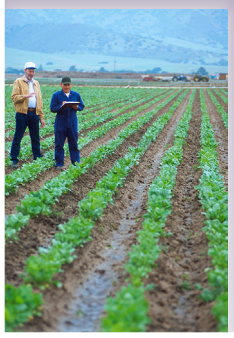
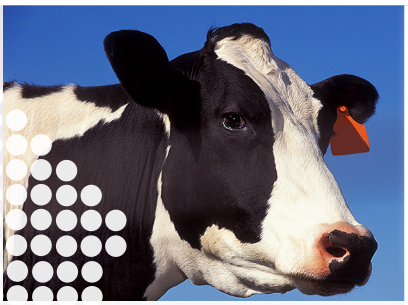
CALIFORNIA ADAPTATION PLANNING GUIDE





UNDERSTANDING REGIONAL CHARACTERISTICS

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Executive Summary

The *California Adaptation Planning Guide* (APG), a set of four complementary documents, provides guidance to support communities in addressing the unavoidable consequences of climate change. The APG, developed by the California Emergency Management Agency and California Natural Resources Agency, introduces the basis for climate change adaptation planning and details a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.

The *APG: Understanding Regional Characteristics* provides environmental and socioeconomic information for a series of 11 climate impact regions. The choice to designate regions is due to the statewide diversity in biophysical setting, climate, and jurisdictional characteristics. While conditions may be diverse within each region, the range of conditions will be narrower than at the statewide level. Designating regions allows for greater depth and more detailed information to be presented.

California Adaptation Planning Guide Documents

- *APG: Planning for Adaptive Communities* – This document presents the basis for climate change adaptation planning and introduces a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. All communities should start with this document.

- *APG: Defining Local & Regional Impacts* – This supplemental document provides a more in-depth understanding of how climate change can affect a community. Seven "impact sectors" are described to support communities conducting a climate vulnerability assessment.

YOU ARE HERE

- *APG: Understanding Regional Characteristics* – The impact of climate change varies across the state. This supplemental document identifies climate impact regions, including their environmental and socioeconomic characteristics.

- *APG: Identifying Adaptation Strategies* – This supplemental document explores potential adaptation strategies that communities can use to meet adaptation needs. Adaptation strategies are categorized into the same impact sectors used in the *APG: Defining Local & Regional Impacts* document.

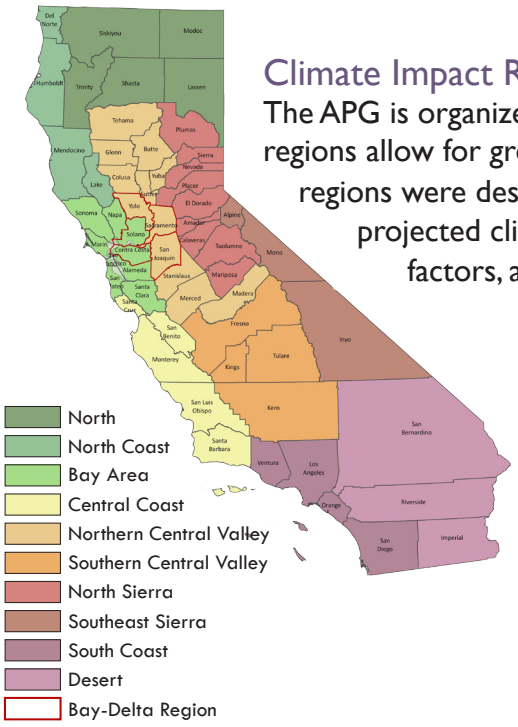


Figure1. Climate Impact Regions.

Climate Impact Regions

The APG is organized into a series of climate impact regions (see Figure 1). The regions allow for greater depth and more detailed guidance to be presented. The regions were designated based on county boundaries in combination with projected climate impacts, existing environmental setting, socioeconomic factors, and regional designations and organizations.

The 11 regions presented in this document are listed below, along with a selection of the potential impacts faced by each region.

North Coast

- Sea level rise
- Threats to sensitive species
- Reduced agricultural productivity

North

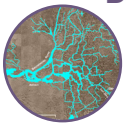
- Increased wildfire
- Reduced snowpack
- Ecosystem shifts

Bay Area

- Coastal inundation and erosion
- Public heath - heat and air pollution
- Reduced agricultural productivity

Northern Central Valley

- Reduced agricultural productivity
- Increased wildfire
- Public health - heat



Bay-Delta Region

- Flooding
- Reduced agricultural productivity
- Public heath - heat and air pollution

Southern Central Valley

- Reduced agricultural productivity
- Public health - heat
- Reduced water supply

Central Coast

- Reduced agricultural productivity
- Coastal flooding
- Biodiversity threats

North Sierra

- Reduced tourism
- Ecosystem change
- Increased wildfire

Southeast Sierra

- Economic impacts – tourism decline
- Substantially reduced snowpack
- Flooding

South Coast

- Sea level rise
- Reduced water supply
- Public healsth - heat and air pollution

Desert

- Water supply
- Public health and social vulnerability
- Biodiversity threats

Introduction

The State of California has been taking action to address climate change for over 20 years, focusing on both greenhouse gas emissions reduction and adaptation. The California Adaptation Planning Guide (APG) continues the state's effort by providing guidance and support for communities addressing the unavoidable consequences of climate change.

The APG includes four documents (see Figure 1). *APG: Understanding Regional Characteristics* is one of three documents developed to supplement an overarching planning process document, *APG: Planning for Adaptive Communities*.

- *APG: Planning for Adaptive Communities* – Presents the basis for climate change adaptation planning and introduces a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.

- *APG: Defining Local & Regional Impacts* – Use this supplemental document to gain a more in-depth understanding of how climate change can impact a community. Seven sectors of impacts are presented to support local communities conducting a climate vulnerability assessment.

YOU ARE HERE

- ***APG: Understanding Regional Characteristics*** – The impact of climate change varies across the state. Use this supplemental document to understand the distinct climate impact regions including their environmental and socioeconomic characteristics.

- *APG: Identifying Adaptation Strategies* – Use this supplemental document to explore potential adaptation strategies that communities can use to meet their adaptation needs. Adaptation strategies are categorized into the same sectors used in the APG: *Defining Local & Regional Impacts* document and include examples from jurisdictions already pursuing adaptation strategies and offer considerations for tailoring strategies to meet local needs.

Figure 1. The four California Adaptation Planning Guide (APG) documents. All APG users should start with the *APG: Planning for Adaptive Communities*. The other three documents support the process presented in the first document by providing additional information and greater detail.

What is the *APG: Understanding Regional Characteristics* document and how should it be used?

The *APG: Understanding Regional Characteristics* is organized into a series of climate impact regions (see Figure 2). The choice to designate regions is due to the statewide diversity in biophysical setting, climate, and jurisdiction characteristics. While conditions may be diverse within each region, the range of conditions will be narrower than at the statewide level. Designating regions allows for greater depth and more detailed information to be presented.

Each region is still diverse. The regional section is meant to summarize some of the key considerations for each region, above and beyond the statewide considerations presented in *APG: Defining Local & Regional Impacts*. If an impact is included in the *APG: Defining Local & Regional Impacts,* it is not included in this document unless there are region-specific details that require assessment for impact evaluation such as a paricularly vulnerable ecosystem unique to the region. As a result, some of the presented information varies between regions based on how well, or not, the information in *APG: Defining Local & Regional Impacts* applies to the region. Each region includes a summary of climate exposure, considerations considered critical for jurisdictions in the region, and regionally-specific resources that may aid communities in the region. Communities can use this document to assess regional context or identify other jurisdictions facing similar climate pressures.

How were the regions defined?

Regions were designated based on county boundaries in combination with projected climate impacts, existing environmental setting, socioeconomic factors, and regional designations. The choice to use counties (e.g. political boundaries) was based on a commitment to make the APG as useful as possible for local governments, including counties. The counties were clustered into regions based on the following factors:

- Projected climate change impacts were evaluated using Cal-Adapt. Cal-Adapt climate impact projections for precipitation, temperature, snowpack, and wildfire risk were used to identify counties that share a similar group of projected impacts.

- Existing regional designations were evaluated because there are some climate-related impacts best addressed at a regional scale. Counties that share a regional designation (e.g., air districts, regional water quality control boards) are more likely to have already established relationships with neighboring jurisdictions that are necessary for regional strategy development and implementation. The regional designations examined include regional water quality control boards, air basins and air districts, California Emergency Management Agency Regions, and metropolitan planning organizations. Figures 3 through 6 overlay the impact regions with these regional designations.

- Habitat was assessed based on bioregion, habitat, and land cover maps developed by the California Department of Forestry and Fire Protection, Fire and Resource Assessment Program (FRAP). These data were included when determining the regions because the potential consequences of a change in climate (e.g., temperature and precipitation) vary based on the preexisting biophysical setting. Figure 7 displays the climate impact regions in comparison to bioregion.

- Socioeconomic characteristics, including the location of major population centers and economic base, were considered. These characteristics were particularly important for counties that have more than one area with distinct suites of projected climate impacts. For example, a county that shares some characteristics with the Northern Sierra and others with the Northern Central Valley was evaluated based on which setting supported the local economy to a greater degree and/or was home to a larger portion of residents.

What are the designated climate impact regions?

Based on the factors described above, 11 regions were identified (see Figure 2). Some of the regions were based on specific factors particularly relevant to the region. For example, the Central Valley was split into north and south based on hydrologic boundaries; this results in the Northern Central Valley region containing all counties draining to the Sacramento-San Joaquin Delta. The Sierra Nevada area was split based on ecosystem differences as well as variation in projected climate impacts. The Bay-Delta is the only region that shares all its counties with other regions. The designation of the Bay-Delta as a region recognizes that this area is distinct due to its elevation profile and flood vulnerability. Additional detail about the characteristics of each region can be found in the following section.

The regions are defined as follows:

- **North:** Lassen, Modoc, Shasta, Siskiyou, and Trinity counties
- **North Coast:** Del Norte, Humboldt, Lake, and Mendocino counties
- **Bay Area:** Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties
- **Northern Central Valley:** Butte, Colusa, Glenn, Madera, Merced, Sacramento, San Joaquin, Stanislaus, Sutter, Tehama, Yolo, and Yuba counties
- **Bay-Delta:** Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties
- **Southern Central Valley:** Fresno, Kern, Kings, and Tulare counties
- **Central Coast:** Monterey, San Benito, San Luis Obispo, Santa Barbara, and Santa Cruz counties
- **North Sierra:** Amador, Calaveras, El Dorado, Mariposa, Nevada, Placer, Plumas, Sierra, and Tuolumne counties
- **Southeast Sierra:** Alpine, Inyo, and Mono counties
- **South Coast:** Los Angeles, Orange, San Diego, and Ventura counties
- **Desert:** Imperial, Riverside, and San Bernardino counties

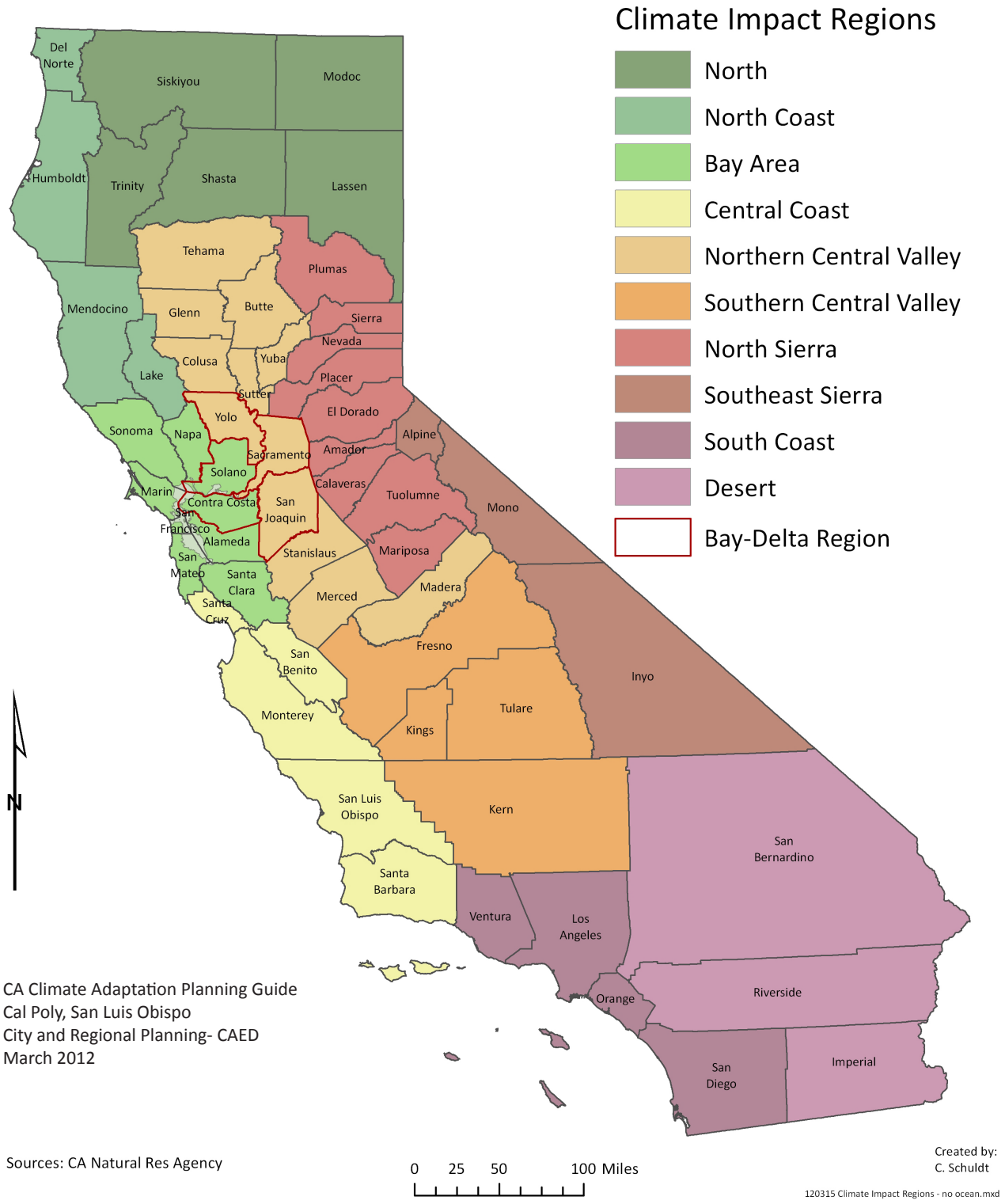


Figure 2. Adaptation Planning Guide Climate Impact Regions

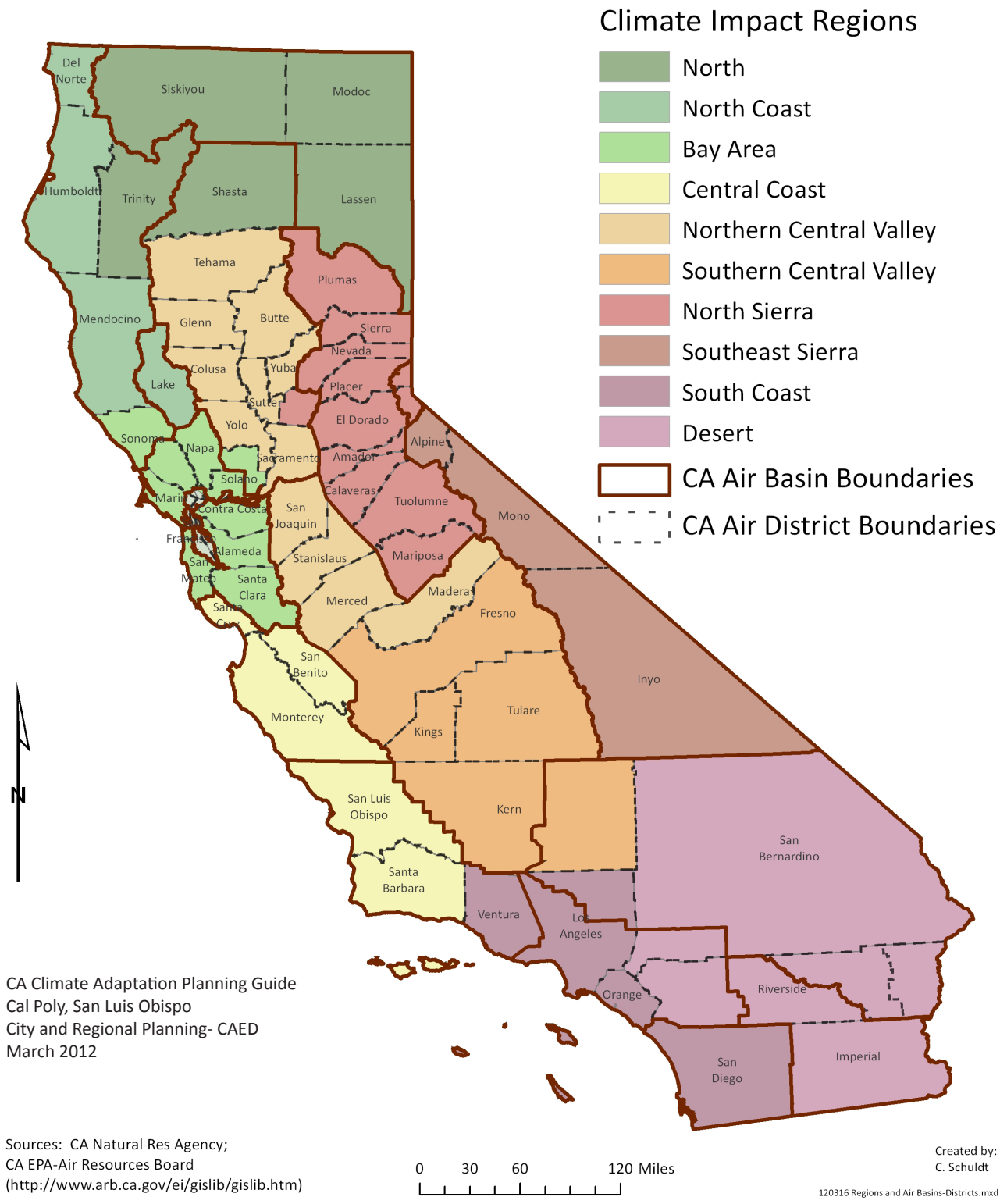


Figure 3. California Air Resources Board Air Basin and Air District Boundaries In Comparison to the Adaptation Planning Guide Climate Impact Regions.

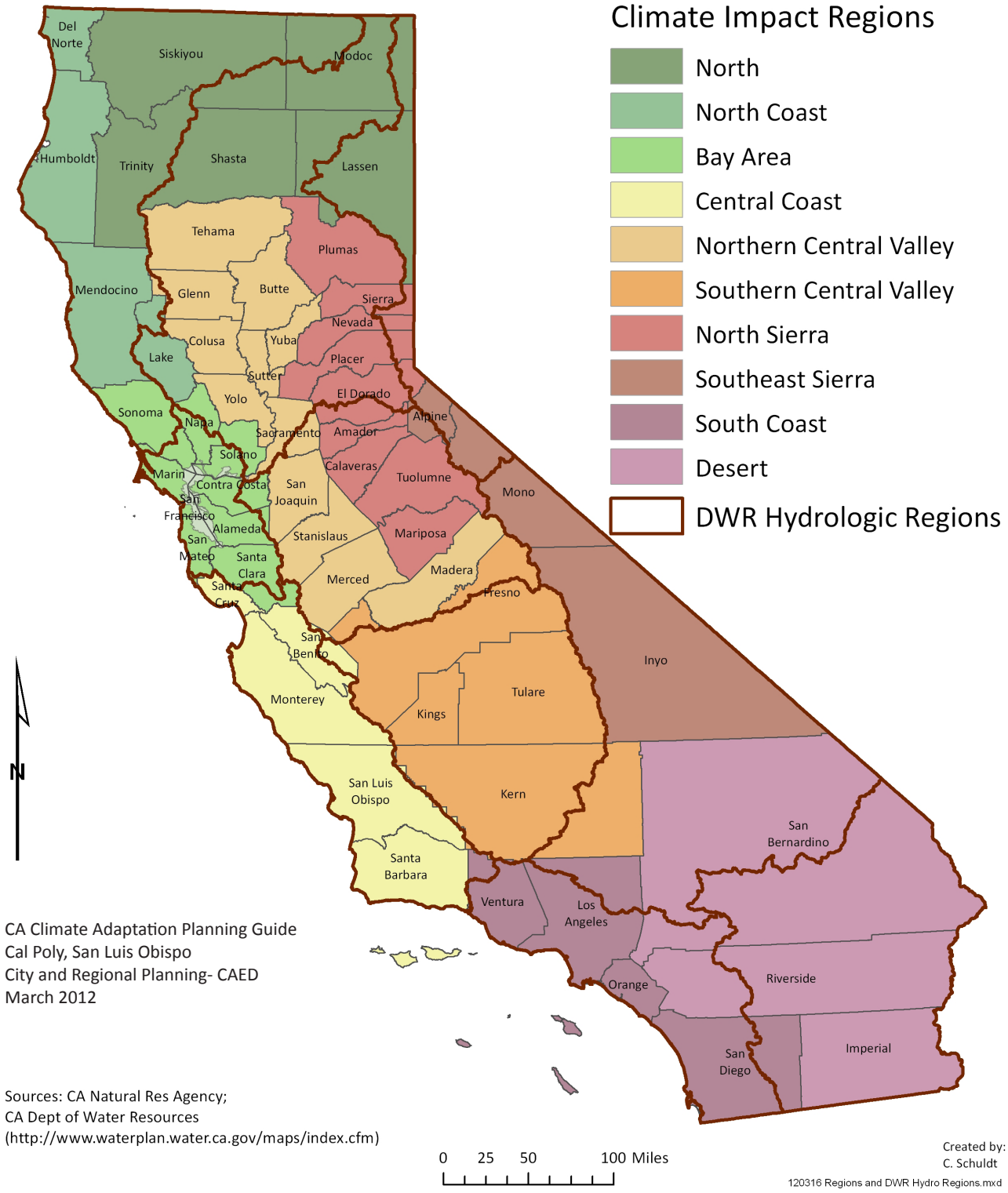


Figure 4. California Department of Water Resources Hydrologic Regions in Comparison to the Adaptation Planning Guide Climate Impact Regions.

