupa and Bart Ostro. 2009. *A Multi-County Analysis Identifying the Vulnerable Populations for Mortality Associated with High Ambient Temperature in California*. PIER Research Report, CEC-500-2009-035-D, Sacramento, CA: California Energy Commission.

Drechsler, Deborah M. 2009. Climate Change and Public Health in California. PIER Research Report, Sacramento, CA: California Energy Commission.

Green, Rochelle, Rupa Basu, Brian Malig, Rachel Broadwin, Janice Kim, and Bart Ostro. 2009. *The Effect of Temperature on Hospital Admissions in Nine California Counties*. PIER Research Report, CEC-500-2009-037-D, Sacramento, CA: California Energy Commission.

Iacobellis, Sam F., Joel R. Norris, Masao Kanamitsu, Mary Tyree, and Daniel R. Cayan. 2009. *Climate Variability and California Low Level Temperature Inversions*. PIER Research Report, CEC-500-2009-020-D, Sacramento, CA: California Energy Commission.

Millstein, Dev E. and Robert A. Harley. 2009. *Impact of Climate Change on Photochemical Air Pollution in Southern California*. PIER Research Report, CEC-500-2009-021-D, Sacramento, CA: California Energy Commission.

Ostro, Bart D., Lindsey A. Roth, Rochelle S. Green, and Rupa Basu. 2009. *Estimating the Mortality Effect of the July 2006 California Heat Wave*. PIER Research Report, CEC-500-2009-036-D, Sacramento, CA: California Energy Commission.

Sheridan, Scott, Katharine Hayhoe, and Laurence Kalkstein. 2009. *Estimating Climate Change Impacts from Atmospheric Circulation Patterns and Air Masses.* PIER Research Report, CEC-500-2009-031-D, Sacramento, CA: California Energy Commission.

[xxxvi] Bedworth, L. 2008. Climate Change and California's Public Health Institutions. A report of the Public Policy Institute of California prepared as part of the *Preparing California for a Changing Climate project*. Available at: http://www.ppic.org/main/publication.asp?i=858.

[xxxvii] California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. Sacramento, California. Available at: http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF, page 30.

[xxxviii] Office of Emergency Services. 2008. San Luis Obispo Dam and Levee Failure Evacuation plan. Available at: http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf.

[xxxix] Luber G, and Hess. 2007. J. *Climate change and human health in the United States*. *J of Env Health* 70(5):43-44.

[xl] Basu, Rupa and Bart Ostro. 2009. *A Multi-County Analysis Identifying the Vulnerable Populations for Mortality Associated with High Ambient Temperature in California*. PIER Research Report, CEC-500-2009-035-D, Sacramento, CA: California Energy Commission.

Drechsler, Deborah M. 2009. Climate Change and Public Health in California. PIER Research Report, Sacramento, CA: California Energy Commission.

[xli] California Health and Human Services Agency. 2003. Strategic Plan for an Aging California Population: Getting California Ready for the "Baby Boomers". (Accessed 1/27/2012, http://www.ccoa.ca.gov/res/docs/pubs/population.pdf).

[xlii] SLO County Department of Planning and Building. 2009. Housing Element 2009-2014: County of San Luis Obispo General Plan. Amended December 8, 2009. Available at http://www.slocounty.ca.gov/Assets/PL/Elements/Housing+Element.pdf

[xliii] SLO County is documented as having "Low AC Ownership" compared to other counties in California in CA Department of Public Health and Public Health Institute. 2008. Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies. Report No. 1: Heat-Related Illness and Mortality. Available at: http://www.energy.ca.gov/2008publications/DPH-1000-2008-014/DPH-1000-2008-014.PDF, page 21.

[xliv] Basher, R. 2006. Global early warning systems for natural hazards: systematic and people-centred. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 364*(1845), 2167-2182.

Mileti, D. S., Bandy, R., Bourque, L. B., Johnson, A., Kano, M., Peek, L., et al. 2006. *Annotated Bibliography for Public Risk Communication on Warnings for Public Protective Actions Response and Public Education*. Boulder, CO: Natural Hazards Center.

U.S. Environmental Protection Agency. 2006. *Excessive Heat Events Guidebook*. Washington, DC: United States Environmental Protection Agency, Office of Atmospheric Programs.

[xlv] Taeuber, C. and M.R. Graham. 2009. The Geographic Distribution and Characteristics of Older Workers in California: 2004. A U.S. Census Report (LED-OW04-CA). Available at: http://www.census.gov/prod/2009pubs/ledow04ca.pdf, page 11.

[xlvi] SLO County Air Quality Control District website. About Air Quality (webpage), Accessed April 2010. Available at: http://www.slocleanair.org/air/index.php.

[xlvii] County of San Luis Obispo Air Pollution Control District. Exceptional Event Document: Ozone – Eight Hour Average Wildland Fire Smoke, SL County – June & July 2008. Dated March 10, 2009. Available at: http://www.slocleanair.org/air/pdf/Exceptional%20Events/SLOCoAPCDExceptionalEvent.pdf.

[xlviii] Westerling, A., B. P. Bryant, H.K. Preisler, H G. Hidalgo, T. Das. 2009. Climate change, Growth, and California Wildfire – Final Report. PIER. Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-046-F ; B.P.

