



Western Riverside Adaptation and Resiliency Strategy: Part 1, Vulnerability Assessment

INTRODUCTION

The greenhouse gas (GHG) mitigation reduction strategies in the WRCOG Climate Action Plan (CAP) support the statewide approach to reduce long-term climate change effects. However, the State is already experiencing adverse effects from climate change (CEPA and OEHHA 2013; Cal OES and CNRA 2012; WRCC 2013a). Even if global concentrations of GHGs stopped increasing today, climate change will impact the subregion for the foreseeable future. If GHG levels continue to rise, climate change effects will likely become more severe (IPCC 2013).

The Western Riverside Council of Governments (WRCOG) subregion is a diverse area, exhibiting a variety of socioeconomic conditions, infrastructure types, neighborhood compositions, geographies, and character. Nearly two million people live, work, and recreate in Western Riverside County.

For the subregion to flourish, it is important to understand how the climate could change and begin implementing strategies that help the subregion thrive in a variety of future climate conditions. To achieve this objective, the Adaptation and Resiliency Strategy provides a brief overview of expected climate change effects, assets in the subregion that are vulnerable to climate change effects, and adaptation strategies intended to reduce vulnerability and increase resilience. The strategies in this document represent actions that increase resilience to natural hazards regardless of the rate and severity of climate change. The Adaptation and Resiliency Strategy concludes with sample work plans to enable local government implementation.

Appendix A provides information regarding the adaptation planning process and background research.

Climate Adaptation and GHG Mitigation

“Greenhouse gas mitigation” strategies reduce greenhouse gas emissions.

“Climate adaptation” strategies reduce the vulnerability of life, property, and natural resources to climate change effects. WRCOG intends to develop adaptation strategies that are GHG emissions neutral, or net negative, to ensure they are consistent with the CAP emissions reduction target.

“Climate resilience” refers to the ability of an asset, system, or organization to withstand the effects of climate change.

“Negative GHG emissions” refers to ability to absorb more carbon dioxide than produced. This would include the net removal of carbon dioxide from the atmosphere.

CLIMATE CHANGE IN THE SUBREGION

As part of the technical work undertaken to prepare the Adaptation and Resiliency Strategy, WRCOG considered a number of climate change–related hazards. Some hazards, such as possible increases in wind, have too much uncertainty in regard to severity and likelihood of change to reliably assess impacts. WRCOG identified extreme agricultural pests and diseases, air quality, drought, extreme heat, human health hazards, landslides, severe weather, and wildfire as the most likely and impactful climate change-related hazards in the subregion. This section explains how these hazards are expected to change as a result of climate change through 2100.

AGRICULTURAL PESTS AND DISEASES

The Western Riverside subregion contains thousands of acres of agricultural land that contributes approximately \$300 million to the \$3.61 billion economy and 27,442 agricultural jobs in Riverside County (County of Riverside 2017, Hall 2018). The farms and ranches in the WRCOG subregion all face risk from assorted pests and diseases that may affect crops, vineyards, and livestock. These pests and diseases can cause plants and animals to grow slower, damage them so that their products are less appealing and harder to sell, or even die. While there are treatment options for a number of agriculture diseases, some have no cure.

Temperature increases play a key role in agricultural pests and diseases, as higher temperatures can increase the rate of reproduction for insects and mites (Hall 2018). High temperatures earlier and later into the year also create a wider window for pests and diseases to be active (IPCC 2013). Many crop plants, trees, and livestock may also be harmed and consequently weakened by warmer temperatures and changes in precipitation. The weaker plants and animals may not be able to fend off infestations or infections as well as a stronger plants and animals, causing pests and diseases to affect more of the population.

AIR QUALITY

Air Quality within the Western Riverside subregion is impacted by high levels of ozone and particle pollution that has plagued the region. Rising temperatures can exacerbate the air pollution and trap harmful ground-level ozone in the air due to increased water vapor. Poor air quality can have direct health effects, such as reduced lung function, pneumonia, asthma, cardiovascular diseases, and premature death. Ozone concentrations are projected to increase by 5 to 10 parts per billion by 2050 in the Los Angeles region, especially in those areas that currently experience high levels of ozone (Jacobson 2008).

DROUGHT

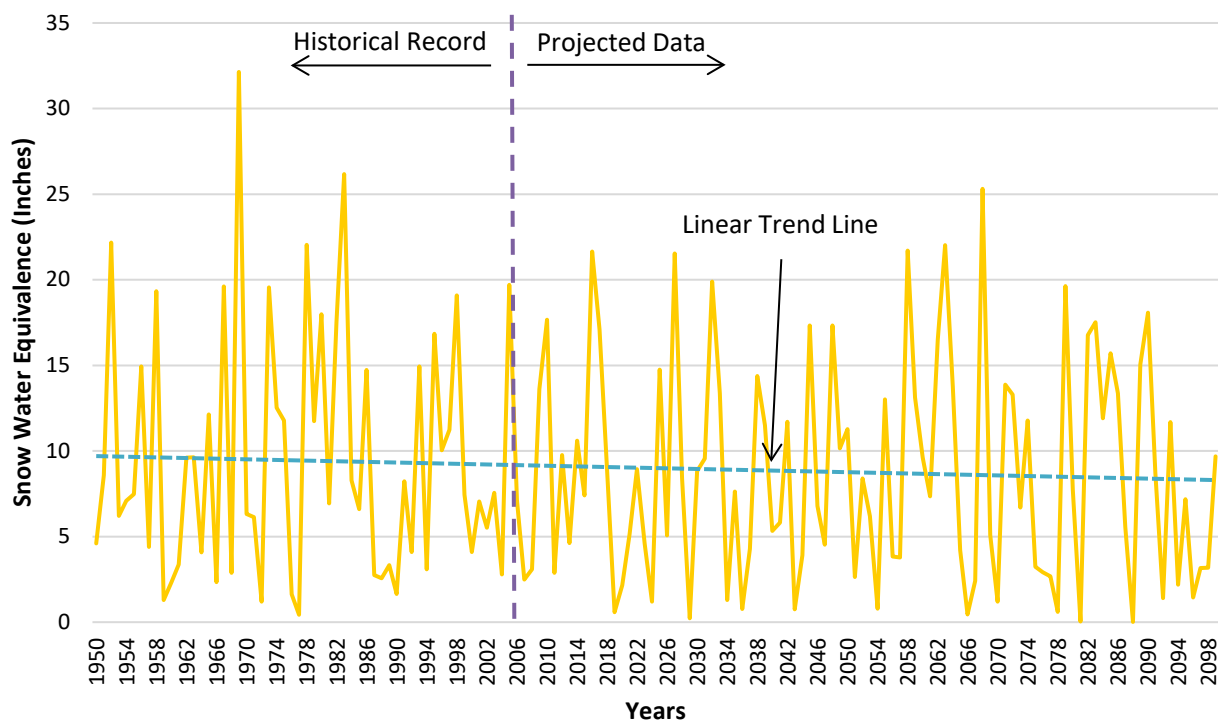
The subregion contains numerous water agencies and municipal departments that supply water to customers from local and imported sources. From a local government standpoint, the mix of water agencies presents a challenge to implementing jurisdictional water conservation strategies, as some jurisdictions have multiple providers within their boundaries, and some water suppliers function as sub-agencies to others. Eastern Municipal Water District (EMWD) and Western Municipal Water District (WMWD), which account for the majority of residential and commercial water accounts in the subregion, import roughly 75% of their water from the Sacramento-San Joaquin Bay Delta via the State Water Project and from the Colorado River (EMWD 2011; WMWD 2011). The imported sources rely on winter snowpack to deliver supplies year-round. Other parts of the subregion depend on groundwater resources. Aquifer recharge occurs when local rainwater percolates through the ground.

Since the 1950s, Riverside County has received an average of 8 inches of rainfall per year, although that number can vary greatly between years (CEC 2019). In late 2014, the National Drought Mitigation Center classified the entire region as being in an “extreme drought,” the second-most intense drought condition classification

(Rosencrans 2014). Although precipitation projections tend to be less certain than other types of climate change projections, a slight increase in average precipitation is expected through mid and late century (CEC 2013). However, the frequency of precipitation events is projected to be more variable between years.

Most of the imported water used in the WRCOG subregion comes from the Sierra Nevada range. Reduced winter precipitation levels and warmer temperatures have greatly decreased the size of the Sierra Nevada snowpack (the volume of accumulated snow), which in turn makes less fresh water available for communities throughout California. Continued decline in the Sierra Nevada snowpack volume is expected, which may lead to lower volumes of available imported water (Cal OES and CNRA 2012). An example of this change can be seen in **Figure 1**, which shows historic and projected April snow water equivalence from 1950 to 2099.

Figure 1: April Snow Water Equivalence in the Southern Sierra 1950–2099



Source: CEC 2019

EXTREME HEAT

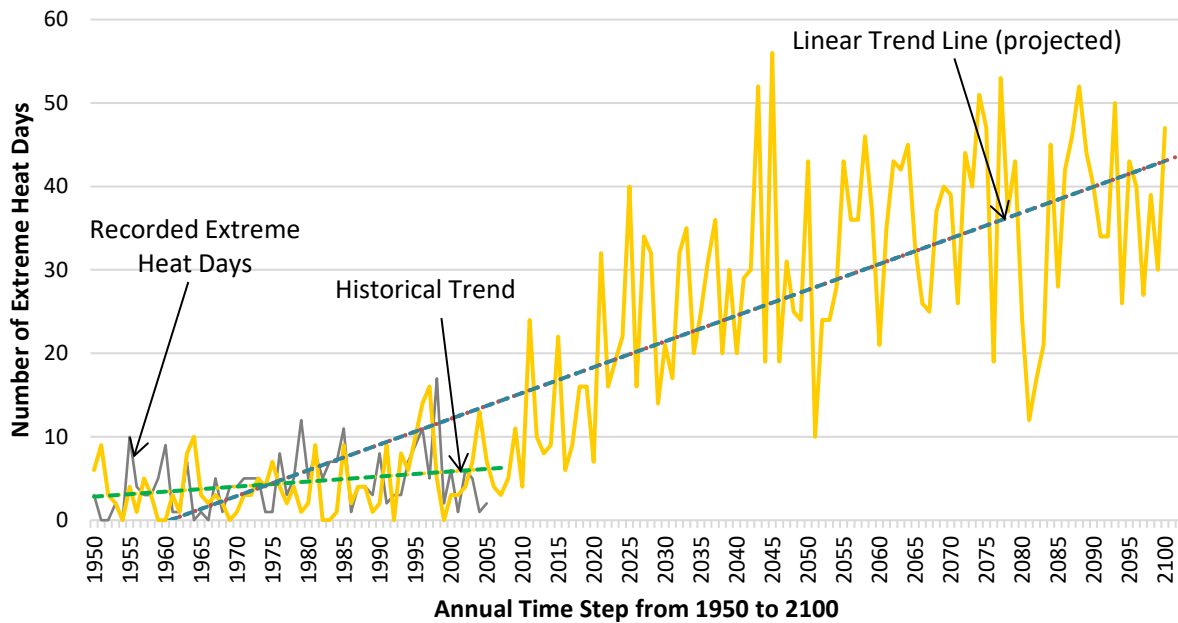
The WRCOG subregion is a combination of Mediterranean and semi-arid climates. Both climate types are known for hot (sometimes very hot) and dry summers. Residents in the subregion generally expect these desert-like conditions and most of the built environment was designed to withstand extreme heat.¹ In the City of Riverside, for example, the extreme heat day threshold is 103.6°F. Between 1960 and 1991, the subregion averaged four extreme heat days per year.

Climate change is expected to increase overall global temperatures (IPCC 2013). The subregion will experience this increase in average annual heat in a variety of ways, including an increased number of extreme heat days and

¹ This CAP defines an extreme heat day as a day in April through October when the maximum temperature exceeds the 98th historical percentile of maximum temperatures based on daily temperature maximum data between 1961 and 1990 (CEC 2013).

heat waves, warmer summer evenings, and warmer average annual temperatures (CEC 2013). In addition to the direct physical threat posed by extreme heat, elevated temperatures impose air quality hazards and can increase the rate of ground-level ozone (smog) formation (EPA 2013). As identified in **Figure 2**, the number of extreme heat days is projected to rise through 2050, where the average year could include 15 extreme heat days, and 30 extreme heat days per year by 2099 (CEC 2019).

Figure 2: Historic and Projected Extreme Heat Days, 1950 to 2099

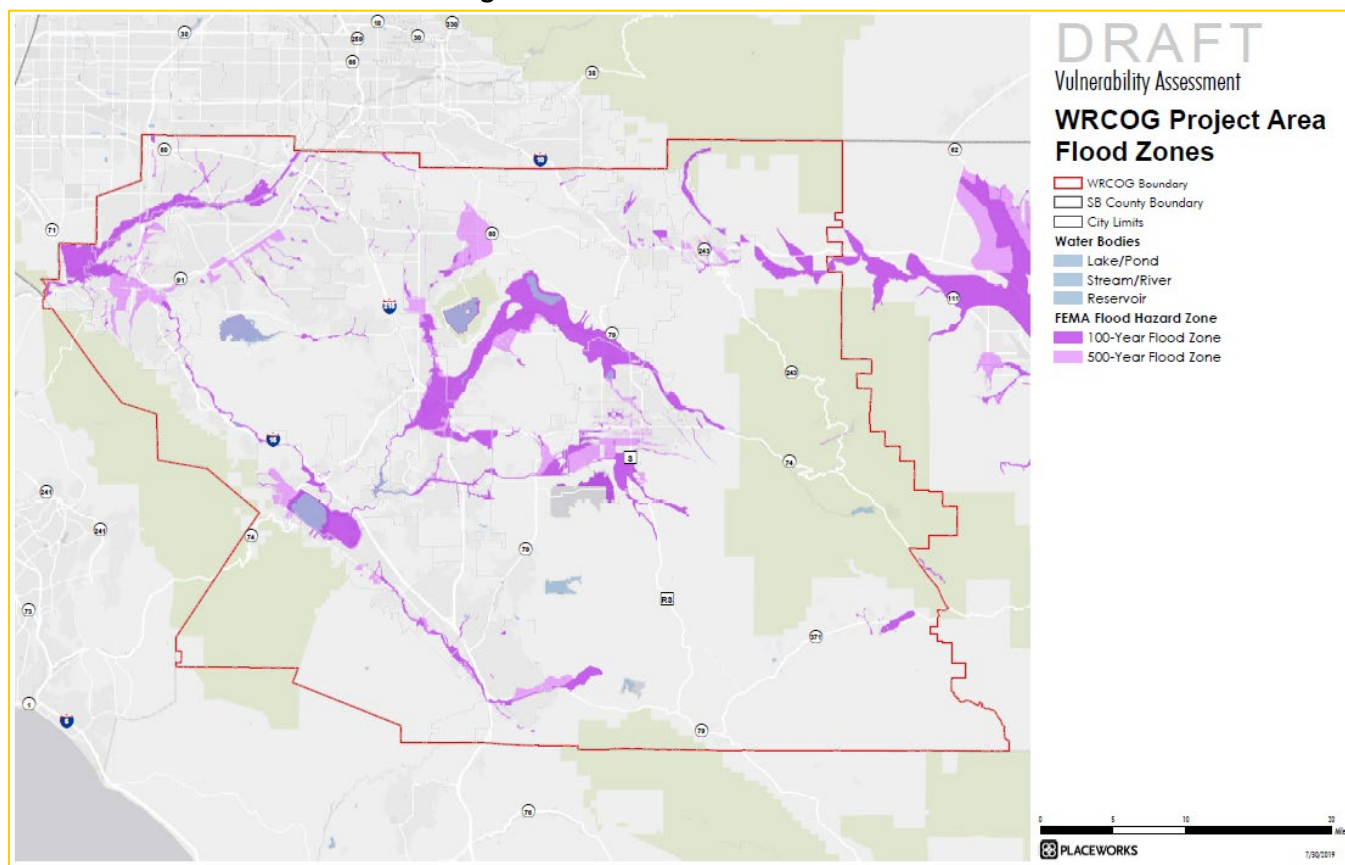


Source: CEC 2019

FLOODING

The WRCOG subregion consists of valleys nestled within mountain ranges; this topography makes it susceptible to flooding. High volume monsoons are common in the summer. Although flooding may occur in areas not designated as flood zones, the regulatory standard for identifying flood areas are through the Federal Emergency Management Agency (FEMA) special hazard flood zone maps, which identify 100-year flood zones.² **Figure 3** identifies FEMA 100-year flood zones for the subregion.

Figure 3: FEMA 100-Year Flood Zones



Source: FEMA 2018, WRCOG 2019

Although Southern California is likely to experience a decrease in overall precipitation levels due to climate change, the region is also expected to see an increase in the number of extreme precipitation events. A meteorological phenomenon known as the “atmospheric river,” a narrow stream of extremely moist air, is frequently responsible for the more intense storms that strike California. Atmospheric rivers generally deliver high levels of precipitation, up to 50% of the state’s total precipitation in any given year.