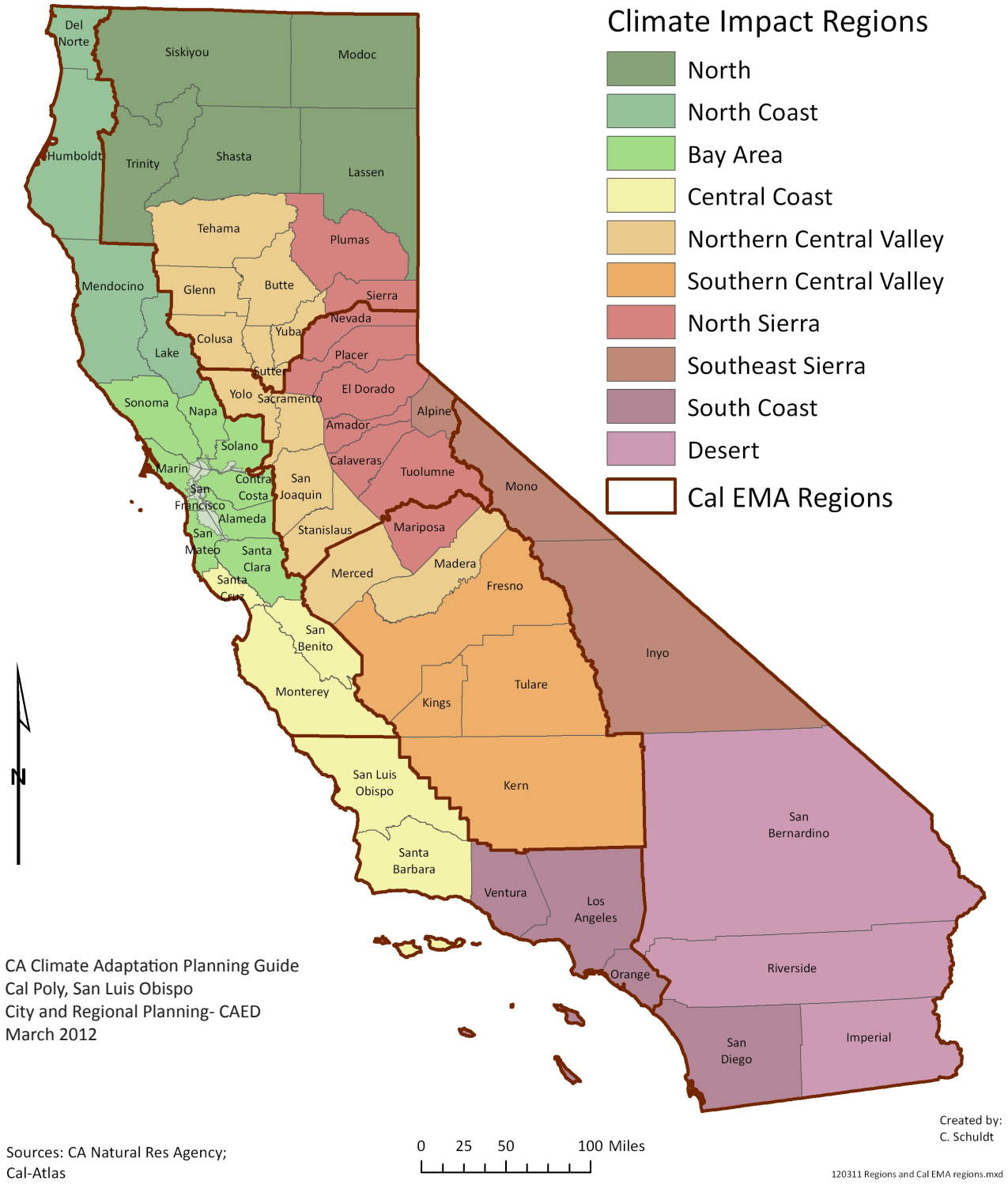


Figure 5. California Emergency Management Agency Regions in Comparison to the Adaptation Planning Guide Climate Impact Regions.

Figure 6. Adaptation Planning Guide Climate Impact Regions in Comparison to the Boundaries of California Councils of Government (COGs), Municipal Planning Organizations (MPOs), and Regional Transportation Planning Agencies.

Figure 7. California State Bioregions in Comparison to the Adaptation Planning Guide Climate Impact Regions.

What is included in the regional profiles?

APG: Understanding Regional Characteristics reviews each region in the state, providing detail or specificity above and beyond that presented in *APG: Defining Local & Regional Impacts*. For each region, specific information likely to help communities evaluate vulnerability and formulate adaptation strategies is provided. This information includes the following:

- **Cal-Adapt Projections.** Cal-Adapt projections for the region are summarized. The table provided for each region is intended to generally identify the types of changes projected for the region. Local jurisdictions also should use the web-based Cal-Adapt tool (www.Cal-Adapt.org) to generate projections specific to their locations.

- **Water Sources.** The primary sources of water for the region are identified to allow for general identification of potential vulnerability associated with water supply. Because each jurisdiction acquires rights to its community water supply, individual jurisdictions should assess their supplies. This evaluation will have much greater specificity, allowing for community-based vulnerability assessment.

- **Biophysical Characteristics.** A short summary of major regional features is provided. In regions with ecosystems or special-status species that are particularly vulnerable to climate change, additional discussion of these issues is provided following the listing of basic data.

- **Regional Entities.** A list of air districts, regional organizations, and tribal lands in the region is provided. Some climate change impacts are best addressed on regional scales. Regional organizations, and the local jurisdictions associated with them, may represent potential collaboration partners for devising regional adaptation strategies, from infrastructure continuity to migration corridors for sensitive species.

- **Major Infrastructure and Selected Regional Resources.** A brief summary of major infrastructure and other regional facilities is provided. Infrastructure, including transportation, electricity, water, wastewater, and natural gas, involves linear systems critical for the provision of services. Major infrastructure can link communities in a region and facilitate processes on a state and national level. Other resources addressed include wastewater treatment plants and power plants. Also included are state and federal parks that may be affected by climate change but also serve as a resource in devising adaptation strategies, particularly for sensitive species.

- **Selected Demographic Data**. Selected employment and population data for the region are provided. Certain populations, such as children, the elderly, and people living at or below the poverty level, are more likely to be affected by climate change than others. The table provided for each region lists the population younger than five years old, the population older than 65 years old, and the population at or below the poverty level. Local jurisdictions should complement these data with locally-specific information, such as demographic data (poverty, percent elderly, percent children) that are available on a county basis. Local jurisdictions will need to evaluate these data on a scale appropriate to the jurisdiction.

- **Adaptation Considerations.** The discussion of each region concludes with a summary of issues to consider in developing climate change adaptation policy for jurisdictions within the region. The content included in this section varies from region to region depending on the extent to which the content presented in *APG: Defining Local & Regional Impacts* applies. If regional information is already included in *APG: Defining Local & Regional Impacts*, it has not been included in the regional discussion here.

North Coast Region

TOTAL 2010 POPULATION	
North Coast Region	**315,739**
Del Norte	28,610
Humboldt	134,623
Lake	64,665
Mendocino	87,841

[U.S. Census Bureau, 2010]

Counties: Del Norte, Humboldt, Lake, Mendocino
Five Largest Cities (CDOF, 2011): Eureka (27,283); Arcata (17,318); Ukiah (16,109); Clearlake (15,289); Fortuna (11,977)

The North Coast is a lightly populated, sparsely settled region, with only one city over 20,000 people (Eureka). It represents the northern coast of the state. It is home to the largest timber-producing county in the state (Humboldt) and two wine grape-growing counties (Mendocino and Lake). In addition, the North Coast is home to sandy beaches and several estuaries that support rich biodiversity. Due to varied terrain, it is also home to several microclimates and distinct ecosystems.

Potential climate change impacts to be considered by North Coast communities include the following:

- Reduced snowpack
- Increased wildfires
- Sea level rise and inland flooding
- Threats to sensitive species (e.g. coho salmon)
- Loss in agricultural productivity (e.g. forestry, wine grapes, nursery products, dairy)
- Public health and safety

Cal-Adapt Projections

Table 1. Summary of Cal-Adapt Climate Projections for the North Coast Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 2°F by 2050 and up to 5°F by 2100 July increase in average temperatures: 3°F by 2050 and up to 6°F by 2100 (Modeled average temperatures; high emissions scenario)
Precipitation	Annual precipitation varies by location with a subtle decrease throughout the century in most areas. Areas of heavy rainfall (80 inches or more) are projected to lose 5 to 7 inches by 2050 and 11 to 15 inches by the end of the century. Slightly drier places are projected to see a decrease of around 3 to 4 inches by 2050 and 6 inches of precipitation by 2100. (CCSM3 climate model; high carbon emissions scenario)
Sea Level Rise	By 2100, sea levels may rise up to 55 inches, posing threats to many areas in the region, particularly in bays and estuaries. The increase in acreage vulnerable to 100-year floods due to sea level rise in the region will be 18 percent in both Humboldt and Mendocino counties and 17 percent in Del Norte County.
Heat Wave	Heat wave is defined as five consecutive days over 68°F over most of the coastal areas and as high as 93°F in some inland areas to the south. Little change is expected by 2050 with possibly one to three more heat waves projected in region. By 2100, projected heat waves are more variable. Along much of the coast eight to 15 more heat waves than currently occur are projected. Inland it is variable, but generally lower, between two and eight more waves per year.
Snowpack	March snow levels in the eastern, higher-elevation portion of the region will drop to almost zero by the 2090s, a decrease of 2 to 10 inches from 2010 levels. In areas with more snow, 3 to 5 inches of reduction will occur by 2050. In areas with currently little snow (<3 inches), the snowpack is projected to be near zero by 2050. (CCSM3 climate model; high carbon emissions scenario)
Wildfire Risk	Substantial increase in fire risk is expected throughout the region. Modest increases in area burned are projected for 2050. By 2100, the projected frequency increases dramatically, eight times greater in parts of Del Norte, Humboldt, and Mendocino counties. Lake County and northern Mendocino County are projected to have up to 2.5 times greater wildfire frequency. (GFDL climate model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

The primary supply of water in the North Coast Region (which includes this climate impact region, plus Siskiyou County) is from the Klamath River and Eel River systems, and accounts for about 17 of the approximately 18 million acre-feet available in 2005 (DWR, 2009). The remaining supply is from groundwater (primarily in coastal areas), reuse, and state or federal projects. Water outflow goes primarily to scenic rivers (again nearly 17 million acre-feet), with a small minority going to urban areas, irrigated agriculture, and managed wetlands. Total storage capacity in the region's reservoirs is 3.78 million acre-feet (DWR, 2009).

Biophysical Characteristics

The landscape of the North Coast region consists primarily of the Coast Mountain Ranges, where peaks vary from 2,000 to 5,000 feet. The Klamath River, which originates in Oregon, winds its way through the north end of the state, culminating 45 miles south of Crescent City. The other major river system, the Eel, extends from Lake County to the Pacific Ocean 15 miles south of Eureka (CERES, 2005). Most of this region, part of the larger Klamath/North Coast Bioregion, is covered by forest. It receives more rainfall than any other part of the state (CDFG, 2007). The region supports diverse wildlife in varied ecosystems that include sand coastlines, coastal estuaries, grasslands, coastal shrub, freshwater aquatic ecosystems, riparian areas, pine forests, mixed evergreen forests, and redwood forests (CERES, 2005; CDFG, 2007). These ecosystems support human activities from basic services to industries such as forestry and fishing.

Regional Entities

- Air Districts: Lake, Mendocino, North Coast Unified
- Regional Organizations: Del Norte Local Transportation Commission, Humboldt County Association of Governments, Lake County/City Area Planning Council, Mendocino Council of Governments
- Tribal Lands (U.S. EPA, 2011): Big Lagoon, Big Valley, Blue Lake, Coyote Valley, Elk Valley, Hoopa Valley Indian, Hopland, Laytonville, Manchester (Point Arena), Middletown, Pinoleville, Redwood Valley, Resighini, Robinson, Rohnerville, Round Valley, Sherwood Valley, Smith River, Sulphur Bank (El Em), Table Bluff, Trinidad, Upper Lake, Yurok

Selected Infrastructure and Regional Resources

Table 2. Infrastructure and Resources in the North Coast Region

TYPES	NAMES
Airports	Andy McBeth, Arcata, Dinsmore, Eureka Municipal, Garberville, Jack McNamara Field, Kneeland Field, Little River, Murray Field, Rohnerville, Shelter Cove, Ward Field, Willits Municipal, Ukiah Municipal
National and State Parks	National: Humboldt Bay National Wildlife Reserve, Redwoods National Park State: Azalea S.N.R., Clear Lake S.P., Grizzly Creak Redwoods S.P., Henry A. Merlo S.R.A., Humboldt Lagoons S.P., Humboldt Redwoods S.P., Jug Handle S.P., Mallard Redwoods S.P., Manchester S.P., Montgomery Woods S.P., Navarro River Redwoods S.P., Patrick's Point S.P., Prairie Creek Redwood S.P., Richardson Grove S.P., Russian Gulch S.P., Sinkyone Wilderness S.P., Van Damme Beach S.P.
Ports	Crescent City Harbor, Humboldt Bay Harbor, Noyo Harbor
Power Plants (MWs)*	Humboldt Bay (137).

S.P. = State Park; S.R.A. = State Recreation Area; S.N.R. = State Natural Reserve; MWs = megawatts
*Located within the 100-year flood zone for 1.5-meter sea level rise.

Selected Demographic Data

Table 3. Top Five Employment Sectors in the North Coast Region

EMPLOYMENT SECTOR RANKING					
County	1	2	3	4	5
Del Norte	Government	Health Care	Retail Trade	Lodging & Food Services	Construction
Humboldt	Government	Retail Trade	Health Care	Lodging & Food Services	Construction
Mendocino	Government	Retail Trade	Health Care	Lodging & Food Services	Construction
Lake	Government	Health Care	Retail Trade	Lodging & Food Services	Construction

[CA REAP, 2011]

Table 4. Selected Population Data for the North Coast Region

						POPULATION BELOW POVERTY LEVEL		
	TOTAL 2010 POP.	POP. <5 YEARS	PERCENT < 5 YEARS	POP. ≥65 YEARS	PERCENT ≥65 YEARS	ESTIMATED - ALL AGES	ESTIMATED PERCENT	MARGIN OF ERROR
County	280,490	15,529	5.50%	46,897	16.70%	50,077		
Del Norte	28,610	1,703	6.00%	3,873	13.50%	5,824	23.5	4.6
Humboldt	134,623	7,738	5.70%	17,725	13.20%	23,752	18	2.2
Lake	64,665	3,633	5.60%	11,440	17.70%	13,438	21	3.4
Mendocino	87,841	5,347	6.10%	13,493	15.40%	16,976	19.6	3.3

[US Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

Many of the stressors already affecting the varied ecosystems in this region are exacerbated by climate change. These include water management, forest management, fire regimes, agricultural and urban development, coastal management and development, and public health (CDFG, 2007). Changes in these areas can result in secondary consequences that affect the local economy, public health, and safety.

Water Management

Depending on location, parts of this region are projected to experience between 6 inches and 15 inches less rainfall by 2100 (see Table 1). Reduced rainfall, combined with reductions in snowpack and existing diversions, could result in an altered flow regime in the region. This change would be particularly challenging due to its impact on anadromous fish, such as the coho salmon. Reduced flow, altered timing of flows, and periodic extreme events can result in reduced water quality, habitat destruction, and/or isolation of habitats. Local jurisdictions should carefully assess local aquatic ecosystems for vulnerability to these changes.

Forest Management and Fire Regimes

In 2010, this region was one of the highest timber-producing areas in the state in both volume and value (BOE, 2010). Humboldt and Mendocino counties are two of the highest timber-producing counties in California (BOE, 2010).

Productivity of forestry operations is likely to be affected by climate change due to forest growth rates and wildfire vulnerability. While in the short term increased carbon dioxide concentrations can promote growth, climate change can affect invasive species, pest populations, and seasonal temperature and moisture regimes, which, over the long term, can affect productivity of forestry operations. The northern part of the state is projected to have a greater increase in wildfire risk than other parts of the state. This projected increase is based only on climate (e.g., temperature projections) and does not include an assessment of other factors such as vegetation type or fuel load. In the North Coast region, moderate to large increases in large fires (>200 ha) (Westerling et al., 2009; Westerling and Bryant, 2006) are projected in inland areas. A slight decrease in wildfire risk along the coast is projected due to changes in vegetative composition (Lenihen et al., 2006).

Wildfire threatens not only the forestry industry but also the safety of residents. The projected wildfire frequency is a considerable change from current conditions, meaning communities are less likely to be accustomed to the risks of fire and the measures required to address them. Of particular concern for the elderly and children under the age of five (see Table 4) are eye and respiratory

illnesses due to air pollution resulting from wildfires, and exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular diseases. Wildfire also threatens safety at the wildland-urban interface. With the increase in wildfire likelihood, more residents are likely to be vulnerable to wildfire in the future, and additional strategies will need to be developed to address this risk. Smoke management, especially the use of prescribed burning as a fuel-reduction tool, should be coordinated with the air districts.

Agriculture

The highest value agricultural product of the northernmost areas of the region (Del Norte and Humboldt counties) is timber (California Farm Bureau Federation, 2012). In addition to timber, other products include milk, nursery products, and wine grapes. The southern two counties (Mendocino and Lake) produce wine grapes, valued at more than double any other crop.

Each of the products from this region will be affected by climate change differently. Forests will experience changed seasonal patterns that may alter moisture and temperature regimes, both of which may affect growth rates. Further threatening timber production is that temperature and precipitation along with management and invasive species (fuel load) will result in increased fire risk in this region (see above).

For wine grapes, the largest crop in the southern part of the region, climate can affect productivity, as well as the quality of the grape for wine production. North Coast communities should collaborate closely with local agricultural organizations to best support and prepare for changes in this economic sector.

Coastal Development

The region is relatively undeveloped on the coast and therefore will generally be resilient as sea level rise occurs. Notable exceptions are the Arcata/Eureka/Fortuna area, which is in a coastal plain subject to flooding, and Crescent City, which is currently susceptible to tsunami. For example, Humboldt County is projected to see an 18 percent increase in coastal inundation by 2100. The earthen levees holding back the sea in many of these areas are at or near capacity. These communities should carefully assess the potential consequences of these impacts.

U.S. Highway 101 is a key transportation route and lifeline for all communities in Humboldt and Del Norte counties. In many areas, the roadbed is located at or below sea level and protected by aging shoreline protective structures (near Humboldt Bay, for example). The highway corridor also crosses major river

systems and estuaries, where bridged crossings will be particularly vulnerable to increased erosion of support structures, and eventually, to flooding. State Route 1 performs a similar function in rural Mendocino County. There too, the roadway faces future stress from coastal erosion and may be inundated in lower lying areas.

Sea level rise is expected to affect vulnerable populations along the coast through the immediate effects of flooding and temporary displacement and longer-term effects of permanent displacement and disruption of local tourism. Some populations do not have the resources to prepare for, respond to, and recover from disasters. These populations are vulnerable to temporary and permanent displacement, drowning, and property damage, as well as coastal erosion harming recreational activities, tourism, and the tourism industry.

In addition to causing inundation of built structures and public safety hazards, sea level rise can affect tourism. In 2000, over 7 percent of the region's employment was dependent on coastal resources (NOEP, 2005), with tourism-based activities representing the largest part of this percentage. Preparing for potential impacts of climate change means taking action to preserve the coastal ecosystems that serve as the tourist attraction. From an ecological perspective, the estuaries at the mouth of the Smith River, Humboldt Bay, and the mouth of the Eel River are of particular concern.

Public Health, Socioeconomic, and Equity Impacts

Extreme heat events are less likely to occur in the North Coast region than in other parts of the state. When they do occur, vulnerable populations may be severely affected because of a historic lack of adaptive capacity having to do with historically milder temperatures. For instance, "low air conditioner ownership" is found along the California coast. Humboldt County has "only medium air conditioner ownership (60-65 percent of the population)" (English et al., 2007). Humboldt County has moderately high proportions of populations eligible for energy utility financial assistance programs (47 to 55 percent) (English et al., 2007). Households eligible for these programs are an indicator of potential impacts, as these households may be more at risk of not using cooling appliances, such as air conditioning, due to associated energy costs. Del Norte County has a relatively higher poverty level (more than 23 percent), which suggests residents may not have the material resources needed to prevent, respond, or recover from impacts.

Populations that are isolated in some of the rural areas of this region and may not have the access to care or means necessary to recognize impacts and/or evacuate are at increased risk for injuries and death from burns and smoke inhalation and heat-related illnesses. Mendocino County is one of the state's counties with the highest proportion of elderly living alone (English et al., 2007).

ADDITIONAL RESOURCES

- Sea level rise and biodiversity and ecosystem resources
  - Humboldt Bay is a critical aquatic resource in this region. A collaborative of local and state agencies participated to develop an approach to adaptation titled the Humboldt Bay Initiative: Adaptive Management in a Changing World, http://ca-sgep.ucsd.edu/sites/ca-sgep.ucsd.edu/files/advisors/sschlosser/files/HBI%20StratPlan2009.pdf
- Wildfire resources include the following:
  - California Fire Science Consortium, Northern California Module: http://www.cafiresci.org/home-northern-ca/
  - Northern California Prescribed Fire Council: http://www.norcalrxfirecouncil.org/Home_Page.html
  - NorCal Society of American Foresters: http://norcalsaf.org/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The North Coast-Klamath Region overlaps with the North Coast region.

North Region

Counties: Lassen, Modoc, Shasta, Siskiyou, Trinity
Five Largest Cities (CDOF, 2011): Redding (90,250); Susanville (17,554); Shasta Lake (10,125); Anderson (10,125); Yreka (7,775)

TOTAL 2010 POPULATION	
North Region	**280,490**
Lassen	34,895
Modoc	9,686
Shasta	177,223
Siskiyou	44,900
Trinity	13,786

[U.S. Census Bureau, 2010]

The North region is an inland region that is sparsely settled (280,000+ people), with the exception of the city of Redding (90,000+ people). The region is characterized by rugged mountains and thick forests in the west. The mountain ranges result in a series of microclimates and distinct ecosystems. To the east, the Modoc Plateau supports high desert ecosystems and associated species. The prominent features include Mt. Shasta and Shasta Dam. Major economic activities include tourism and timber.

Climate-change impacts that jurisdictions in the North region should consider evaluating include the following:

- Increased wildfire
- Reduced snowpack
- Ecosystem shifts and non-native species
- Flooding
- Economic impact (timber, tourism, grazing)
- Reduced public health due to air pollution (especially for elderly)

Cal-Adapt Projections

Table 5. Summary of Cal-Adapt Climate Projections for the North Region

EFFECT	RANGES
Temperature Change, 1990-2100	January average temperature increase of 0.5°F to 4°F by 2050 and 3°F to 6°F by 2100. July average temperature increase 3°F to 5.5°F by 2050 and 8°F to 10°F by 2100, with larger temperature increases in the mountainous areas in the northeastern portion of the region. (Modeled high temperatures – average of all models; high carbon emissions scenario)
Precipitation	Annual precipitation is projected to decline by approximately an inch by 2050 and 2 inches by 2100 for most of the region. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	Heat wave is defined as five days above a temperature between 89°F and 99°F depending on location. By 2050 there is projected to be two to four more heat waves than 2010. Projected heat wave occurrence in 2100 is variable depending on location, between six and 15 per year.
Snowpack	March snowpack disappears by 2090 for most of the region with the exception of areas near Mt. Shasta. (CCSM3 climate model; high carbon emissions scenario)
Wildfire Risk	Substantial increases in the likelihood of wildfires are projected in most of the region, especially in Shasta and Siskiyou counties where risks may be multiplied 6 to 14 times by the end of the century. (GFDL climate model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

The North region overlaps portions of the Sacramento River, Northern Lahontan, and North Coast hydrologic regions as defined by the California Department of Water Resources (2009). Water supply relies on a mix of imported, regional surface water and groundwater resources for meeting local demand. Overdraft and illegal diversions create challenges for resource management in some areas, contributing to concerns about the preservation of aquatic and riparian habitats (DWR, 2009). Most of Shasta County, the southeastern corner of Siskiyou County, the central portions of Modoc County, and the northwestern area of Lassen County are located in the Sacramento River hydrologic region. In this region there is heavy reliance on groundwater and on the surface water conveyance systems that provide much of the Delta inflow. The easternmost parts of Modoc County and much of Lassen County are located in the North Lahontan hydrologic region (DWR, 2009). The Susan River drains the North Lahontan area and serves as a critical source of water. Trinity County, much of Siskiyou County, and the northwestern portions of Modoc

County are in the North Coast hydrologic region. Trinity Lake, located 40 miles northwest of Redding, is the largest reservoir in the North region, containing a volume of over 2.4 million acre-feet. This and other North Coast sources export water to the Sacramento River region via the Clear Creek Tunnel (DWR, 2009). The abundance of rivers and groundwater basins in the region allows for many of the small communities to rely on local resources to meet water demand.