Bryant, A.L. Westerling . 2009. Potential Effects of Climate Change on Residential Wildfire Risk in California – Final Report. PIER. Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-048-F .

[xlix] CA Department of Public Health and Public Health Institute. 2008. Public Health Impacts of Climate Change in California: Community Vulnerability Assessments and Adaptation Strategies. Report No. 1: Heat-Related Illness and Mortality. Available at: http://www.energy.ca.gov/2008publications/DPH-1000-2008-014/DPH-1000-2008-014.PDF.

[l] SLO County. 2010. South County Phase 2 Particulate Study: SLO County Air Pollution Control District Executive Summary. February 2010. Available at: http://www.slocleanair.org/pdf/PM2-ExecSummary.pdf.

[li] SLO County Air Pollution Control District website. Emissions Inventory (webpage). Accessed April 2010, Available at: http://www.slocleanair.org/air/emissions.php.

[lii] S. L. Cutter, B. J. Boruff, and W. L. Shirley. 2003. Social Vulnerability to Environmental Hazards. *Social Science Quarterly* 84 (2): 242-261.

[liii] US Census Bureau, available at: http://factfinder.census.gov.

[liv] U.S. Census. 2008 State and County Quickfacts. Accessed March 2010, available at: http://quickfacts.census.gov/qfd/states/06000.html.

[lv] California Employment Development Department. Labor Market Info webpage. Accessed March 2010, Available at: http://www.labormarketinfo.edd.ca.gov/.

[lvi] American Community Survey, 2005-2007 Available at: http://factfinder.census.gov/servlet/NPTable?_bm=y&-geo_id=05000US06079&-qr_name=ACS_2007_3YR_G00_NP01&-ds_name=&-redoLog=false.

[lvii] SLO County Department of Planning and Building. 2009. Housing Element 2009-2014: County of San Luis Obispo General Plan. Amended December 8, 2009. Available at http://www.slocounty.ca.gov/Assets/PL/Elements/Housing+Element.pdf , see page 11

[lviii] City of San Luis Obispo Housing Element, January 2010 (Accessed May 2010). San Luis Obispo City Council Resolution Nos. 10146 and 10147 (2010 Series). Available at: http://www.ci.san-luis-obispo.ca.us/communitydevelopment/housingelement2009/councilapprovedjanuary2010.pdf

[lix] Fedstats website. Accessed February 2010 at: http://www.fedstats.gov/qf/states/06/06079.html.

[lx] Produced with data from http://factfinder.census.gov, estimates 2006-2008 SLO County, America Community Survey).

[lxi] Morrow, B.H. 1999. Identifying and mapping community vulnerability. *Disasters* 23(1):1-18.

Bolin, R.C. 1986. Race, Religion, and Ethnicity in Disaster Recovery. University of Colorado, Boulder.

Peacock, W.G. and C. Girard. 1997. Ethnic and Racial Inequalities in Disaster Damage and Insurance Settlements. In W.G. Peacock, B.H. Morrow and H. Gladwin (eds.) *Hurricane Andrew: Ethnicity, Gender, and the Sociology of Disaster*. Routledge, London.

[lxii] Fedstats website. Accessed February 2010 at: http://www.fedstats.gov/qf/states/06/06079.html.

[lxiii] Fedstats website. Accessed February 2010 at: http://www.fedstats.gov/qf/states/06/06079.html.

[lxiv] US Census Bureau, available at: http://factfinder.census.gov.

[lxv] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf.

[lxvi] US Census Bureau, available at: http://factfinder.census.gov.

[lxvii] California Employment Development Department. Labor Market Info webpage. Accessed March 2010, Available at: http://www.labormarketinfo.edd.ca.gov/.

[lxviii] City of San Luis Obispo Housing Element, January 2010 (Accessed May 2010). San Luis Obispo City Council Resolution Nos. 10146 and 10147 (2010 Series). Available at: http://www.ci.san-luis-obispo.ca.us/communitydevelopment/housingelement2009/councilapprovedjanuary2010.pdf

[lxix] City of San Luis Obispo Housing Element, January 2010 (Accessed May 2010). San Luis Obispo City Council Resolution Nos. 10146 and 10147 (2010 Series). Available at: http://www.ci.san-luis-obispo.ca.us/communitydevelopment/housingelement2009/councilapprovedjanuary2010.pdf, page 113.

[lxx] City of San Luis Obispo Housing Element, January 2010 (Accessed May 2010). San Luis Obispo City Council Resolution Nos. 10146 and 10147 (2010 Series). Available at: http://www.ci.san-luis-obispo.ca.us/communitydevelopment/housingelement2009/councilapprovedjanuary2010.pdf, page 113.

[lxxi] Cutter, Susan C., Christopher T. Emrich, Jeniffer J. Webb, and Daniel Morath. 2009. *Social Vulnerability to Climate Variability Hazards: A Review of the Literature*. Final Report to Oxfam America. University of South Carolina: Columbia, SC.

[lxxii] In addition, there is an estimated 1,300 faculty and approximately 1,650 staff at these two institutions.