Some recent studies indicate that atmospheric rivers may strengthen as a result of climate change. This is expected to lead to an increase in the number of storms caused by atmospheric rivers (Dettinger 2018; Gershunov et al. 2013). Additionally, there is some indication that the most powerful atmospheric river storms will increase in intensity (Dettinger, Das, and Cayan, n.d.). Although there are no specific flooding projections for the subregion,

² A 100-year flood is one that, given historic conditions, is expected to occur once every 100 years, or has a 1% chance of occurring in any given year.

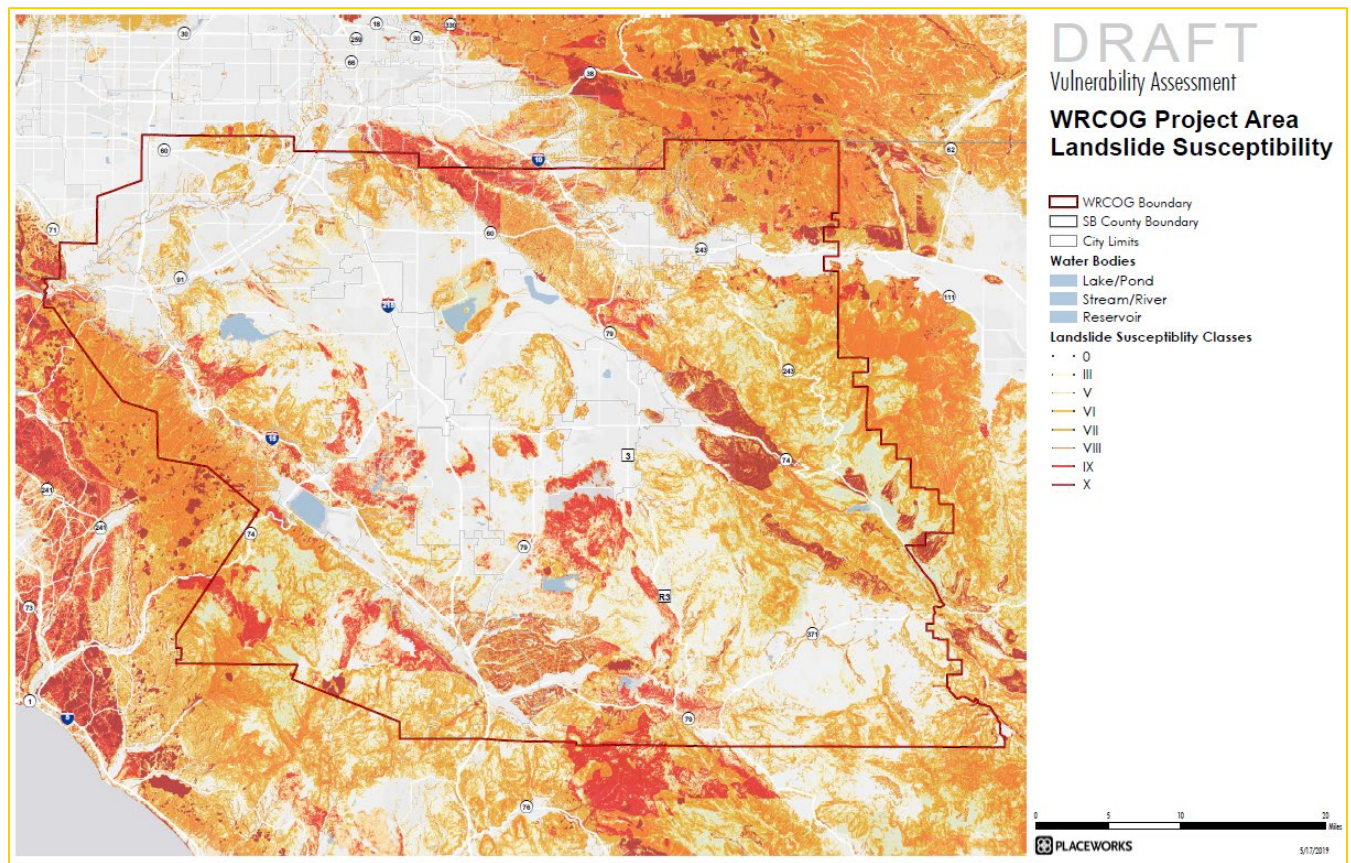
flood events are expected to become more frequent, and it is possible that the areas subject to flooding will expand.

HUMAN HEALTH HAZARDS

There are a number of diseases that are linked to climate change and can be harmful to the health of WRCOG community members. Many of these diseases are carried by animals such as mice, rats, ticks, and mosquitos, and include West Nile Virus, dengue fever, and Zika virus. Others, such as Valley Fever, derive from fungus endemic to the Southwest region that can travel via dust in the air. Climate change can increase the rates of infection for various diseases because many of the animals that carry diseases are more active during warmer weather. Warmer temperatures earlier in the spring and later in the winter can cause these animals to be active for longer periods, increasing the time that these diseases can be transmitted. Although some of these diseases may not be serious for most people, others can be debilitating or even fatal.

LANDSLIDES

Landslides occur when a hillside becomes unstable, causing soil and rocks to slide downslope. Hillsides (especially steep slopes) commonly absorb water, which increases instability of the slope, leading to increased slope failure. In some cases, the hillside can become so saturated that slope failure can result in a mudslide (a mixture of soil and water moving downslope). Landslides and mudslides can move fast enough to damage or destroy buildings or other structures, block roads or railways, and injure or kill people caught in their path. Climate change is expected to cause an increase in the intensity of precipitation events, which can cause an increase in the number of landslides and mudslides within the Western Riverside subregion. Increased wildfire frequency can destabilize hillsides due to loss of vegetation and change soil composition, which can contribute to greater runoff and erosion. Combined with the anticipated increase in intense rainfall years, there may be a significant increase in landslides and mudslides because of climate change. **Figure 4** shows the current landslide risk levels in the Western Riverside subregion. **Figure 4** identifies the areas with the greatest susceptibility (Class VI or greater) to landslides based on steepness of hillsides, underlying soils and rock units, and presence of historic or recent landslides. Areas that have a high degree of susceptibility will be susceptible to increase landslide risk during intense precipitation events and/or if a wildfire has removed vegetation. Impacts from these conditions would compound landslide potential for the most susceptible locations. Unfortunately **Figure 4** does not identify the likelihood that a landslide would occur.

Figure 4: Landslide Susceptibility

Source: CGS 2018, WRCOG 2019

SEVERE WEATHER

Severe weather is usually caused by intense storm systems that cause strong winds, hail, lightning and thunderstorms. Strong winds, such as the Santa Ana winds, can occur without a large storm system and have the potential to cause substantial damage to buildings and infrastructure. Severe weather can cause injuries or deaths, damage to buildings and structures, fallen trees, road and railway blockages by debris, and fires sparked by lightning. Climate change is expected to cause an increase in intense rainfall, which is usually associated with strong storm systems (OPR, CNRA, CEC 2018). For the Western Riverside subregion it is anticipated that more intense storms could occur in the coming years and decades.

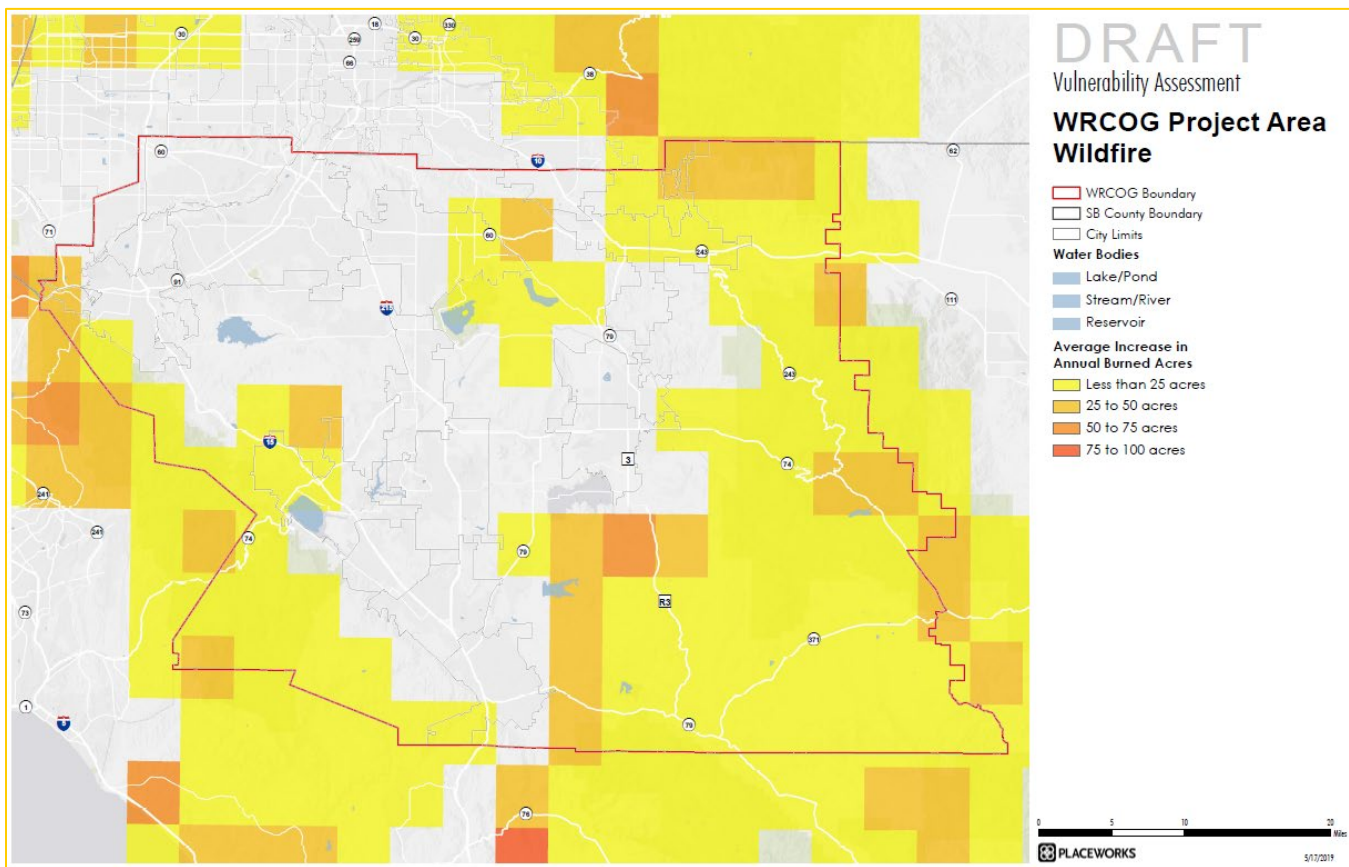
WILDFIRE

A wildfire is an uncontrolled fire spreading through vegetative fuels and is one of the hazards in the subregion that poses the greatest risk to life and property (County of Riverside 2012). Wildfire already poses a substantial risk to the planning area, as documented in the 2018 Riverside County Multi-Jurisdictional Hazard Mitigation Plan (MJHMP). The MJHMP identifies wildfire as one of the natural hazards with the highest probability of occurring, and the hazard with the third highest severity. According to the California Fourth Climate Change Assessment, overall burned area may increase by as much as 60 percent during Santa Ana Wind events (typically October to March), and 75 percent during periods without Santa Ana Winds (typically April to September). These models also suggest that the WRCOG region may see a 13.4 percent increase in average annual acres burned above historic

levels by mid-century. By the end of the century this increase is projected to decrease to 2.3 percent above historic levels due to wildfire fuel reductions associated with increased drought and extreme heat conditions.

In addition to the direct physical threat to life and property, smoke released during an event can have a detrimental effect on the subregion's air quality. **Figure 5** shows the average increase between historic and future annual acres burned within the Western Riverside subregion. The yellow color on Figure 5 indicates that there will be less than a 25-acre increase in acres burned from 2070 to 2099 compared to historic annual acres burned. The red color shows a 75 to 100-acre increase in acres burned from 2070 to 2099 compared to historic annual acres burned.

Figure 5: Average Increase Between Historic (1962-1990) and Future (2070-2099) Annual Burned Acres



Source: CEC 2019

Wildfires may start for any number of reasons, including arson, human error, or lightning, irrespective of climate change. However, with climate change, wildfire risks are expected to increase as a result of hotter and drier conditions and associated secondary impacts such as reduced ground moisture, humidity, and changes to plant communities, as shown in **Figure 6**.

Figure 6: Climate Change Effects on Wildfire and Related Hazards



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Western Riverside Adaptation and Resiliency Strategy: Part 1, Vulnerability Assessment Technical Appendix

INTRODUCTION

The Western Riverside Council of Governments (WRCOG) developed **Chapter 5** of the Climate Action Plan (CAP) in 2014 using a two-step adaptation planning process, consistent with the approach outlined by the California Adaptation Planning Guide (Cal OES and CNRA 2012). The first step was to complete a vulnerability assessment which identified and ranked vulnerable assets within WRCOG communities. The second step was to develop strategies that reduce climate change vulnerability in the subregion. The 2019 updated Climate Action Plan uses the same process to identify and assess vulnerabilities, in addition to updating the adaptation strategies.

This technical appendix identifies data and guidance sources, and explains and reports outcomes of the vulnerability assessment process.

KEY TERMS

The Vulnerability Assessment uses several key terms that are defined in accordance with the California Natural Resource Agency's 2012 *California Adaptation Planning Guide*. The following list provides definitions for these terms:

- **Hazard:** climate changes that pose a risk to a community.
- **Exposure:** the degree to which a community or asset will experience a climate hazard.
- **Sensitivity:** a structure, function, or population that could be affected by climate change.
- **Adaptive Capacity:** the ability of a system to respond to climate change, moderate potential damages, take advantage of opportunities, and cope with the consequences.
- **Vulnerability:** the degree to which a system is exposed to, susceptible to, and unable to cope with the adverse effects of climate change.
- **Impact:** an effect of climate change on the structure or function of a system.
- **Adaptation Strategy:** an action taken to protect an asset or community from climate change impacts.

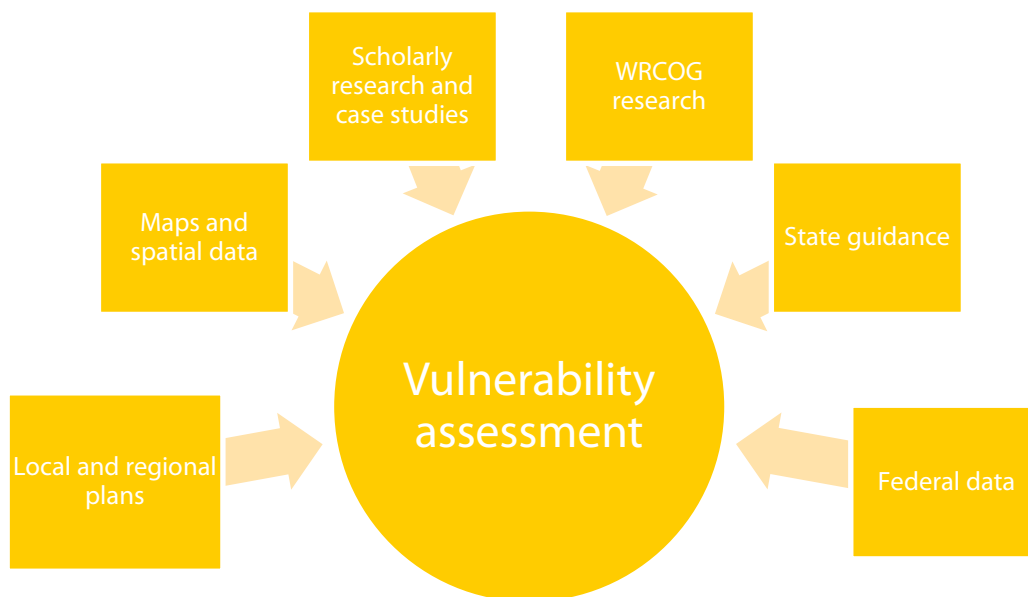
- **Resilience Strategy:** a set of methods and measures to enhance a system’s ability to withstand and respond to climate change.

VULNERABILITY ASSESSMENT DATA SOURCES

The vulnerability assessment relies on the latest climate projections and datasets, scholarly research, and guidance provided by the state of California (State). These sources help identify how climate change may increase the frequency and severity of climate hazards and how hazards could impact sensitivity areas, such as transportation infrastructure, disadvantages communities, and natural resources.

Figure A-1 identifies the sources used in **Chapter 5** and this Technical Appendix. The sources are discussed following the figure. The **Works Cited** section at the end of this appendix provides a complete list of resources cited in the vulnerability assessment.

Figure A-1: Vulnerability Assessment Data Sources



LOCAL AND REGIONAL PLANS

Where available, WRCOG obtained and reviewed local general plan safety elements, emergency operations plans, local hazard mitigation plans, and climate change adaptation plans for jurisdictions in the subregion. The plans were used to identify existing planning framework conditions and information about local hazard conditions.