Biophysical Characteristics

The majority of the region is located between 3,000 and 12,000 feet above sea level. Aquatic and riparian resources within the area include Goose Lake, Clear Lake Reservoir, the Klamath River, the Pit River, Shasta Lake, the Sacramento River, Eagle Lake, and Honey Lake (DWR, 2009). Natural vegetation differs based on location within the region. The southwestern portion of the region is characterized by oak, pine, mixed-conifer, and hardwood-conifer forests accompanied by mixed chaparral and low sage (FRAP, 1998). Areas in Lassen and Modoc counties offer habitat characterized by Joshua trees and juniper woodland, perennial grassland, wetland meadows, and freshwater emergent wetlands (DWR, 2007). The Modoc Plateau and dependent species are declining due to excessive grazing and invasive species.

Regional Entities

- Air Districts: Lassen, Modoc, North Coast Unified, Shasta, Siskiyou
- Regional Organizations: Lassen County Transportation Commission, Modoc County Local Transportation Commission, Shasta County Regional Transportation Planning Association, Trinity County Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Alturas, Big Bend, Cedarville, Fort Bidwell, Karuk, Likely, Lookout, Montgomery Creek, Quartz Valley, Redding, Roaring Creek, Round Valley, Susanville, XL Ranch

Selected Infrastructure and Regional Resources

Table 6. Infrastructure and Resources in the North Region

TYPES	NAMES
Airports	Trinity Center, Weaverville, Hayfork, Hyampom, Ruth, Butte Valley, Happy Camp, Weed, Dunsmuir Municipal-Mott Airport, Montague-Yreka Rohrer Field, Redding Municipal, Fall River Mills, Shingletown, Alturas Municipal, California Pines, Cedarville, Tulelake Municipal
National and State Parks	National: Klamath National Forest, Lassen Volcanic National Park, Modoc National Forest, Shasta National Forest State: Ahjumawi Lava Springs State Park, Castle Crags State Park, Hayden Hill-Silva Flat State Game Refuge, McArthur-Burney Falls Memorial State Park
Passenger Rail	Coast Starlight (Union Pacific Railroad); Lake County Railroad (Modoc Northern Railroad); Central Oregon & Pacific Railroad (Union Pacific); Yreka Western Railroad (Kyle Railways) Humboldt Bay (137).

Selected Demographic Data

Table 7. Top Five Employment Sectors in the North Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Lassen	Government	Retail Trade	Health Care & Social Assistance	Other Services	Lodging & Food Services
Modoc	Government	Farm Employment	Other Services	Retail Trade	Real Estate
Shasta	Government	Health Care & Social Assistance	Retail Trade	Lodging & Food Services	Other Services
Siskiyou	Government	Health Care & Social Assistance	Retail Trade	Lodging & Food Services	Other Services
Trinity	Government	Retail Trade	Lodging & Food Services	Construction	Other Services

[CA REAP, 2011]

Table 8. Selected Population Data for the North Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
County	280,490	15,529	5.50%	46,897	16.70%	50,077		
Lassen	34,895	1,625	4.70%	3,474	10.00%	4,198	16.8	4
Modoc	9,686	545	5.60%	1,905	19.70%	2,061	21.9	4.1
Shasta	177,223	10,268	5.80%	29,967	16.90%	31,766	18.2	2.4
Siskiyou	44,900	2,473	5.50%	8,782	19.60%	9,558	21.5	3
Trinity	13,786	618	4.50%	2,769	20.10%	2,494	18.4	4.4

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

Several aspects of the local economy in this region – including timber harvest, tourism, grazing, and water supply – rely on the local ecosystem. The changes projected for the North region may detrimentally affect these systems as well as threaten public safety and public health.

Ecosystems and Wildfire

Changes in temperature, amount of precipitation, and reduction in snowpack (see Table 5) have potential impacts on water quantity and quality. Siskiyou and Trinity counties are home to rivers and streams that support the current and historic range for endangered coho salmon. Alteration of flow regimes and water quality will affect this species (CDFG, 2007). Changes to aquatic systems affect more than just the species, but also economy and human health. Severe Blue Green Algae (BGA) has already affected the Klamath River; local officials have issued health advisories affecting reservoirs used for fishing and boating activities. Thus, BGA, in addition to posing a health risk, threatens tourism. Moreover, Native American tribes that use the river for ceremonial purposes have been affected (CDPH, 2008).

In the northeast portion of the state (Modoc and Lassen counties), grazing is a major economic activity. Grazing has altered the vegetative pallet of the region by reducing herbaceous vegetation. This change has affected native herbivores and created conditions that provide invasive species a competitive advantage. Riparian areas are also detrimentally affected by livestock grazing (CDFG, 2007).

Climate change can increase forest productivity in the short term, due to increased carbon dioxide and increased temperature. Ultimately, however, reduced water availability, drier conditions, altered pest and invasive species ranges, and increased fire severity and

frequency can harm forests. Large increases in wildfire are projected in all parts of the region (Klamath Mountains, Siskiyou Mountains, Southern Cascade Mountains, Modoc Plateau) (Lenihan et al., 2006; Westerling and Bryant, 2006; Westerling et al., 2009).

Wildfire affects not only the local ecosystem and timber industry, but also public health and safety. Of particular concern for the elderly and children under the age of five (see Table 8) are eye and respiratory illnesses due to air pollution resulting from wildfires, and exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular diseases. Fires would not only jeopardize safety and property, but also destroy resources for the timber industry and affect the local economy.

Water Resources

In addition to affecting aquatic ecosystems, shorter rainfall events and rapid snowmelt will reduce the region's water supply. Recreation and tourism in the region are likely to suffer due to lower water levels in waterways and reservoirs and declining snowpack in north-central areas of the region. Unstable working conditions in the tourism industry may increase the economic vulnerability of employees in this industry.

Rapid snowmelt events and intense rainfall can result in flooding. Flood events may overwhelm water treatment and wastewater management facilities and risk exposing communities to contaminated water resources. Higher temperatures and early snowmelt may also lengthen the life and impact of vector-borne diseases.

Public Health, Socioeconomic, and Equity Impacts

Households eligible for energy utility financial assistance programs are an indicator of potential impacts. These households may be more at risk of not using cooling appliances, such as air conditioning, due to associated energy costs. Siskiyou and Trinity counties have some of the state's highest proportions of population eligible for energy assistance (56 to 63 percent). Lassen County also has a moderately high proportion of population eligible (47 to 55 percent) (English et al, 2007). Modoc and Siskiyou counties have relatively higher poverty levels (more than 21 percent), which suggests residents may not have the material resources needed to prevent, respond, or recover from impacts.

The second largest employment sector in Modoc County is farming. In Trinity, Siskiyou, and Lassen counties, lodging and food are in the top five employment sectors, indicating that tourism is an important industry. Foothills and mountainous communities of this region may be particularly subject to respiratory problems and heat stress due to a combination of higher ozone levels, higher elevations, and increasing temperatures in these areas (English et al., 2007; Drechsler et al., 2006). In areas such as these, conditions conducive to ozone formation are projected to increase by as much as 25 to 80 percent by 2100 (Drechsler et al., 2006, Karl and Roland-Holst, 2008).

Those most vulnerable to high levels of ozone and particulate matter include people who work or spend a lot of time outdoors, such as employees of the agricultural and the tourism industries. People over the age of 65 have the largest increase in mortality with increased concentrations of ozone (Medina-Ramon and Schwartz, 2008). Trinity, Modoc, Siskiyou and Shasta counties have a relatively high percentage of population older than 65. This population is more vulnerable to heat events and air quality problems.

Modoc County is one of the state's counties with the highest proportion of elderly living alone (English et al., 2007). Populations that are isolated in some of the rural areas of this region and may not have the means necessary to recognize impacts and/or evacuate are at increased risk for injuries and death from burns and smoke inhalation and heat-related illnesses.

ADDITIONAL RESOURCES

- Wildfire resources include the following:
  - California Fire Science Consortium, Northern California Module: http://www.cafiresci.org/home-northern-ca/
  - Northern California Prescribed Fire Council: http://www.norcalrxfirecouncil.org/Home_Page.html
  - NorCal Society of American Foresters: http://norcalsaf.org/
  - Quincy Library Group: http://qlg.org/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The North Coast-Klamath and Modoc Plateau Regions overlap with the North region.

Bay Area Region

Counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma
Five Largest Cities (CDOF, 2011): San Jose (958,789); San Francisco (812,820); Oakland (392,932); Fremont (215,711); Santa Rosa (168,856)

TOTAL 2010 POPULATION	
Bay Area Region	**7,150,739**
Alameda	1,510,271
Contra Costa	1,049,025
Marin	252,409
Napa	136,484
San Francisco	805,235
San Mateo	718,451
Santa Clara	1,781,642
Solano	413,344
Sonoma	483,878

[U.S. Census Bureau, 2010]

The Bay Area is a heavily urbanized region (over 7 million people). The predominant feature of this region is San Francisco Bay and the miles of shoreline, both on the Pacific coast and along the bay, extending north to Sonoma County, inland to the Delta, and south to San Jose. The urbanized areas are concentrated primarily around the bay. To the north and south, the region is characterized by low coastal mountains (CDFG, 2007). Sonoma and Napa counties produce wine grapes valued over $850 million in 2010 (California Farm Bureau Federation, 2012). To the east, Solano and Contra Costa counties are on the western edge of the low-lying California Delta.

Communities in the Bay Area should consider evaluating the following climate change impacts:

- Increased temperatures
- Reduced precipitation
- Sea level rise – coastal inundation and erosion
- Public health – heat and air pollution
- Reduced agricultural productivity (e.g., wine grapes)
- Inland flooding
- Reduced tourism

Cal-Adapt Projections

Table 9. Summary of Cal-Adapt Climate Projections for the Bay Area Region

EFFECT	RANGES
Temperature Change, 1990-2100	January: 4°F to 5°F increase in average temperatures July: 5°F to 6°F increase in average temperatures (Modeled high temperatures – average of all models; high carbon emissions scenario)
Precipitation	Precipitation varies widely in this region, with annual totals over 40 inches in northern Sonoma County to roughly 15 inches in the eastern portions of Solano and Contra Costa counties. A moderate decline in annual rainfall, 1 to 3 inches by 2050 and 4 to 5 inches by 2090, is projected throughout the region. (CCSM3 climate model; high carbon emissions scenario)
Sea Level Rise	By 2100, sea levels may rise up to 55 inches, posing considerable threats to coastal areas and particularly to low-lying areas adjacent to San Francisco Bay. The number of acres vulnerable to flooding is expected to increase 20 to 30 percent in most parts of the Bay Area, with some areas projected for increases over 40 percent. Coastal areas are estimated to experience an increase of approximately 15 percent in the acreage vulnerable to flooding.
Heat Wave	Along the coast, particularly to the south, heat wave is defined as five days over 72°F to 77°F; in other areas the threshold is in the mid- to upper 90s. Over most of the region a limited increase in the number of heat waves is expected by 2050 with only the eastern areas expecting more than one or two more per year. By 2100, between six and 10 more heat waves can be expected per year.
Fire Risk	There is little change in projected fire risk in this region, save for the slight increases expected in western Marin County. (GFDL climate model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

Approximately 70 percent of the water used in the region is imported, with another 15 percent supplied via groundwater. The imported water comes from a variety of sources, including the Russian River (4 percent); the Delta (approximately 32 percent, via San Luis Reservoir, North Bay Aqueduct, Contra Costa Canal, South Bay Aqueduct); Lake Berryessa (5 percent); Mokelumne River (25 percent); and Tuolumne River (33 percent). The vast majority of these water sources (e.g., Delta sources, Mokelumne River, Tuolumne River) originate in the Sierra Nevada, meaning that climate change impacts on snowpack may have a dramatic impact on the Bay Area water supply. Total reservoir storage capacity in the Bay Area is 746,000 acre-feet (DWR, 2009).

Biophysical Characteristics

The Bay Area region is located in an area characterized by a Mediterranean climate, with warmer summer temperatures observed in the eastern portions of the region. San Francisco Bay and the associated estuarine ecosystem sit at the center of the region and serve as the outlet for

the Sacramento and San Joaquin rivers. This estuary supports rich biodiversity, including many special-status species (CDFG, 2007).

The eastern portions of Contra Costa and Solano counties meet the western edge of the area commonly known as the Delta. This area has subsided and has elevations below sea level.
The topography in the Bay Area region reaches to over 4,000 feet in the Coastal Range and falls to the low-lying areas along the coast and bay. In the west, the dominant vegetation is coniferous forest with a mix of hardwoods. To the east, shrubs and grasses begin to emerge (FRAP, 1998; FRAP, 2003).

Regional Entities

- Air Districts: Bay Area Air Quality Management District
- Regional Organizations: Association of Bay Area Governments, Metropolitan Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Dry Creek, Stewarts Point

Selected Infrastructure and Regional Resources

Table 10. Infrastructure and Resources in the Bay Area Region

TYPES	NAMES
Airports	International: Oakland International, San Francisco International, San Jose International General Aviation: Angwin-Parrett Field, Byron, Concord/Buchanan Field, Cloverdale Municipal, Gnoss Field, Half Moon Bay, Hayward Executive, Healdsburg Municipal, Livermore Municipal, Napa County, Nut Tree Airport, Ocean Ridge, Palo Alto, Petaluma Municipal, Rio Vista Municipal, San Carlos, Sonoma County, Sonoma Valley, South County
National and State Parks	National: Golden Gate National Recreation Area, Gulf of the Farallones National Marine Sanctuary, Muir Woods National Monument, Point Reyes National Seashore, San Francisco Bay National Wildlife Refuge Complex (7 sites) State: Albany State Marine Reserve, Angel Island S.P., Annadel S.P., Ano Nuevo S.P., Armstrong Redwoods Natural Reserve, Big Basin Redwoods S.P., Bothe-Napa Valley S.P., Butano S.P., Castle Rock S.P., China Camp S.P., Eastshore S.P., Emeryville Crescent State Marine Reserve, Henry W. Coe S.P., Kruse Rhododendron Natural Reserve, Mount Diablo S.P., Mount Tamalpais S.P., Pacheco S.P., Portola Redwoods S.P., Robert Louis Stevenson S.P., Robert W. Crown Memorial Beach, Salt Point S.P., Samuel P. Taylor S.P., San Bruno Mountain S.P., Sonoma Coast S.P., Sugarloaf Ridge S.P., Tomales Bay S.P.
Passenger Rail	Altamont Commuter Express, Amtrak, Bay Area Rapid Transit, Caltrain, San Francisco Muni Metro, Santa Clara Valley Transportation Authority
Ports	Bulk and Container: Benicia, Oakland, Pittsburg, Richmond, Redwood City, San Francisco Other: Pillar Point Harbor, Porto Bodega Marina
Power Plants (MWs)*	Duke Energy Oakland (165), Newby Island 2 (6.5), Pittsburg (1310), GWF Power Systems L.P. (22.8), Foster-Wheeler Martinez Cogen L.P. (114), Nove Power Plant (3), American Canyon Power Plant (1.7), Hunters Point (215), United Cogen Inc. (31), Gianera (49.5), Gas Recovery Systems-Fremont (3.75), Solano Cogen (1.45)

S.P. = State Park; MWs = megawatts
*Located within the 100-year flood zone for 1.5-meter sea level rise

Selected Demographic Data

Table 11. Top Five Employment Sectors in the Bay Area Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Alameda	Government	Professional & Technical Services	Health Care	Retail Trade	Manufacturing
Contra Costa	Retail Trade	Health Care	Government	Professional & Technical Services	Finance & Insurance
Marin	Professional & Technical Services	Health Care	Retail Trade	Government	Other Services
Napa	Manufacturing	Government	Lodging & Food Services	Health Care	Retail Trade
San Francisco	Professional & Technical Services	Government	Lodging & Food Services	Finance & Insurance	Health Care
San Mateo	Professional & Technical Services	Retail Trade	Health Care	Finance & Insurance	Government
Santa Clara	Manufacturing	Professional & Technical Services	Government	Retail Trade	Health Care
Solano	Government	Retail Trade	Health Care	Lodging & Food Services	Construction
Sonoma	Government	Health Care	Retail Trade	Professional & Technical Services	Manufacturing

[CA REAP, 2011]

Table 12. Selected Population Data for the Bay Area Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Bay Area	7,150,739	447,811	6.30%	878,229	12.30%	781,399		
Alameda	1,510,271	97,652	6.50%	167,746	11.10%	200,273	13.5	1
Contra Costa	1,049,025	67,018	6.40%	130,438	12.40%	97,544	9.3	0.9
Marin	252,409	13,932	5.50%	42,192	16.70%	22,456	9.2	1.5
Napa	136,484	8,131	6.00%	20,594	15.10%	14,189	10.7	1.8
San Francisco	805,235	35,203	4.40%	109,842	13.60%	100,910	12.8	1.1
San Mateo	718,451	46,360	6.50%	96,262	13.40%	49,908	7	0.9
Santa Clara	1,781,642	124,464	7.00%	196,944	11.10%	186,051	10.6	0.7
Solano	413,344	26,852	6.50%	46,847	11.30%	49,159	12.2	1.4
Sonoma	483,878	28,199	5.8%	67,364	13.9%	60,909	12.8	1.2

Adaptation Considerations

Large urban areas are prone to specific secondary climate-change impacts due to population density and urban settlement patterns. In the Bay Area region, the location of the urbanized area near a bay that serves as the mouth of two major river networks creates the potential for additional impacts. Outside of the urbanized region, ecosystem shifts and impacts on agriculture, specifically wine grapes, may be experienced.

Sea Level Rise

Since much of the urbanized part of the region is near the ocean or bay, sea level rise will significantly affect development and infrastructure. This is likely to be the greatest threat from climate change to the Bay Area. A 1.4-meter rise in sea level will increase the population vulnerable to a 100-year coastal storm from 10,610 to 13,730 (CCCC, 2009).

The San Francisco Bay Conservation and Development Commission (BCDC) evaluated vulnerability to sea level rise in the region and potential adaptation strategies. Key issues identified by BCDC for the region include the following:

- A "55-inch rise in sea level would place an estimated 270,000 people in the Bay Area at risk from flooding, 98 percent more than are currently at risk. The economic value of Bay Area shoreline development (buildings and their contents) at risk from a 55-inch rise in sea level is estimated at $62 billion…" (BCDC, 2011, p. 3).

- Coastal flooding presents a risk to major transportation infrastructure in the region including freeways, rail lines, ports, and airports (especially San Francisco and Oakland).
- "The impacts of climate change are expected to substantially alter the Bay ecosystem by inundating or eroding wetlands and transitional habitats, altering species composition, changing freshwater inflow, and impairing water quality. Changes in salinity from reduced freshwater inflow may adversely affect fish, wildlife and other aquatic organisms in intertidal and subtidal habitats. The highly developed Bay shoreline constrains the ability of tidal marshes to migrate landward, while the declining sediment supply in the Bay reduces the ability of tidal marshes to grow upward as sea level rises" (BCDC, 2011, p. 5).

With the large number of local and special purpose governments in the region, addressing the sea level rise problem will require regional collaboration involving the California Coastal Commission and San Francisco Bay Conservation and Development Commission. The San Francisco Planning + Urban Research Association (2012) has recommended the following actions for addressing climate change:

- Barrier(s) or tidal barrage(s) to manage tidal flows in and out of San Francisco Bay (at the Golden Gate or in smaller, strategic parts of the bay)
- Coastal armoring with linear protection, such as levees and seawalls, to fix the shoreline in its current place
- Elevated development in which the height of land or existing development is raised and protected with coastal armoring
- Floating development on the surface of the water, or development that may be floated occasionally during a flood, making it largely invulnerable to changing tides
- Floodable development designed to withstand flooding or to retain stormwater
- Living shorelines with wetlands that absorb floods, slow erosion, and provide habitat
- Managed retreat that safely removes settlement from encroaching shorelines, allowing the water to advance unimpeded, and bans new development in areas likely to be inundated

Alameda and San Mateo counties could see significant increases in the number of United States Environmental Protection Agency (U.S. EPA)-regulated sites at risk for sea level rise, including Superfund sites, hazardous waste generators, facilities required to report emissions for the Toxics Release Inventory, facilities regulated under the National Pollutant Discharge Elimination System (NPDES), major dischargers of air pollutants with Title V permits, and brownfield properties (CCCC, 2009).

Sea level rise is also expected to affect vulnerable populations along the coast through the immediate effects of flooding and temporary displacement and longer-term effects of permanent displacement and disruption of local tourism. Of particular concern are populations that do not have the resources to prepare for, respond to, and recover from disasters. Impacts could include temporary and/or permanent displacement, drowning and property damage, and coastal erosion harming recreational activities, tourism, and the tourism industry.

Vulnerable populations living in institutional settings are disproportionately vulnerable during evacuations from disasters. For instance, Solano and Marin counties have a high proportion of elderly living in nursing homes that could be affected (English et al., 2007).

Flooding

The risk of flooding is highest for the inland, low-lying areas in the eastern part of the region. Reduced snowpack and increased number of intense rainfall events in the Northern Sierra are likely to put additional pressure on water infrastructure, including the Delta levees, which are already vulnerable (DWR, 2011). These impacts increase the chance of flooding associated with breached levees or dams (e.g., in the Sacramento-San Joaquin Delta). Flooding and damage to infrastructure can put large populations in adjacent regions at risk (CDPH, 2008), including:

- The elderly and children less than five years of age, who are isolated or dependent on others for evacuation.
- Populations that may lack the resources or knowledge to prepare or respond to disaster due to language or economic status, including having access to transportation, which would allow them to escape flooding, at least temporarily.
- Vulnerable populations living in institutional settings who are particularly vulnerable during evacuations from disasters. For instance, Solano, and Marin counties have a high proportion of elderly living in nursing homes that could be affected (English et al., 2007).

Public Health, Socioeconomic, and Equity Impacts

Some of the state's highest percentages of impervious surfaces are in the urban areas of the San Francisco Bay Area, increasing the potential impacts of heat islands (English et al., 2007). Santa Clara, Alameda, San Francisco, and Contra Costa counties rank fifth, sixth, ninth, and tenth in the absolute numbers of the elderly and children less than five years of age. These two populations are most likely to suffer from heat-related illnesses and heat events (English et. al, 2007). The highest risk of heat-related illness occurred in the usually cooler regions found in coastal counties and not in the Central Valley where the highest actual temperatures were experienced (Gershunov and Cayan, 2008; CDPH, 2008).

Because of a lack of acclimatization, the largest mortality rate percent increases in California are expected in coastal cities such as San Francisco (CNRA, 2009). Lodging and food services are among the top five employment sectors in Napa, San Francisco, and Solano counties, indicating that may be a significant number of employees who work in the tourism industry/outdoors. Sea level rise may impact employees in the tourism industry. Air quality and heat events may impact outdoor workers, including agricultural and dairy workers.

The higher cost of living in some areas of this region (i.e. San Francisco, Silicon Valley, Marin County) means low-income families pay a high percentage of their income on housing and transportation. Increases in food and energy costs may impact low-income residents.

Fire

A slight increase in fire occurrence is projected for the region. This increase is projected to be largest in the northeastern part of the region. Despite moderate increases in fire risk, huge increases in fire damages are projected due to high population in fire-vulnerable areas (Bryant and Westerling, 2009). Along with impacts associated with temporary and/or permanent displacement, long-term impacts on the elderly and children under the age of five are of concern. Eye and respiratory illnesses due to air pollution resulting from wildfires, and exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular diseases, are likely to increase.

Agriculture

Alteration of temperature and precipitation regimes changes the seasons as experienced by plants and animals. These changes are expected to affect the wine industry because the wine grape is a crop that requires a fairly narrow range of climate conditions (Todorov, 2011). These changes might affect not only wine grape growers, but also the businesses and residents dependent on this industry. Communities reliant on the wine industry as an employment base, tourist attraction, or local economic base should closely collaborate with vintner associations and other local agricultural organizations to best understand the risk and support grower efforts to adapt. Communities also may need to plan for a future in which wine grapes and associated activities make up a smaller part of their local economy.