[lxxiii] Cal Poly website. Quick Facts (webpage). Accessed April 2010, Available at: http://www.calpolynews.calpoly.edu/quickfacts.html.

[lxxiv] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf, page 7.

[lxxv] Mastrandrea, M., C. Tebaldi, C.P. Snyder, S.H. Schneider. 2009. Current and Future Impacts of Extreme Events in California. PIER Report (CEC-500-2009-026-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-026-F.

Cayan, D. M. Tyree, M. Dettinger, H. Hidalgo, T.h Das, E. Maurer, P. Bromirski, N. Graham, R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California – 2008 Climate Change Scenarios Assessment – Final Report. PIER Report (CEC-500-2009-014-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F.

Dettinger, M., H. Hidalgo, T. Das, D. Cayan, N. Knowles. 2009. Projections of Potential Flood Regime Changes in California – Final Report. PIER Report (CEC-500-2009-050-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-050-F.

[lxxvi] Sperling's Best Places website. Best Places to Live in San Luis Obispo County, California. Accessed March 2010, Available at: http://www.bestplaces.net/county/San_Luis_Obispo-California.aspx#.

[lxxvii] "Congregational "adherents" include all full members, their children, and other who regularly attend services." Available at: http://www.thearda.com.

[lxxviii] Between 1990 and 2000, the number of adherents increased by 32,687, see: http://www.thearda.com/mapsReports/reports/counties/06079_2000_Congregations.asp.

[lxxix] Association of Religion Data Archives website. County Membership Report (San Luis Obispo County). Available at: http://www.thearda.com/mapsReports/reports/counties/06079_compare_Adherents.asp.

[lxxx] Cutter, S. L., Boruff, B. J., & Shirley, W. L. 2003. Social Vulnerability to Environmental Hazards. *Social Science Quarterly 84*(1), 242-261.

[lxxxi] Research Department of the San Luis Obispo Chamber of Commerce. 2009. Community Economic Profile for the City of San Luis Obispo (with additional information about San Luis Obispo County). Available at: http://slochamber.org/Library/PDFs/2010CommunityEconomicProfile.pdf.

[lxxxii] American Community Survey, 2005-2007 Available at: http://factfinder.census.gov/servlet/NPTable?_bm=y&-geo_id=05000US06079&-qr_name=ACS_2007_3YR_G00_NP01&-ds_name=&-redoLog=false.

[lxxxiii] Research Department of the San Luis Obispo Chamber of Commerce. 2009. Community Economic Profile for the City of San Luis Obispo (with additional information about San Luis Obispo County). Available at: http://slochamber.org/Library/PDFs/2010CommunityEconomicProfile.pdf.

[lxxxiv] U.S. Bureau of the Census, 2007 Economic Census. Table 1: Selected Statistics by Economic Sector for San Luis Obispo County, CA. Accessed date: 3/5/2010, available at: http://factfinder.census.gov/servlet/GQRTable?_bm=y&-geo_id=05000US06079&-ds_name=EC0700A1&-_lang=en.

[lxxxv] Research Department of the San Luis Obispo Chamber of Commerce. 2009. Community Economic Profile for the City of San Luis Obispo (with additional information about San Luis Obispo County). Available at: http://slochamber.org/Library/PDFs/2010CommunityEconomicProfile.pdf.

[lxxxvi] Cayan, D. M. Tyree, M. Dettinger, H. Hidalgo, T.H. Das, E. Maurer, P. Bromirski, N. Graham, R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California – 2008 Climate Change Scenarios Assessment – Final Report. PIER Report (CEC-500-2009-014-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F.

lxxxvii

Green, R., R. Basu, B. Malig, R. Broadwin, J. Kim, B. Ostro. 2009. *The effect of temperature on hospital admissions in nine California counties*. A Report From the California Climate Change Center (CEC-500-2009-037-F), available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-037/CEC-500-2009-037-F.PDF.

Moser, S.C., G. Franco, S. Pittiglio, W. Chou, and D. Cayan. 2009. The Future is Now: An Update on the Climate Change Science Impacts and Response Options for California (May 2009). A Special Report From the California Climate Change Center. Available at: http://www.energy.ca.gov/2008publications/CEC-500-2008-071/CEC-500-2008-071.PDF.

[lxxxviii] Grismer, M., Synder, R.L, Faber, B. 2000. Avocado and citrus orchards along the coast may use less water. *California Agriculture* 54(3):25-29. Available at: http://ucanr.org/repository/CAO/landingpage.cfm?article=ca.v054n03p25&fulltext=yes.

[lxxxix] Research Department of the San Luis Obispo Chamber of Commerce. 2009. Community Economic Profile for the City of San Luis Obispo (with additional information about San Luis Obispo County). Available at: http://slochamber.org/Library/PDFs/2010CommunityEconomicProfile.pdf.

[xc] Data taken from: http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/; accessed May 2010.

[xci] http://www.slocounty.ca.gov/agcomm/Disaster_Designations.htm and http://www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=edn&newstype=ednewsrel&type=detail&item=ed_20081015_rel_1514.html

[xcii]SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf.