STAKEHOLDER INTERVIEWS

When the 2014 vulnerability assessment was drafted, WRCOG interviewed representatives from 11 cities in the subregion. Participants varied by city, but generally included staff from planning, engineering, and

public safety departments. The objective of the interviews was to engage key stakeholders in the planning process and obtain local information about exposure to climate change hazards and the political feasibility of climate adaptation strategies. WRCOG interviewed the following cities:

- City of Canyon Lake
- City of Eastvale
- City of Hemet
- City of Lake Elsinore
- City of Menifee
- City of Moreno Valley
- City of Murrieta
- City of Riverside
- City of San Jacinto
- City of Temecula
- City of Wildomar

During the 2019 vulnerability assessment update, stakeholder engagement was conducted through regularly held meetings of the WRCOG Planning Directors and Public Works Directors Committees with all 18 cities in the subregion and the County.

MAPS AND SPATIAL DATA

WRCOG gathered spatial data for existing spatial hazards conditions (air quality, flooding, landslides, and wildfire) and to identify vulnerable assets. For the 2014 vulnerability assessment, WRCOG also collected spatial data for the social vulnerability index, which was not updated as part of the 2019 update. GIS data obtained from Riverside County, the California Energy Commission, and California Office of Emergency Services provided information about the location of various structures such as recreational facilities, critical infrastructure, and civic offices, and how these locations overlap with hazard zones (e.g., fire and flood). Climate projection data are sourced primarily from Cal-Adapt, with additional hazard data derived from the Federal Emergency Management Agency (FEMA), California Geologic Survey (CGS), and California Department of Forestry and Fire Protection (CAL FIRE). Spatial data is cited under each map and a complete list of resources used to complete the vulnerability assessment is provided in the citations list at the end of this document.

SCHOLARLY RESEARCH AND CASE STUDIES

The vulnerability assessment uses peer-reviewed research to estimate the hazards created by climate change on the various types of populations, structures, and functions in the subregion. The research relies heavily on the California Fourth Climate Change Assessment and the Los Angeles Regional Report, which includes the western areas of Riverside County. Additional reports include publications by federal agencies (e.g., United States Geological Survey or FEMA), peer-reviewed studies published in academic journals (e.g., *Journal of Public Health*, *Journal of Geophysical Research*, and *The Lancet*), and assessments completed by non-profit organizations (e.g., EcoAdapt). WRCOG has made its best effort to only use research that studies conditions comparable to those experienced in the subregion. For a complete list of resources used to complete the vulnerability assessment, see the citations list at the end of this document.

WRCOG RESEARCH

Evacuation Route Study

Transportation infrastructure is critical to the economic and social viability of the subregion. To support the vulnerability assessment process, WRCOG completed a hazards analysis of evacuation routes to assess critical transportation linkages and networks that may have higher levels of vulnerability to hazards related to climate change. This study generated a set of maps to provide a portfolio of city-level maps

identifying evacuation routes, potential hazard vulnerabilities, and future priority improvement locations to ensure future evacuation efforts are effective.

Social Vulnerability Index

In addition to physical vulnerability, the 2014 vulnerability assessment considered “social vulnerability,” or the susceptibility of different populations to harm from exposure to a hazard based on its ability to prepare for, respond to, and recover from that hazard (Cooley et al. 2012). Some demographic groups tend to be more vulnerable to hazards than others; the 2014 report gathered Census data from CalEnviroScreen and Southern California Association of Governments at the census tract level for the following (this data was not updated as part of the 2019 update):¹

- Age
- Education
- English speaking ability
- Poverty
- Low birth weight rates
- Ethnicity
- Group quarters population
- Housing tenure
- Vehicle access
- Older adults that live alone
- Outdoor workers
- Disabilities
- Single-headed households with very young children
- Overcrowding

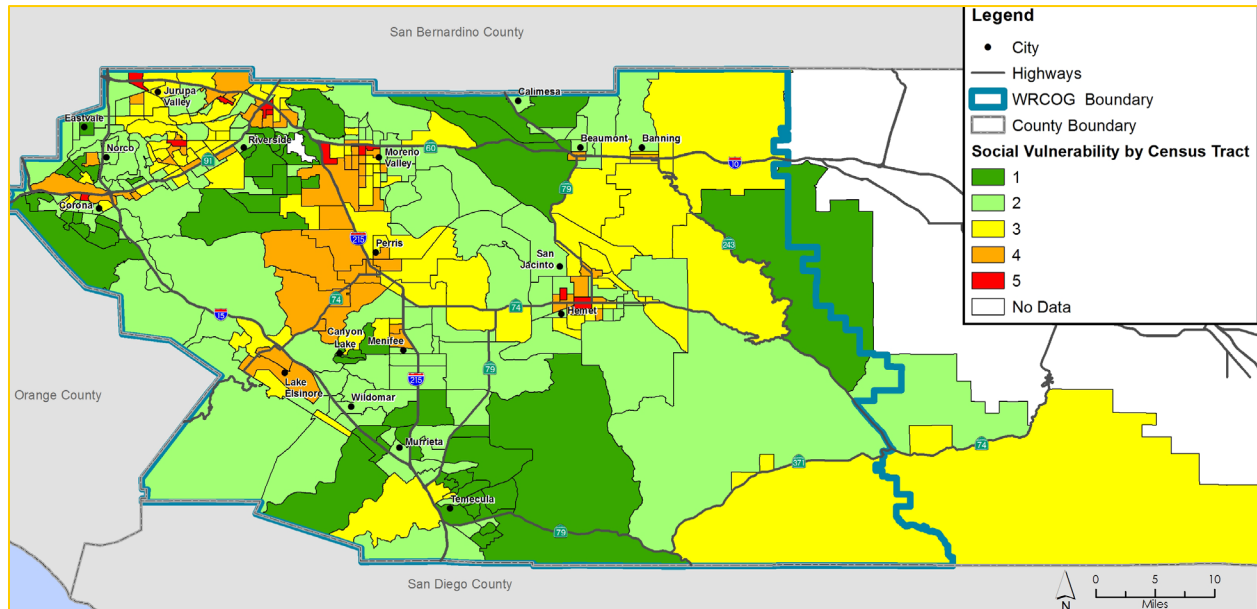
Since the interaction of these variables identifies populations that would be more or less vulnerable to climate change effects (i.e., low-income elderly populations may be more vulnerable than high-income elderly populations), WRCOG developed a Social Vulnerability Index (SoVI). A SoVI is a way of assessing variables across multiple geographies. The SoVI process produced a single index or number for each census tract that explains its vulnerability relative to other census tracts.

WRCOG identified the average value for each variable for all census tracts in the subregion (e.g., on average, 5% of residents in all census tracts in the subregion do not have personal vehicles). Then, WRCOG identified how different each tract was compared to that average. These differences were added together to create a composite index. Census tracts that are two standard deviations or more away the sub-regional mean were identified as having high social vulnerability, shown as red census tracts in **Figure A-2**.²

¹ Homelessness is also an important variable, but data was not available at the census tract level at the time of this report.

² It should be noted that SoVI scores report vulnerability relative to the other geographies in the study. SoVI scores from this report should not be compared to SoVI scores in other reports for other regions. (The SoVI scores were not updated as part of the 2019 report).

Figure A-2: Social Vulnerability (2014)



STATE GUIDANCE

California Adaptation Planning Guide

The California Adaptation Planning Guide (Adaptation Planning Guide) provides guidance to support regional and local communities in proactively addressing climate change effects. The Adaptation Planning Guide provides a step-by-step process for local and regional climate vulnerability assessments, adaptation strategy development, and is a primary source of methods for the vulnerability assessment. As the data in the Adaptation Planning Guide does not cover all anticipated exposures, the discussions on exposures in the vulnerability assessment are supplemented with data from other sources as needed.

Cal-Adapt

The CEC maintains Cal-Adapt, a web-based climate adaptation planning tool. Cal-Adapt allows users to identify potential changes to the climate in specific geographic areas throughout the state. Cal-Adapt currently uses data from the Coupled Model Inter-comparison Project phase 5 (commonly referred to as CMIP 5), a multi-model climate set generated for the 2013 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. The global CMIP 5 data was downscaled to the subregional level for California by the Scripps Institute of Oceanography at UC San Diego and allows users to view climate change projections for different emissions scenarios through 2099. Cal-Adapt is updated as needed to incorporate the most current climate projections. **Figure A-3** provides a screenshot of the Cal-Adapt tool.

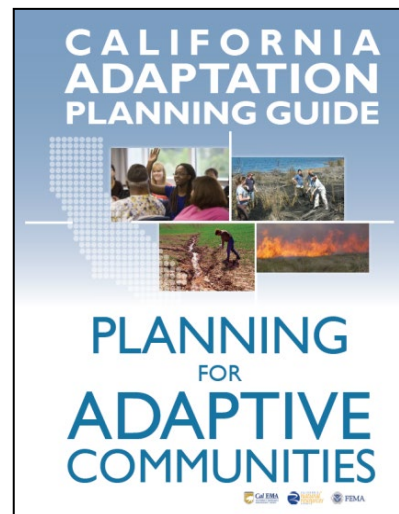
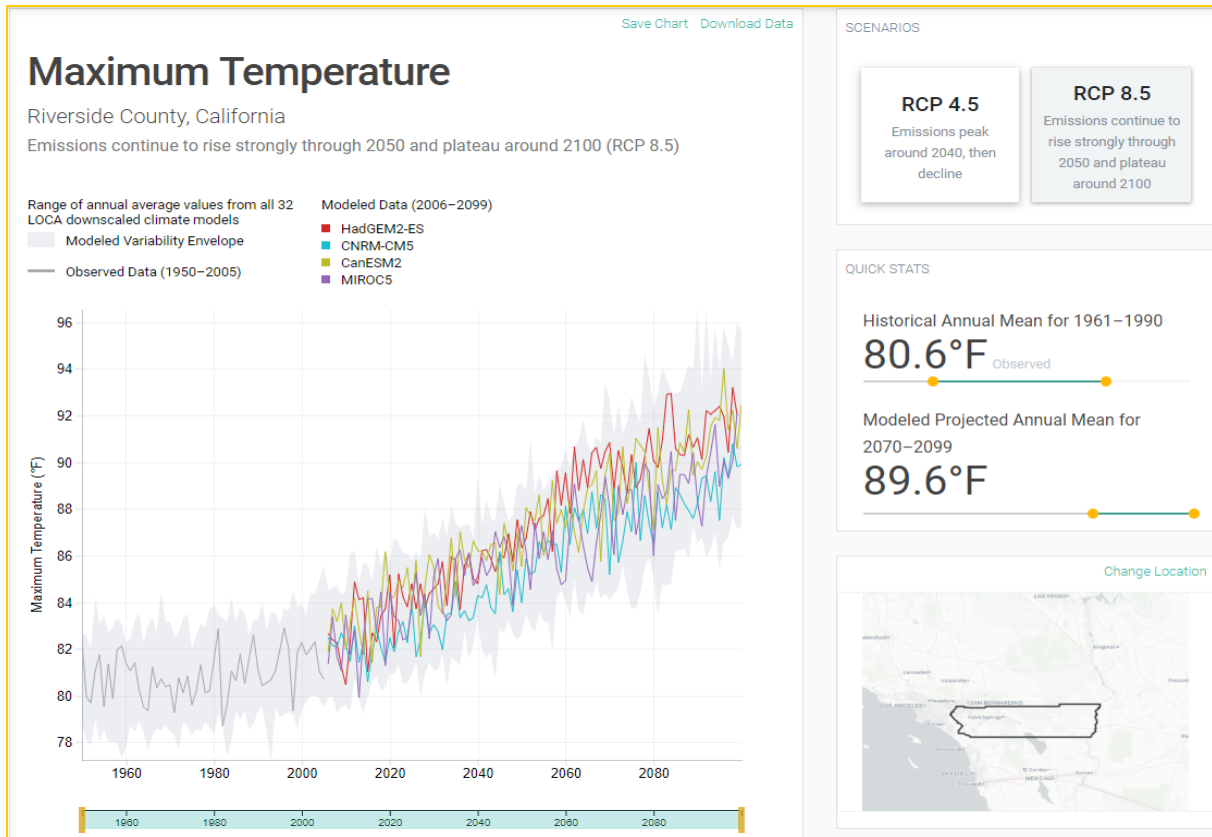


Figure A-3: Cal-Adapt Screenshot



Source: CEC 2019

California Fourth Climate Change Assessment

The California Fourth Climate Change Assessment, including the Los Angeles Regional Report, provides information about climate-related hazards and vulnerabilities. The Los Angeles Regional Report covers Los Angeles, Ventura, and Orange Counties, as well as the western portions of San Bernardino and Riverside Counties. This report focuses on hazard exposures specific to the region and identifies how human, economic, and natural systems are currently changing due to climate change.

FEDERAL DATA

The vulnerability assessment uses the 2017 American Community Survey (ACS) as a primary source for demographic information. The Fourth National Climate Assessment, specifically the Southwest Chapter, was also used to supplement hazard and vulnerability information not included in the California Climate Change Assessment.

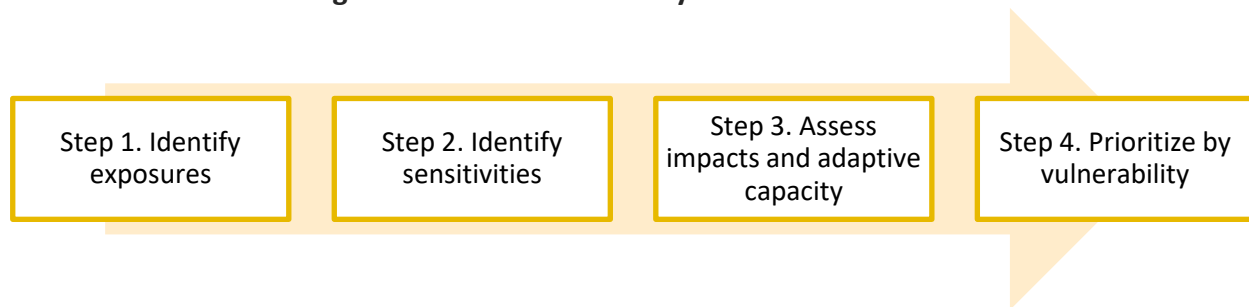
VULNERABILITY ASSESSMENT PROCESS

WRCOG conducted the 2019 vulnerability assessment update using a four-part process consistent with the approach provided by the Adaptation Planning Guide. The process addresses the following questions:

- What hazards (see **Table A-1** for a list of hazards assessed) could change in the planning area as a result of climate change?
- What assets or populations in the WRCOG subregion (known as *sensitivities* – See **Table A-2** for a list of sensitivities assessed) could be affected by the exposures?
- How would hazards affect assets or populations (known as *impacts*), and how are those assets and populations currently prepared to deal with such impacts (known as *adaptive capacity*)?
- What topics should adaptation strategies address (what sensitivities are the most *vulnerable*)?

Figure A-4 summarizes the four-part process to answer these questions in sequence.

Figure A-4: The Vulnerability Assessment Process



EXPOSURES

Communities will likely be exposed to climate-related hazards (Cal OES and CNRA 2012), which are identified using best available projections and data. This section discusses climate change hazard exposures based on projections provided by Cal-Adapt, the California Fourth Climate Change Assessment, FEMA, CAL FIRE, the California Geological Survey, and scholarly research. **Table A-1** lists the hazards included in the assessment, in addition to the corresponding data sources.

Table A-1: Climate Hazards Analyzed in the Vulnerability Assessment

Climate Hazard	Data Sources
Agricultural Pests and Diseases	California 4 th Climate Change Assessment, EcoAdapt, and scientific literature
Air Quality	California 4 th Climate Change Assessment, CalEnviroScreen 3.0, California Department of Public Health, and scientific literature
Drought	California 4 th Climate Change Assessment, EcoAdapt, and scientific literature
Extreme Heat	Cal-Adapt, California 4 th Climate Change Assessment, and scientific literature
Flooding	Cal-Adapt, FEMA flood maps, California 4 th Climate Change Assessment, and scientific literature
Human Health Hazards	California 4 th Climate Change Assessment and scientific literature
Landslides	California 4 th Climate Change Assessment, California Geological Survey, US Geological Survey, and scientific literature
Severe Weather	California 4 th Climate Change Assessment, and scientific literature
Wildfire	Cal-Adapt, California 4 th Climate Change Assessment, CAL FIRE, and scientific literature

Hazard Considerations

When assessing exposure to these hazards and determining how they apply to the WROCG subregion, there are a few important considerations to keep in mind: differences in climate scenarios, the distinction between weather and climate, and what climate models and downscaling are.

Forecast Uncertainty

Understanding exposure to future climate hazards helps identify what future conditions are expected to be like. Like any forecast, these projections have some degree of uncertainty. Because climate change is caused by an increase in greenhouse gases (GHGs) in the atmosphere, especially as a result of human activities, the specific severity of climate hazards will depend largely on the volume of GHGs that are emitted in the future, how long they are emitted for, and whether they are emitted in the near or distant future. Levels of GHG emissions themselves are affected by several factors, such as population levels, economic activity, government policies, and personal behavior. If GHG emissions drop quickly and significantly, emission levels overall will be lower, and exposures will be less severe. Continued and long-term increases in GHG emissions will lead to greater changes and more severe exposure to climate hazards.