ADDITIONAL RESOURCES

- Public Health, Socioeconomic, and Equity Impacts
  - San Francisco's Healthy Development Measurement Tool (www.theHDMT.org) provides health-based rationales, goals, and indicators applicable to other jurisdictions. The San Francisco Public Health Department has also used it to generate a wide range of health-oriented maps, including proximity to farmers markets, noise levels, bike collisions, and truck routes.
  - Issues and Opportunities Papers for the City of Richmond's upcoming general plan update (http://www.cityofrichmondgeneralplan.org/docManager/1000000640/Existing%20Condictions%20Report%20August%202007.pdf) include a baseline assessment built largely from the framework of the Healthy Development Measurement Tool described above.
  - The Oakland Health Profile (2004) includes maps comparing diabetes and childhood asthma hospitalization rates across the city and county (Public Health Law and Policy, How to Create a Healthy General Plan, 2008).
  - The San Jose area has a Health Heat Watch Warning System in place (CDPH, 2008).
- Wildfire Resources
  - California Fire Science Consortium, Central & South Coast Module: http://www.cafiresci.org/home-central-and-southern-ca/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- Biodiversity and Ecosystems
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The Marine and Central Valley and Bay-Delta Regions overlap with the Bay Area region.

Northern Central Valley Region

Counties: Butte, Colusa, Glenn, Madera, Merced, Sacramento, San Joaquin, Stanislaus, Sutter, Tehama, Yolo, Yuba
Five Largest Cities (CDOF, 2011): Sacramento (469,566); Stockton (293,515); Modesto (202,290); Elk Grove (154,594); Chico (86,900)

TOTAL 2010 POPULATION	
Northern Central Valley	3,725,950
Butte	220,000
Colusa	21,419
Glenn	28,122
Madera	150,865
Merced	255,793
Sacramento	1,418,788
San Joaquin	685,306
Stanislaus	514,453
Sutter	94,737
Tehama	63,463
Yolo	200,849
Yuba	72,155

[U.S. Census Bureau, 2010]

The Northern Central Valley is a largely agricultural, inland region with over 3.7 million people, with substantial cities, the largest being the state capital, Sacramento (469,000+ people). The central portion of the region is defined by the Delta, with inland marshes intermingled with agriculture, interspersed with cities along transport corridors. The region contains the Port of Stockton, the most inland port for ocean-going vessels, approximately 80 miles from the Golden Gate Bridge. Agriculture is the predominant economic activity. The agricultural operations in this region include rice, dairy, and nut trees (almond and walnut) (California Farm Bureau Federation, 2012). The region's agricultural activity is one of the most productive in the nation.

In the Northern Central Valley region, communities will need to assess vulnerability to the following impacts:

- Temperature increases – particularly nighttime temperature
- Reduced precipitation
- Flooding – increase flows, snowmelt, levee failure in the Delta
- Reduced agricultural productivity (e.g., nut trees, dairy)
- Reduced water supply
- Wildfire in the Sierra foothills
- Public health and heat
- Reduced tourism

Cal-Adapt Projections

Table 13. Summary of Cal-Adapt Climate Projections for Northern Central Valley

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperature of 4°F to 6°F and between 8°F and 12°F by 2100. July increase in average temperature of 6°F to 7°F in 2050 and 12°F to 15°F by 2100. (Modeled high temperatures – average of all models; high carbon emissions scenario)
Precipitation	Annual precipitation is projected to decline by approximately one to two inches by 2050 and three to six inches by 2100. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	Heat wave is defined as five days over 102°F to 105°F, except in the mountainous areas to the east. Two to three more heat waves per year are expected by 2050 with five to eight more by 2100.
Wildfire Risk	By 2085, the north and eastern portions of the region will experience an increase in wildfire risk, more than 4 times current levels in some areas. (GFDL model, high emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

Two rivers, the San Joaquin and Sacramento, run through this region. The rivers originate from snowmelt in the Sierra Nevada and the mountainous regions in the north and flow toward San Francisco Bay, where the flows eventually reach the Pacific Ocean. The confluence of the rivers occurs in the Sacramento-San Joaquin Delta.

Water moves through the region through natural waterways as well as a network of canals and reservoirs. The reservoir and canal systems that hold much of the region's water allow it to be leveraged for energy generation and recreational use (DWR, 2009). The water supply network for the region is highly complex. One third of the regional water supply relies on groundwater pumping, which can increase during drought periods when more water may be pumped to make up for surface water shortfalls. For the remaining majority of the water supply, there is heavy reliance on the surface water conveyance systems that provide the inflow to the Sacramento-San Joaquin Delta (also known as the California Delta or the Bay-Delta.

The Delta serves as a primary water source for the entire state, serving approximately 25 million residents as far south as San Diego and an agricultural industry valued at over $25 billion (San Diego County Water Authority, n.d.). These supplies are delivered through the State Water Project, the Central Valley

Project, and a host of other federal water projects. In the Delta, the system of canals, bordered by levees, also serves to deliver floodwater, support commercial fishing, provide for recreational activities, and maintain ecosystem health. The network of reservoirs within the region also plays a vital role in preventing saltwater intrusion in the California Delta by providing freshwater flushes during the summer and fall (DWR, 2009).

The Northern Central Valley region overlaps three hydrologic regions as defined by the Department of Water Resources: San Joaquin River, Sacramento River, and Sacramento-San Joaquin Delta. Reservoir storage capacity in the Sacramento River and San Joaquin River hydrologic regions is 16.15 and 11.48 million acre-feet, respectively (DWR, 2009).

Biophysical Characteristics

While elevations range from 3,000 to 12,000 feet in the eastern areas of Madera, Butte, Sutter, and Tehama counties, areas located within the primary Delta zone in southern Yolo County and eastern Sacramento and San Joaquin counties are at or below sea level (CDFG, 2007). On average, elevation in the Northern Central Valley region is less than 300 feet above sea level. The region is bordered by the Sierra Nevada to the east and the coastal mountain ranges to the west. The extensive natural vegetation in the region is dominated by grasslands and scrub but also contains hardwood and coniferous forest and woodland (FRAP, 1998). Major rivers include the Sacramento, San Joaquin, Feather, Merced, and Stanislaus. Many of the large lakes in the region are the result of river damming as part of reservoir and water project construction.

Regional Entities

- Air Districts: Butte, Colusa, Feather River, Glenn, San Joaquin Valley Unified, Tehama, Yolo-Solano
- Regional Organizations: Butte County Association of Governments, Tehama County Transportation Commission, Glenn County Transportation Commission, Colusa County Transportation Commission, Sacramento Area Council of Governments, San Joaquin Council of Governments, Stanislaus Council of Governments (StanCOG), Merced County Association of Governments, Madera County Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Berry Creek, Colusa (Cachil Dehe), Cortina, Enterprise, Grindstone Creek, Mooretown, North Fork, Picayune, Rumsey

Selected Infrastructure and Regional Resources

Table 14. Infrastructure and Resources in the Northern Central Valley Region

TYPES	NAMES
Airports	International: Sacramento International Airport General Aviation: Chico Municipal Airport, Oroville Municipal Airport, Paradise Airport, Ranchaero Airport, Richvale Airport, Colusa County Airport, Willows-Glenn County Airport, Haigh Field, Madera Municipal Airport, Chowchilla Airport, Merced Regional Airport, Castle Airport, Gustine Airport, Los Banos Municipal Airport, Sacramento Mather Airport, Sacramento Executive Airport, Stockton Metropolitan Airport, Escalon Airport, Lodi Airport, Tracy Municipal Airport, Modesto City-County Airport, Oakdale Airport, Patterson Airport, Turlock Airpark, Sutter County Airport, Red Bluff Municipal Airport, Corning Municipal Airport, Watts Woodland Airport, UC Davis University Airport, Yolo County Airport, Borges Airport, Yuba County Airport, Brownsville Aero Airport
National and State Parks	National: Lassen National Forest, Lassen Volcanic National Park, Mendocino National Forest, Yosemite National Park State: Bidwell-Sacramento S.P., Great Valley Grasslands S.P., Pacheco S.P., Caswell Memorial S.P., Henry W. Coe S.P., Sutter Buttes S.P.
Ports	Port of Sacramento, Port of Stockton, Rio Vista Harbor
Passenger Rail	Cal-P (Central Pacific), SP West Valley Line (California Northern Railroad), Feather River (Union Pacific), Altamont Commuter Express (Union Pacific Railroad), San Joaquin (Union Pacific Railroad), Sacramento Regional Light Rail System, Central California Traction Company (Union Pacific & BNSF Railway), Modesto & Empire Traction Company (Beard Land & Investment Company), Sierra Northern Railway (Sierra Railroad Company)

S.P. = State Park

Selected Demographic Data

Table 15. Top Five Employment Sectors in the Northern Central Valley Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Butte	Health Care	Government	Retail Trade	Other Services	Lodging & Food Services
Colusa	Government	Farm Employment	Manufacturing	Lodging & Food Services	Wholesale Trade
Glenn	Government	Farm Employment	Retail Trade	Other Services	Lodging & Food Services
Madera	Government	Health Care	Retail Trade	Farm Employment	Manufacturing
Merced	Government	Retail Trade	Manufacturing	Health Care	Farm Employment
Sacramento	Government	Health Care	Retail Trade	Professional & Technical Services	Finance & Insurance
San Joaquin	Government	Health Care	Retail Trade	Manufacturing	Lodging & Food Services
Stanislaus	Government	Retail Trade	Health Care	Manufacturing	Lodging & Food Services
Sutter	Retail Trade	Health Care	Government	Lodging & Food Services	Farm Employment
Tehama	Government	Retail Trade	Farm Employment	Health Care	Manufacturing
Yolo	Government	Retail Trade	Health Care	Professional & Technical Services	Transportation & Warehousing
Yuba	Government	Retail Trade	Farm Employment	Construction	Other Services

[CA REAP, 2011]

Table 16. Selected Population Data for the Northern Central Valley Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Northern Central Valley	3,725,950	276,063	7.40%	414,921	11.10%	679,162		
Butte	220,000	12,409	5.60%	33,817	15.40%	43,392	20.1	2.2
Colusa	21,419	1,841	8.60%	2,495	11.60%	3,161	14.9	3
Glenn	28,122	2,178	7.70%	3,737	13.30%	4,890	17.6	3.6
Madera	150,865	11,983	7.90%	17,262	11.40%	30,912	21.7	3.3
Merced	255,793	22,226	8.70%	23,960	9.40%	58,212	23.1	2.3
Sacramento	1,418,788	101,063	7.10%	158,551	11.20%	234,470	16.7	1.1
San Joaquin	685,306	54,228	7.90%	71,181	10.40%	128,331	19	1.5
Stanislaus	514,453	39,779	7.70%	54,831	10.70%	100,554	19.7	1.5
Sutter	94,737	7,153	7.60%	11,990	12.70%	15,780	16.8	2.7
Tehama	63,463	4,409	6.90%	10,071	15.90%	12,810	20.4	3.3
Yolo	200,849	12,577	6.30%	19,771	9.80%	31,942	16.4	2.3
Yuba	72,155	6,217	8.60%	7,255	10.10%	14,708	20.7	3.5

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

Waterways in the Northern Central Valley region drain to the California Delta. Part 1 of the APG identifies the California Delta as a special sector due to the distinctiveness of the setting and the challenges faced there. The issues, particularly flooding, identified in the section on the California Delta will not be repeated here but should be carefully considered.

Flooding

The eastern part of the Northern Central Valley contains the foothills of the Sierra Nevada mountain range. The mountainous areas of the state are projected to have less precipitation falling as snow and to be subject to rapid melt events. This will result in extreme, high-flow events and flooding in the Central Valley. Communities should evaluate local floodplains and recognize areas where a small increase in flood height would inundate large areas and potentially threaten structures, infrastructure, agricultural fields, and/or public safety. As the rivers of the region flow toward San Francisco Bay, the land decreases in elevation and is protected by levees, many of which are vulnerable, particularly to seismic events. The threat of flooding due to climate-induced increased flows in the California Delta is examined in Part 1 of this document.

Flooding and damage to infrastructure can put large populations at risk (CDPH, 2008), including:

- The elderly and children less than five years of age, who are isolated or dependent on others for evacuation. As an example, Sutter County is one of California's counties with a high proportion of elderly living in nursing homes (English et al., 2007).
- Populations that may lack the resources or knowledge to prepare or respond to disaster due to language or economic status, including having access to transportation, which would allow them to escape flooding, at least temporarily.

Addressing the flood threats in this region may require regional collaboration. This collaboration should include counties, cities, special districts, the California Department of Water Resources (DWR), the California Emergency Management Agency (Cal EMA), the Federal Emergency Management Agency (FEMA), the Central Valley Flood Protection District, and other entities.

Agriculture

The Northern Central Valley is one of the largest agricultural producing regions, not only in California, but in the United States. Between climate change impacts on water availability and seasonal temperature regimes, the health of livestock, and productivity of trees and crops are likely to be affected.

Agriculture in this region is varied, with rice, nuts (almonds, walnuts, pistachios), and dairy being three of the most predominant products. Others include pears, cattle, wine grapes, chicken, sweet potatoes, and plums.

Each crop is likely to react slightly differently to alteration in seasonal temperature regimes and water availability. Rice is projected to experience a moderate loss in productivity (less than 10 percent; CCCC, 2009). In the case of nut trees, it is the reduction in nighttime cooling that may have the most impact (Luedeling et al., 2011). Jurisdictions reliant on almonds, walnuts, pistachios, or other nuts should specifically evaluate projected changes in daily low temperatures and/or loss of nighttime chill hours. It is difficult to specifically project the production impact on crops because this relates to many factors in addition to temperature and precipitation, including pest regimes, availability of imported or groundwater irrigation water, and management practices (Luedeling et al, 2011).

As with crops, climate change impacts on dairy cows depend on a variety of factors. For example, the severity of heat stress, which can influence productivity, is influenced by the following factors (Chase, 2006, p.2):

- The actual temperature and humidity
- The length of the heat stress period
- The degree of night cooling that occurs
- Ventilation and air flow
- The size of the cow
- The level of milk production and dry matter intake prior to the heat stress (higher-producing animals will experience greater effects of heat stress)
- Housing – type, ventilation, overcrowding, etc.
- Water availability
- Coat color (lighter color coats absorb less sunlight)

The impact of climate change on agricultural productivity has the potential to alter a community's economic continuity, including its employment base. Communities should work with farm bureaus and other agricultural organizations to understand the challenges faced and to support these organizations and their members as much as possible. Communities should also consider developing plans that limit the impact of productivity reductions on community operations and the provision of basic services.

Public Health, Socioeconomic, and Equity Impacts

Increased temperatures and more frequent heat waves are expected in the region. Sacramento County ranked eighth in the absolute numbers of the elderly and children less than five years of age. These two populations are most likely to suffer from heat-related illnesses and heat events (English et al., 2007). Impervious surfaces are increasing in the Central Valley, increasing the potential impacts of heat islands (English et al., 2007).

Farm employment or lodging and food services are among the top five employment sectors in several of the counties in this region. Agricultural workers and employees in the tourist industry are more susceptible to heat events. The foothill areas outside of the Sacramento area (e.g., Placerville, Auburn, Grass Valley) show higher ozone levels and increased temperatures. Those most vulnerable to high levels of ozone and particulate matter include people who work or spend a lot of time outdoors, such as residents of this region who are employees of the tourist industry (Lake Tahoe) in the nearby Northern Sierra region. (Medina-Ramon and Schwartz, 2008).

Regardless of their occupation, the poor are less likely to have the adaptive capacity to prevent and address impacts for reasons stated above. For instance, Merced and Madera counties are considered "high poverty" counties (English et al., 2007). Butte, Stanislaus, Tehama, and Yolo all have poverty levels at approximately 20 percent. Households eligible for energy utility financial assistance programs are an indicator of potential impacts. These households may be more at risk of not using cooling appliances, such as air conditioning, due to associated energy costs. A relatively high proportion of Yuba County's population (56 to 63 percent) is eligible for energy assistance. Merced and Madera counties have moderately high proportions of populations eligible (47 to 55 percent) (English et al., 2007).

Water Supply

Shorter rainfall events and rapid snowmelt will reduce the region's water supply by making water more difficult to capture in reservoirs or retain for groundwater recharge. Recreation and tourism in the region are also likely to suffer due to lower water levels in waterways and reservoirs and declining snowpack.

Agriculture will also be impacted due to reduced or altered precipitation. Water supply (for irrigation) can alleviate some of the other climate stresses (altered temperature or precipitation) or, in the case of reduced water supply, exacerbate them. The challenge of climate change is that water supply is projected to be reduced and water that is available will be more costly for users. Employees of water-reliant industries such as agriculture may become more economically vulnerable because of unstable working conditions.

Fire

Fire risk is projected to increase in the foothills lining the eastern edge of the region. The areas northeast of Sacramento, due to population density and fire risk, are projected to have large property loss (Westerling and Bryant, 2006). Jurisdictions should pay careful attention to the wildland-urban interface and enforcement of mitigation measures such as residential vegetation and setbacks.

ADDITIONAL RESOURCES

- Wildfire Resources
  - California Fire Science Consortium, Central & South Coast Module: http://www.cafiresci.org/home-central-and-southern-ca/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- Biodiversity and Ecosystems
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The Central Valley and Bay-Delta Regions overlap with the Northern Central Valley region.

Bay-Delta Region

Counties: Contra Costa, Sacramento, San Joaquin, Solano, and Yolo
Five Largest Cities (CDOF, 2011): Sacramento (469,566); Stockton (293,515); Elk Grove (154,594); Vallejo (116,508); Fairfield (104, 815)

TOTAL 2010 POPULATION	
Bay-Delta Region	3,638,618
Contra Costa	1,049,025
Sacramento	1,418,788
San Joaquin	685,306
Solano	413,344
Yolo	72,155

[U.S. Census Bureau, 2010]

Among the APG regions, the Bay-Delta region is unique in that it overlaps with two other regions: Bay Area and Northern Central Valley. The Bay-Delta is included as a distinct region because of the distinct challenges faced by the area and the critical importance it plays in statewide water supply. While the Bay-Delta region contains diverse and vulnerable aquatic ecosystems, the discussion of this region focuses specifically on water management..

While the Bay-Delta region contains diverse and vulnerable aquatic ecosystems, the content of this region focuses specifically on water management. The state water system (Central Valley Project and State Water Project) relies on the Delta for water export from the North to the South. In its entirety, the Delta is home to over a half a million people, yet more than 23 million people rely on water that travels through the Delta, and one sixth of all irrigable land in the United States is in the Delta watershed (PPI, 2007). Any community reliant on water that travels through the Delta must understand how climate change alters the vulnerability of this supply. This section is intended to provide an overview of the levee system that protects residents, Bay-Delta agriculture, and the water supply of much of the state.

Prior to the 1850s, the Delta was a vast wetland of channels and islands nourished by semi-annual flooding and sediment deposits. With flood control and land conversion to agriculture, the elevation of large portions of the Delta dropped below sea level. Levees were constructed to protect the agricultural and residential areas, which are now below-sea-level islands. The lower Delta islands are continuously dropping in elevation, below sea level, because of topsoil loss from agricultural activities, increase in temperatures causing organic soils to dry out, and potential wind storm severity. These factors could result in lower island

elevations, increased static levee loading, and higher levee vulnerability.
In the Bay-Delta region, communities will need to assess vulnerability to the following impacts:

- Temperature increases
- Reduced precipitation
- Sea level rise
- Flooding – increased flows in areas below sea level, exacerbated by levee failure
- Reduced agricultural productivity
- Reduced water supply
- Public health – heat & air pollution
- Decline in Biodiversity - erosion of riparian habitats

Cal-Adapt Projections

Table 17. Summary of Cal-Adapt Climate Projections for the Bay-Delta Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 3°F to 4°F by 2050 and 6°F to 7°F by 2100. July increase in average temperatures: 3°F to 5°F by 2050 and 7° to 9°F by 2100 (Modeled high temperatures; average of all models; high carbon emissions scenario)
Precipitation	Precipitation across the region is projected to decline by approximately 3 to 5 inches. The most dramatic decline of 5 inches is projected around Richmond, while most other areas are projected to experience a decline of 4 inches, although Stockton may only experience a 3-inch decline in precipitation. (CCSM3 climate model; high carbon emissions scenario)
Sea Level Rise	The portions of the region close to San Francisco Bay are projected to be increasingly susceptible to 1.4-meter sea level rise. Solano County is anticipated to experience a 13% increase in estimated acreage of land vulnerable to a 100-year flood event. This indicator rises to 40% in Contra Costa County and 59% in Sacramento County. Most flooding is projected to occur in areas around Suisun City, Pittsburg, Benicia, Richmond, and Vallejo.
Heat Wave	Heat wave is defined as five days above 97°F to 100°F. There is projected to be four more heat waves per year by 2050 and eight to ten by 2100.
Wildfire Risk	Portions of western and northern Yolo County, northwestern Solano County, southern Contra Costa County, and eastern San Joaquin and Sacramento counties are projected to experience limited increases in potential area burned by wildfire. There are moderately high increases projected for the far eastern areas of San Joaquin County. (GFDL model, high carbon emissions scenario)

[Public Interest Energy Research (2011). Cal-Adapt. Retrieved from: http://cal-adapt.org]

Water Sources

The largest source of water for the Bay-Delta is the Sacramento River, which is fed by several major tributaries including the Pit River and Feather River, as well as other water bodies within the Sacramento River watershed. In addition to the 21 million acre-feet of water that the Sacramento River discharges to the Bay-Delta, just over 3.9 million acre-feet of water flows into the Delta from the Yolo Bypass, San Joaquin River, and other eastern rivers. Precipitation adds about another 1 million acre-feet. A large amount of water in the Sacramento River watershed is diverted and used before it reaches the Delta.

Groundwater supplies are continually recharged because of flows in the channels and the soft, deep soils of Delta islands. Groundwater levels fluctuate because of droughts, development, delivery of surface waters to the region, and periods of extended wet weather (DWR, 2009, pg. D-14). The water table is relatively shallow and groundwater levels in most basins have declined as a result of agricultural and urban development. For example, the Eastern San Joaquin Subbasin has been in severe overdraft with significant land depressions east of Stockton and Lodi (DWR, 2009, pg. D-14).

Groundwater supplies are threatened by climate change due to seawater intrusion. In the Delta, groundwater supports agriculture. The contamination of groundwater is just one threat to the agriculture in the region.

Biophysical Characteristics

The Bay-Delta region is a floodplain estuary that connects river to ocean and land to water. It was once a large marshland formed by the Sacramento and San Joaquin rivers, but, as people began to settle in the area, the marsh was drained and diked for flood control and land conversion to agriculture. More than 90 percent of the marshland has been converted to farms or urban areas. Structures like dams and levees in the Delta have also been detrimental to the migration of species, such as the Chinook salmon (CDFG, 2007)

Floodplain estuaries are among the most productive ecosystems on the planet, but the Delta has very low levels of primary productivity in the upper surface waters of both the Suisun Marsh and the Delta because of a variety of ecological stressors (CDFG, 2007). Wildlife and plant species have been subject to habitat loss, degradation, and fragmentation because of agriculture and urban land development, which has profoundly affected species' ability to survive. The grizzly bear and gray wolf no longer reside in the Delta, but a population of tule elk has been established in the Suisun Marsh. The Suisun Marsh is an important wintering and nesting area for waterfowl using the Pacific Flyway (DWR, 2009, pg. D-5-6).

The ecosystem functions of the Delta have been significantly affected and irrevocably changed by introduced, non-native, and invasive species. Introduced species now dominate all habitats in the Delta; these species include the aquatic weed *Egeria densa*, the water hyacinth, the Asian clam and the overbite clam, and the striped bass and largemouth bass, which are predatory and outcompete native fish species (DWR, 2009, pg. D-5-6).

Regional Entities

- Air Districts: Bay Area Air Quality Management District
- Regional Organizations: San Francisco Bay Conservation and Development Commission, Association of Bay Area Governments, Sacramento Area Council of Governments, San Joaquin Council of Governments

Selected Infrastructure and Regional Resources

Table 18. Infrastructure and Resources in the Bay-Delta region.