[xciii] SLO County Department of Agriculture/Weights & Measures. 2008. 2008 Annual Report. San Luis Obispo, CA. Available at http://www.slocounty.ca.gov/agcomm/Crop_Reports.htm

[xciv] SLO County Department of Agriculture/Weights & Measures. 2007. 2007 Annual Report. San Luis Obispo, CA. Available at http://www.slocounty.ca.gov/agcomm/Crop_Reports.htm

[xcv] SLO County Department of Agriculture/Weights & Measures. 2005. 2005 Annual Report. San Luis Obispo, CA. Available at http://www.slocounty.ca.gov/agcomm/Crop_Reports.htm, see page 11.

[xcvi] Lobell, D. and C. Field (2009). California perennial crops in a changing climate. Research report prepared for the California Energy commission's PIER Program, CEC-500-2009-039-F, Sacramento, CA.

[xcvii] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report, page 10, available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf.

[xcviii] MKF Research LLC. 2007. Economic Impact of Wine and Grapes in the Paso Robles AVE and Greater San Luis Obispo County 2007. Report Prepared for the Paso Robles Wine Country Alliance. Available at http://www.pasowine.com/files/Economic%20Impact%20Summary%20Chart.pdf.

[xcix] See North and South SLO County Wintery Maps available at http://www.slocountywineries.com/north.html and http://www.slocountywineries.com/south.html

[c] Research Department of the San Luis Obispo Chamber of Commerce. 2009. Community Economic Profile for the City of San Luis Obispo (with additional information about San Luis Obispo County). Available at: http://slochamber.org/Library/PDFs/2010CommunityEconomicProfile.pdf.

[ci] GIS data available at: http://lib.calpoly.edu/gis/browse.jsp?browseType=theme&theme=Agriculture

[cii] Mariani, T. 2009. SLO County Wine Region: Where Chardonnay Meets Cabernet. *San Luis Obispo County: The Central Coast's Premier Travel Magazine* (Summer 2009). Available at: http://www.thesloguide.com/winter28_00.htm.

[ciii] Hayhoe, K., D. Cayan, C. Field, P. Frumhoff, et al. 2004. Emissions pathways, climate change, and impacts on California. *PNAS* 101(34):12422-12427.

White, M.A., N.S. Diffenbaugh, G.V. Jones, J.S. Pal, and F. Giorgi. 2006. Extreme heat reduces and shifts United States premium wine production in the 21st century. *PNAS* 103(30):11217-11222.

Cahill, KN. 2009. "Global change in local places: Climate change and the future of high-quality winegrowing in Napa and Sonoma, California." Ph.D. Dissertation, Interdisciplinary Graduate Program in Environment and Resources, Stanford University, Stanford, CA. 210 pp.: 145

Webb, L.B., P.H. Whetton, and E.W.R. Barlow. 2008. Climate change and winegrape quality in Australia. *Climate Research* 36:99–111.

Studies from other wine-growing regions of the world show similar, if regionally specific results, and are thus not further discussed in detail here. See for example:

Jones, G., M. White, O. Cooper, and K. Storchmann. 2005. Climate Change and Global Wine Quality. *Climatic Change* 73 (3):319-343.

White, M. A., N. S. Diffenbaugh, G. V. Jones, J. S. Pal, and F. Giorgi. 2006. Extreme heat reduces and shifts United States premium wine production in the 21st century. *Proceedings of the National Academy of Sciences* 103 (30):11217-11222.

[civ] Lobell, D.B. and C.B. Field. 2009. California Perennial Crops in a Changing Climate. A Paper From the California Climate Change Center (CEC-500-2009-039-F), Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-039/CEC-500-2009-039-F.PDF, page 15.

[cv] *Moser, S.C., G. Franco, S. Pittiglio, W. Chou, and D. Cayan. 2009. The Future is Now: An Update on the Climate Change Science Impacts and Response Options for California* (May 2009). A Special Report From the California Climate Change Center. Available at: http://www.energy.ca.gov/2008publications/CEC-500-2008-071/CEC-500-2008-071.PDF, page 33.

[cvi] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf.

[cvii] Cahill, KN. 2009. "Global change in local places: Climate change and the future of high-quality winegrowing in Napa and Sonoma, California." Ph.D. Dissertation, Interdisciplinary Graduate Program in Environment and Resources, Stanford University, Stanford, CA., page 145.

[cviii] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf.

[cix] Wolfe, D. W., Ziska, L., Petzoldt, C., Seaman, A., Chase, L., & Hayhoe, K. 2008. Projected change in climate thresholds in the Northeastern U.S.: Implications for crops, pests, livestock, and farmers. *Mitigation and Adaptation Strategies for Global Change 13*(5-6), 555-575.

[cx] Backlund, P., Janetos, A., Schimel, D., Hatfield, J., Boote, K., Fay, P., et al. 2008. *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*. *Synthesis and Assessment Product 4.3.* Washington, DC: Climate Change Science Program, page 45.

[cxi] Shaw, M. Rebecca, Linwood Pendleton, Dick Cameron, Belinda Morris, Greg Bratman, Dominique Bachelet, Kirk Klausmeyer, Jason MacKenzie, Dave Conklin, James Lenihan, Erik Haunreiter and Chris Daly. 2009. *The Impact of Climate Change on California's Ecosystem Services*. PIER Research Report, CEC-500-2009-025-D, Sacramento, CA: California Energy Commission.