Many forecasts of exposure to climate hazards rely on multiple scenarios that reflect different levels of GHG emissions. These forecasts cover a reasonable range of future climate conditions, although it is possible that future changes may occur outside of these ranges. The Intergovernmental Panel on Climate Change (IPCC), an organization that represents the global scientific community on the subject of climate change, commonly uses four scenarios, known as Representative Concentration Pathways (RCPs). RCPs are labeled with different numbers (e.g. RCP 2.6, RCP 6, etc.) that refer to the increase in the amount of energy that reaches each square meter of Earth's surface under that scenario. More GHGs in the

atmosphere means more heat energy is trapped close to Earth's surface, so higher GHG levels lead to greater increases in surface-level energy. The four RCPs are:

- RCP 2.6: Under this scenario, global GHG emissions peak around 2020 and then decline quickly. Emissions of carbon dioxide, the most common GHG, reach zero around 2075.
- RCP 4.5: Under this scenario, global GHG emissions peak around 2040 and then decline. Carbon dioxide levels are less than half of current levels by 2080.
- RCP 6: Global emissions continue to rise until the middle of the century. Carbon dioxide emissions decline, although they remain higher than current levels.
- RCP 8.5: Global emissions continue to increase at least until the end of the century.

For California-specific projections, the most accurate data is available for the RCP 4.5 and RCP 8.5 scenarios. These are the two scenarios that the Cal-Adapt database has downscaled to provide detailed data on climate projections (see the Climate Models and Downscaling discussion below). WRCOG chose to use RCP 8.5³, which assumes a continuation of business-as-usual emissions and GHG concentrations throughout the 21st century.

The Difference between “Weather” and “Climate”

“Weather” is a short-term description of the conditions at a particular location at a particular time; “climate” is a long-term *average* description of conditions (IPCC 2013). In other words, climate is a description of what one can generally expect to occur; weather is a much less predictable description of what actually occurs and may be similar to the average or be substantively different, as weather can vary substantially from day to day, month to month, or year to year. For example, in any given year, variability in weather means that rainfall levels in the City of Riverside may be less than 3 inches or close to 25 inches, but the climate in Riverside says that, *on average*, the community will see slightly more than 10 inches per year (Western Regional Climate Center 2019). This is why scientists are able to make reasonably confident projections about climate conditions several decades into the future, while forecasters are often challenged to make accurate weather projections more than a few days in advance.

Because climate is a long-term average, it does not change quickly. The IPCC finds with very high confidence that the present rate of change is unprecedented in the past 22,000 years, and with medium confidence that it is unprecedented in the past 800,000 years (IPCC 2013).⁴ Even with the accelerated nature of the current rate of climate change, differences to the climate may be indistinguishable from one year to the next and are generally only discernible when compared across multiple decades. Although the vulnerability assessment discusses projected changes to the climate for specific years or time frames, it does not mean that temperatures will remain constant at current levels until 2049 and suddenly increase the following year. In general, temperatures are expected to increase gradually from current levels to the

³ RCP 8.5 denotes a global radiative forcing of 8.5 W/m² by the year 2100.

⁴ Confidence levels (e.g., very high, medium) are qualitative terms and are not quantitatively identified in the manner of probability levels as shown in Table A-2. Confidence levels are based on the type, amount, quality, and consistency of evidence, and the degree of agreement among scientists (IPCC 2013).

projected midcentury levels.⁵ This long-term, gradual change will occur for all climate hazards. Even as the climate changes, variability in weather is expected to continue (CEC 2019).

Geographic Scale

Another important consideration is the scale of hazard exposure data. The effects of climate change are estimated using global models that project conditions at a continental or subcontinental level. While some exposures will apply globally, some may only apply to only one hemisphere, or certain regions.

Cal-Adapt and the California Fourth Climate Change Assessment present the global projections from the IPCC and others, scaled down to a regional level in California. The California Fourth Climate Assessment has 9 regions, each comprised of between 1 and 18 counties, and presents climate forecasts that are much more locally applicable than the continental and subcontinental projections of the IPCC. In the instances when the California Fourth Climate Change Assessment information remains too broad to specifically address changes in the WRCOG planning area, the vulnerability assessment uses data from the Cal-Adapt tool.

Cal-Adapt provides a downscaled version of this data for many climate effects at the quadrant level. The WRCOG subregion covers 23 full quadrants (60 square miles each in size) and approximately two dozen partial quadrants. Given the number of partial quadrants, varied topography, urbanization, and geography of the WRCOG subregion, especially between east and west, future climate conditions analysis includes some approximations and may vary slightly from the projections provided in this section.

Despite the uncertainty and scale considerations discussed above, these projections are still extremely useful, as they provide a reasonable range of expected future conditions for which to plan. WRCOG used Cal-Adapt, the California Adaptation Guide, the California Fourth Climate Change Assessment, and other scholarly research to identify nine main climate change hazards for the subregion. The nine main hazards are: Agricultural Pests and Diseases, Air Quality, Drought, Extreme Heat, Flood, Human Health Hazards, Landslides, Severe Weather, and Wildfire.

Agricultural Pests and Diseases

The Western Riverside subregion contains thousands of acres of agricultural land that contributes to a portion of the \$3.61 billion economy in the Los Angeles region, and 27,442 agricultural jobs in Riverside County (County of Riverside 2017). The Los Angeles Regional Report estimates that approximately \$300 million is derived from the WRCOG subregion. The majority of the agricultural products include vegetable, melon, trees, and vineyards, in addition to livestock, poultry, and citrus (County of Riverside 2017).

The farms and ranches in the WRCOG subregion all face risk from assorted pests and diseases that may affect crop plants and livestock. These pests and diseases can cause plants and animals to grow slower, to be damaged making them less appealing and harder to sell, or even die. While there are treatment options for a number of agriculture diseases, some have no cure – such as the devastating citrus disease Huanglongbing (HLB), which is already in the region (CCPDPC 2018).

⁵ Although this is generally how projections are presented, due to the highly complicated nature of climate interactions, some competing research suggests that climate changes could occur relatively rapidly once certain “tipping points” are met (Alley et al. 2003; Lenton et al. 2007). However, there is a high degree of uncertainty in these studies (IPCC 2013).

One of the most direct effects of climate change is that average temperatures are increasing, which has a bearing on pests and diseases. Higher temperatures can increase the rate of reproduction for insects and mites, which can result in increased pesticide use and damage to crops (Hall 2018). Temperatures are expected to get warmer earlier in the year and remain warmer until later in the year due to climate change, creating a wider window for pests and diseases to be active (IPCC 2013).

Climate change can also indirectly create a greater risk of agriculture and forestry pests and diseases. Many crop plants, trees, and livestock may be harmed and consequently weakened by warmer temperatures and changes in precipitation. The weaker plants and animals may not be able to fend off infestations or infections as well as a stronger plants or animal, causing pests and diseases to affect more of the population. Increased temperatures may also increase evapotranspiration rates and water demand, which can increase production costs, salinity buildup in topsoil, and adversely impact yield and quantity of crops and livestock (Hall 2018).

Evapotranspiration

Evapotranspiration is the sum of water loss from soil through evaporation and water loss from plants through transpiration. Factors affecting evapotranspiration include temperature, wind, and soil moisture (Earth Science 2019).

Air Quality

The Western Riverside subregion currently has high levels of ozone and particle pollution above acceptable levels (ALA 2019). While air quality in the region has improved in recent decades, rising temperatures threaten this trend (Hall 2018). Higher temperatures can increase surface ozone concentrations through both chemical reactions and increased water vapor that can trap ozone in already polluted areas (Steiner et al. 2006). Ground-level ozone is associated with a variety of negative health outcomes, including reduced lung function, pneumonia, asthma, cardiovascular diseases, and premature death. Ozone concentrations are projected to increase in most places that already experience high levels, such as the WRCOG subregion (Jacobson 2008).

Drought

Multiple water suppliers serve the WRCOG subregion, including the City of Riverside, the Eastern Municipal Water District, the Elsinore Valley Municipal Water District, the Metropolitan Water District, the Rancho California Water District, the Rubidoux Community Services District, and the Western Municipal Water District, as well as several small community providers and numerous private groundwater wells. The potable drinking water consumed in the WRCOG subregion is either from groundwater resources or imported. Groundwater is drawn from roughly a dozen separate groundwater basins (as defined by the Department of Water Resources Bulletin 118). Imported water supply comes from two primary sources: the California State Water Project, which brings water from the northern Sierra Nevada to Southern California, and the Colorado River. Lengthy and/or severe droughts can result in supply challenges for certain water suppliers and water restrictions throughout the region.

According to Cal-Adapt, historical average snow-water equivalence in the northern Sierra Nevada is 15.6 inches, which is likely to decline by an average of 5 inches (32 percent) by 2050 and 12 inches (77 percent) by 2099. Ranges for precipitation levels in the southern Sierra Nevada are broader but estimates indicate smaller potential decreases; the historical average snow water equivalence is 9.9 inches and Cal-Adapt anticipates a decline of up to 1 inch (10 percent) by 2050 and up to 4 inches (40 percent) by 2099 in the

southern Sierra Nevada (CEC 2019). As a contrast, precipitation levels are not expected to change by any significant degree for the Colorado River Basin as a whole, although there may be small localized increases or decreases (Colorado Water Conservation Board 2012).

It is not only precipitation levels in the Sierra Nevada and Colorado River Basin that affect imported water supplies. When snow falls in these mountainous areas, it is often cold enough to build up on the ground; this accumulated snow is called snowpack. Much of the snow eventually melts and runs off into rivers during the spring and summer months, continuing to supply water during times when California generally receives little or no rain. As temperatures rise and precipitation levels decrease, the snowpack volume is expected to drop. Snowpack volume is also expected to decline in the Colorado River Basin, resulting in a 9 percent decline in the total flow of the Colorado River (USBR 2011). Measurements of snowpack levels show that these declines may already be occurring.

The year 2014 was one of the driest years in California's recorded history, following three years with below-normal precipitation (NIDIS 2018). This prompted Governor Brown to declare a state of emergency as a result of the drought on January 17, 2014 and call on Californians to reduce total water use by 20 percent. At the time of the announcement, the volume of the Sierra Nevada snowpack was only about 14 percent of normal (Cal DWR 2014a). Drought conditions persisted throughout the year; in the end of November of 2014, all of California was considered "abnormally dry" and approximately 94 percent of the state was in a condition of "severe," "extreme," or "exceptional" drought. The WRCOG subregion was in a state of "extreme" drought, the second-most intense category (National Drought Mitigation Center 2014). During the winter and spring of 2014, when the Sierra Nevada sees the most precipitation, the volume of the Sierra Nevada snowpack peaked at only approximately 35 percent of normal levels (Cal DWR 2014a). By the end of October 2014, the major reservoir for the State Water Project, Lake Oroville, was only 45 percent as full as usual for this period, and only held 27 percent of its maximum capacity (Cal DWR 2014b).

Droughts are hardly unheard of in California. As with any individual event, it is not possible to state with certainty whether this drought would have occurred if climate change was not happening, or to what extent climate change made this drought more severe. There is some evidence that the driving factors behind this drought are linked to climate change, although other studies have failed to find a definitive link (Herring et al. 2014). However, this drought is indicative of the changes to precipitation levels, and ultimately to water supply, that are expected to occur as a result of climate change. In his emergency proclamation, Governor Brown observed that dry conditions "may continue beyond this year and more regularly into the future, based on scientific projections regarding the impact of climate change on California's snowpack" (California Office of the Governor 2014).

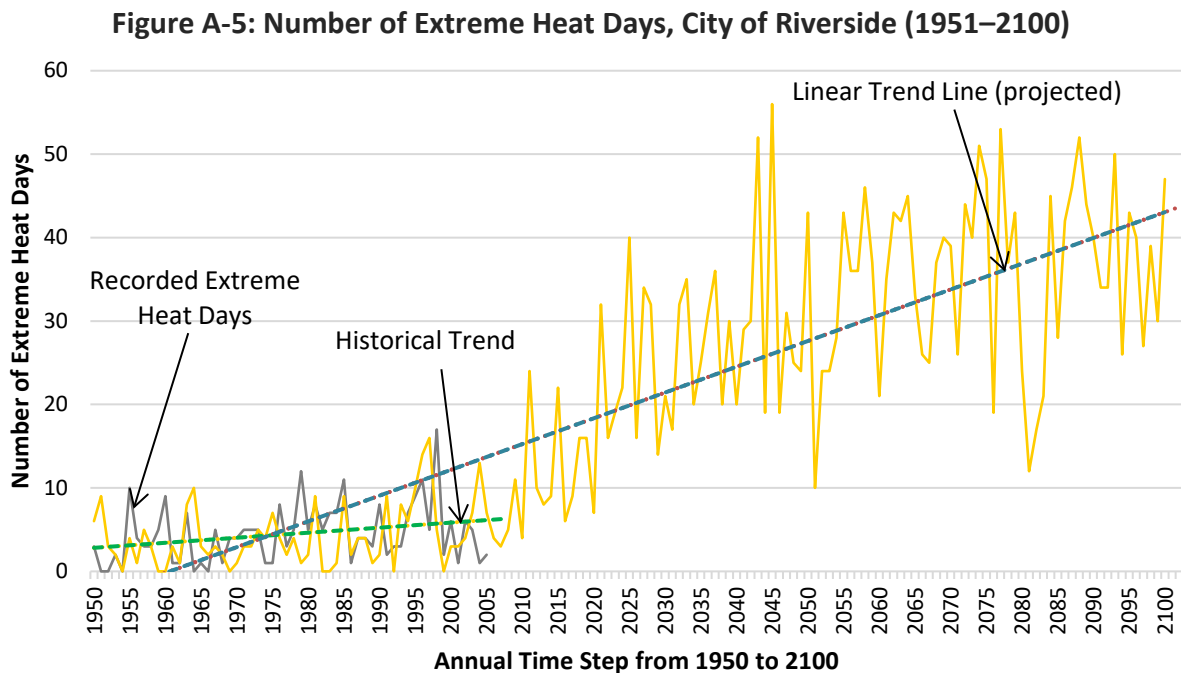
Extreme Heat

The Western Riverside subregion is a combination of hot-summer Mediterranean and semi-arid climates. Both climate types are known for hot (sometimes very hot) and dry summers. Residents in the subregion generally expect these desert-like conditions and most of the built environment was designed to withstand extreme heat.⁶ In the City of Riverside, used here as a proxy for the subregion, the extreme

⁶ This CAP defines an extreme heat day as a day in April through October when the maximum temperature exceeds the 98th historical percentile of maximum temperatures based on daily temperature maximum data between 1961 and 1990 (CEC 2013).

heat day threshold is 103.6°F. Between 1960 and 1991, the subregion averaged four extreme heat days per year.

Climate change is expected to increase overall global temperatures (IPCC 2013). The subregion will experience this increase in average annual heat in a variety of ways, including increased number of extreme heat days and heat waves, warmer summer evenings, and warmer average years. As identified in **Figure A-5**, the number of extreme heat days is projected to rise through 2050, when the average year could include 15 extreme heat days, and 30 extreme heat days per year by 2099 (CEC 2019).



Source: CEC 2019

Flooding

As noted in the Drought section above, Riverside County is likely to see reduced precipitation and reduced snowpack leading to lower surface water levels. However, the subregion is also likely to experience higher intensity precipitation and storm events. A meteorological phenomenon known as the “atmospheric river,” a narrow stream of extremely moist air, is frequently responsible for the more intense storms that strike California. Atmospheric rivers generally deliver high levels of precipitation, up to 50 percent of the state’s total precipitation in any given year.