TYPES	NAMES
Airports	International: Sacramento Airport General Aviation: Borges-Clarksbug, Buchanan Field, Byron, Franklin Field, McClellan Airfield, New Jerusalem, Nut Tree, Rancho Murrieta, Rio Vista Municipal, Sacramento Executive, Sacramento Mather, Stockton Metropolitan, Tracy Municipal, University, Yolo County
National and State Parks	State: Bidwell-Sacramento S.P., Caswell Memorial S.P., Mount Diablo S.P., Sutter Buttes S.P.
Passenger Rail	Altamont Commuter Express, Amtrak, Bay Area Rapid Transit, Cal-P (Central Pacific), Southern Pacific West Valley Line, San Joaquin (Union Pacific Railroad), Sacramento Regional Light Rail System
Ports	Benicia, Pittsburg, Richmond, Sacramento, Stockton, Vista Harbor
Power Plants (MWs)*	Foster-Wheeler Martinez Cogen L.P., Nove Power Plant (3), Pittsburg (1310), GWF Power Systems L.P., Solano Cogen (1.45)

S.P. = State Park; MWs = megawatts
*Located within the 100-year flood zone for 1.5-meter sea level rise

Selected Demographic Data

Table 19. Top Five Employment Sectors in the Bay-Delta Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Contra Costa	Retail Trade	Health Care	Government	Professional & Technical Services	Finance & Insurance
Sacramento	Government	Health Care	Retail Trade	Professional & Technical Services	Finance & Insurance
San Joaquin	Government	Health Care	Retail Trade	Manufacturing	Lodging & Food Services
Solano	Government	Retail Trade	Health Care	Lodging & Food Services	Construction
Yolo	Government	Retail Trade	Health Care	Professional & Technical Services	Transportation & Warehousing

[CA REAP, 2011]

Table 20. Selected Population Data for the Bay-Delta Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Delta	3,767,312	261,738	6.95%	426,788	11.33%	541,446		
Contra Costa	1,049,025	67,018	6.40%	130,438	12.40%	97,544	9.3	0.9
Sacramento	1,418,788	101,063	7.10%	158,551	11.20%	234,470	16.7	1.1
San Joaquin	685,306	54,228	7.90%	71,181	10.40%	128,331	19	1.5
Solano	413,344	26,852	6.50%	46,847	11.30%	49,159	12.2	1.4
Yolo	200,849	12,577	6.30%	19,771	9.80%	31,942	16.4	2.3

[US Census, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

The California Delta is critical to the overall function of the state including water supply, biodiversity, and economy. This regional section focuses primarily on threats to water supply, so that reliant communities can assess vulnerability. The immediate threats to communities located in the Delta extend well beyond water supply, however. Flooding, seawater intrusion, and alteration of the Delta ecosystems can threaten a wide variety of regional assets and resources, including the physical safety of residents; the viability of economic activities including agriculture, fisheries, and recreation; the health of community members; and regional biodiversity.

Setting and History

The California Delta is the center of a vast river network that drains the central valley of California, receiving roughly 80 percent of the water in the state (Delta Vision, 2008). The Delta is fed by several rivers, the largest being the Sacramento River and the San Joaquin River, in addition to the Mokelumne, American, and Calaveras rivers. These rivers empty into the low-lying basin of the Delta, which outlets to San Francisco Bay and then the Pacific Ocean.

Before the 1850s, the Delta was nourished by semi-annual flooding and the accompanying sediment deposits, making for vast wetlands of channels and islands. As the sediment supply was curtailed through flood control and the land was converted to agriculture, the elevation of large portions of the Delta dropped below sea level making this area prone to more frequent flooding. Levees were constructed to protect the agricultural and residential areas on what are now below-sea-level islands. The drop in elevation continues, resulting in a need for increased levee height over the roughly 2,000 kilometers of levees that continuously hold back water in the low-lying areas(see Figuire 8).

The state water system (Central Valley Project and State Water Project) relies on the Delta as the conduit for water exported from the north to the south. In its entirety, the Delta is home to over half a million people, yet more than 23 million people rely on water that travels through the Delta, and one sixth of all irrigable land in the United States is in the Delta watershed (PPI, 2007). Conditions in the Delta have been altered dramatically from its pre-developed state. These changes have endangered many native species and created habitat for even more non-native species.

The water supply, economic viability, and environmental resources of the Bay-Delta region are critical to the state.

Climate Change Impacts in the Lower Bay-Delta

Climate change is expected to result in the following impacts in the lower Bay-Delta:

- Higher temperatures and increased storm/wind activity may exacerbate drops in elevation of low-lying areas.
- Changes in the magnitude of precipitation and precipitation/snowmelt runoff intensity may reduce control of the salt water front that is artificially held downstream of water export pumps.
- Sea level rise is not expected to have an appreciable impact on the seismic vulnerability of the lower Delta.

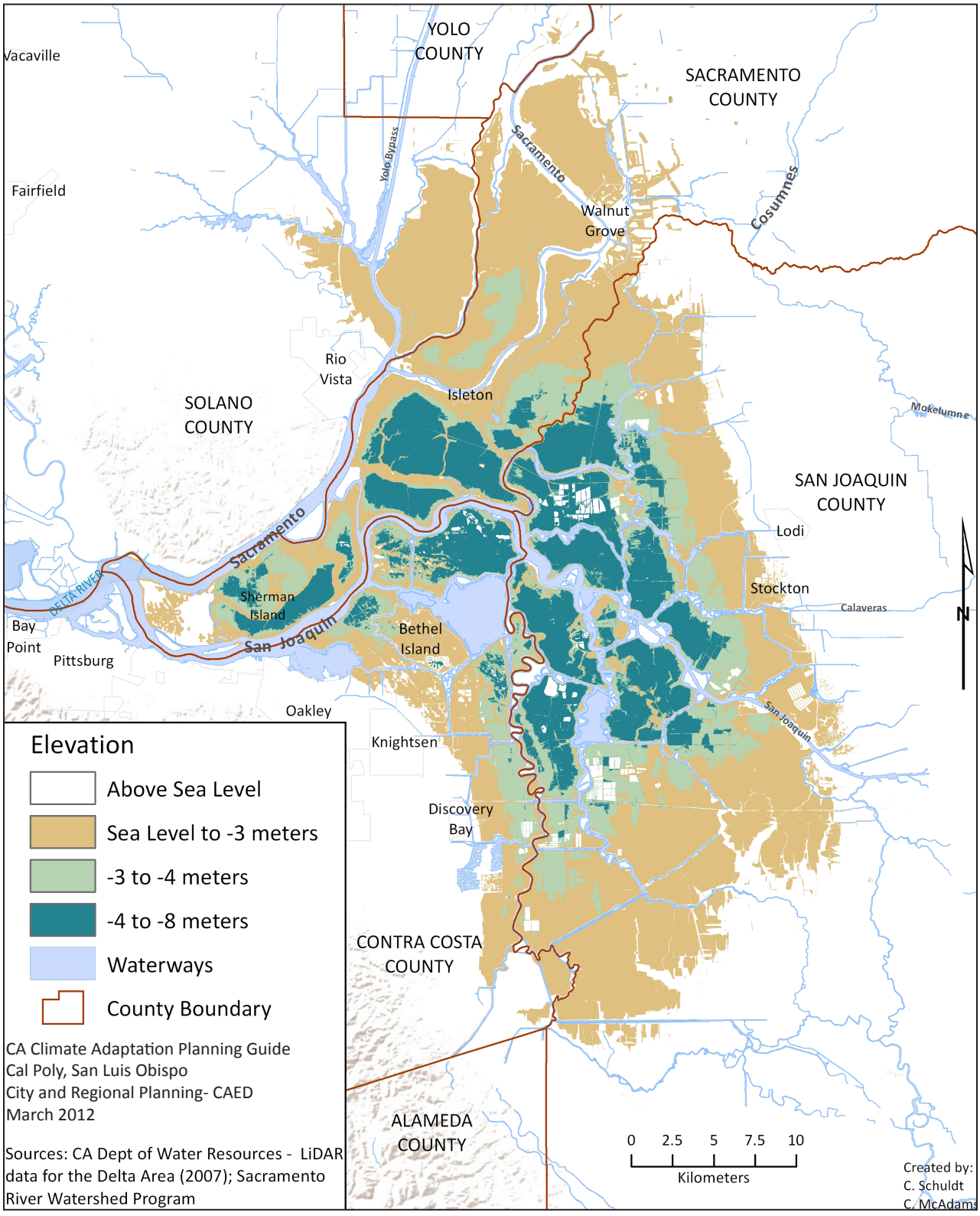


Figure 8. Bay-Delta Region with Elevation

The islands in the lower Bay-Delta are defined as those areas below mean sea level (see Figure 8). These areas hold back water on a continuous basis and crest heights target the peak water conditions due to tidal fluctuations from the sea, peak flows from the rivers, or the combination of the two. Levee failures and subsequent island flooding regularly occur; over 160 failures occurred in the last century (DWR, 2009). Levee failures and flooding occur due to peak water level conditions, but they can also take the form of what are called "sunny day" failures during which there are no adverse loading conditions.

The Delta has yet to experience a substantial earthquake in its current configuration. The seismic behavior of the levees in the Delta is a concern, however, because the levees have not been designed or tested for such loading conditions and may fail via several different mechanisms (e.g., seismic liquefaction of the foundation or embankment soil, co-seismic deformation of the foundation or embankment soil, or post-seismic reconsolidation of the foundation soil). The scenario that threatens disruption of the state's water supply is an earthquake that can result in multiple levee failures, flooding the freshwater into the below sea level islands, and allowing saltwater intrusion to degrade water quality thereby shutting down water exports to the south (DWR, 2009).

Because the levees in the lower Delta currently hold back water on a continuous basis (in some places upwards of 8 meters) incremental increases in sea level or increase in peak-flow heights will not have an appreciable impact on the seismic vulnerability. The concern is earthquake loading of the vulnerable levees, not relatively small increases in the static loading from increased water level heights. This also holds true for any other asset or community in the lower Delta residing below mean sea level. Seismic levee integrity and static levee integrity are not necessarily addressing the same failure mechanisms.

The lower Delta islands are continuously dropping in elevation, below sea level, due to a number of factors. One main factor is the loss of topsoil from agricultural activities. An increase in average temperatures accelerating the drying of peaty organic soils and an increase in wind storm severity could exacerbate this process, resulting in lower island elevations, increased static levee loading, and higher levee vulnerability. Also of concern are the high water conditions and erosion that are associated with winter storms. While they might not cause the widespread failure that may result from a seismic event, storm events have the potential to result in a notable increase in levee failure.

Changes in precipitation can have an influence on maintaining the saltwater front below the intake pumps for the water delivery to the south. Currently the saltwater front is maintained primarily by controlling the release from Shasta Dam,

among other flood control structures. Unreliable water supply and timing from the input rivers (Sacramento, Mokolumne, and San Joaquin) due to changes in precipitation and snow melt will make ensuring water quality and water delivery increasingly difficult.

Climate Change Impacts in the Upper Bay-Delta

Climate change is expected to result in the following outcomes in the upper Bay-Delta:

- Increased precipitation and snowmelt peak runoff are likely to increase the static vulnerability of levee.
- Not have an appreciable impact on the seismic vulnerability of the levees.

For communities in the upper Delta that are above mean sea level (behind levees that are not continuously holding back water), increased peak flows due to climate change pose a threat to the static stability of the levees but will not have an appreciable impact on the seismic vulnerability of the levees. The odds of coincidence of higher peak flows with earthquake ground shaking are negligible. However, earthquake ground shaking could damage levees, and if not repaired in time, subsequent peak water levels could result in levee failures. Increase in sea level will affect the static stability of the levees just above current mean sea level and may provide more static push during seismic events, but again the change is insignificant compared to the overall seismic vulnerability of the levees. Again, seismic levee integrity and static levee integrity are not necessarily addressing the same failure mechanisms. The "Water Management" section of *APG: Defining Local & Regional Impacts* provides further discussion of flooding.

Evaluating Climate Change Impacts

An approach to evaluating levee vulnerability to climate change impacts is to divide adaptation needs into chronic ongoing problems and catastrophic impacts. Ongoing problems address small-scale damage and disruption such as property damage, crop loss, or similar effects that can usually be quantified in terms of insurance claims and can be addressed with maintenance. Catastrophic impacts include the shut-down of the state water exports, disruption of regional or state infrastructure (highways, rail lines, telecommunication and power grids, gas and water mains, etc), or other broad multi-jurisdictional or dramatically disabling impacts that often require more substantial fixes.

Addressing impacts requires close collaboration between local jurisdictions and the levee districts and other flood control or levee management entities. For Delta communities these stakeholders are critical members of the climate change adaptation team who can aid in supplying critical data and providing feedback in understanding risk.

Some of the questions that should be considered when evaluating the current state of preparedness are as follows:

- Have the levees protecting the community and associated resources been assessed for integrity?
- Is there a funding mechanism for ongoing maintenance and repair? Is it adequate for current needs?
- Are levee improvements planned in the near future?
- Is there a monitoring system in place to assess levee integrity?
- Is this monitoring used to adjust management practices?
- Is there a local hazard mitigation plan? What are the measures identified for flood mitigation preparation and response?
- Does the urban water management plan include contingency measures in the event of levee breach?

For structures located in or near floodplains or levee-protected areas, questions to consider include the following:

- Are critical business or community resources located in areas that may be subject to flooding?
- Are there neighborhoods that may face increased flood risk due to climate change?
- Are there some members of particularly vulnerable populations (e.g. elderly) that may be less able to evacuate from vulnerable areas?
- Does local land use policy (e.g. general plan, zoning, or specific plans) allow for expansion of designated flood zones?
- Is development planned in areas likely to have increasing flood risk (e.g. near levee toe)

For agricultural productivity, questions to consider include the following:

- Are agricultural facilities and equipment located in areas currently or projected to be at risk for flooding?
- Do local growers have plans for product protection and post-flood recovery?

For public safety, questions to consider include the following:

- Are employees and residents aware of the local flood risk?
- Are employees and residents aware of standard procedures in the event of a flood due to a levee over-topping or failing?
- Are local resources for emergency response and medical care adequately prepared in the event of increased flood risk?

For infrastructure, questions to consider include the following:

- Do vulnerable regions have evacuation routes identified?
- Are there contingency plans in the event of water, wastewater, energy, or communication networks interruption?

ADDITIONAL RESOURCES

- Delta Protection Commission. 2007. DPC Land Use & Resource Management Plan for the Primary Zone of the Delta. Retrieved from http://www.delta.ca.gov/Land%20Use%20and%20Resource%20Management%20Plan%20for%20the%20Prim.htm
- Department of Water Resources. 2011. Delta Risk Management Strategy. Retrieved from http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/

Southern Central Valley Region

Counties: Fresno, Kern, Kings, Tulare
Five Largest Cities (CDOF, 2011): Fresno (500,121); Bakersfield (351,443); Visalia (125,770); Clovis (97,218); Tulare (59,926)

TOTAL 2010 POPULATION	
Southern Central Valley	**2,365,242**
Fresno	930,450
Kern	839,631
Kings	152,982
Tulare	442,179

[U.S. Census Bureau, 2010]

The Southern Central Valley is a largely agricultural, inland region with over 2 million people. Its regional character is defined largely by agriculture, interspersed with cities along primary transport corridors, with Fresno (500,000+ people) prominent in the northern end and Bakersfield (350,000+ people) in the southern end. Agriculture is the predominant economic activity; the region contained the top three agricultural counties in the state in 2010 when evaluated on value, totaling roughly $16 billion California Farm Bureau Federation, 2012). The region also stretches into the foothills of the Sierra Nevada and is known as a prominent tourism access point for Yosemite National Park, Kings Canyon National Park, and Sequoia National Park. Several communities in the region rely on tourism.

Communities in the Southern Central Valley should evaluate vulnerability to the following impacts:

- Temperature increases
- Reduced precipitation
- Reduced water supply
- Reduced agricultural productivity
- Flooding
- Decrease in tourism – Sierra Nevada foothills
- Wildfire risk in the Sierra Nevada foothills

Cal-Adapt Projections

Table 21. Summary of Cal-Adapt Climate Projections for the Southern Central Valley Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 3°F to 4°F by 2050 and 7°F to 10°F by 2100. July increase in average temperatures: 5°F to 6°F in 2050 and 9°F to 11°F by 2100, with larger temperature increases in the mountainous regions to the east. (Modeled high temperatures; average of all models; high carbon emissions scenario)
Precipitation	Low areas are projected to experience declines in annual precipitation of 1 or 2 inches by 2050 and up to 3.5 inches by 2100, while more elevated areas are projected to experiences loses of up to 10 inches. (CCSM3 climate model; high carbon emissions scenario)
Snowpack	Snowpack in the eastern elevated regions is projected to decrease by approximately 9 inches, resulting in pack that is less than 4 inches by March 2090. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	The threshold temperature that defines a heat wave is over 100°F in most of the region. In the mountains, a heat wave is defined by lower termperatures, 70°F to 90°F. By 2050, the number annual heat waves is projected to increase by three to five. An increase of seven to 10 is expected by 2100 in most of the region, with an increase of up to 14 expected in the mountain areas.
Wildfire Risk	The eastern edge of the region is projected to experience an increase in wildfire risk of 4 to 6 times current conditions. (GFDL model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

Most of the Southern Central Valley region is located within the Tulare Lake hydrologic region. The water supply in this region relies primarily on Sierra snowmelt, delivered by natural waterways and canal systems, and groundwater. During parts of the year, water is limited. As a result, the region has developed a careful management system, integrating groundwater and surface water resources to assure year-round supply (DWR, 2009). This management system seeks to avoid groundwater overdraft but has not always succeeded, leading to increased water table depths and associated land subsidence.

Within the region, western areas are subject to more limited resources. Therefore, they rely on imported resources from the Central Valley Project and the State Water Project. These imported sources have increased salt concentrations, which have led to a salt build-up in soils and groundwater.

Agriculture is the largest water user in the region (more than 80 percent), followed by environmental and urban uses. In addition, the extensive network of reservoirs is used for power generation and storage. Reservoir storage capacity in the region totals 2.05 million acre-feet (DWR, 2009).

Biophysical Characteristics

The western portion of the Southern Central Valley is approximately 300 feet above sea level, with the central areas of Fresno and Kings counties lying below an elevation of150 feet. In contrast, the eastern areas of Kern and Tulare counties range from 1800 to 12,000 feet above sea level (CDFG, 2007).

The region features warm, dry summers, with rainfall generally occurring in the winter. Elevations over 5,000 feet receive consistent snowfall. While the western portions of the region are drier than the east, the region contains wetlands, vernal pools, and an extensive network of rivers and associated riparian habitats. Despite having lost the majority of the historic distribution of these habitats, they continue to support an average of 5.5 million waterfowl annually (DWR, 2009). Ecosystems outside urbanized areas accommodate diverse vegetation including irrigated cropland, grassland and a variety of shrub-lands, oak and juniper woodland, and red and white fir forests (DWR, 2011).

Regional Entities

- Air Districts: San Joaquin Valley Unified
- Regional Governments: Fresno Council of Governments, Kings County Association of Governments, Kern Council of Governments, Tulare County Association of Governments
- Tribal Lands (U.S. EPA, 2011): Big Sandy, Cold Springs, Santa Rosa, Tule River

Selected Infrastructure and Regional Resources

Table 22. Infrastructure and Resources in the Southern Central Valley Region

TYPES	NAMES
Airports	International: Fresno Yosemite International Airport, Meadows Field International Airport General Aviation: Fresno Chandler Executive Airport, Firebaugh Airport, Mendota Airport, New Coalinga Municipal Airport, Reedley Municipal Airport, Sierra Sky Park Airport, California City Municipal Airport, Delano Municipal Airport, Kern Valley Airport, Lost Hills Airport, Mojave Airport, Shafter Airport, Taft Airport, Tehachapi Municipal Airport, Wasco Airport, Hanford Municipal Airport, Visalia Municipal Airport, Sequoia Field
National & State Parks	National: Sequoia National Park, Kings Canyon National Park, Red Rock Canyon National Park, Sequoia National Forest, Sierra National Forest State: Red Rock Canyon State Park
Passenger Rail	Altamont Commuter Express, Amtrak, Bay Area Rapid Transit, Cal-P (Central Pacific), SP West Valley Line, San Joaquin (Union Pacific Railroad), Sacramento Regional Light Rail System, San Joaquin Valley Railroad (Rail America)

S.P. = State Park

Selected Demographic Data

Table 23. Top Five Employment Sectors in the Southern Central Valley Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Fresno	Government	Heath Care	Retail Trade	Forestry & Fishing	Manufacturing
Kern	Government	Retail Trade	Health Care	Forestry & Fishing	Construction
Kings	Government	Federal Military	Health Care	Retail Trade	Manufacturing
Tulare	Government	Retail Trade	Farm Employment	Health Care	Manufacturing

[CA REAP, 2011]

Table 24. Selected Population Data for the Southern Central Valley Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Southern Central Valley	2,365,242	205,816	8.70%	222,667	9.40%	555,610		
Fresno	930,450	78,980	8.50%	93,421	10.00%	245,330	26.8	1.3
Kern	839,631	72,885	8.70%	75,437	9.00%	172,531	21.4	1.4
Kings	152,982	12,877	8.40%	12,030	7.90%	29,606	22.5	3
Tulare	442,179	41,074	9.30%	41,779	9.40%	108,143	24.6	2

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

Climate change impacts in the Southern Central Valley region are varied, but not necessarily new. In many cases, climate is projected to exacerbate existing challenges such as limited water supply, agricultural conditions, social vulnerability, and wildfire.

Agriculture

Agriculture in this region is critical to the food supply in California as well as the rest of the country. In 2010, the counties in the Southern Central Valley were ranked first, second, third, and ninth in the state in terms of the economic value of their agricultural production (California Farm Bureau Federation, 2012).

The crops produced are varied and include almonds, milk, cattle, cotton, oranges, and poultry. Each crop type is likely to react differently to alteration in seasonal temperature regimes and changes in water availability. It is difficult to specifically project the production impact on crops because it relates to many factors in addition to temperature and precipitation, including pest regimes, availability of irrigation water, and management practices (Luedeling et al., 2011). The particular aspect of climate change most important to assessing impact also will vary. In the case of nut trees, it is the reduction in nighttime cooling that may have the most impact (Luedeling et al., 2011). Jurisdictions reliant on almonds, walnuts, pistachios, or other nuts should specifically evaluate projected changes in daily low temperatures.

As with crops, climate-change impacts on dairy cows depend on a variety of factors. For example, the severity of heat stress, which can influence productivity, is influenced by the following factors (Chase, 2006, p.2):

- The actual temperature and humidity
- The length of the heat stress period
- The degree of night cooling
- Ventilation and air flow
- The size of the cow
- The level of milk production and dry matter intake prior to the heat stress (higher- producing animals will experience greater effects of heat stress)
- Housing – type, ventilation, overcrowding, etc.
- Water availability
- Coat color (lighter color coats absorb less sunlight)

The impact of climate change on agricultural productivity has the potential to alter a community's economic continuity, including its employment base. Communities should work with farm bureaus and other agricultural organizations to understand the challenges being faced and support these organizations as much as possible. Communities should also consider developing plans that limit the impact of productivity reductions on community operations and the provision of basic services.

Public Health, Socioeconomic, and Equity Impacts

Heat is a contributing factor in the production of ground level ozone, an air pollutant that affects respiratory function. Visalia is a location in the San Joaquin Valley traditionally high in ozone. Using Visalia and Riverside, two areas traditionally high in ozone, Dreschler et al. (2006) projected that the number of days in California with "conditions conducive to ozone" could increase by 25 to 80 percent by 2100, "depending on warming scenarios" (Kahrl and Roland-Holst, pg. 105).