[cxii] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf, page 10.

[cxiii] Lobell, D., A. Torney, and C. Field. 2009. Climate Extremes in California Agriculture. A Paper From the California Climate Change Center (CEC-500-2009-040-F). California Energy Commission.

[cxiv] San Luis Obispo County Department of Agriculture Weights & Measures. 2007 Annual Report http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_for_the_Year_2007.pdf and

San Luis Obispo County Department of Agriculture Weights & Measures. 2009 Annual Report. http://www.slocounty.ca.gov/agcomm/Crop_Report_2009_Press_Release_April_1_2010.htm.

[cxv] Lobell, D.B. and C.B. Field. 2009. California Perennial Crops in a Changing Climate. A Paper from the California Climate Change Center (CEC-500-2009-039-F). Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-039/CEC-500-2009-039-F.PDF, page 21.

[cxvi] Backlund, P., Janetos, A., Schimel, D., Hatfield, J., Boote, K., Fay, P., et al. 2008. *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*. *Synthesis and Assessment Product 4.3.* Washington, DC: Climate Change Science Program, page28.

[cxvii] Baldocchi, D. and S. Wong. 2008. Accumulated winter chill is decreasing in the fruit growing regions of California. Climatic Change 87(Supp 1):S153-S166. Available at: http://meteora.ucsd.edu/cap/pdffiles/Baldocchi_fruit_jan2008.pdf.

Lobell, D.B. and C.B. Field. 2009. California Perennial Crops in a Changing Climate. A Paper from the California Climate Change Center (CEC-500-2009-039-F), Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-039/CEC-500-2009-039-F.PDF.

[cxviii] Backlund, P., Janetos, A., Schimel, D., Hatfield, J., Boote, K., Fay, P., et al. 2008. *The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*. *Synthesis and Assessment Product 4.3.* Washington, DC: Climate Change Science Program, page 28.

[cxix] Lobell, D.B. and C.B. Field. 2009. California Perennial Crops in a Changing Climate. A Paper from the California Climate Change Center (CEC-500-2009-039-F), Available at http://www.energy.ca.gov/2009publications/CEC-500-2009-039/CEC-500-2009-039-F.PDF, page 9.

[cxx] Lobell, D.B. and C.B. Field. 2009. California Perennial Crops in a Changing Climate. A Paper from the California Climate Change Center (CEC-500-2009-039-F), Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-039/CEC-500-2009-039-F.PDF, pp. 1, 23-24.

[cxxi] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf, page 12.

[cxxii] SLO County Department of Agriculture/Weights and Measures. 2008. Fresh from the Field: 2008 Annual Report. Available at: http://www.slocounty.ca.gov/Assets/AG/croprep/Crop_Report_Year_2008.pdf.

[cxxiii] Kildow, J. and C. Colgan. 2005. California's Ocean Economy. A Report to the Resources Agency, State of California. National Ocean Economics Program. Available at: http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf.

[cxxiv] Kildow, J. and C. Colgan. 2005. California's Ocean Economy. A Report to the Resources Agency, State of California. National Ocean Economics Program. Available at: http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf.

[cxxv] Kildow, J. 2009. State of the U.S. Ocean and Coastal Economies. Coastal and Ocean Economic Summaries of the Coastal States 2009. National Ocean Economies Project. Full report and state summaries available at: www.OceanEconomics.org/NationalReport.

[cxxvi] http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF, page 68.

[cxxvii] Norman, K., J. Sepez, H. Lazrus, N. Milne, C. Package, S. Russell, K. Grant, R.P. Lewis, J. Primo, E. Springer, M. Styles, B. Tilt, and I. Vaccaro. 2007. *Community Profiles for West Coast and North Pacific Fisheries: Washington, Oregon, California, and other U.S. States*, U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-85, 602pp. Available at: http://www.nwfsc.noaa.gov/assets/25/6718_01082008_153910_CommunityProfilesTM85WebFinalSA.pdf.

[cxxviii] Norman, K., J. Sepez, H. Lazrus, N. Milne, C. Package, S. Russell, K. Grant, R.P. Lewis, J. Primo, E. Springer, M. Styles, B. Tilt, and I. Vaccaro. 2007. *Community Profiles for West Coast and North Pacific Fisheries: Washington, Oregon, California, and other U.S. States*, U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-85, 602pp. Available at: http://www.nwfsc.noaa.gov/assets/25/6718_01082008_153910_CommunityProfilesTM85WebFinalSA.pdf.

[cxxix] Fabry, Siebel, et al. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science*. 65(3):414-432. Available at: http://icesjms.oxfordjournals.org/cgi/content/abstract/65/3/414.

[cxxx] As an example, see Dr. Gretchen Hoffman's Lab at UC Santa Barbara: http://hofmannlab.msi.ucsb.edu/.

[cxxxi] The Nature Conservancy (website). California Central Coast Groundfish Project (Accessed April 2010, Available at: http://www.nature.org/wherewework/northamerica/states/california/initiatives/ccgp.html.