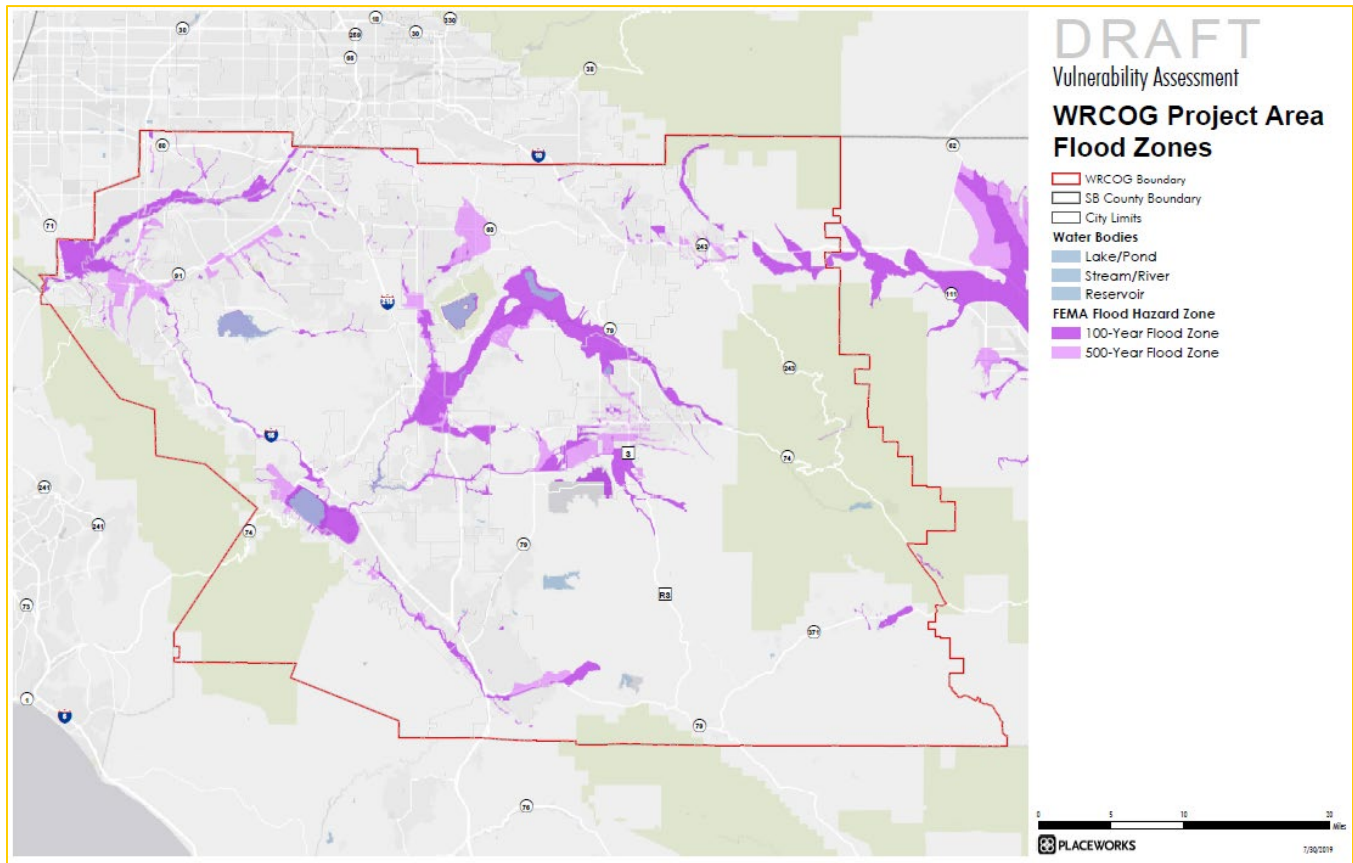
Atmospheric rivers are expected to strengthen as a result of climate change, and while there is no scientific consensus on this issue yet, recent studies (Dettinger 2012; Rajagopalan 2013) suggest that this could lead to an increase in the number of intense storms that California experiences. Recently, California has experienced an average of about four atmospheric river storms per year, although some years can see significantly more (20 atmospheric river storms struck California in the winter of 2010–2011) (NOAA’s Earth System Research Laboratory, n.d.). On average, some studies indicate that 20–30 percent more

atmospheric river storms will strike the state by the middle of the century and that the number of years that see the most atmospheric river storms (15 to 20 or more) will double. Additionally, there is some indication that the most powerful atmospheric river storms will increase in intensity (Dettinger, Das, and Cayan, n.d.).

Figure A-6 shows the areas in the WRCOG subregion that are designated as 100-year flood zones, meaning that they are most likely to flood. This does not mean that areas outside of these flood zones do not face any flooding risk, only that the risk of such an event is lower. Due to the atmospheric river changes described above, flood events are expected to become more frequent, increasing the likelihood of a “100-year”⁷ flood in those flood plains. There is also a possibility that the areas subject to flooding will expand.

⁷ A 100-year flood is a flood event that has a 1 percent chance of occurring in any given year. It does not refer to a flood that only happens once every 100 years; there may be multiple 100-year floods over a relatively short time frame.

Figure A-6: 100-Year and 500-Year Flood Zones



Source: FEMA 2018, WRCOG 2019

Human Health Hazards

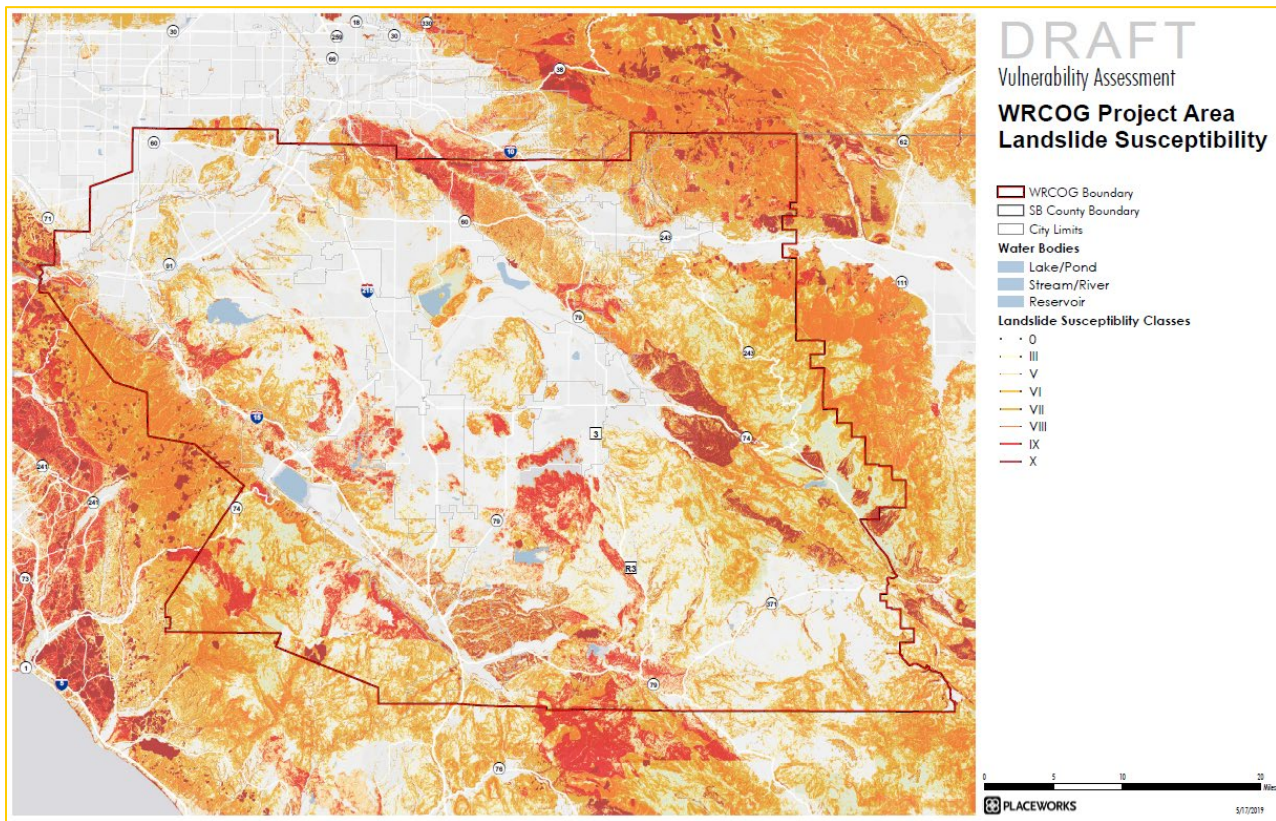
There are a number of diseases that are linked to climate change and can be harmful to the health of WRCOG community members. Examples of these diseases include Valley Fever, West Nile Virus, dengue fever, Zika virus, and chikungunya virus (Hall 2018). Many of these diseases are carried by animals such as mice and rats, ticks, and mosquitos, which are usually seen as pests even if they do not cause infections. Others are derived from fungus endemic to soils in the Southwest that can travel through dust in the air. Although some of these diseases may not be serious for most people, others can be debilitating or even fatal.

Climate change can increase the rates of infection for various diseases because many of the animals that carry diseases are more active during warmer weather. Warmer temperatures earlier in the spring and later in the winter can cause these animals to be active for longer periods, increasing the time that these diseases can be transmitted. Warmer temperatures may also cause some mosquito-carried illnesses not currently present in California, such as Zika, to potentially appear. West Nile virus appears to be more active during drought periods, and periods of intense precipitation can increase populations of rodents and ticks (OPR, CNRA, CEC 2018).

Landslides

Landslides occur when a hillside becomes unstable, causing soil and rocks to slide downslope. They can be caused by earthquakes, but the vulnerability assessment will focus on landslides caused by rain. Hillsides commonly (especially steep slopes), absorb water, which increases instability of the slope, leading to increased slope failure. Steep slopes made up of loose or fractured material are more likely to slide. In some cases, the hillsides can become so saturated that slope failures can result in a mudslide (a mixture of soil and water moving downslope). Landslides and mudslides can move fast enough to damage or destroy buildings or other structures in their path, block roads or railways, and injure or kill people caught in them.

Climate change is expected to cause an increase in the intensity of precipitation events, which can increase the number of landslides and mudslides within the Western Riverside region. Heavy rainfall could cause an increase in the number of landslides or make landslides larger than normal. Vegetation helps to hold the material of a hillside together, but vegetation can be stripped away by exposure to climate hazards such as increased wildfires, more frequent and intense droughts, or disease/pest infestations. Without vegetation to help stabilize the slope, hills may be more likely to slide. Combined with the increase in intense rainfall years, there may be a significant increase in landslides because of climate change. **Figure A-7** identifies the areas with the greatest susceptibility (Class VI or greater) to landslides based on steepness of hillsides, underlying soils and rock units, and presence of historic or recent landslides. Areas that have a high degree of susceptibility will be susceptible to increase landslide risk during intense precipitation events and/or if a wildfire has removed vegetation. Impacts from these conditions would compound landslide potential for the most susceptible locations. Unfortunately **Figure A-7** does not identify the likelihood that a landslide would occur.

Figure A-7: Landslide Susceptibility

Source: CGS 2018, WRCOG 2019

Severe Weather

Severe weather includes strong winds, hail, and lightning. Severe weather is usually caused by intense storm systems, although some types of strong winds, such as the Santa Ana Winds, can occur without a storm. The types of dangers posed by severe weather vary widely and may include injuries or deaths, damage to buildings and structures, fallen trees, roads and railways blocked by debris, and fires sparked by lightning. In the Western Riverside subregion, most severe weather is linked to high winds and thunderstorms. Hail events are rare; there have been only two reported injuries from hail in Riverside County from 1950 to present. Lightning happens occasionally, and there has been one reported death and six reported injuries from lightning reported in the Western Riverside subregion.

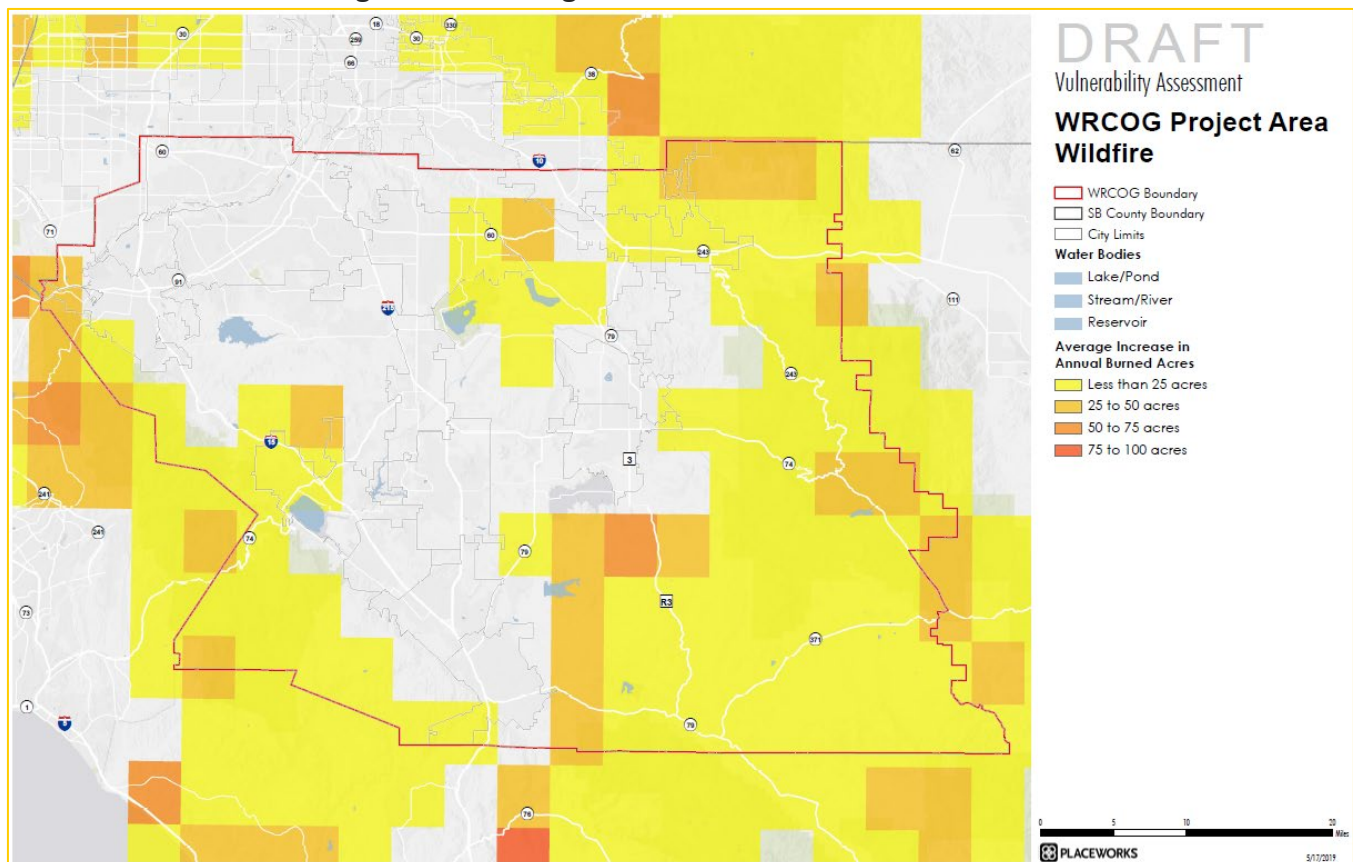
Climate change is expected to cause an increase in intense rainfall, which is usually associated with strong storm systems (OPR, CNRA, CEC 2018). This means that the Western Riverside subregion could see more intense storms in the coming years and decades. Such an increase may not affect all forms of severe weather and may not always be apparent. For example, hail is rare enough in Riverside County that even if it does become more common, the increase and any effects may not be apparent.

Wildfire

Wildfire already poses a substantial risk to the WRCOG subregion, as documented in the 2018 Riverside County Multi-Jurisdictional Hazard Plan (the Plan). The plan identifies wildfire as one of the natural hazards with the highest probability of occurring, and the hazard with the third highest severity (below earthquake and pandemic flu).

Some uncertainty remains about how climate change could affect the risk of wildfires (Westerling and Bryant 2007), as changes to the fire regime are dependent on changes to a number of other factors (e.g., winds, precipitation levels, storm frequency, temperatures, etc.). According to the California Fourth Climate Change Assessment, nearly 80 percent of wildfires occur during the summer and fall, with one-quarter of annual fires burning during Santa Ana events. Overall burned area may increase by as much as 60 percent during Santa Ana Wind events (typically October through March), and 75 percent during periods without Santa Ana Winds (typically April to September). These models also suggest that the Los Angeles region may see an increase in annual burned area by 2,000 hectares by mid-century, with a slightly lower increase by late century. Wildfire may decrease by 2070 to 2099 due to warming temperatures reducing overall fuel for wildfire. **Figure A-8** shows the average annual increase in acres burned within the Western Riverside subregion.

Figure A-8: Average Annual Increase in Acres Burned



Source: CEC 2019

SENSITIVITIES

Sensitivities are the structures, populations, or other assets that could be affected by climate change. As the second step in the vulnerability assessment process, this section identifies sensitivities that are potentially vulnerable to climate change.

The Adaptation Planning Guide provides an initial set of lists of structure and demographic sensitivities to consider. These lists of sensitivities have been refined and supplemented to reflect the specific populations and areas of special focus for the WRCOG subregion. The sensitivity categories used for this analysis are described in **Figure A-9**.

Figure A-9: Types of Sensitivities

Populations	• A group of people that share a demographic trait • <i>Examples:</i> Individuals 85 years and older, ethnic communities
Buildings and Infrastructure	• A physical building or group of buildings, or a piece of infrastructure or infrastructure network • <i>Examples:</i> City halls, houses, electrical transmission lines
Biological Resources	• A distinct type of habitat that supports specific plants and animals • <i>Examples:</i> Riparian areas, chaparral, desert scrub
Important Economic Assets	• Properties and activities that make significant contributions to the Western Riverside subregion economy • <i>Examples:</i> Renewable energy, agricultural lands
Key Community Services	• Important functions to community members provided by government agencies and private companies • <i>Examples:</i> Emergency response, electricity, water delivery

Population Sensitivities

Not all assets or populations are impacted by each hazard. While certain sensitivities may be impacted by all hazards, some are only impacted by one or two. For example, an increase in drought conditions is not likely to have direct impacts on the older housing stock in the subregion. Therefore, the impact and adaptive capacity for housing related to drought conditions were not assessed. Where sensitivity is not exposed to a particular hazard, it is omitted. **Table A-2** presents the sensitivities considered for each climate hazard.