Inland low-lying areas in California, such as the San Joaquin Valley, reported the greatest number of heat-related deaths in the 2006 heat wave. The counties in the Southern Central Valley region have a relatively large number of agricultural workers. Extreme heat and temperature-related declines in air quality are likely to contribute to increased physical strain, respiratory issues, and general health conditions. Agricultural workers will have increased exposure to heat events and will be especially at risk of heat illness due to the combination of outdoor work and jobs demanding physical exertion. In addition, farmworker housing may lack air conditioning. Farm employment is one of the top five industries in Tulare County, and while not registering in the top five employment sectors in the remaining counties, the absolute number of employees involved in agriculture in this region is significant.

Regardless of their occupation, the poor are less likely to have the adaptive capacity to prevent and address impacts. For instance, Fresno County is considered a "high poverty" county (English et. al., 2007). All of the counties in this region exceed poverty levels of greater than 20 percent of their populations. Households eligible for energy utility financial assistance programs are an indicator of potential impacts. These households may be more at risk of not using cooling appliances, such as air conditioning, due to associated energy costs. Kings and Tulare counties have moderately high proportions of populations eligible (47 to 55 percent) (English et al., 2007).

The foothill areas outside of and between Fresno and Bakersfield may experience higher ozone levels and temperatures. Those most vulnerable to high levels of ozone and particulate matter include people who work or spend a lot of time outdoors, such as residents of this region who are employees of the tourist industry (Sequoia, Kings Canyon, and Yosemite national parks) in the nearby North Sierra and Southeast Sierra regions.

Water Supply

Water supply in this region relies primarily on snowmelt from the Sierra. Climate change is projected to result in a dramatic decrease in snowpack. This change will not only limit the availability of water in the warmer summer months, but also may result in flooding during the spring. Precipitation falling as rain rather than snow and/or in intense rainfall events can limit the ability to capture the water in reservoirs or groundwater.

Further threatening local water supply is the vulnerability of the levees protecting the California Delta. The Delta feeds the State Water Project and Central Valley Project, two key water sources for the region. There is the potential for this source to be compromised by catastrophic levee failure (DWR, 2011).

Communities in this region should evaluate their vulnerability to loss of the water supply from the Delta and plan accordingly.

Limited water supply could have drastic impacts on the economic stability of the region. The vast majority of the region's water supply (approximately 80 percent; DWR, 2011) supports agriculture. Loss or reduction of water supply would undermine the economic engine of the region. Communities should carefully plan to bolster water supply, simultaneously working to improve the local efficiency of use.

Surface Water and Flooding

Rapid snowmelt or intense rain affects not only water supply, but also the aquatic systems that rely on the flows and the safety of communities in the Sierra foothills. Aquatic systems (e.g., river, lakes, and wetlands) rely on a seasonal hydrological regime. Climate change will disrupt this regime, forcing species to adapt. Recreation and tourism in the region are also likely to suffer due to lower water levels in waterways and reservoirs and declining snowpack. Employees of these industries may become more economically vulnerable because of unstable working conditions.

The mountainous areas are projected to have less precipitation falling as snow and to be subject to rapid melt events. This will result in extreme, high-flow events and flooding in the valley. Communities should evaluate local floodplains and recognize areas where a small increase in flood height would inundate large areas and potentially threaten structures, infrastructure, agricultural fields, and/or public safety.

Fire

A big increase in large fire occurrence is projected for the eastern portion of the region. Once burned, these areas may be prone to landslide or debris flow. Large property loss should be expected in areas with higher population densities, such as tourist destinations in the foothills to the east of Fresno.

ADDITIONAL RESOURCES

- Wildfire Resources
  - California Fire Science Consortium, Central & South Coast Module: http://www.cafiresci.org/home-central-and-southern-ca/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- Biodiversity and Ecosystems
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html

Central Coast Region

Counties: Monterey, San Benito, San Luis Obispo, Santa Barbara, Santa Cruz
Five Largest Cities (CDOF, 2011): Salinas (151,219); Santa Maria (100,062); Santa Barbara (89,253); Santa Cruz (60,800); Watsonville (51,495)

TOTAL 2010 POPULATION	
Central Coast	1,426,240
Monterey	415,057
San Benito	55,269
San Luis Obispo	269,637
Santa Barbara	423,895
Santa Cruz	262,382

[U.S. Census Bureau, 2010]

The Central Coast region is a largely agricultural, intermittently settled region of over 1 million people, with substantial cities, the largest being Salinas (150,000+ people). Its character is defined by features such as coastal mountains, the Big Sur coastline, wooded hillsides, and the Salinas River Valley. Inland valleys have a somewhat different character from the coastal areas, but agriculture and tourism are common themes on both sides of the coastal ranges.

Communities in the Central Coast region may face one or more of the following climate change impacts:

- Increased temperatures
- Reduced precipitation
- Reduced agricultural productivity
- Sea level rise – coastal flooding and infrastructure damage
- Biodiversity threat
- Public health threats
- Reduced tourism

Cal-Adapt Projections

Table 25. Summary of Cal-Adapt Climate Projections for the Central Coast Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 1°F to 2°F in 2050 and 4°F to 5°F by 2100. July increase in average temperatures: 2°F to 3°F by 2050 and 4°F to 7°F by 2100, with larger increases in the mountainous regions to the east. (Modeled high temperatures – average of all models; high carbon emissions scenario)
Precipitation	Low areas are projected to experience declines in annual precipitation of about 2 inches by 2050 and 3 to 4 inches, by 2100 while more elevated areas are projected to experiences loses of approximately 10 inches. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	Heat waves are defined as five days over 79°F to 85°F along the coast and 99°F to 101°F inland. Coastal areas should expect one more heat wave per year by 2050 and four to eight more per year by 2100. Inland, three to four more heat waves are expected to 2050 and eight to ten more per year in 2100.
Snowpack	Snowpack in the eastern elevated regions is projected to decrease by approximately 9 inches, resulting in pack that is less than 4 inches by March 2090. (CCSM3 climate model; high carbon emissions scenario)
Wildfire Risk	The eastern edge of the region is projected to experience an increase in wildfire risk of 4 to 6 times current conditions. (GFDL model, high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

Except for the State Water Project, which derives from Sierra Nevada sources, most of the region's water comes from the region itself. Overall, 66 percent of the region's water comes from groundwater, with the remainder split mostly between federal projects and reuse. Only about 6 percent of the region's total, mostly in San Luis Obispo and Santa Barbara counties, comes from the State Water Project (DWR, 2009). Federal projects (the U.S. Bureau of Reclamation's Santa Maria and Cachuma projects) store floodwater from the Santa Maria River watersheds, using it to replenish groundwater and mitigate saltwater intrusion. The region's water supply in 2005 totaled approximately 1.4 million acre-feet, less than 1 percent of which came from outside regions. Agriculture accounted for the majority of use at about 0.9 million acre-feet, followed by urban use at 0.25 million acre-feet. Total reservoir storage capacity in the region is 1.23 million acre-feet (DWR, 2009).

Biophysical Characteristics

The Central Coast region is characterized by the mountains of the Coast Ranges, which surround the Salinas River valley. The Santa Cruz Mountains, the Santa Lucia Range, and the Diablo Range make up the higher-elevation areas, which reach around 5,800 feet on Junipero Serra Peak.

Redwood forests cover much of Santa Cruz County. Scrub and annual grassland make up most of the coastal vegetation, with annual grasses occupying much of San Benito, San Luis Obispo, Monterey, and Santa Barbara counties. Mixed chaparral is also widespread in the latter three counties along the mountain ranges. Irrigated cropland makes up most of the land along the Salinas River Valley, along with portions of southern Santa Cruz and northern San Benito counties. The coastal areas of this region host a variety of critical habitats, from the near-shore ecosystems along Big Sur to bays such as Monterey to the estuaries, including Elkhorn Slough and Morro Bay.

Regional Entities

- Air Districts: Monterey Bay Unified, San Luis Obispo, Santa Barbara
- Regional Organizations: Association of Monterey Bay Area Governments, San Benito Council of Governments, San Luis Obispo Council of Governments, Santa Barbara County Association of Governments, Santa Cruz County Regional Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Santa Ynez

Selected Infrastructure and Regional Resources

Table 26. Infrastructure and Resources in the Central Coast Region

TYPES	NAMES
Airports	Bonny Doon Village, Hancock Field, Lompoc, Marina Municipal, McChesney Field, Mesa del Rey, Monterey Peninsula, Paso Robles, Salinas Municipal, Santa Barbara Municipal, Santa Ynez, Watsonville Municipal
National and State Parks	National: Channel Islands National Park, Ellicott Slough National Wildlife Reserve, Elkhorn Slough National Estuarine Sanctuary, Los Padres National Forest, Morro Bay National Estuary, Pinnacles National Monument, Salinas River National Wildlife Refuge State: Andrew Molera S.P., Big Basin Redwoods S.P., California Sea Otter State Game Refuge, Castle Rock S.P., Estero Bluffs S.P., Forest of Nisene Marks S.P., Fort Ord Dunes S.P., Fremont Peak S.P., Garrapata S.P., Gaviota S.P., Harmony Headlands S.P., Henry Cowell Redwoods S.P., John Little S.N.R., Julia Pfieffer Burns S.P., Limekiln S.P., Los Osos Oaks S.N.R., Montana de Oro S.P., Morro Bay S.P., Moss Landing State Wildlife Area, Pfeiffer Big Sur S.P., Point Lobos S.N.R., San Simeon S.P., Wilder Ranch S.P.
Passenger Rail	Amtrak
Ports	Monterey Fisherman's Wharf, Moss Landing Harbor District, Santa Cruz Harbor
Power Plants (MWs)*	Marina Landfill (5.4), Southern California Gas/UCSB (.2), Water Street Jail (.18)

S.P. = State Park; S.N.R. = State Natural Reserve; MWs = megawatts
*Located within the 100-year flood zone for 1.5-meter sea level rise, capacity .1 or greater

Selected Demographic Data

Table 27. Top Five Employment Sectors in the Central Coast Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Monterey	Government	Lodging & Food Services	Retail Trade	Health Care	Professional & Technical Services
San Benito	Government	Manufacturing	Retail Trade	Construction	Lodging & Food Services
San Luis Obispo	Government	Retail Trade	Lodging & Food Services	Health Care	Professional & Technical Services
Santa Barbara	Government	Retail Trade	Health Care	Professional & Technical Services	Lodging & Food Services
Santa Cruz	Government	Retail Trade	Health Care	Professional & Technical Services	Construction

[CA REAP, 2011]

Table 28. Selected Population Data for the Central Coast Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Central Coast	1,426,240	92,377	6.50%	174,360	12.20%	219,506		
Monterey	415,057	32,547	7.80%	44,422	10.70%	68,031	17.1	1.7
San Benito	55,269	4,092	7.40%	5,360	9.70%	7,010	12.7	2.6
San Luis Obispo	269,637	13,343	4.90%	41,022	15.20%	36,179	14.3	1.7
Santa Barbara	423,895	27,350	6.50%	54,398	12.80%	72,112	17.7	1.5
Santa Cruz	262,382	15,045	5.70%	29,158	11.10%	36,174	14.2	2

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

The Central Coast region is defined primarily by its coastal setting and a temperate climate that makes it an ideal location for agricultural operations such as berries, lettuce, and wine grapes (California Farm Bureau Federation, 2012). Climate change will affect coastal conditions and temperatures, as well as fire risk and public health and safety.

Sea Level Rise

The region has numerous small communities that depend significantly on tourism. The following areas are likely to see coastal recreation resources such as beaches, wharves, and campgrounds affected by sea level rise: Santa Barbara, Pismo Beach, Morro Bay, Monterey Peninsula, Santa Cruz, and Half Moon Bay. In addition, several large downtowns – including those in Santa Barbara, Monterey, Castroville, and Santa Cruz – lie within areas subject to coastal flooding that will be exacerbated by sea level rise. A 1.4-meter rise in sea level will increase the population vulnerable to a 100-year coastal storm from 26,070 to 38,000. Most of the population at risk is in Monterey and Santa Cruz counties (CCCC, 2009).

Sea level rise is expected to affect vulnerable populations along the coast through the immediate effects of flooding and temporary displacement and longer-term effects of permanent displacement and disruption of local tourism. Impacts could include temporary and/or permanent displacement; drowning and property damage; and coastal erosion harming recreational activities, tourism, and the tourism industry. Of particular concern are populations that do not

have the resources to prepare for, respond to, and recover from disasters. Vulnerable populations living in institutional settings are particularly vulnerable during evacuations from disasters. For instance, Santa Cruz County has a high proportion of elderly living in nursing homes that could be affected (English et al., 2007).

Sea level rise also will affect the provision of basic services through disruption of linear infrastructure. Portions of two of the state's major north-south roadways—US 101 and the Pacific Coast Highway (PCH or SR 1)—are located on the coast. Impacts on these roadways could affect regional transportation, access to communities, and access to tourism areas. Weather-related landslides already regularly close SR 1 through Big Sur.

Sea level rise and severe storm surges are a concern for nuclear power plants near the Pacific Ocean, including Diablo Canyon Nuclear Power Plant in San Luis Obispo County. Risks associated with this facility include flooding of containment buildings where highly radioactive spent nuclear fuel is stored and loss of generating capacity owing to severe erosion from the intrusion of seawater and other damages to the facility due to sea level rise. The plant's cooling practices might be affected due to rising ocean temperatures (CDPH, 2008). These impacts could affect those populations who live near the facility or rely on the power produced by the facility.

Finally, communities that depend on groundwater basins within the coastal zone may be affected by saltwater intrusion driven by sea level rise. Of particular concern is the Pajaro Valley, which supplies water for Watsonville and surrounding agricultural areas.

Agriculture

Residential and agricultural development already dramatically impacts some of the endemic species in this region (e.g., through habitat loss). Climate change is projected to further stress these species either through a lack of water (e.g., vernal pools and wetlands) or alteration of habitat conditions (CDFG, 2007). In some cases, species are able to migrate as long as appropriate habitat is available and a pathway to the habitat is unobstructed. In the eastern, warmer, and drier portions of the region, this is a critical consideration for species such as the San Joaquin kit fox (CDFG, 2007).

The ecosystem changes that affect species–including changes in vegetative cover, water availability, seasonal temperature, and precipitation regimes–also affect agricultural. Agriculture plays a significant role in the local economies of the Central Coast region, which produces a large amount of wine grapes, strawberries, lettuce, and vegetable crops (California Farm Bureau Federation,

2012). Climate change has the potential to reduce the productivity of these operations (CAT, 2009). Each crop type has distinct water and temperature needs. As a result, jurisdictions will need to collaborate with agricultural organizations in the region to best support and prepare for impacts.

Fire

A slight increase in large fire occurrence is projected for the region (Westerling and Bryant, 2006), with a large increase in the Monterey Bay Area based on shifting vegetative regimes (Westerling et al., 2009). In addition, a large number of home losses is predicted in Monterey due to large fire occurrence in combination with population density (Bryant and Westerling, 2009). Collaboration with air districts will be required for prescribed burning as a fuel reduction tool. The southern subdistrict of Cal Fire's Coastal District (counties of Santa Cruz, Santa Clara, San Mateo, San Francisco, and Marin) may require extra types of regulations beyond normal California Forest Practice Rules.

Public Health, Socioeconomic, and Equity Impacts

Lodging and food services are among the top five employment sectors in all five counties. Sea level rise may impact the tourism industry and its employees. In addition, workers in these industries who work outside are more susceptible to extreme heat events. Extreme heat events are less likely to occur in the Central Coast region than in California's inland valleys. When they do occur, however, vulnerable populations may be severely affected because of a historic lack of adaptive capacity due to historically milder temperatures.

The higher cost of living in some areas of this region (i.e. San Luis Obispo, Santa Barbara) means low-income families pay a high percentage of their income on housing and transportation. Increases in food and energy costs may impact low-income residents.

ADDITIONAL RESOURCES

- Sea Level Rise
  - A notable example of regional cooperation is the effort being led by the Center for Ocean Solutions and Monterey Bay National Marine Sanctuary/NOAA to address sea level rise in the Monterey Bay region: http://www.centerforoceansolutions.org/news-events/press-releases/monterey-bay-communities-convened-prepare-climate-change
- Wildfire
  - California Fire Science Consortium, Central & South Coast Module: http://www.cafiresci.org/home-central-and-southern-ca/
  - California Fire Alliance: http://cafirealliance.org/
- California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The Central Coast Region defined in the Wildlife Action Plan overlaps with the Central Coast region described in this APG.

North Sierra Region

Counties: Amador, Calaveras, El Dorado, Mariposa, Nevada, Placer, Plumas, Sierra, Tuolumne
Five Largest Cities (CDOF, 2011): Roseville (120,593); Rocklin (57,901); Lincoln (43,248); South Lake Tahoe (21,557); Truckee (16,212)

TOTAL 2010 POPULATION	
North Sierra	808,786
Amador	38,091
Calaveras	45,578
El Dorado	181,058
Mariposa	18,251
Nevada	98,764
Placer	348,432
Plumas	20,007
Sierra	3,240
Tuolumne	55,365

[U.S. Census Bureau, 2010]

The North Sierra is a mountainous region that is very sparsely settled (808,000+ people), with a few cities scattered along primary transport routes, the largest being Roseville (118,000+) in the foothills near Folsom Dam. Seventy-two percent of the region's residents reside in El Dorado, Nevada, and Placer counties. The most prominent feature is Lake Tahoe and the surrounding summer and winter resorts. Tourism is a primary economic activity; the region contains six of the top seven counties in the state when tourism revenue is measured as a percentage of total earnings (Sierra Business Council, 2007).

Climate change impacts that should be evaluated by communities located in the North Sierra region include the following:

- Increased temperature
- Decreased precipitation
- Reduced snowpack
- Reduced tourism
- Ecosystem change
- Sensitive species stress
- Increased wildfire

Cal-Adapt Projections

Table 29. Summary of Cal-Adapt Climate Projections for the North Sierra Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 2.5°F to 4°F by 2050 and 6°F to 7°F by 2100. The largest changes are observed in the southern part of the region. July increase in average temperatures: 4°F to 5°F by 2050 and 10°F by the end of the century, with the greatest change in the northern part of the region. (Modeled average temperatures; high emissions scenario)
Precipitation	Precipitation decline is projected throughout the region. The amount of decrease varies from 3 to 5 inches by 2050 and 6 inches to more than 10 inches by 2100, with the larger rainfall reductions projected for the southern portions of the region. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	Heat waves are defined as five consecutive days over 83°F to 97°F depending on location. By 2050, the number of heat waves per year is expected to increase by two. A dramatic increase in annual heat waves is expected by 2100, eight to 10 more per year.
Snowpack	Snowpack levels are projected to decline dramatically in many portions of the region. In southern portions of the region, a decline of nearly 15 inches in snowpack levels – a more than 60 percent drop – is projected by 2090. (CCSM3 climate model; high carbon emissions scenario)
Wildfire Risk	Wildfire risk is projected to increase in a range of 1.1 to 10.5 times throughout the region, with the highest risks expected in the northern and southern parts of the region. (GFDL climate model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

The North Sierra climate region primarily overlaps two Department of Water Resources hydrologic regions: Mountain Counties and North Lahontan. The Sierra Nevada snowpack is the major water source for the entire state of California, but local populations rely on local surface and groundwater resources. For example, South Lake Tahoe's primary water supply comes from underground aquifers through wells, and not from Lake Tahoe. Groundwater aquifers are located in areas such as the upper portions of the substantial Feather River watershed (DWR, 2009). Melting of snowpack provides groundwater recharge throughout the Sierra Nevada and valley aquifers. Reservoirs with the largest capacities, over one million acre-feet, depend on water derived from the Sierra Nevada and include the Don Pedro, Lake Almanor, Lake McClure, New Melones, and Oroville reservoirs (DWR, 2009).

Biophysical Characteristics

The elevation of the counties in the North Sierra region range from under,1000 feet above sea level on the eastern edge of the Central Valley to 14,000 feet above sea level at some of the higher mountain peaks. Major land forms include the canyons in the Sierra Nevada carved by glaciers, such as Yosemite Valley.

Melting snowpack feeds the extensive network of rivers and streams that connect to hundreds of lakes and reservoirs in the region. The major rivers in the Sacramento River hydrologic region include the Feather, Yuba, Bear, and American rivers. The major rivers in the San Joaquin River hydrologic region include the Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, and San Joaquin rivers. Most of the streams and rivers lie on the western slopes because of the pronounced rain shadow effect, leaving desert-like conditions on the other side of the mountain range (DWR, 2009).

With the variation in temperature and elevation, the Sierra Nevada is home to diverse and complex ecosystems. The westernmost edge of the Sierra Nevada along the Central Valley boundary is characterized by woodland and chaparral, where there is high plant biodiversity. The encroachment of human settlements has, however, become a concern at these boundaries. In the lower mountain zone, starting at 3,000 feet, the Ponderosa and Jeffrey pines are characteristic plant forms. With increasing elevation, the mixed conifer zone transitions into an upper mountain zone around 7,000 feet. Generally beginning at 9,500 feet, above the tree line, the alpine zone has limited vegetation because of the harsh climate conditions (UCSNEP, 1996). This region contains more than 3,500 native species of plants, making up more than 50 percent of the plant diversity in California. Vegetation grows along a north-south axis pattern, with the dominant watersheds that flow from east to west contributing to a secondary pattern. Native animal species include the endangered Sierra Nevada red fox, Sierra bighorn sheep, and yellow-legged frog (Sierra Nevada Alliance, 2010).

Regional Entities

- Air Districts: Amador, Calaveras, El Dorado, Mariposa, Northern Sierra, Placer, Tuolumne
- Regional Governments: Amador County Transportation Commission, Calaveras Council of Governments, El Dorado County Transportation Commission, Mariposa County Transportation Commission, Nevada County Transportation Commission, Placer County Transportation Planning Agency, Plumas County Transportation Commission, Sierra County Transportation Commission, Tahoe Metropolitan Planning Organization, Tahoe Regional Planning Agency, Tuolumne County/Cities Area Planning Council
- Tribal Lands (U.S. EPA, 2011): Chicken Ranch, Greenville, Jackson, Sheep Ranch, Shingle Springs, Tuolumne

Selected Infrastructure and Regional Resources

Table 30. Infrastructure and Resources in the North Sierra Region

TYPES	NAMES
Airports	International: Lake Tahoe-Reno Airport General Aviation: Truckee-Tahoe, Nevada County, Auburn Municipal, Georgetown, Placerville, Cameron Airpark, Amador County-Westover Field, Calaveras County, Columbia
National and State Parks	National: Plumas National Forest, El Dorado National Forest, Stanislaus National Forest, Yosemite National Park, Tahoe National Forest, Sequoia National Forest, Kings Canyon National Park State: Burton Creek S.P., Calaveras Big Trees S.P., D.L. Bliss S.P., Donner Memorial S.P., Ed Z'berg Sugar Pine Point S.P., Emerald Bay S.P., Plumas-Eureka S.P., South Yuba River S.P., Tahoe Recreation Area, Washoe Meadows S.P.