[cxxxii] Cayan, D. M. Tyree, M. Dettinger, H. Hidalgo, T.H. Das, E. Maurer, P. Bromirski, N. Graham, R. Flick. 2009. Climate Change Scenarios and Sea Level Rise Estimates for California – 2008 Climate Change Scenarios Assessment – Final Report. PIER Report (CEC-500-2009-014-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F

Dettinger, M., H. Hidalgo, T. Das, D. Cayan, N. Knowles. 2009. Projections of Potential Flood Regime Changes in California – Final Report. PIER Report (CEC-500-2009-050-F). Available at: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-050-F.

[cxxxiii] Strategic Marketing Group and Dean Runyan Associates. 2008. *Tourism San Luis Obispo: San Luis Obispo County Tourism Analysis Report*. A Study Commissioned by Economic Vitality Corporation. Available at: http://www.sloevc.org/events/2008%20Tourism%20Analysis%20-%20Final%20Report%20v2(2).pdf.

[cxxxiv] Strategic Marketing Group and Dean Runyan Associates. 2008. *Tourism San Luis Obispo: San Luis Obispo County Tourism Analysis Report*. A Study Commissioned by Economic Vitality Corporation. Available at: http://www.sloevc.org/events/2008%20Tourism%20Analysis%20-%20Final%20Report%20v2(2).pdf.

[cxxxv] Strategic Marketing Group and Dean Runyan Associates. 2008. *Tourism San Luis Obispo: San Luis Obispo County Tourism Analysis Report*. A Study Commissioned by Economic Vitality Corporation. Available at: http://www.sloevc.org/events/2008%20Tourism%20Analysis%20-%20Final%20Report%20v2(2).pdf.

[cxxxvi] County of San Luis Obispo Local Hazard Mitigation Plan (LHMP) 2005. Available at: http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf.

[cxxxvii] Cayan, D., P. Bromirski, K. Hayhoe, M. Tyree, M. Dettinger, and R. Flick. 2006. Projecting Future Sea Level (white paper). A Report From California Climate Change Center. PIER Report (CEC-500-2005-202-SF), Available at: www.energy.ca.gov/2005publications/CEC-500-2005-202/CEC-500-2005-202-SF.PDF.

Pendleton, L. P. King, C. Mohn, D.G. Webster, R.K. Vaughn, P. Adams. 2009. Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches. A Paper From the California Climate Change Center. Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-F.PDF, page 15.

[cxxxviii] World Tourism Organization. 2003. Climate Change and Tourism, Proceedings of the 1st International Conference on Climate Change and Tourism, Djerba, Tunisia, 9-11 April 2003. Available at: http://www.world-tourism.org/sustainable/climate/final-report.pdf.

[cxxxix] Crook, S. 2008. *Estimating the Economic Impacts of Coastal Hazards and Climate Change in the Low Elevant Coastal Zone of the Monterey Bay*. A Project of the Internship Program at MBARI. Available at: http://www.mbari.org/education/internship/08interns/08papers/Crook.pdf.

[cxl] Pendleton, L. P. King, C. Mohn, D.G. Webster, R.K. Vaughn, P. Adams. 2009. Estimating the Potential Economic Impacts of Climate Change on Southern California Beaches. A Paper from the California Climate Change Center. Available at: http://www.energy.ca.gov/2009publications/CEC-500-2009-033/CEC-500-2009-033-F.PDF, page 11.

[cxli] Department of Boating and Waterways. 200?. Beach Nourishment Projects in California (table). California Coastal Sediment Management Workgroup.

[cxlii] Kildow, J. and C. Colgan. 2005. California's Ocean Economy. A Report to the Resources Agency, State of California. National Ocean Economics Program. Available at: http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf.

[cxliii] Koopman, M. E., R. S. Nauman and J. L. Leonard. 2009. Projected Future Climatic and Ecological Conditions in San Luis Obispo County. National Center for Conservation Science and Policy Report. 33 pages. .

[cxliv] City of Paso Robles, available at: http://www.prcity.com/Government/departments/publicworks/water/pdf/Presentation-June18.pdf

[cxlv] SLO County Water Master Plan 2001 http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/Table%20of%20Contents/pdf/Distribution%20Infrastructure.pdf

[cxlvi] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cxlvii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cxlviii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cxlix] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cl] SLO County Water Master Plan 2001 http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/Table%20of%20Contents/pdf/Distribution%20Infrastructure.pdf

[cli] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cliii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[cliv] S.S. Papadopulos & Associates, Inc. 2004. Nipomo Mesa Groundwater Resources Capacity Study, SLO County, Report Prepared for SLO County March 2004, Available at http://www.slocountywater.org/site/Water%20Resources/Reports/Nipomo%20Mesa/pdf/MAIN%20TEXT%20Nipomo%20Mesa%20GW%20Resource%20Capacity%20Study.pdf

[clv] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clvi] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clvii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary. http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf see page 54.

[clviii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clix] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clx] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf, see page 45.