Table A-2: Sensitivities and Hazards Considered in the Vulnerability Assessment

Sensitivity	Agricultural Pests and Diseases	Air Quality	Drought	Extreme Heat	Flood	Human Health Hazards	Landslides	Severe Weather	Wildfire
Populations (19 sensitivities considered)									
Children age <10		✓		✓		✓			✓
Ethnic communities/non-English speakers		✓		✓	✓	✓		✓	✓
Healthcare workforce				✓	✓	✓		✓	✓
Homeless persons		✓	✓	✓	✓	✓		✓	✓
Household renters		✓	✓	✓	✓		✓	✓	✓
Householders age >65		✓		✓	✓	✓	✓	✓	✓
Households in poverty		✓	✓	✓	✓	✓	✓	✓	✓
Households overpaying for housing (>30% of income)		✓	✓	✓	✓	✓	✓	✓	✓
Individuals chronically ill		✓	✓	✓	✓	✓	✓	✓	✓
Individuals uncertain about available resources because of citizenship		✓		✓	✓	✓		✓	✓
Individuals with disabilities		✓		✓	✓	✓	✓	✓	✓
Individuals without access to lifelines		✓		✓	✓	✓	✓	✓	✓
Low-income individuals		✓	✓	✓	✓	✓	✓	✓	✓
Outdoor workers	✓	✓	✓	✓			✓	✓	✓
Overcrowded households		✓	✓	✓	✓	✓		✓	✓
Persons in mobile homes		✓		✓	✓	✓	✓	✓	✓
Pregnant or nursing women		✓		✓	✓	✓		✓	✓

Sensitivity	Agricultural Pests and Diseases	Air Quality	Drought	Extreme Heat	Flood	Human Health Hazards	Landslides	Severe Weather	Wildfire
Seasonal residents/migrant workers		✓	✓	✓	✓	✓	✓	✓	✓
Senior citizens living alone		✓		✓	✓	✓	✓	✓	✓
Buildings and Structures (38 sensitivities considered)									
Adult residential care facilities							✓	✓	
Airports				✓	✓			✓	✓
Bridges					✓		✓	✓	✓
City Halls and government offices					✓		✓	✓	✓
Commercial structures					✓		✓	✓	✓
Communication infrastructure				✓	✓		✓	✓	✓
Community gathering areas					✓		✓	✓	✓
Dams					✓		✓	✓	✓
Emergency Systems					✓			✓	
Energy generation infrastructure		✓	✓		✓		✓	✓	✓
Energy transmission/delivery				✓	✓		✓	✓	✓
Evacuation routes					✓		✓	✓	✓
Fire stations					✓		✓	✓	✓
Flood control center					✓			✓	✓
Foster homes					✓			✓	✓
Fueling infrastructure and pipelines				✓	✓		✓	✓	✓
Healthcare facilities				✓	✓		✓	✓	✓
Major roads and highways				✓	✓		✓	✓	✓

Sensitivity	Agricultural Pests and Diseases	Air Quality	Drought	Extreme Heat	Flood	Human Health Hazards	Landslides	Severe Weather	Wildfire
Industrial structures					✓		✓	✓	✓
Military facilities								✓	
Natural gas facilities					✓		✓		✓
Old residential structures				✓	✓		✓	✓	✓
Parks	✓		✓	✓	✓		✓	✓	✓
Police/sheriff stations					✓			✓	✓
Private recreational sites	✓		✓	✓	✓		✓	✓	✓
Public housing					✓			✓	✓
Public open space and protected land	✓		✓	✓	✓		✓	✓	✓
Public works corporation yards					✓			✓	
Railway				✓	✓		✓	✓	✓
Residential structures					✓		✓	✓	✓
Road signals/traffic control centers					✓		✓	✓	✓
Schools and childcare centers							✓	✓	✓
Senior care centers							✓	✓	✓
Sidewalks, bikeways, trails							✓	✓	✓
Transit infrastructure					✓		✓	✓	✓
Transportation facilities and infrastructure				✓	✓		✓	✓	✓
Wastewater treatment plant and collection infrastructure			✓	✓	✓		✓	✓	✓

Sensitivity	Agricultural Pests and Diseases	Air Quality	Drought	Extreme Heat	Flood	Human Health Hazards	Landslides	Severe Weather	Wildfire
Water treatment plant and delivery infrastructure			✓	✓	✓		✓	✓	✓
Biological Resources (10 sensitivities considered)									
Chaparral	✓		✓	✓			✓	✓	✓
Coastal sage scrub	✓		✓	✓	✓		✓	✓	✓
Desert scrub	✓		✓	✓			✓	✓	✓
Grassland	✓		✓	✓	✓		✓	✓	✓
Meadows and marshes	✓		✓	✓	✓			✓	✓
Montane coniferous forest	✓		✓	✓			✓	✓	✓
Playas and vernal pools	✓		✓	✓	✓			✓	✓
Riparian scrub, woodland, and forest	✓		✓	✓	✓		✓	✓	✓
Riversidean alluvial san sage scrub	✓		✓	✓	✓		✓	✓	✓
Woodland and forests	✓		✓	✓			✓	✓	✓
Important Economic Assets (4 sensitivities considered)									
Agricultural lands	✓		✓	✓	✓		✓	✓	✓
Renewable energy		✓	✓	✓	✓		✓	✓	✓
State and federally owned land	✓	✓	✓	✓	✓	✓	✓	✓	✓
Tourism	✓	✓	✓	✓	✓	✓	✓	✓	✓
Key Community Services (10 sensitivities considered)									
Communications				✓	✓		✓	✓	✓
Electricity			✓	✓	✓		✓	✓	✓

Sensitivity	Agricultural Pests and Diseases	Air Quality	Drought	Extreme Heat	Flood	Human Health Hazards	Landslides	Severe Weather	Wildfire
Emergency medical response				✓	✓	✓	✓	✓	✓
Government administration		✓			✓	✓			✓
Healthcare service delivery		✓		✓	✓	✓	✓	✓	✓
Natural gas									✓
Public safety				✓	✓	✓	✓	✓	✓
Transit access				✓	✓		✓	✓	✓
Wastewater treatment			✓	✓	✓		✓	✓	✓
Water delivery			✓	✓			✓	✓	✓

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IMPACTS AND ADAPTIVE CAPACITY

Vulnerability, for the purposes of this analysis, is defined as susceptibility to harm or change. To compare vulnerability across sensitivities, the Adaptation Planning Guide recommends identifying how each sensitivity would be impacted and how each sensitivity could cope with that impact. This section provides an overview of methods for assessing impacts and adaptive capacity.

The vulnerability assessment evaluates both primary and secondary impacts. Primary impacts are those caused directly by exposure to a climate hazard, such as an extreme weather event that damages infrastructure. Secondary impacts are not caused directly by hazards; they occur as a result of a direct impact (e.g., warmer temperatures make conditions more favorable for mosquitoes, resulting in greater risk of mosquito-transmitted diseases). To determine the vulnerability of each sensitivity for each hazard, it is necessary to identify two characteristics: How is the sensitivity *impacted* by the hazard, and what *adaptive capacity* does the sensitivity have to the hazard?

Impacts

The impact assessment methods used in the vulnerability assessment follow the recommended approach in the Adaptation Planning Guide, using a combination of qualitative and quantitative information to determine the severity of each impact. For infrastructure components or functions/services, this evaluation includes the following:

- What is the value of the structure or function, including its assessed value and intangible importance to the community (e.g., contributions to overall quality of life)?
- Does the structure or function benefit only select members of the community, or is it used by most or all residents?
- How substantial must damage be to the structure or function from exposure to the hazard in question, before the structure or function ceases to provide the level of service that community members require or expect?
- If the structure or function can no longer provide adequate service, how easy is it to restore service?
- If the structure or function can no longer provide service, is there a risk of mortality or morbidity?
- Is the structure(s) that provide(s) the service located in an area currently at risk for the hazard in question? If not, what is the likelihood that the area will be at risk for the exposure in question as climate change occurs?

A similar set of questions was used to evaluate impacts to populations, including the following:

- What sort of hardships would be felt by the population as a result of exposure to the hazard? Would it result in a decrease in quality of life or threaten to damage and/or destroy property?
- Is there a risk of mortality or morbidity to the population as a result of the hazard?
- How many people are affected by the hazard? Is it a relatively small group within the community, or is it most or all of the residents?
- In the event that hardships occur, how long would the population be affected? Would hardships diminish in severity over time or remain at the same level of severity during the course of the impact?

Each sensitivity was given a score from IM0 (minimal impact) to IM4 (severe impact) for each hazard. **Table A-3** reports how each score was qualitatively determined.

Table A-3: Impact Scores

Impact Score	Summary (Buildings and Infrastructure, Economic Assets, Community Services)	Summary (Populations and Biological Resources)
IM0	Impacts are minimal. There are no service disruptions that community members are aware of.	All impacts are minimal. Community members may not notice effects.
IM1	Performance or services may be somewhat degraded on occasion.	Community members notice minor impacts. There may be mild disruptions to some behaviors or actions.
IM2	The asset is likely to experience chronic stress, limiting the ability to reliably function. Effectiveness may be entirely disrupted on occasion.	There is a marked decline in overall quality of life. Reductions to health, public safety, and/or community viability are likely.
IM3	The asset may only function in a limited way. It may frequently or always be unable to meet community needs.	There is a substantial drop in the well-being of the affected communities. Current lifestyles/habitat may no longer be viable.
IM4	The ability of the asset to provide beneficial service is destroyed.	There is a severe risk of injury or death in human populations and of major habitat shifts or degradation for biological communities.

Adaptive Capacity

The vulnerability assessment evaluates the adaptive capacity of each sensitivity to each hazard. Adaptive capacity is the ability of the sensitivity to respond to impacts using existing resources. While the process for assessing impact includes a combination of qualitative and quantitative data, the adaptive capacity assessment is primarily a qualitative effort. The adaptive capacity evaluation for structures and functions includes the following considerations:

- Are there existing policies, plans, or programs in place or being considered to guide the response? How complete are these resources (e.g., do they allow for a full or partial recovery)?
- Do the owners or operators of the asset have the financial means to respond to impacts? Would such a response be complete or partial?
- Would recovery be voluntary (i.e., does the owner/operator have the ability to choose if and to what degree recovery occurs)? Are there existing laws and regulations that require recovery?
- Are there alternatives to the asset that the community can rely on while service is being restored? Do these alternatives adequately meet the community's needs?

- Are there any significant or insurmountable barriers to a response? Does the response require solutions that are technologically and/or politically infeasible?

A similar set of questions was used to evaluate the adaptive capacity of populations, including:

- Are there any existing/planned policies or programs to assist individuals with the response? Do community members have easy access to such services or are there difficulties associated with receiving assistance?
- Does the population have the financial means to respond to the impact? How complete would the response be?
- What alternatives exist to reduce or eliminate the hardships caused by the hazard?
- Do other barriers exist to the response, including technological capabilities and/or political will?

Each sensitivity associated with each hazard was also given an adaptive capacity score from AC0 (no adaptive capacity) to AC4 (high adaptive capacity). **Table A-4** reports how each score was qualitatively determined. Note that for impacts, a lower score is preferable, while a higher score is better for adaptive capacity.

Table A-4: Adaptive Capacity Scores

Impact Score	Summary
AC4	Assets and populations can adapt with little or no effort. Overall quality of life may improve as a result.
AC3	Adaptive solutions are feasible for most or all sensitivities. Some sensitivities may face limited challenges.
AC2	Threats can be reduced or mitigated, but solutions are only feasible for some assets. Many assets are likely to face substantive difficulties in adapting.
AC1	Adaptive solutions are expensive and/or technologically difficult, but feasible. Approach may require politically unpopular actions or widespread lifestyle changes.
AC0	No method of adapting is currently feasible, although solutions may be possible in the future.

Assessing Vulnerabilities

The combination of each sensitivity's impact score and adaptive capacity score results in a vulnerability score, ranging from V0 (low) to V5 (high). A low impact score and high adaptive capacity score results in a low vulnerability score, while the opposite results in a higher vulnerability score. **Table A-5** illustrates how a sensitivity's impact score and adaptive capacity score combine to create a vulnerability score.

Table A-5: Vulnerability Scoring Matrix

		Impact Score				
		IM0	IM1	IM2	IM3	IM4
Adaptive Capacity Score	AC0	V2	V3	V4	V5	V5
	AC1	V1	V2	V3	V4	V5
	AC2	V1	V1	V2	V3	V4
	AC3	V0	V1	V1	V2	V3
	AC4	V0	V0	V0	V1	V2

VULNERABILITY ASSESSMENT OUTCOMES

This section provides information about sensitivities that had a score of V3 or higher. The sensitivities are sorted by hazard, category, and by vulnerability score. Each subsection begins with a brief overview of vulnerability for the respective hazard.

Sensitivities are sorted into five categories: populations, buildings and infrastructure, biological resources, important economic assets, and key community services. **Figure A-11** identifies icons used for each category.

Figure A-11: Sensitivity Categories



Populations

Buildings and
InfrastructureBiological
ResourcesImportant
Economic AssetsKey Community
Services

AGRICULTURAL PESTS AND DISEASES

Agricultural pests and diseases in Riverside County include a variety of insects and pathogens, including historical occurrences of Bagworm, California Red Scale, Asian Tramp Snail, Whiel Fly, Scale, Pineapple Mealybug, and Olive Bark Beetle. Higher average temperatures and changes in precipitation can weaken crop plants, trees, and livestock, making them more susceptible to pests and diseases. Temperatures are

expected to get warmer earlier in the year and remain warmer until later in the year due to climate change, creating a wider window for pests and diseases to be active (IPCC 2013). Agricultural lands, montane coniferous forests, and woodland and forests would be highly vulnerable to pests and diseases. Agricultural lands may be able to use pesticides and herbicides to resist pests and diseases, however, if pests evolve quickly, the crops and livestock may not be able to recover. Pests such as bark beetles, which have increased due to drought and higher temperature, can decimate woodland and coniferous habitats and these species may not be able to recover. While buildings and infrastructure may not be highly vulnerable to these impacts, outdoor workers can be indirectly harmed by pests and diseases due to agricultural lands being threatened, which provide their livelihood.

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Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Biological Resources						
V4	Montane Coniferous Forest		Most conifer species are highly vulnerable to pests and diseases, particularly if the trees have already been weakened by extreme heat or drought events. A number of insect species, such as bark beetles, can decimate conifer forests in their weakened states, when they are unable to effectively resist infestation.	IM3	Montane coniferous forests may have some ability to resist pests and diseases with the appropriate temperatures. However, the adaptive capacity of this ecosystem plummets significantly when the forest is stressed by drought or extreme heat. Under these conditions, the trees have virtually no ability to resist pests and diseases, and can be substantially harmed as a result.	AC1
V4	Woodland and Forests		Oak woodlands and Broad-leafed upland forests in the region can be damaged by forestry pests and diseases such as sudden oak death and bark beetles. This can decimate the trees in the ecosystems and cause the woodland and forests to shift to grassland habitat.	IM3	Although oak species can typically recover from disturbances, oak canopies often include only one or two tree species. The loss of these species can alter the entire habitat and decrease the ability to recover.	AC1
Important Economic Assets						
V4	Agricultural Land		Pest and disease can affect the quality and/or viability of crops and vineyards that are within Western Riverside County. Impacts could become chronic as conditions continue to change and warmer temperatures persist. This can harm the economic viability of agricultural land, as the land and crops may become more difficult to manage effectively.	IM3	Pesticide and herbicides can help agricultural land, crops, and vineyards resist pests and diseases. However, if the pests and diseases evolve quickly, this may not be possible for all plant species.	AC1