S.P. = State Park

Selected Demographic Data

Table 31. Top Five Employment Sectors in the North Sierra Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Amador	Government	Retail Trade	Health Care	Professional & Technical Services	Construction
Calaveras	Government	Construction	Retail Trade	Other Services	Real Estate
El Dorado	Government	Professional & Technical Services	Retail Trade	Finance and Insurance	Real Estate
Mariposa	Lodging & Food Services	Government	Construction	Other Services	Retail Trade
Nevada	Retail Trade	Government	Construction	Health Care	Professional & Technical Services
Placer	Retail Trade	Government	Health Care	Lodging & Food Services	Finance & Insurance
Plumas	Government	Retail Trade	Construction	Lodging & Food Services	Health Care
Sierra	Government	Health Care	Administrative & Waste Services	Professional & Technical Services	Finance & Insurance
Tuolumne	Government	Health Care	Retail Trade	Lodging & Food Services	Construction

[CA REAP, 2011]

Table 32. Selected Population Data for the North Sierra Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
North Sierra	808,786	42,285	5.20%	136,635	16.90%	82,876		
Amador	38,091	1,431	3.80%	7,865	20.60%	4,286	12.8	2.6
Calaveras	45,578	1,992	4.40%	9,565	21.00%	4,996	11.1	2.7
El Dorado	181,058	9,513	5.30%	26,524	14.60%	16,825	9.4	1.6
Mariposa	18,251	775	4.20%	3,821	20.90%	2,665	14.8	3
Nevada	98,764	4,365	4.40%	19,174	19.40%	11,456	11.7	1.8
Placer	348,432	20,851	6.00%	53,562	15.40%	31,489	9.1	0.9
Plumas	20,007	883	4.40%	4,154	20.80%	3,012	15.3	2.7
Sierra	3,240	147	4.50%	676	20.90%	427	13.4	3
Tuolumne	55,365	2,328	4.20%	11,294	20.40%	7,720	15.2	3

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates

Adaptation Considerations

The North Sierra is rich in natural resources. It is the source for the majority of the water used by the state and home to a varied landscape supporting rich biodiversity.

In the past, this region relied on industries such as mining, timber production, and agriculture. Population growth in recent decades has shifted the region's economy to be driven by the provision of services, tourism, and second home development (Sierra Business Council, 2007). Today, the region's economy is primarily tourism-based. Climate change has the potential to disrupt many features that characterize the region, including ecosystem health, snowpack, and the tourist economy.

Ecosystems and Biodiversity

One of the biggest threats to the ecosystems of the North Sierra is development pressure, including ski area development, second home development, and agriculture (including timber). While these pressures are not caused by climate change, they interact with the changes in climate to further stress ecosystems and endemic species. Climate change can cause habitats to shift, creating conditions inhospitable to these species (CDFG, 2007). As a result, plant and animal species tend to migrate either up in elevation or farther north. Development can limit opportunities for migration and also introduce non-native species, which can further damage habitat.

Timber practices have also had ecosystem consequences that are exacerbated by climate change. The timber industry has resulted in forests with trees of similar age, lacking snags and underbrush. These management practices reduce the diversity of the habitat. In addition, logging road construction and fire suppression has also altered these habitats (CDFG, 2007).

The most altered habitat in the Sierra is aquatic and riparian systems. The causes of this change include development and water diversion (CDFG, 2007). Changes in hydrologic flow regime and increased temperature will further stress these systems, which are home to many special- status species.

Snowpack and Flooding

The North Sierra snowpack serves as a reservoir for the rest of the state. The climate-related decrease in snowpack therefore will have dramatic consequences on the lowland area that depends on this water.

In addition, the snowpack decrease may cause the North Sierra region to experience detrimental impacts from flooding, landslide, and loss of economic base (e.g., skiing). These flood events are likely to put additional pressure on water infrastructure and increase the chance of flooding along waterways. Flooding and damage to infrastructure can put large populations at risk (CDPH, 2008). The populations at risk include the elderly and children, who are isolated or dependent on others for evacuation. Populations that lack the resources or knowledge to prepare or respond to disaster due to language barriers or economic status, including having access to transportation, which would allow them to escape, at least temporarily, flooding also may be at risk (English et al., 2007).

More than any other part of the state, the North Sierra region relies on tourism as its economic base. Recreation and tourism are also likely to suffer due to lower water levels in waterways and reservoirs and declining snowpack. Reduced recreational opportunities due to fewer ski days or low water levels will affect the other economic sectors fed by tourism such as hotels, restaurants, and second home development. In addition, employees of these industries may become more economically vulnerable because of unstable working conditions.

Wildfire

Despite the fact that the ecosystems in the North Sierra have evolved with recurring fire, there is a long history of fire suppression in the North Sierra region. Recently, fire has been recognized as a critical part of ecosystem function (CDFG, 2007). The challenge is twofold: (1) a century of built-up fuel due to suppression cannot be remedied quickly, and (2) the number of structures that have been built throughout the region make it difficult to let fires burn.

To this mix, climate change is added. Climate change is projected to result in large increases in wildfire frequency and size. The expected property loss is likely to be highest in areas with higher population densities (Westerling and Bryant, 2006).

Fire can also set in motion a series of other potential impacts. Following fire, an intense rainstorm can result in landslide or large erosion events that can have drastic consequences for the receiving stream, river, or lake.

Public Health, Socioeconomic, and Equity Impacts

The foothill areas outside the Sacramento area (e.g., Placerville, Auburn, Grass Valley) show higher ozone levels and increased temperatures. People over the age of 65 have the largest increase in mortality with increased concentrations of ozone (Medina-Ramon and Schwartz, 2008), and the elderly make up approximately 20 percent of the population in Amador, Calaveras, Mariposa, Nevada, Plumas, Sierra, and Tuolomne counties. In addition, people who work or spend a lot of time outdoors, such as employees of the tourist industry (Lake Tahoe), are vulnerable. In Mariposa, Placer, Plumas, and Tuolomne counties, lodging and food services rank among the top five employment sectors. The combination of diminished snowpack and exposure to higher ozone levels may make these populations particularly vulnerable.

ADDITIONAL RESOURCES

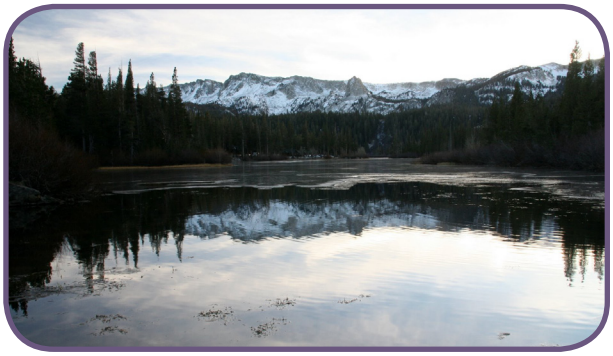
- Wildfire Resources
  - California Fire Science Consortium, Sierra Nevada Module: http://www.cafiresci.org/homepage-sierra-nevada/
  - Northern California Prescribed Fire Council: http://www.norcalrxfirecouncil.org/Home_Page.html
  - NorCal Society of American Foresters: http://norcalsaf.org/
  - Quincy Library Group: http://qlg.org/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- Biodiversity and Ecosystems
  - Sierra Nevada Ecosystem Project: http://ceres.ca.gov/snep/
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The Sierra Nevada and Cascades Region overlaps with the North Sierra region.
  - Tahoe Regional Planning Agency: http://www.trpa.org/

Southeast Sierra Region

Counties: Alpine, Inyo, Mono
Cities (CDOF, 2011): Mammoth Lakes (8,286); Bishop (3,893)

TOTAL 2010 POPULATION	
Southeast Sierra	33,923
Alpine	1,175
Inyo	18,546
Mono	14,202

[U.S. Census Bureau, 2010]



The Southeast Sierra is a combination mountainous and desert region and is the most sparsely settled (33,000+ people) of all the climate regions. A few small towns scattered along Highway 395 are heavily used for tourism access to Las Vegas and Lake Tahoe to the north as well as the Sierra Nevada to the west. The largest settlement is the ski resort town of Mammoth Lakes (8,200+), where the winter population swells with ski season. Tourism is a major economic activity in this region, with 50 percent or more of new home construction in Alpine and Mono counties being second home development. There are also modest agricultural operations in this region.

Communities located in the Southeast Sierra region should consider evaluating the following climate change impacts:

- Increased temperatures
- Reduced precipitation
- Reduced tourism
- Substantially reduced snowpack
- Flooding

Cal-Adapt Projections

Table 33. Summary of Cal-Adapt Climate Projections for the Southeast Sierra Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 1.5°F to 2.5°F by 2050 and 5°F to 10°F by 2100. July increase in average temperatures: 3°F to 5°F by 2050 and 8°F to 10°F (Modeled high temperatures; average of all models; high carbon emissions scenario)
Precipitation	Potential precipitation decline is between 0 and 4 inches by 2050 and 1 and 15 inches by 2100. The range varies widely depending on location. Some areas receive less than 6 inches annually, with projected reductions bringing totals under 4 inches by 2090. In other areas, total rainfall exceeds 45 inches per year and is projected to decrease by roughly 15 inches by 2090. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	There is a lot of variation in heat wave threshold in this region. To the north a heat wave is five days over temperatures in the 80s. To the south, a heat wave is five days over temperatures as high as 115°F. By 2050, there will be 2 to 3 more heat waves per year, increasing up to over 14 to 16 per year by 2100.
Snowpack	Snowpack levels are projected to decline dramatically by 2090 in some areas, with drops of over 50 percent. (CCSM3 climate model; high carbon emissions scenario)
Wildfire Risk	By 2085, wildfire risk is projected to increase substantially (up to 19.1 times) over current levels in Alpine County and the northern part of Mono County. The rest of Mono County and all of Inyo County is projected to have a wildfire risk between 1.1 to 4.8 times greater than current levels. (GFDL climate model; high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org. Sierra Nevada Alliance, 2010.]

Water Sources

This climate region occupies the southern portion of the North Lahontan hydrologic region and the Mono and Inyo county portions of the South Lahontan hydrologic region. Groundwater meets over 65 percent of urban, agricultural, and environmental water demands in the South Lahontan. Locally developed surface water accounts for 90 percent of water consumption in the region (DWR, 2009). Much of the surface water, however, is not available locally because of water appropriation rights that lay claim to the region's water resources. For example, Inyo County has a joint agreement with the Los Angeles Department of Water and Power for groundwater pumping and surface water management in the Owens Valley. The Owens Valley Basin has an estimated capacity of 30 to 35 million acre-feet (DWR, 2009). Replenishment of the basin comes primarily from percolation of the surrounding mountains' stream flow. Major water bodies include Mono Lake, June Lake, Grant Lake, and Lundy Reservoir (Mono County Community Development Department, Planning Division, 2007).

Biophysical Characteristics

The southeastern part of the Sierra is generally dry and arid, typical of regions affected by the rain shadow along mountain ranges. The Southeast Sierra is the location of the highest point in California–Mount Whitney, at 14,505 feet above sea level–and also the lowest point, at 282 feet below sea level in Death Valley National Park. Both features are in Inyo County. Mono Lake in Mono County supports a distinct ecosystem, while the dry lakebed of Owens Lake in Inyo County is a significant reminder of the critical role of water in the state. Mono Lake is also a prominent stop for migrating birds. Major vegetation in the three counties bordering the desert of Nevada include desert shrub, alkali desert shrub, and bristlecone pines in Inyo County and Jeffrey pine, red firs, and subalpine conifers in Alpine County (FRAP, 1998).

Regional Entities

- Air District: Great Basin Unified
- Regional Organizations: Alpine Local Transportation Commission, Inyo County Transportation Commission, Mono County Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Benton Paiute, Big Pine, Bishop, Bridgeport, Fort Independence, Lone Pine, Washoe (Woodfords Community)

Selected Infrastructure and Regional Resources

Table 34. Infrastructure and Resources in the Southeast Sierra Region

TYPES	NAMES
Airports	Primary: Mammoth Yosemite Airport General Aviation: Eastern Sierra Regional, Independence, Lone Pine, Bryant, Lee Vining
National & State Parks	National: Death Valley National Park, Inyo National Forest State: Grover Hot Springs State Park, Mono Lake Tufa State Park

Selected Demographic Data

Table 35. Top Five Employment Sectors in the Southeast Sierra Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Alpine	Lodging & Food Services	Government	Arts, Entertainment & Recreation	Construction	Other Services
Inyo	Government	Lodging & Food Services	Retail Trade	Other Services	Construction
Mono	Lodging & Food Services	Government	Real Estate	Retail Trade	Construction

[CA REAP, 2011]

Table 36. Selected Population Data for the Southeast Sierra Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
South-east Sierra	33,923	2,034	6.00%	5,078	15.00%	4,261		
Alpine	1,175	71	6.00%	166	14.10%	196	16.9	4
Inyo	18,546	1,070	5.80%	3,535	19.10%	2,535	13.9	2.7
Mono	14,202	893	6.30%	1,377	9.70%	1,530	10.8	2.5

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

The sparsely populated Southeast Sierra region relies heavily on tourism. All three counties in the Southeast Sierra rank in the top seven in the state for tourism revenue as a percentage of total revenue. Second home construction makes up more than half of all home construction in two of the counties.

Similar to the North Sierra, the Southeast Sierra region serves as a source for water for other areas of the state, specifically Los Angeles.

Ecosystems and Biodiversity

This region has an incredibly varied set of ecosystems, from high mountains to arid regions to areas with high rainfall. This diversity means that a large number of endemic species are supported in the region. Climate change–from reduced rainfall to increased temperatures to altered hydrologic regimes–will stress these species. In some areas, there is currently very little rainfall. A small decrease or prolonged drought can detrimentally affect species adapted to this setting (CDFG, 2007).

Species stressed by alteration of their preferred habitat may have the ability to migrate. Migration is easiest for terrestrial species; these species will most often move farther north or to a higher elevation. Any number of factors, such as road construction or development, can inhibit migration.

Snowpack and Flooding

The Southeast Sierra region is home to mountainous areas that have consistent annual snowpack. Aquatic systems rely on this snowpack, as do those downstream jurisdictions that depend on it for water supply. Increased temperatures can result in precipitation falling as rain instead of snow and in rapid snowmelt events. These events can cause flooding and erosion and

ultimately result in reduced water supply. Flood events also put additional pressure on water infrastructure. These impacts increase the chance of flooding along waterways. Flooding and damage to infrastructure can put large populations at risk (CDPH, 2008), particularly the elderly and children less than five years of age, who are isolated or dependent on others for evacuation (English et al., 2007).

The loss of snowpack will also have detrimental economic consequences as it is a primary draw for the tourist industry in the region, particular in Mammoth Lakes. Employees of this industry may become more economically vulnerable because of unstable working conditions.

Public Health, Socioeconomic, and Equity Impacts

Inyo County is one of California's counties with the highest proportion of elderly living alone in the state, although the absolute number is relatively smaller than in more urban areas (English et al., 2007). Extreme heat events are less likely to occur in the Southeast Sierra region than in other parts of the state. However, when extreme heat events do occur, vulnerable populations may be severely affected because of a historic lack of adaptive capacity having to do with historically milder temperatures.

ADDITIONAL RESOURCES

- Wildfire Resources
  - California Fire Science Consortium, Sierra Nevada Module: http://www.cafiresci.org/homepage-sierra-nevada/
  - Northern California Prescribed Fire Council: http://www.norcalrxfirecouncil.org/Home_Page.html
  - SoCal Society of American Foresters: http://norcalsaf.org/
  - California Fire Alliance: http://cafirealliance.org/
  - California FireSafe Council: http://www.firesafecouncil.org/
- Biodiversity and Ecosystems
  - Sierra Nevada Ecosystem Project (http://ceres.ca.gov/snep/
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
  - The Wildlife Action Plan divides the state into regions. The Sierra Nevada and Cascades and Mojave Desert Regions overlap with the Southeast Sierra region.

South Coast Region

Counties: Los Angeles, Orange, San Diego, Ventura
Five Largest Cities (CDOF, 2011): Los Angeles (3,810,129); San Diego (1,311,882); Long Beach (463,894); Anaheim (341,034); Santa Ana (325,228)

TOTAL 2010 POPULATION	
South Coast	16,747,468
Los Angeles	9,818,605
Orange	3,010,232
San Diego	3,095,313
Ventura	823,318

[U.S. Census Bureau, 2010]

The South Coast (16+ million people) is the most heavily urbanized region in the state. The region consists of sprawling suburban development interspersed with dense urban centers, most notably Los Angeles (3.8+ million people) and San Diego (1.3+ million people). The character of the region is defined by the predominant feature of the Southern California coastline, accompanied by the San Gabriel Mountains and coastal mountains to the south. Corners of the region, such as the high desert community of Lancaster, differ substantially in context. However, the most prominent regional feature is the sprawling coastal metropolis along a coastal plain, interspersed with low-lying hills and a few inland areas such as the San Fernando and San Gabriel valleys.

Communities in the South Coast region should consider evaluating the following climate change impacts:

- Increased temperatures
- Reduced precipitation
- Sea level rise
- Reduced tourism
- Reduced water supply
- Wildfire risk
- Public health - heat and air quality
- Coastal erosion

Cal-Adapt Projections

Table 37. Summary of Cal-Adapt Climate Projections for the South Coast Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 1°F to 2.5°F by 2050 and 5°F to 6°F by 2100 July increase in average temperatures: 3°F to 4°F by 2050 and 5°F to 10°F by 2100 with larger increases projected inland. (Modeled high temperatures; high carbon emissions scenario)
Precipitation	Annual precipitation will vary by area but decline overall throughout the century. Low-lying coastal areas will lose up to 2 inches by 2050 and 3 to 5 inches by 2090, while high elevations will see a drop of 4 to 5 inches by 2050 and 8 to 10 inches by 2090. (CCSM3 climate model; high emissions scenario)
Sea Level Rise	By 2100, sea levels may rise 55 inches, posing threats to many areas in the region including Venice Beach, the Port of Long Beach, the South Coast naval stations, and San Diego Harbor. As a result of sea level rise, 45 percent more land in Los Angeles County, 40 percent more land in San Diego County, 35 percent more land in Ventura County, and 28 percent more land in Orange County will be vulnerable to 100-year floods.
Heat Wave	Along the coast, a heat wave is five days over temperature in the 80s. Inland, the temperature must hit the 90s and 100s for five days. All areas can expect 3 to 5 more heat waves by 2050 and 12 to 14 by 2100 in most areas of the region.
Snowpack	March snowpack in the San Gabriel Mountains will decrease from the 0.7-inch level in 2010 to zero by the end of the century. (CCSM3 climate model; high emissions scenario)
Wildfire Risk	Little change is projected in the already high fire risk in this region, save for slight increases expected in a few coastal mountainous areas such as near Ojai and in Castaic, Fallbrook, and Mission Viejo.

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

The South Coast hydrologic region encompasses Ventura, Los Angeles, Orange, and San Diego counties, as well as the southwestern portion of San Bernardino County and western Riverside County. The region derives its water supply primarily from the State Water Project (SWP) (which draws from the Sierra), the Colorado River, groundwater, and local imports. These sources vary in quantity in a given year, but on average the SWP and groundwater provide more than 1 million acre-feet each, while the Colorado River provides nearly the same. Depending on the water supply in a given year, approximately 5 million acre-feet of water are used. Most of the use is by urban areas at around 4 million acre-feet, followed by agriculture, which uses about 0.5 to 1 million acre-feet annually. Total reservoir storage capacity is about 3 million acre-feet (DWR, 2009).

Biophysical Characteristics

The South Coast region contains several mountain ranges surrounding the coastal basins of the Santa Clara, Los Angeles, and Santa Ana rivers. Elevation ranges from sea level at the coast to around 200 feet for most of the urban areas (State of California, 2005c). The mountain ranges, which peak at about 8,000 feet, are the major physical features of the South Coast counties and include the Sierra Madres, the Transverse Ranges, and the Peninsular Ranges in Ventura, Los Angeles, and San Diego counties, respectively (DWR, 2009). Between the latter two ranges lies the 35mile-by-15-mile Los Angeles Basin, which is almost entirely urbanized. The largest rivers are the Los Angeles, San Diego, San Gabriel, San Luis Rey, Santa Ana, Santa Clara, and Santa Margarita. Due to urbanization, vegetation is constrained to the mountains and consists mostly of scrub and chaparral. Wildlife includes mountain lions, coyotes, raccoons, golden eagles, ospreys, brown pelicans, kangaroo rats, and foxes (grey and kit) (FRAP, 1998). Marine life includes whales, dolphins, and California sea lions.

Regional Entities

- Air Districts: San Diego, South Coast, Ventura
- Regional Governments: Southern California Association of Governments, San Diego Association of Governments, Los Angeles Metropolitan Transportation Authority, Orange County Transportation Authority, Ventura County Transportation Commission
- Tribal Lands (U.S. EPA, 2011): Barona; Campo, Capitan Grande, Cuyapaipe, Inaja-Cosmit, Jamul Indian Village, La Jolla, La Posta, Los Coyotes, Manzanita, Mesa Grande, Pala, Pauma-Yuima, Rincon, San Pasqual, Santa Ysabel, Sycuan, Table Mountain, Viejas

Selected Infrastructure and Regional Resources

Table 38. Infrastructure and Resources in the South Coast Region

TYPES	NAMES
Airports	International: Los Angeles International, San Diego International General Aviation: Bob Hope, Camarillo, El Monte, Fallbrook Community Airpark, John Wayne, Long Beach, Oxnard, Van Nuys, Whiteman
National and State Parks	National: Angeles National Forest, Cabrillo National Monument, Channel Island National Park, Cleveland National Forest, Los Padres National Forest, Santa Monica Mountains National Recreation Area State: Antelope Valley Poppy Reserve, Arthur Ripley Desert Woodland S.P., Anza-Borrego Desert S.P., Border Field S.P., Chino Hills S.P., Crystal Cove S.P., Cuyamaca Rancho S.P., Leo Carillo S.P., Malibu Creek S.P., Palomar Mountain S.P., Placerita Canyon S.P., Point Mugu S.P. Ripley Desert Woodland S.P., Saddleback Butte S.P., Topanga S.P., Torrey Pine State Reserve
Passenger Rail	Amtrak, Los Angeles County Metro Rail, Metrolink, San Diego County Coaster and Sprinter
Ports	Bulk & Container: Port of Hueneme, Port of Long Beach, Port of Los Angeles, Port of San Diego Other: Avalon, Dana Point Harbor, Oceanside Harbor, Redondo Beach Harbor, Two Harbors
Power Plants (MWs)*	El Segundo (1,020), Southeast Resource Recovery (34.6), Harbor Cogen (107), Long Beach Peaker (260), Alamitos Generating Station (2,010), Queen Mary (1), Haynes (1,570), Orange County Sanitation District-Plant No. 2 (18), Huntington Beach (904), Goodrich Cogeneration Center Plant (9.5), Eastside Water Renovation (.5), Mandalay (560), Ormond Beach (1,520)

S.P. = State Park; MW: Megawatt

Selected Demographic Data

Table 39. Top Five Employment Sectors in the South Coast Region

EMPLOYMENT SECTOR RANKING					
County	**1**	**2**	**3**	**4**	**5**
Ventura	Government	Retail Trade	Health Care	Manufacturing	Finance & Insurance
Los Angeles	Government	Health Care	Retail Trade	Professional & Technical Services	Manufacturing
Orange	Professional & Technical Services	Retail Trade	Manufacturing	Government	Health Care
San Diego	Government	Professional & Technical Services	Retail Trade	Health Care	Lodging & Food Services

[CA REAP, 2011]

Table 40. Selected Population Data for the South Coast Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	% < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
South Coast	16,747,468	1,096,243	6.50%	1,863,110	11.10%	2,598,624		
Los Angeles	9,818,605	645,793	6.60%	1,065,699	10.90%	1,699,264	17.6	0.4
Orange	3,010,232	191,691	6.40%	349,677	11.60%	363,924	12.2	0.6
San Diego	3,095,313	203,423	6.60%	351,425	11.40%	445,556	14.8	0.7
Ventura	823,318	55,336	6.70%	96,309	11.70%	89,880	11	1.3

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

The South Coast is a highly urbanized region. High population density also creates greater vulnerability to climate-related hazards simply because more people are in harm's way. The concentration of population on the coast has the potential to affect public safety, infrastructure, and the integrity of coastal ecosystems. In addition, the urban setting can also amplify public health risks because increased temperatures are even higher due to the urban heat island.

Sea Level Rise

Sea level rise has the potential to result in far-reaching impacts on the South Coast region. Sea level rise may affect the region's tourism–the largest value tourist industry in the state (NOEP, 2005)–as well as other considerable assets, including international airports and seaports.