[clxi] SLO County Water Master Plan. Exhibit 2: Summary by Water Planning Area. Available at http://www.slocountywater.org/site/Major%20Projects/State%20Water%20Project/pdf/swp_map_coastal.pdf

[clxii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clxiii] SLO County. 2008. Resource Management System: 2008 Annual Resource Summary http://www.slocounty.ca.gov/Assets/PL/RMS/2008+RMS+Report.pdf

[clxiv] City of San Luis Obispo website. Water: Supply Sources (webpage). Accessed April 2010, Available at http://slocity.org/utilities/sources.asp

[clxv] Rice, A. Another SLO County Community Declares Building Moratorium, Accessed March 2010, posted on website: http://aboutcambria.com/2009/12/04/another-san-luis-obispo-county-community-declares-building-moratorium/ (cited as from "Master Plan, Similar Realities, Solution by Amanda Rice").

[clxvi] SLO County Water Master Plan. Exhibit 2: Summary by Water Planning Area. Available at http://www.slocountywater.org/site/Major%20Projects/State%20Water%20Project/pdf/swp_map_coastal.pdf

[clxvii] Wimer, K., M. Goldin, P. Reilly, E. Watson. 2010. Viewpoint: Help sustain Los Osos basin, Published in SLO Tribune, February 12, 2010. Accessed March 2010, Available at http://www.sanluisobispo.com/2010/02/11/1025557/viewpoint-help-sustain-los-osos.html

[clxviii] Cambria Community Services District, Water Wait List webpage, Accessed on March 1, 2010 http://www.cambriacsd.org/cm/water_wastewater/water_permits/wait_list.html

[clxix] Presentation to Paso Robles Public Works. Paso Robles Water (presentation slides), Accessed March 2010, Available at http://www.prcity.com/Government/departments/publicworks/water/pdf/Presentation-June18.pdf

[clxx] Newspaper update on the crisis of water in PR: http://www.sanluisobispo.com/opinion/columnists/phil-dirkx/story/989828.html

[clxxi] SLO County Water Master Plan 2001 http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/Table%20of%20Contents/pdf/Distribution%20Infrastructure.pdf, page 4

[clxxii] SLO County, 2001. San Luis Obispo County Mater Water Plan: Distribution Infrastructure and Emergency Preparedness. Accessed March 2010, Available at http://www.slocountywater.org/site/Frequent%20Downloads/Master%20Water%20Plan/Table%20of%20Contents/pdf/Distribution%20Infrastructure.pdf.

[clxxiii] Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. Roadways vulnerable to a 100-year coastal flood with a 1.4 meter sea level-rise (map), In The Impacts of Sea-Level Rise on the California Coast. A Paper from the California Climate Change Center (CEC-500-2009-024-F). Available at http://www.pacinst.org/reports/sea_level_rise/PDF/Fig19_Roadways_CA.pdf.

[clxxiv] SLO County website. Los Oso Wasterwater Project (webpage), Accessed March 2010, Available at http://www.slocounty.ca.gov/PW/LOWWP.htm

[clxxv] Caltrans District 5: http://www.dot.ca.gov/dist05/

[clxxvi] SLO County Regional Airport website, Accessed March 2010, Available at http://sloairport.com/index.php?p=schedule&departures=1.

[clxxvii] Regional Transit Authority, San Luis Obispo County website. Accessed April 2010, Available at: http://www.slorta.org/

[clxxviii] California Department of Transportation. 2009. *Climate Adaptation and California's Transportation Infrastructure*. Strategy White Paper developed for the California Adaptation Strategy; Sacramento, DOT.

[clxxix] Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. Roadways vulnerable to a 100-year coastal flood with a 1.4 meter sea level-rise (map), In *The Impacts of Sea-Level Rise on the California Coast*. A Paper from the California Climate Change Center (CEC-500-2009-024-F). Available at http://www.pacinst.org/reports/sea_level_rise/PDF/Fig19_Roadways_CA.pdf.

[clxxx] California Department of Transportation, 2008. Climate Change Adaptation and Transportation System (presentation slides). Available at http://www.climatechange.ca.gov/adaptation/infrastructure/2008-12-05_meeting/CAS_INF_PDF.pdf)

[clxxxi] Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. Roadways vulnerable to a 100-year coastal flood with a 1.4 meter sea level-rise (map), In The Impacts of Sea-Level Rise on the California Coast. A Paper from the California Climate Change Center (CEC-500-2009-024-F). Available at http://www.pacinst.org/reports/sea_level_rise/PDF/Fig19_Roadways_CA.pdf, page 81.

[clxxxii] Griggs, G. (1999), cited in Stamski, R. 2005. *The Impacts of Coastal Protection Structures in California's Monterey Bay National Marine Sanctuary*. Silver Spring, MD: NOAA, National Ocean Service, Marine Sanctuaries Division. Available at: http://sanctuaries.noaa.gov/special/con_coast/stamski.pdf

[clxxxiii] See: http://www.climatechange.ca.gov/adaptation/documents/2009_Preliminary_Trans_Assessment.pdf, page 9.

[clxxxiv] CalPoly Emergency Preparedness: http://www.afd.calpoly.edu/administration/emergency.asp.