AIR QUALITY

Air Quality within the Western Riverside subregion is impacted by high levels of ozone and particle pollution that has plagued the region. Rising temperatures can exacerbate the air pollution and trap harmful ground-level ozone in the air due to increased water vapor. Poor air quality can have direct health effects such as reduced lung function, pneumonia, asthma, cardiovascular diseases, and premature death. Sensitive populations are the most vulnerable to poor air quality, especially individuals who spend prolonged durations outdoors or may not have access to adequate healthcare. Populations that are extremely vulnerable include homeless persons, outdoor workers, and seasonal residents and migrant workers due to direct exposure to poor air quality. Children under 10 years old, households in poverty, chronically ill individuals, pregnant or nursing women, and senior citizens living alone are also highly vulnerable due to existing conditions that may create difficulty in adapting to poor air quality or lack of access to healthcare services.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V5	Homeless persons		Homeless persons face greater exposure to air quality, as they lack access to permanent shelter and may not have access to temporary shelter. Homeless persons may face a significant decline in health due to direct exposure to poor air quality that can cause reduced lung function, pneumonia, asthma, and cardio-vascular-related morbidity (Hall, 2018).	IM4	Homeless persons can seek shelter from poor air quality. Riverside County and the Incorporated Cities have a variety of homeless programs that can enable persons experiencing homelessness to find shelter and medical care during poor air quality conditions. However, poor air quality is frequent in western Riverside and homeless persons with behavioral health issues or limited mobility may be unable to reach these locations.	AC1
V5	Outdoor workers		Outdoor workers are directly exposed to poor air quality due to the nature of their occupation. This can lead to reduced lung function, pneumonia, asthma, and cardiovascular-related morbidity (Hall, 2018). If outdoor work is halted due to poor air quality, outdoor workers can face economic hardship.	IM4	Outdoor workers can wear masks to protect themselves from poor air quality. However, masks may not be able to prevent exposure to all air pollutants and other adaptive solutions may not be available to those working outdoors.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V5	Seasonal residents / Migrant workers		Migrant workers, similar to outdoor workers, are directly exposed to poor air quality due to the nature of their occupation. This can lead to reduced lung function, pneumonia, asthma, and cardiovascular-related morbidity (Hall, 2018). If work is halted due to poor air quality, outdoor workers can face economic hardship.	IM4	Seasonal residents and migrant workers can wear masks to protect themselves from poor air quality or install air purifiers in their homes. However, masks may not be able to prevent exposure to all air pollutants and other adaptive solutions may not be available to migrant or seasonal residents.	AC1
V4	Children age <10		Increased ground level ozone can disproportionately effect children under 10 and cause reduced lung function, pneumonia, asthma, and cardiovascular-related morbidity (Hall, 2018). Children tend to spend more time doing physical activity outdoors, which can worsen the health outcomes of poor air quality.	IM3	Children can stay inside and be prevented from participating in outdoor activities when poor advisories are given. Children can also seek medical attention to help with asthmatic conditions that may develop from poor air quality. However, keeping children indoors and reducing physical activity is difficult to do over an extended period and could cause other adverse health effects. The County of Riverside does provide a variety of programs to ensure children have adequate care if effected by poor air quality.	AC1
V4	Households in poverty		Riverside County frequently has poor air quality conditions. Households in poverty are often disproportionately affected by poor air quality due to lack of vegetation and trees in the area and lower access to air conditioning (Reid, 2009; Gould, 2012). This can contribute to poorer air quality both indoors and outdoors for low income households. These individuals may become more susceptible to cardiovascular and respiratory illnesses.	IM3	Households in poverty may live with poor housing conditions and have the fewest resources to protect themselves from poor air quality conditions, which may create difficulty when adapting to changing air quality conditions. AC units can be installed in homes to filter air pollutants out of homes, but this can be expensive and not always financially feasible.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Individuals chronically ill		Individuals with existing chronic health conditions may face increase health risk during periods of poor air quality. Poor air quality can exacerbate existing conditions such as asthma and respiratory diseases, in addition to cause pneumonia.	IM4	Persons with chronic illnesses can stay indoors and reduce exposure to poor air quality. Individuals with chronic health conditions may also be strongly dependent on formal or informal support networks, which may help individuals respond properly to days with reduced air quality. The County of Riverside has In-Home Supportive Services, which can help the chronically ill recover from poor air quality conditions.	AC2
V4	Pregnant or nursing women		Pregnant or nursing women and especially susceptible to harm from poor air quality. Poor air quality can cause low birth weight and precursors of asthma in children. Western Riverside County frequently has poor air quality due to high ozone and particulate matter levels, and thus these complications are chronic and can worsen in the region.	IM4	Pregnant and nursing women can stay indoors and away from pollution caused by traffic. However, this may not always be possible because pregnant or nursing women may have to work or travel outdoors on a daily basis.	AC2
V4	Senior citizens living alone		Seniors living alone, similar to other seniors, are more susceptible to cardiovascular and respiratory diseases, which can be exacerbated by poor air quality. Poor air quality is a frequent occurrence in Western Riverside County and consecutive days of poor air quality may restrict seniors to indoors and reduce overall quality of life and lifestyle.	IM3	Seniors living alone can stay indoors and filter air pollutants out of the air or seek relief at a senior or community center. Reduced mobility or medical conditions may make traveling to a relief center difficult. Seniors living alone may also be largely disconnected from the area and may not be aware of poor air quality conditions.	AC1

DROUGHT

Most water used in Western Riverside County is imported from the Sierra Nevada (through the State Water Project) and the Rocky Mountains (through the Colorado River, delivered to the region by the Metropolitan Water District of Southern California). Close to a quarter of the subregion's water is supplied by local groundwater. Climate change is expected to cause a decrease in precipitation in many parts of California, resulting in less local water to replenish groundwater supplies and less water in the Sierra Nevada to be delivered through the State Water Project. Warmer temperatures are also likely to increase the melting of the snowcap in the Sierra Nevada and the Rocky Mountains and cause increased evaporation from reservoirs and aqueducts, decreasing the amount of water available during summer and early autumn. Some evidence suggests that severe water shortages, such as the recent statewide drought, may become more frequent as climate change exacerbates conditions that result in such droughts, although more research is needed.

Most impacts from droughts are expected to affect population and biological resource sensitivities. Industries that rely on prevalent water supplies, such as agriculture, may be forced to scale back operations if enough water is not available, causing financial difficulties for individuals in these industries and supporting businesses. In communities that lack sufficient water supplies (particularly those more dependent on groundwater), individuals may be forced to buy retail water at significantly elevated rates, causing economic hardships for those of limited financial means; this has already happened in some communities in the San Joaquin Valley as a result of the recent drought. A number of biological communities may also be affected by limited water supplies, particularly if droughts persist for multiple years.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V4	Households in poverty		During droughts, water prices may be raised, or high fees may be levied, for increased water use. This can have a disproportionately high impact on households in poverty because they may be unable to pay for water services.	IM3	Households can conserve water through switching to low water use landscaping and high efficiency indoor appliances. However, these upgrades can be expensive and not always feasible for households with limited incomes. Existing financial burdens may make it difficult for households in poverty to maintain water supply to their homes. Some local water districts provide rebates/incentives for low-income customers to make water efficient upgrades, but renters are not likely to benefit from such programs.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Low-income individuals		During droughts, water prices may be raised, or high fees may be leveled, for increased water use. This can have a disproportionately high impact on low-income households because they may be unable to pay for water services.	IM4	Households can conserve water through switching to low water use landscaping and high efficiency indoor appliances. However, these upgrades can be expensive and not always feasible for households with limited incomes. Existing financial burdens may make it difficult for low-income households to maintain water supply to their homes. Some local water districts provide rebates/incentives for low-income customers to make water efficient upgrades, but renters are not likely to benefit from such programs.	AC2
V4	Outdoor workers		Drought can reduce water availability for agricultural operations and vineyards, which can indirectly harm outdoor workers. Agricultural operations can be halted, which may cause outdoor workers to lose jobs.	IM3	Individuals working in agriculture and wine production may have few options if these industries have water shortages. Agricultural operations can implement water efficiency upgrades; however this can be expensive and requires a system wide change. Some outdoor workers may be able to transfer industries through educational programs offered at adult schools in Hemet, Jurupa Valley, Corona, Riverside, UC Cooperative Extension, and Lake Elsinore.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Seasonal residents / Migrant workers		Seasonal workers frequently work in agriculture and will be among the first to be affected economically if agricultural produce suffers from water shortages. Work may be suspended if agricultural operations have water shortages, causing major economic hardship for migrant workers that are also seasonal residents.	IM3	Individuals working in agriculture and wine production may have few options if these industries have water shortages. Agricultural operations can implement water efficiency upgrades; however this can be expensive and requires a system wide change. Migrant workers may not have the option to switch jobs and use educational programs offered in the County.	AC1
Biological Resources						
V5	Meadows and marshes		Hydrology is the single most important characteristic of wet meadows and marshes, and availability of water determines the vegetation stability of these communities.	IM4	Decline in water availability in wet meadows over many successional years could lead to a conversion to drier communities such as woodland or grassland.	AC1
V5	Montane coniferous forest		Montane coniferous forests are highly susceptible to drought conditions, as they can cause decreased growth and seedling survival, reduced forests extent, shifts in species, and widespread mortality of conifers. Drought can also worsen pests and diseases such as bark beetles and fungus.	IM4	Drought could cause migration of this ecosystem to higher elevations; however, several dominant species, such as lodgepole pine, are able to tolerate a wide range of environmental factors such as low soil moisture. Other habitat types are severely limited in extent due to changing conditions and development pressures. Many coniferous forests may take 40-60 years to recover from major stressors, and major droughts may occur more frequently than that by 2100.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Riparian scrub, woodland, and forest		Riparian systems are typically prepared for periods of summer drought. However, successive drought years could lead to an earlier, more rapid seasonal drying down of riparian communities. This can cause a compositional shift in the community and altered water chemistry due to lack of water.	IM4	Herbaceous species could die out due to loss of surface water; however, established trees could persist by accessing ground water with their deep roots. Nonetheless, growth and reproduction could become suppressed. General shrinking of riparian zone will put pressure on species that use these areas. Groundwater may keep larger trees alive; however, severe drought could cause water table to sink below the reach of roots.	AC2
V4	Playas and vernal pools		Drought could result in a reduced hydroperiod for ephemeral water features. The size and species composition of these features is dependent upon rainfall and temperature. Precipitation is the primary source for vernal pools. During drought year, vernal pools may be invaded by upland species. Early drying of pools will cut growing season short, and possibly interrupt reproduction processes.	IM4	Vernal pools and playas are adapted to annual fluctuations in rainfall. Seeds and wildlife associated with these features have adaptive strategies for dealing with long periods of dry conditions; however, successional drought years may have a detrimental effect on these features as upland species invade.	AC2
Important Economic Assets						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Agricultural land		Agriculture will be directly harmed from drought conditions due to an increase in soil salinity, topsoil erosion, and reduced water supply (US Dept. Interior 2017). This can limit crop production and in turn result in a loss of income for agriculture owners. The economy in Western Riverside County can be especially harmed by limited water for agricultural production.	IM3	Water conservation methods, change in irrigation methods, soil management, and a reduction in overall production can be implemented in crop production to ensure that farmers have adequate supplies of water. However, these methods can be expensive and farm owners may not be able to implement sufficient water conservation measures. Limiting crop production could also result in an economic loss for farm owners. Water may run out during an extensive drought (US Dept. Interior 2017).	AC1
Key Community Services						
V4	Water delivery		Drought conditions may cause stress on the water agencies and municipal districts that provide water to Western Riverside County and incorporated areas. Supplies on the State Water Project, Colorado River, and groundwater may be significantly reduced because of lack of snowmelt or recharge into the groundwater system. This may cause the water agencies to raise water prices and require mandatory reductions in overall water use.	IM3	Water delivery agencies can provide water rebate or retrofit programs to help businesses and residents in the area reduce overall water consumption. However, the water agencies may not be able to obtain or store additional supplies to meet the demands of the community. The region could also retrofit wastewater treatment plants to create a toilet to tap system, but this is expensive, and the region may not have the financial means to do this.	AC1

EXTREME HEAT

Extreme heat refers to temperatures that are hotter than 98 percent of all observed historic high temperatures. When extreme heat occurs at least five days in a row, the event is known as a heat wave. Within Western Riverside County, extreme heat days are days in which the maximum temperature exceeds 103.6°F. Historically, the area has seen an average of four extreme heat days each year. Warmer air temperatures are a direct consequence of climate change and are likely to cause an increase in extreme heat. By mid-century, projections estimate an average of 15 to 30 extreme heat days each year, and potentially more in some parts of the subregion.

The greatest threat posed by extreme heat is health impacts caused by higher temperatures, which can be particularly problematic for children and older individuals, individuals who spend prolonged periods outside, individuals with existing chronic illnesses, and those who lack effective cooling in their homes or workplaces. Some types of infrastructure, particularly electricity transmission and delivery wires, may be less efficient and more vulnerable to disruptions as a result of very high temperatures. Extreme heat can also increase water loss in plants and animals, which may put stress on the subregion's biological communities and agricultural productivity.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V5	Homeless persons		Homeless persons lack permanent, and often temporary, shelter, which leaves them more exposed to extreme heat. Dehydration is common among persons experiencing homelessness, which can complicate existing medical conditions. Homeless persons are more likely to suffer from respiratory and other illnesses, which can be exacerbated during periods of extreme heat. Homeless persons often lack access to water, sunscreen, or protective clothing such as hats, further increasing their exposure to extreme heat events.	IM4	Persons experiencing homelessness do not have regular access to cool indoor locations. Riverside has various homeless shelter locations that can provide shelter from extreme heat conditions. However, homeless persons may not have adequate communication to know about them or may be unable to travel to those locations.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V5	Outdoor workers		Oak woodlands and Broad-leaved upland forests in the region can be damaged by forestry pests and diseases such as sudden oak death and bark beetles. This can decimate the trees in the ecosystems and cause the woodland and forests to shift to grassland habitat.	IM3	Although oak species can typically recover from disturbances, oak canopies often include only one or two tree species. The loss of these species can alter the entire habitat and decrease the ability to recover.	AC1
V5	Senior citizen living alone		Approximately 10% of the subregion work in outdoor-oriented fields such as agriculture, forestry, and construction. Outdoor workers are disproportionately impacted by extreme heat because their occupations typically do not have air-conditioned facilities onsite and are directly exposed extreme heat. Outdoor work is often physically intense, increasing the risk of individuals overheating and suffering heat-related medical complications. Outdoor work may be curtailed during significant extreme heat events, which can cause significant economic hardships.	IM4	Outdoor worksites can make water, shelter, and protective gear available, although not all sites may do so even when required to. Persons working outdoors are often aware of the warning signs of heat-related illnesses, which can prevent serious injury or death. However, persons working outdoors may not have the option to stop working in extreme heat conditions. Additionally, access to medical care may be more limited due to financial means.	AC1
V4	Children age <10		Children are highly susceptible to extreme heat because they spend a disproportionately longer amount of time outdoors than adults, which increases the risk of health impacts. Some evidence also suggests that the physiology of children makes it more difficult for them to stay cool, although the science remains mixed (Falk and Dotan 2008, Rowland 2008). Child athletes (due to high levels of exertion and increased time spent outdoors), as well as children under the age of 4, are considered to be at especially high risk (NTCSN 2018).	IM4	While adaptation measures are feasible for children, children tend to be less aware of the health impacts of extreme heat events. Preventative actions, such as staying hydrated or staying in air-conditioned spaces, may not be possible, especially for the children who do not have adult supervision. Children may not have access to air-conditioned spaces with alternative activities and medical care if severely impacted by heat related illnesses.	AC2

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Householder age >65		Regardless of race or gender, individuals 65 years of age or older, which make up 3% of the sub-region as a whole, but as much as 30% of certain zip code areas, are more susceptible to the adverse effects of heat than are younger adults. "The risk for heat-related death increases sharply with age, as those 85 years of age or older are most at risk for heat-related mortality."	IM4	The elderly have little inherent adaptive capacity to heat. Air conditioning can limit impacts, but may not be utilized due to the electricity expense associated with its use. Those with adequate transportation options could also go to cooling centers or other air-conditioned public facilities such as a library, if they are available.	AC2
V4	Households in poverty		Households in poverty are less likely to live in a well-insulated building that has an air conditioning system. During extreme heat events, this can increase their exposure to high temperatures. Households in poverty may not have access to medical services, which means that they are more likely to have medical conditions that can be exacerbated by extreme heat.	IM3	Financial limitations can restrict households in poverty from purchasing air conditioning units or seeking medical care for illnesses that are exacerbated by extreme heat conditions.	AC1
V4	Individuals chronically ill		Extreme heat events can exacerbate existing illnesses that persons with chronic illnesses may have such as diabetes, cardiovascular conditions, respiratory ailments, and cerebrovascular diseases (Zanobetti et al 2011, Luber et al 2014, US Climate Resilience Toolkit 2016). Furthermore, persons with chronic illnesses may take medication that make it more difficult to maintain a safe internal temperature during higher temperatures (CDC 2011). Persons with chronic illnesses are more reliant on devices that require electricity to function, which may not be available during extreme heat conditions.	IM3	Individuals with chronic illnesses may be strongly dependent on formal or informal support networks, including medical care and social assistance. The presence of these networks is essential as people with chronic illnesses may not notice changes in air temperature and be able to respond accordingly. Persons with chronic health illnesses are also more likely to face financial hardships, which can limit their resiliency.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Low-income individuals		Individuals with low-income are less likely to have access to high quality housing units and may be unable to afford the cost of effective cooling in their homes. Certain areas of the subregion are over 70% low-income, potentially concentrating and aggravating vulnerability, due to lack of resources within their social networks.	IM3	Low income residents have little ability to adapt. Cities can provide cooling centers or other resources.	AC1
V4	Seasonal residents / Migrant workers		Seasonal workers are typically lower income and less aware of community resources and safety nets. They are more likely to work in the outdoors and thus have more extreme exposure to high heat conditions. They also have less control over their living environment and frequently have poor quality housing units that are less likely to provide adequate refuge.	IM3	Major employers of migrant workers could be required or incentivized to provide resources or refuge in extreme conditions. Without action by employers or regulators, outdoor workers ability to adapt without risk to employment is low.	AC1
Buildings and Infrastructure						
V4	Energy transmission and delivery infrastructure		Extreme heat decreases the ability of the grid to transmit electricity; the Department of Energy estimates that for a 9-degree increase in temperatures, transmission line capacity falls by 7-8%, and substation capacity falls by 2-4%. These problems are compounded by the fact that electricity demand often spikes during a heat wave, primarily due to the increased AC load.	IM3	Retrofits and modifications to operating procedures can offset capacity losses, and improved efficiency can help to reduce demand during heat waves. However, implementation may be an expensive and lengthy process. The WRCOG communities have little or no operational control over the electricity grid.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Railways		Metrolink and freight lines run through Western Riverside County. Extreme heat can lead to thermal expansion of railroad tracks and cause warping or buckling of the tracks (Hall 2018). This can subsequently cause train accidents, slowing of rail services, and/or suspension of rail traffic.	IM3	The rail lines are managed by multiple agencies, which may require coordination and funding to complete retrofits or repairs if the rail lines are damaged. When damaged, the railways would not be able to meet the needs of the community, and few alternative rail lines are available.	AC1
Biological Resources						
V4	Meadows and marshes		An increase in extreme heat days could result in a reduced hydroperiod for ephemeral water features. The size and species composition of these features is dependent upon rainfall and temperature. Communities associated with perennial features could experience increased heat/water stress and reduced growing season.	IM3	An increase in evaporation could lead to less water in wetland features. This could lead to features shrinking and eventually disappearing altogether. Less water means less survival of hydrophytic vegetation.	AC1
Important Economic Asset						
V4	Agricultural land		Extreme heat conditions can damage crops or reduce yield, which can create economic hardships for landowners that depend on agricultural production in Western Riverside County. High heat conditions can also make crops more difficult to manage and can lead to die-off of crops. Wine grapes are expected to experience a decline in fruit quality due to extreme heat (Kerr et al 2018).	IM3	Very few options are available for farmers to protect their crops from extreme heat. Heat-resistant varieties of some crops exist, but the cost to replace existing crops with heat-resistant strains can be very expensive and may not be economically viable.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Key Community Services						
V4	Electricity		Electricity may be chronically interrupted due to extreme heat events. The electrical system may have reduced efficiency and increased demand, which can damage electricity lines and infrastructure. Electricity delivery disruptions can cause power outages that impact the entire region. Medical and emergency services may not function properly and residents using AC units may not be able to use those to find relief from the heat.	IM3	Alternative forms of energy and infrastructure can be installed to create redundancy in the system to ensure that energy delivery is not interrupted. These can include solar panels on homes and placing transmission lines underground to protect them from extreme temperatures. Backup generators can also be installed to ensure electricity is not interrupted. However, these installations can be expensive and it is not also possible to underground electrical lines.	AC1