A study by the California Department of Boating and Waterways and San Francisco State University (*n.d.*) using three example beaches in the region shows considerable loss of recreational and ecological benefits due to sea level rise. A 1.4-meter rise in sea level will increase the population vulnerable to a 100-year coastal storm from 86,000 to 149,300. Most of the population at risk is in Orange County (CCCC, 2007). Areas near Huntington Beach, Seal Beach, the Port of Long Beach, Marina Del Rey, and Port Hueneme also will be of particular concern in the region due to the significant inland penetration of flood waters exacerbated by sea level rise (cal-adapt.org, PIER, 2011).

Sea level rise is expected to affect vulnerable populations along the coast through the immediate effects of flooding and temporary displacement and longer-term effects of permanent displacement and disruption of local tourism. Of

particular concern are populations that do not have the resources to prepare for, respond to, and recover from disasters. Impacts could include temporary and/or permanent displacement; drowning and property damage; and coastal erosion harming recreational activities, tourism, and the tourism industry.

Sea level rise and severe storm surges are a concern for nuclear power plants near the Pacific Ocean, including the San Onofre Nuclear Power Plant in Orange County. Risks associated with this facility include flooding of containment buildings where highly radioactive spent nuclear fuel is stored, loss of generating capacity owing to severe corrosion from the intrusion of seawater, and other damages to the facility due to sea level rise. The plant's cooling practices might be impacted due to rising ocean temperatures. (CDPH, 2008) These impacts could affect populations that live near the facility or rely on the power produced by the facility. Industrial development in the region has left a legacy of brownfields and contaminated waste sites. Some of these will be exposed to coastal flooding due to sea level rise. These sites need to be identified, and priorities for their clean-up may need to be set before contamination spreads.

Wildfire

The South Coast already experiences wildfire. The extent to which climate change is projected to alter existing wildfire risk is variable (Westerling and Bryant, 2006). Wildfire frequency and severity will depend on shifts in vegetation and Santa Ana wind behavior (Miller and Schlegal, 2006; Westerling et al., 2009). Management of fire risk such as prescribed burns may be subject to regulations beyond normal California forest practice. For example, the "High Use" subdistricts of Cal Fire's Southern District (counties of Ventura, Santa Barbara, Los Angeles, San Bernardino, Orange, Riverside, Imperial, San Diego, Monterey, San Luis Obispo, and those portions of Placer and El Dorado counties lying within the authority of the Tahoe Regional Planning Agency) may have additional stipulations with regard to management practice.

Increased temperature and decreased moisture, such as longer drought periods, will increase fire vulnerability in a number of areas. Along with impacts associated with temporary and/or permanent displacement, long-term impacts on the elderly and children under the age of five are of concern. Eye and respiratory illnesses due to air pollution resulting from wildfires, and exacerbation of asthma, allergies, chronic obstructive pulmonary disease (COPD), and other cardiovascular diseases are likely to increase.

Public Health, Socioeconomic, and Equity Impacts

In the highly populated areas within this region, "urban heat islands" will exacerbate the public health impacts that poor air quality and heat waves have upon the more vulnerable populations of this area. The highest percentages of impervious surfaces are in the urban areas of Los Angeles and San Diego counties, increasing the potential impacts of heat islands (English et al., 2007). Southern California's urban centers are warming more rapidly than other parts of the state (English et al., 2007). Los Angeles, San Diego, and Orange counties rank first, second, and third in the state in absolute numbers of the elderly and children less than five years of age. These two populations are most likely to suffer from heat-related illnesses and heat events (English et al., 2007).

Because of the significant and varied population in this region, there is also likely to be a significant population that fits into a number of the socially vulnerable categories lacking adaptive capacity. This increases the vulnerability of these populations.

The higher cost of living in some areas of this region means low-income families pay a high percentage of their income on housing and transportation. Increases in food and energy costs may impact low-income residents.

Water Supply

Two primary sources of water used by the South Coast region are the State Water Project and the Colorado River. In both cases, these water supplies originate in mountain snowpack. Climate change will result in reduced snowpack, which will translate into reduced water supply. Further threatening the regional water supply is the vulnerability of the levees protecting the California Delta, which feeds the State Water Project (DWR, 2011). Jurisdictions in the South Coast must carefully consider the vulnerability of their water supply.

Climate change will reduce water supply and subsequently increase costs. Industries reliant on water may be affected, resulting in reduced revenue and employment base.

ADDITIONAL RESOURCES

- Sea Level Rise
  - In San Diego, the Public Agency Steering Committee, working with ICLEI-Local Governments for Sustainability and The San Diego Foundation, developed the "Sea Level Rise Adaptation Strategy for San Diego Bay." Source: http://www.cakex.org/sites/default/files/documents/San_Diego_Bay_SLR_Adaptation_Strategy_Complete.pdf. This should serve as a key reference for communities in the region.
- Wildfire
  - California Fire Science Consortium, Central & South Coast Module: http://www.cafiresci.org/home-central-and-southern-ca/
  - SoCal Society of American Foresters: http://norcalsaf.org/
  - Southern California Association of Foresters & Fire Wardens: http://scaffw.org/SCAFFW_home.htm
  - California Fire Alliance: http://cafirealliance.org/
    California FireSafe Council: http://www.firesafecouncil.org/
- Public Health, Socioeconomic, and Equity Impacts
  - The Los Angeles County Department of Health Services' Office of Health Assessment and Epidemiology has produced an excellent resource: Premature Deaths from Heart Disease and Stroke in Los Angeles County: A Cities and Communities Health Report (www.lapublichealth.org/epi/docs/CHR_CVH.pdf). Notably, this report provides information on heart disease and stroke, as well as economic hardship, by city or community (spatializing the data to inform built environmental planning decisions). (Public Health Law and Policy, How to Create a Healthy General Plan, 2008)
  - Los Angeles and San Diego counties are two of a few places in California with real-time surveillance data for communicable diseases and outbreaks. (CDPH, 2008)

Desert Region

Counties: Imperial, Riverside, San Bernardino
Five Largest Cities (CDOF, 2011): Riverside (305,779); San Bernardino (211,076); Fontana (198,456); Moreno Valley (195,215); Ranch Cucamonga (168,181)

TOTAL 2010 POPULATION	
Desert	4,399,379
Imperial	174,528
Riverside	2,189,641
San Bernardino	2,035,210

[U.S. Census Bureau, 2010]

The Desert is a heavily urbanized inland region (4.3+ million people) made up of sprawling suburban development in the west near the South Coast region and vast stretches of open, largely federally owned desert land to the east. Prominent cities within the desert portion include Palm Springs (44,500+) and El Centro (42,500+). The region's character is defined largely by the San Gabriel Mountains, San Gorgonio Mountains, San Jacinto Mountains, and smaller inland mountains reaching through the desert to the Colorado River, which borders the region on the east.

Communities in the Desert region should consider evaluating the following climate change impacts:

- Reduced water supply
- Increased temperature
- Reduced precipitation
- Diminished snowpack
- Wildfire risk
- Public health and social vulnerability
- Stress on special-status species

Cal-Adapt Projections

Table 41. Summary of Cal-Adapt Climate Projections for the Desert Region

EFFECT	RANGES
Temperature Change, 1990-2100	January increase in average temperatures: 2°F to 4°F by 2050 and 5°F to 8°F by 2100 July increase in average temperatures: 3°F to 5°F by 2050 and 6°F to 9°F by 2100 (Modeled high temperatures; high carbon emissions scenario)
Precipitation	Generally, annual rainfall will decrease in the most populous areas. Wetter areas like the western part of Riverside and southwestern San Bernardino counties will experience a 2 to 4 inch decline by 2050 and 3.5 to 6 inch decline by the end of the century. Big Bear is expected to lose around 8 inches per year by 2090. Southern Imperial County will have a small decline of about 0.5 inches. The eastern, desert portion of the region will see little to no change in annual rainfall. (CCSM3 climate model; high carbon emissions scenario)
Heat Wave	Heat waves are defined by five consecutive days over temperatures in the 100s over most of the region. Three to five more heat waves will be experienced by 2050, increasing to 12 to 16 in the western parts of the region to more than 18 to 20 in the eastern parts of the region.
Snowpack	March snowpack in the Big Bear area will diminish from the 2.5-inch level of 2010 to 1.4 inches in 2030 and almost zero by 2090. (CCSM3 climate model; high emissions scenario)
Wildfire Risk	Most areas are projected to have the same or slightly increased likelihood of wildfire risk. The major exceptions are the Mecca San Gorgonio and San Jacinto Mountains, where wildfire will be 1.5 and 2.0 times more likely. (GFDL model, high carbon emissions scenario)

[Public Interest Energy Research, 2011. Cal-Adapt. Retrieved from http://cal-adapt.org]

Water Sources

Water for most of the Desert region is supplied primarily from the State Water Project, the Colorado River, and local groundwater. The less-populated eastern part of the region uses approximately 4.5 million acre-feet of water annually. Nearly 4 million acre-feet come from the Colorado River, while almost 0.5 million acre-feet are supplied from the State Water Project and groundwater. Usage is split between agriculture, at nearly 4 million acre-feet, and urban consumption, at approximately 0.5 million acre-feet. Storage capacity in the region's reservoirs totals 0.62 million acre-feet (DWR, 2009).

Note: The State of California measures water supply/usage for the populous western Riverside County and southwestern San Bernardino County as part of the South Coast hydrologic region, which also includes Los Angeles, San Diego, Orange, and Ventura counties. Please see the South Coast region summary for more information.

Biophysical Characteristics

The Mojave and Colorado deserts dominate the geography of the Desert region. These hot, arid lands lie east of the San Bernardino and San Jacinto mountains. The Colorado Desert is low-lying, below 1,000 feet in elevation, and is home to desert scrub, palm oasis, and desert wash. Native birds and animals include muskrats, mule deer, coyotes, bobcats, and the Yuma antelope ground squirrel (State of California, 2005a). The Salton Sea, a saltwater lake and the largest lake in California, is situated in the middle of the Colorado Desert. Both northwest and south of the Salton Sea are large agricultural areas irrigated by the Colorado River. The vast majority of the population inhabits the western edge of the region, particularly along the Santa Ana River, in the valley between the San Gabriel, San Bernardino, San Jacinto, and Santa Ana mountains (State of California, 2005a).

By contrast, most of the Mojave region is uninhabited and is owned and managed by the United States Bureau of Land Management. Plant species include desert wash and scrub, alkali and Joshua tree scrub, and palm oasis. Native and rare animals include bighorn sheep, desert tortoise, prairie falcon, and the Mojave ground squirrel. The natural recreational attractions for the region include the Salton Sea, the Picacho State Park along the Colorado River at the Arizona border, and Joshua Tree National Park (State of California, 2009).

Regional Entities

- Air Districts: Imperial, Mojave Desert, South Coast
- Regional Organizations: Imperial Valley Association of Governments, Riverside County Transportation Commission, San Bernardino Associated Governments, San Bernardino County Transportation Commission, Southern California Association of Governments, Western Riverside Council of Governments
- Tribal Lands (U.S. EPA, 2011): Agua Caliente, Augustine, Cabazon, Cahuila, Chemehuevi, Colorado River, Fort Mojave, Morongo, Pechanga, Quechan, Ramona, San Manuel, Santa Rosa, Soboba, Torres-Martinez, Twenty-Nine Palms

Selected Infrastructure and Regional Resources

Table 42. Infrastructure and Resources in the Desert Region

TYPES	NAMES
Airports	International: Ontario International General Aviation: Big Bear City; Cable (Upland), Cliff Hatfield Memorial (Calipatria), Corona Municipal, Hesperia, Holtville, Imperial County, Needles, Riverside Municipal
National & State Parks	National: Joshua Tree National Park, Mojave National Preserve, San Bernardino National Forest, Salton Sea National Wildlife Refuge State: Anza-Borrego Desert State Park, Chino Hills State Park, Mount San Jacinto State Park, Salton Sea State Park

Selected Demographic Data

Table 43. Top Five Employment Sectors in the Desert Region

	EMPLOYMENT SECTOR RANKING				
County	**1**	**2**	**3**	**4**	**5**
Imperial	Government	Retail Trade	Health Care	Lodging & Food Service	Manufacturing
Riverside	Government	Retail Trade	Health Care	Lodging & Food Service	Construction
San Bernardino	Government	Retail Trade	Health Care	Lodging & Food Service	Transportation & Warehousing

[CA REAP, 2011]

Table 44. Selected Population Data for the Desert Region

						POPULATION BELOW POVERTY LEVEL		
	Total 2010 Pop.	Pop. <5 years	Percent < 5 years	Pop. ≥65 years	Percent ≥65 years	Estimated - All Ages	Estimated Percent	Margin of Error
Desert	4,399,379	334,754	7.60%	458,086	10.40%	753,533		
Imperial	174,528	13,526	7.80%	18,152	10.40%	36,666	22.3	2.9
Riverside	2,189,641	162,438	7.40%	258,586	11.80%	354,768	16.4	0.9
San Bernardino	2,035,210	158,790	7.80%	181,348	8.90%	362,099	18.1	1.1

[U.S. Census Bureau, 2010, General Population and Housing Characteristics & Small Area Income and Poverty Estimates]

Adaptation Considerations

The Desert region has a large population along its western edge and smaller populations to the east. The higher population areas are more prone to climate change impacts associated with urban areas (heat and air quality). In the desert areas, climate change will have dramatic impacts on the fragile ecosystems.

Ecosystems and Biodiversity

Many of the species endemic to the inland desert areas of California are adapted to a specific, often narrow, temperature and precipitation range. Changes to the seasonal pattern can stress species, particularly aquatic species. Increased temperature and reduced precipitation can limit the existence and extent of habitats such as intermittent streams or other periodic habitats. For terrestrial species, migration becomes a critical point of assessment. Species such as the desert tortoise have had their habitat fragmented and been stressed by invasive species and pest populations (CDFG, 2007).

There are extensive federal land holdings in the region. Preserving species relies partly on managing these lands (for grazing, solar installation, etc and managing the adjoining lands to accommodate migration corridors.

Water Supply

Similar to the South Coast region, the Desert region relies on water from the Colorado River and the State Water Project. Both of these sources begin with mountain snowpack. Climate change will result in drastically reduced supply from these sources. Declining snowpack in the San Gabriel Mountains, San Gorgonio Mountains, and San Jacinto Mountains will lead to permanently diminished local water supply.

Public Health, Socioeconomic, and Equity Impacts

Riverside and San Bernardino counties rank fourth and seventh in the state in the absolute numbers of the elderly and children less than five years of age. These two populations are most likely to suffer from heat-related illnesses and heat events (English et al., 2007).

Impervious surfaces are increasing in Riverside and San Bernardino counties, increasing the potential impacts of heat islands (English et al., 2007). Foothill and mountainous communities of this region may be particularly subject to respiratory and heat stress due to a combination of higher ozone levels, higher elevations, and increasing temperatures in these areas (English et al., 2007; Drechsler et al., 2006). Those most vulnerable to high levels of ozone and particulate matter include people who work or spend a lot of time outdoors, such as agricultural employees in Imperial County and employees of the tourist

industry around Big Bear. As there may be impacts upon tourism from reduced snowpack, floods, and wildfires, employees of this industry may become more economically vulnerable because of unstable working conditions.
Impacts upon safety and emergency response services are of particular concern in this region because of the potential for particularly lengthy and severe heat events. In extreme heat events, roads essential for disaster response could buckle.

Wildfire

The high temperatures that characterize much of the desert landscape in this region limit the production of fuels that result in wildfire. However, short periods of high moisture (intense rainfall events) can increase production of fine fuels. In addition, invasive species, particularly in desert settings, may facilitate fire in areas not historically prone to burn.

ADDITIONAL RESOURCES

- Wildfire
  - California Fire Science Consortium, Mojave and Sonoran Desert Module (http://www.cafiresci.org/home-mojave-desert/)
  - California Fire Alliance (http://cafirealliance.org/)
  - California FireSafe Council (http://www.firesafecouncil.org/)
- Biodiversity and Ecosystems
  - California Department of Fish and Game. 2007. California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento. Retrieved from http://www.dfg.ca.gov/wildlife/wap/report.html
    The Wildlife Action Plan divides the state into regions. The Colorado Desert and Mojave Desert Regions overlap with the Desert region.

References

Bryant, B., and A. Westerling. 2009. Potential Effects of Climate Change on Residential Wildfire Risk in California. Publication #CEC-500-2009-048-D.

California Board of Equalization [BOE]. 2010. California Timber Harvest by County. Retrieved from: http://www.boe.ca.gov/proptaxes/pdf/ytr362010.pdf.

California Climate Change Center [CCCC]. (2009). The impacts of sea level rise on the California coast. Retrieved from http://www.pacinst.org/reports/sea_level_rise/report.pdf.

California Department of Finance [CDOF]. (2011). Tables of January 2011 City Population Ranked by Size, Numeric and Percent Change. Retrieved from http://www.dof.ca.gov/research/demographic/reports/estimates/e-1/view.php.

California Department of Fish and Game [DFG]. (2007). California Wildlife: Conservation Challenges - California's Wildlife Action Plan. Sacramento: author. Retrieved from: http://www.dfg.ca.gov/wildlife/wap/report.html.

California Department of Public Health [CDPH]. 2008. Public Health Climate Change Adaptation Strategy for California. Retrieved from http://www.cdph.ca.gov/programs/CCDPHP/Documents/CA_Public_Health_Adaptation_Strategies_final.pdf.

California Department of Water Resources [DWR] (2009). California Water Plan: Update 2009: Volume 3 Regional Reports. Retrieved from: http://www.waterplan.water.ca.gov/cwpu2009/index.cfm#volume3.

California Department of Water Resources [DWR]. (2011). Climate Change Handbook for Regional Water Planning. Retrieved from: http://www.water.ca.gov/climatechange/docs/Climate_Change_Handbook_Regional_Water_Planning.pdf

California Energy Commission (CEC). 2011. Cal-Adapt. Retrieved from http://cal-adapt.org

California Environmental Resources Evaluation System [CERES]. (2005). The Klamath/North Coast Bioregion -- An Overview. Retrieved from: http://ceres.ca.gov/geo_area/bioregions/Klamath/about.html

California Farm Bureau Federation. (2012). County Farm Bureaus. Retrieved from: http://www.cfbf.com/counties/index.cfm

California Farm Bureau Federation. (2012). County Farm Bureaus. Retrieved from: http://www.cfbf.com/counties/index.cfm

California Fire and Resource Assessment Program [FRAP]. (1998). Wildlife Habitats—Gap Analysis Program. Sacramento, CA: Author. Retrieved from http://frap.cdf.ca.gov/webdata/maps/statewide/gapwhr_map.pdf

California Fire and Resource Assessment Program [FRAP]. (2003). Land Cover—Multi-source Data Compiled for Forest and Range 2003 Assessment. Sacramento, CA: Author. Retrieved from http://frap.cdf.ca.gov/webdata/maps/statewide/fvegwhr13_map.pdf

California Natural Resources Agency. (2009). 2009 California Climate Adaptation Strategy. Retrieved from: http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf.

California Regional Economic Analysis Project (CA REAP). 2011. Full-time and part-time employment by major industry. Retrieved from http://california.reaproject.org/.

Chase, LE. (2006) Factsheet: Climate Change Impacts on Dairy Cattle. Climate Change and Northeast Agriculture. Retrieved from http://climateandfarming.org/pdfs/FactSheets/III.3Cattle.pdf.

Climate Action Team. (2009). Draft Biennial CAT Report. Retrieved from http://www.energy.ca.gov/2009publications/CAT-1000-2009-003/CAT-1000-2009-003-D.PDF.

Delta Vision. (2008). Blue Ribbon Task Force. Retrieved from http://deltavision.ca.gov/BlueRibbonTaskForce/FinalVision/Delta_Vision_Final.pdf.

Department of Water Resources. (2009) Delta Risk Management Strategy Phase 1 – Risk Analysis Report. Sacramento: Retrieved from http://www.water.ca.gov/floodsafe/fessro/levees/drms/phase1_information.cfm.

Drechsler, et al. (2006). Public Health-Related Impacts of Climate Change in California. Sacramento, CA: California Energy Commission. PIER Research Report CEC-500-2005-197-SF.

English et al. (2007). Executive Summary, Heat-Related Illness and Mortality Information for the Public Health Network in California.

Environmental Protection Agency [EPA] (2011). California Tribal Lands. Retrieved from http://www.epa.gov/region9/air/maps/ca_tribe.html.

Kahrl, Friedrich and Roland-Host, David (2008). California Climate Risk and Response. Retrieved from http://www.nextten.org/pdf/report_CCRR/California_Climate_Risk_and_Response.pdf

Lenihan, J.M., D. Bachelet, R. Drapek, and R.P. Neilson. (2006). The response of vegetation distribution, ecosystem productivity, and fire in California to future climate scenarios simulated by the mc1 dynamic vegetation model. California Climate Change Center-California Energy Commission. Publication #CEC-500-2005-191-SF.

Medina-Ramon, M., and J. Schwartz. (2008). Who is more vulnerable to die from ozone air pollution? Epidemiology; 19:672-679.

Miller, N.L. and N.J. Schlegal. 2006. Climate Change–Projected Santa Ana Fire Weather Occurrence. California Climate Change Center-California Energy Commission. Publication # CEC-500-2005-204-SF.

Mono County Community Development Department, Planning Division. (2007). Mono County Watershed Assessment. Retrieved from: http://www.monocounty.ca.gov/cdd%20site/Planning/Documents/Assessments_MonoBasin.pdf.

National Ocean Economics Program [NOEP]. (2005). California's Ocean Economy. California Natural Resources Agency. Retrieved from: http://resources.ca.gov/press_documents/CA_Ocean_Econ_Report.pdf

San Francisco Planning + Urban Research Association. (2012). Climate Adaptation and Sea level Rise in the San Francisco Bay Area. Retrieved from http://www.planning.org/planning/2012/jan/waterwarriorsside2.htm

Sierra Business Council. (2007). The State of the Sierra. Retrieved from http://www.sbcouncil.org/Publications/State-of-the-Sierra-Report-2007

Sierra Nevada Alliance. (2010). Sierra Climate Change Toolkit, 3rd Edition. South Lake Tahoe, CA: author. Retrieved from: http://www.sierranevadaalliance.org/publications/db/pics/1303760072_12034.f_pdf.pdf

State of California (2005). The Colorado Desert Bioregion: An Overview. CERES. Retrieved from: http://ceres.ca.gov/geo_area/bioregions/Colorado_Desert/about.html

State of California (2005). The Mojave Bioregion: An Overview. CERES. Retrieved from: http://ceres.ca.gov/geo_area/bioregions/Mojave/about.html

State of California (2005). The South Coast Bioregion: An Overview. CERES. Retrieved from: http://ceres.ca.gov/geo_area/bioregions/South_Coast/about.html

Todorov, K. (2011, July 14). Climate change may test Napa wine industry. Napa Valley Register. Retrieved from http://napavalleyregister.com/news/local/climate-change-may-test-napa-wine-industry/article_3ef82eb4-ae91-11e0-9ab5-001cc4c002e0.html

U.S. Census Bureau (2010). Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data. Retrieved from http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml

University of California SNEP Science Team [UCSNEP]. (1996). Sierra Nevada Ecosystems. Sierra Nevada Ecosystem Project, pp. 10-12. Retrieved from: http://ceres.ca.gov/snep/pubs/web/PDF/v1_ch01.pdf

Westerling, A. and B. Bryant. (2006). Climate change and wildfire in and around California: Fire modeling and loss modeling. California Climate Change Center-California Energy Commission. Publication # CEC-500-2005-190-SF.

Westerling, A.L., B. P. Bryant, H. K. Preisler, H. G. Hidalgo, T. Das, and S. R. Shrestha. (2009). Climate change, growth, and California wildfire. California Climate Change Center-California Energy Commission. Publication # CEC-500-2009-046-D.