[clxxxv] SLO County website. Know the Risks? (webpage). Accessed March 2010, Available at http://www.slocounty.ca.gov/OES/EPInfo/Knowtherisks.htm -

[clxxxvi] Available at: www.sloplanning.org/gis/mapImagepdf/emergency.pdf

[clxxxvii] Cayan, Dan, Mary Tyree, Mike Dettinger, Hugo Hidalgo, Tapash Das, Ed Maurer, Peter Bromirski, Nicholas Graham, and Reinhard Flick. 2009. *Climate Change Scenarios and Sea Level Rise Estimates for the California 2008 Climate Change Scenarios Assessment.* PIER Research Report, CEC-500-2009-014, Sacramento, CA: California Energy Commission.

Dettinger, Michael, Hugo Hidalgo, Tapash Das, Daniel Cayan, and Noah Knowles. 2009. *Projections of Potential Flood Regime Changes in California*. PIER Research Report, CEC-500-2009-050-D, Sacramento, CA: California Energy Commission.

[clxxxviii] San Luis Obispo County Local Hazard Mitigation Plan (LHMP). 2005. http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf, page 46.

[clxxxix] San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/OES/plans.htm, accessed February 15, 2010

[cxc] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf, page 7, Accessed 2/10/2010, page 11.

[cxci] Lambert, C (2011). South County farmland may be sacrificed in flooding. *The San Luis Obispo Tribune*, Dec. 08, 2011. Available at: http://www.sanluisobispo.com/2011/12/07/1863854/south-county-farmland-may-be-sacrificed.html#storylink=cpy. [last accessed on February 9, 2012]

[cxcii] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf, page 7, Accessed 2/10/2010.

[cxciii] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf, page 7, Accessed 2/10/2010. page 9.

[cxciv] Office of Emergency Services. 2008. San Luis Obispo County Dam and Levee Failure Evacuation Plan, http://www.slocounty.ca.gov/Assets/OES/Dam+and+Levee+Plan.pdf, page 7, Accessed 2/10/2010.

[cxcv] San Luis Obispo County Local Hazard Mitigation Plan (LHMP) 2005. http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf, page 29.

[cxcvi] San Luis Obispo County Local Hazard Mitigation Plan (LHMP) 2005. http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf

[cxcvii] Map of California's fire hazard zones by severity (order of severity by decreasing order: red, orange, yellow, white). Available at: http://frap.cdf.ca.gov/webdata/maps/statewide/fhszs_map.jpg)/.

[cxcviii] See map by CalFire, available at: http://www.fire.ca.gov/fire_prevention/fhsz_maps/fhsz_maps_sanluisobispo.php.

[cxcix] SLO County/CalFire Fire Plan, Executive Summary, Available at: http://cdfdata.fire.ca.gov/pub/fireplan/fpupload/fpppdf553.pdf.

[cc] These are available for viewing at: http://www.calfireslo.org/PreAttack.html.

[cci] California Natural Resources Agency. 2009. *2009 California Climate Adaptation Strategy*. A Report to the Governor of the State of California in Response to Executive Order S-13-2008.

[ccii] http://www.fire.ca.gov/fire_prevention/fhsz_maps/fhsz_maps_sanluisobispo.php

[cciii] San Luis Obispo County Local Hazard Mitigation Plan (LHMP) 2005. Available at: http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf.

[cciv] SLO County FHSZ Maps, available at: http://www.fire.ca.gov/fire_prevention/fhsz_maps/fhsz_maps_sanluisobispo.php.

[ccv] SLO Planning Website of GIS Data. Accessed February 2010 at http://midnight.calpoly.edu/gis/data/slo_county/safety/CDF_fire_stations/CDF_fire_stations.jpg.

[ccvi] A.L. Westerling, H.G. Hidalgo, D.R. Cayan & T.W. Swetnam. 2006 *Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity*, *Science* 313(5789):940-943.

[ccvii] San Luis Obispo County Local Hazard Mitigation Plan (LHMP) 2005. http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf

[ccviii] San Luis Obispo County Local Hazard Mitigation Plan (LHMP) 2005. http://www.slocounty.ca.gov/Assets/OES/LHMPlan.pdf, page 29.

[ccix] Additional information on the current and past status of the plant's operation are available at the Nuclear Regulatory Agency's website (http://www.nrc.gov/info-finder/reactor/diab1.html). The inspection report after the Fukushima accident is also available there.

[ccx] SLO County website, Emergency Planning Zones (map). Accessed March 2010, Available at: http://www.slocounty.ca.gov/Assets/OES/Emergency+Planning+Zone+Map+(PDF).pdf.

[ccxi] SLO County website. Evacuation Routes (webpage). Accessed March 2010, available at http://www.slocounty.ca.gov/OES/NPPInfo/DCPPEmergencyPlanning/PAZInfo/EvacuationRoutes.htm

[ccxii] SLO County website. The Emergency Planning Zone (webpage). Accessed March 2010, available at http://www.slocounty.ca.gov/OES/NPPInfo/DCPPEmergencyPlanning/PAZInfo/EPZ.htm, and http://www.slocounty.ca.gov/Assets/OES/Emergency+Planning+Zone+Map+(PDF).pdf.

[ccxiii] The participatory adaptation planning effort in San Luis Obispo, for which this report served as one of several foundational documents - has been supported by the Local Government Commission and the NCCSP/Geos Institute. Other reports and summaries of the effort have been posted at http://www.lgc.org/adaptation/slo/index.html.