FLOOD

Climate change is expected to cause a decrease in frequency of precipitation events throughout much of California, including Western Riverside County, but there is also evidence that it may strengthen certain atmospheric mechanisms which are responsible for delivering strong storm systems to the state. Some studies indicate that the number of strong storms may increase by 20–30 percent by the middle of the century and that the number of years that see 15 or more strong storms may double. Although overall precipitation is expected to decline, the increased frequency and intensity of these storms can create an increased risk of flooding. There is no specific information on how much flood risk may increase due to climate change, but it is reasonable to assume that flood events will be more frequent in already flood-prone areas and that the size of flood-prone areas will expand.

The primary threat from flooding is damage to buildings, infrastructure, and individuals posed by the floodwaters. Flooding can also affect the viability of agricultural crops and the functionality of wastewater treatment plants. Indirectly, floods can have impacts to economic, social and emotional health by limiting the ability to travel, especially on single access or high traffic volume roadways. Health risks can also occur after floodwaters recede, including respiratory conditions caused by mold and increased threats of diseases from vectors that rely on stagnant water, such as mosquitoes.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V4	Homeless persons		Homeless persons lack permanent, and often temporary shelter, leaving them highly susceptible to impacts from flooding. Persons experiencing homelessness may have temporary shelters that are damaged or destroyed by flooding, creating additional hardships.	IM3	Homeless persons can seek shelter or relocate during flooding events. The County of Riverside has 12 homeless shelter programs where homeless persons can find shelter during flooding events. However, homeless individuals also may be unaware of where shelter facilities are located.	AC1
V4	Households in poverty		Some areas within the County are within the 90th to 100th percentile of individuals in poverty. These areas are also within floodable areas (100-year and 500-year floodplains). Households in poverty are more likely to live in homes that are less well maintained or more structurally deficient, increasing the risk of damage during flood events. Persons in poverty are more likely to live in low-lying areas that are more susceptible to flooding because they are less expensive to live in or may have been built prior to knowledge of the floodplain.	IM3	Financial limitations faced by households in poverty limit their ability and resources to fix homes or retrofit them to be more adaptable to increased flooding or dam failures. Persons in poverty may not be able to relocate to areas outside of the floodplain and may not have flood insurance. During flooding events, evacuations can be difficult if the household does not have a car and there are limited transportation resources. Reconstruction following a flood can also be difficult and assistance is limited to those who have flood insurance. The reconstruction assistance is not likely to reduce the significant burden to households in poverty.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Individuals without access to lifelines		Flooding and debris may block sidewalks and make walking difficult or impossible during and immediately after intense storms, which would have a more direct impact on individuals with no vehicle or other limitations on transportation. Individuals lacking access to communication resources (e.g. internet or phone) may not be aware of blockages or warning to prepare for a storm. Such individuals have little or no capacity to evacuate if necessary.	IM3	Individuals with limited transportation or communication lifelines could invest in better drainage systems that could help reduce flooding. They may also develop more extensive emergency kits that anticipate longer periods of time before help arrives after a flood event. They could participate in any existing door-to-door notification system or informal warning system. Individuals may set up their own support network that could offer transportation in case of poor air quality or evacuation. However, those with limited social networks could not adapt in this way. In these cases, individuals will be fully including reliant on emergency services.	AC1
V4	Low-income individuals		Individuals with low-income are less likely to have access to high quality housing units, or resources necessary, such as sandbags, to prepare their homes against flooding. They are also less able to recover and rebuild their quality of life if fire results in destruction of their property or impacts their health. They may be unable to afford housing in a new location or pay medical bills. Certain areas of the subregion are over 70% low-income, potentially concentrating and aggravating vulnerability, due to lack of resources within their social networks.	IM3	Programs that provide resources and recovery safety nets such as temporary housing and rebuild assistance at reduced or no cost to this group could aid in adaptation but prove costly.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Persons in mobile homes		Several mobile home parks are within or partially within the 100-year floodplain. Persons living in mobile homes are at a higher risk of flooding impacts because mobile homes are generally less structurally resilient than conventionally built houses and are more susceptible to damage. Hazard mitigation strategies can be less effective against mobile homes and mobile homes are more likely to be built on land that may have drainage issues.	IM3	Flood insurance is generally available to manufactured (mobile) homes, but is not available to all mobile homes. Persons in mobile homes generally have lower or fixed income levels, which could reduce the capacity to repair structures if damaged from a flood disaster.	AC1
V4	Senior citizens living alone		Seniors living alone, like all seniors, are more likely to have reduced mobility or other conditions that can make it more difficult to prepare for flooding events. Emergency notifications and warnings may not reach seniors living alone due to a potential absence of support networks, causing emergency response and evacuations to become more difficult.	IM3	Seniors living alone can be heavily dependent on friends, family, or caretakers, if they have reduced mobility, to take care of them. In emergencies, these networks may not be able to provide evacuation assistance and care.	AC1
Buildings and Infrastructure						
V4	Airports		Corona Municipal Airport, Flabob Airport (protected by levee), Banning Municipal Airport, Perris Valley Airport, and Hemet Ryan Airport are within flood hazard zones created by the San Jacinto River, Santa Ana River, and drainage from the San Jacinto Mountains. Flood waters can damage runways, buildings, and essential infrastructure at airport facilities.	IM3	Airports can be protected through levee systems, similar to those close to the Flabob Airport. However, levees can be expensive to build and may require coordination with several agencies. Levees may also not always be effective in preventing floodwater from damaging airports.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Commercial structures		Commercial structures are at risk of flooding, particularly those located within flood zones. There are currently 6,240 acres of commercial land in the 100-year floodplain within the WRCOG sub-region.	IM3	Outside of a flood zone, basic protective actions such as sandbags can reduce the damage caused by flooding. Within flood zones, there are retrofits and design features to make the building more resilient, although their effectiveness could be limited, and such measures may be expensive.	AC1
V4	Railways		Both freight and commuter lines pass through 100-year and 500-year floodplains within Western Riverside County. Flooding can cause the ground to wash out underneath the track or the track to become covered in water, creating dangerous or impassable conditions for train cars to travel over. This can cause major disruptions on the entire railway line.	IM3	Rail lines can be protected by levees or raised to enable water to run underneath the tracks. However, this can be expensive to complete, cause major delays in rail service, and requires coordination with several agencies to complete.	AC1
V4	Residential structures		Homes in flood zones run significant risks of being damaged or destroyed during flooding, particularly if the strength and frequency of flooding increases as a result of climate change. Within the WRCOG sub-region there are approximately 2,896 acres of residential land currently within the 100-year floodplain.	IM3	Homes can be designed or retrofitted to be more resilient to flooding, although not all tenants may be able to afford such retrofits. Residents in 100-year flood plains should have flood insurance, which would assist with recovery costs. Additionally, the ability of these strategies to provide sufficient protection for homes already in a flood plain may be limited.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Wastewater treatment plant and collection infrastructure		Four wastewater treatment plants are located within the 100-year floodplain. Flood damage to wastewater treatment plants can result in the release of sewage, potentially contaminating water supplies and posing health risks. Septic systems are used in more rural parts of the WRCOG area. Such systems are susceptible to floods, potentially causing damage to the system and home, and creating a source of water pollution.	IM3	Some hardening of wastewater treatment facilities to reduce the risk of inundation by flood waters can help, but ultimately treatment facilities have little option but to have large, uncovered pools, which makes them potentially vulnerable to flooding. Individuals can reduce contamination from septic tanks by minimizing the use of the system, although this is a limited and often unfeasible approach.	AC1
Important Economic Assets						
V4	Agricultural lands		Agricultural lands in the center of the WRCOG region are within the 100-year floodplain. Flooding can cause significant damage to crop production because they can damage plants, wash away topsoil nutrients, and degrade essential microbial activity. This can harm plants and reduce agricultural productivity, subsequently harming the agricultural economy.	IM3	Improved drainage swales and berms can help prevent floodwaters from affecting fields and orchards, although these features may not be economically feasible, may take land out of active agricultural production, or may not be capable of preventing floodwaters. Cover crops can be planted to replenish the soil microbiome, although this may postpone economic hardship if the land is normally used for more valuable crops. Sediment and debris can be removed (Soil Science Society of America n.d.).	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Key Community Services						
V4	Wastewater treatment		Four wastewater treatment plants are located within the 100-year floodplain. Flood damage to wastewater treatment plants can result in the release of sewage, potentially contaminating water supplies and posing health risks. Septic systems are susceptible to floods, potentially causing damage to the system and home, and creating a source of water pollution. Wastewater treatment services could be significantly curtailed due to flooding.	IM3	Some hardening of wastewater treatment facilities to reduce the risk of inundation by flood waters can help, but ultimately treatment facilities have little option but to have large, uncovered pools, which makes them highly susceptible to flooding.	AC1

HUMAN HEALTH HAZARDS

Human health hazards, such as vector-borne diseases and Valley Fever, are closely linked to climate change and projected to worsen as temperatures continue to rise. Climate change can increase the rates of infection for various diseases because many of the animals that carry diseases are more active during warmer weather. Warmer temperatures earlier in the spring and later in the winter can cause these animals to be active for longer periods, increasing the time that these diseases can be transmitted. Warmer temperatures may also cause some mosquito-carried illnesses not currently present in California, such as Zika, to potentially appear. West Nile virus appears to be more active during drought periods, and periods of intense precipitation can increase populations of rodents and ticks (OPR, CNRA, CEC 2018).

Sensitive populations are most vulnerable to human health hazards, especially for those that have weaker immune systems and those that may not have access to adequate medical care. Homeless persons are extremely vulnerable due to a lack of basic hygiene supplies and pre-existing illnesses that may go untreated. Chronically ill persons may face additional challenges with treating new illnesses created by vector-borne diseases.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V5	Homeless persons		Persons experiencing homelessness lack access to permanent, and often temporary shelter resulting in increased exposure and risk to vector-borne diseases and other pathogens. Homeless persons may lack basic hygiene supplies and commonly have respiratory illnesses that can be exacerbated by human health hazards.	IM4	The County of Riverside and incorporated cities have homeless programs that can help persons experiencing homelessness prepare and recover from human health hazards. However, persons experiencing homelessness may not be aware of these services or have the means to travel to shelters and care facilities.	AC1
V5	Individuals chronically ill		Persons with chronic illnesses have weakened immune systems that leave them more susceptible to vector-borne diseases and other pathogens. Existing chronic health problems can create challenges for treating new illnesses that arise from human health hazards.	IM4	Persons with chronic illnesses may have compromised immune systems that can make it difficult for individuals to fight off pathogens or recover from other illnesses. Compromised immune systems can make it more difficult for health professionals to treat existing and new illnesses.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V5	Pregnant or nursing women		Vector-borne illnesses and diseases are projected to increase in the Western Riverside County region, which can directly affect pregnant and nursing women. Pregnant or nursing women that become sick due to tick, mosquito, or flea-borne illnesses such as West Nile Virus and Malaria can also infect their unborn or newborn children.	IM4	Pregnant or nursing women can stay away from regions where human health hazards occur. However, this may not always be possible. Treatment of the illnesses once contracted may also be more complicated.	AC1
V4	Senior citizens living alone		Seniors, including seniors living alone, often have weaker immune systems that can make them more susceptible to vector-borne illnesses and other pathogens. Existing health conditions can be exacerbated by additional human health hazards.	IM3	Seniors living alone may have difficulty seeking medical care due to mobility challenges or other disabilities, which can hinder treatment of illnesses. Riverside County and incorporated cities have in home supportive services and other programs that can assist seniors living alone in preparing and recovering from human health hazards. However, some seniors living alone may not be aware of these services and may face significant challenges.	AC1

LANDSLIDES

Landslides occur when a hillside becomes unstable, causing soil and rocks to slide downslope. The mountainous areas in the eastern and western edges of the WRCOG subregion are most susceptible to landslides and mudflow. Climate change is expected to cause an increase in the number of years that see intense levels of precipitation, which could cause an increase in the number of landslides or make landslides larger than normal. Vegetation that holds hillsides together can be removed through wildfire, drought conditions, or pests and diseases, which can also destabilize hillsides as climate change hazards worsen.

In the Western Riverside subregion, buildings and infrastructure are the most susceptible to damage or destruction from landslides and mudflows, especially dams located in the hillside areas, industrial and residential structures, natural gas facilities, and railways. Senior citizens, including those living alone, are also susceptible

to injury from landslides due to limited mobility that may make it difficult to evacuate if landslide warnings are issued. Many mobile home parks are located within high landslide susceptibility areas, and therefore persons in mobile homes are highly vulnerable to landslides.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V5	Senior citizens living alone		Seniors are located throughout WRC, with concentrations in Sun City and south of Beaumont. The physical health of seniors and decreasing mobility makes them more likely to be harmed than younger persons in the event of a landslide.	IM4	Seniors living alone with mobility issues may not be able to evacuate during emergency alerts. However, seniors living alone may not have support or communication networks that can provide warnings and evacuation alerts. Seniors living alone may also have difficulty recovering if an existing support network does not exist.	AC1
V4	Householders age >65		Householders over 65 are located throughout WRC, with concentrations in Sun City and south of Beaumont. The physical health of seniors and decreasing mobility makes them more likely to be harmed than younger persons in the event of a landslide.	IM3	Renters may prioritize living in units that are not located within landslide prone areas. However, for low-income renters these adaptation behaviors may not be possible.	AC1
V4	Persons in mobile homes		Mobile home parks are located within landslide prone areas in WRC. Mobile home parks are more likely to be located on land that is at higher risk of landslide potential. Mobile homes can be severely damaged by landslides and mudflows, creating hardships for those persons living in them. Physical injury or economic loss could occur as a result of landslides, decreasing the well-being of the community.	IM3	Some adaptation methods are available for persons living in mobile homes, such as home insurance and retrofitting structures and properties to reduce the impacts of landslides and mudflows. Barriers to response would primarily be financial in nature, as persons in mobile homes generally have lower or fixed income levels, which could reduce the capacity to repair structures if damage from a landslide.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Buildings and Infrastructure						
V4	Dams		Diamond Valley Lake, Lake Skinner, Lake Mathews, Vail Lake, Lake Hemet, and Lake Perris dams are within high landslide susceptibility areas. Landslides and debris flows can cause instability of a dam or seepage within dam structures (Schuster 2006).	IM3	The dams within the WRCOG subregion can be retrofitted or re-engineered to account for landslides within the dam structure or reservoir. However, retrofit and repairs are expensive and may take a long period of time to complete.	AC1
V4	Industrial structures		Landslides can disturb holding tanks or damage industrial buildings, and cause chemicals to be released into the air, water, or ground in the surrounding areas.	IM3	Industrial structures are typically highly regulated due to the harmful chemicals used in production or cleaning of the facilities. These facilities are often already coordinating together to ensure that toxic releases do not occur. However, if an unexpected landslide occurs, industrial buildings may be unable to take precautionary measures to secure the facility.	AC1
V4	Natural gas facilities		Natural gas lines that connect to homes and businesses in WRC can be damaged or destroyed from landslides (Harp 2008). This can cause gas leakage and explosions in surrounding areas which can cause physical injuries and further damage to buildings and infrastructure.	IM3	Natural gas in the WRCOG subregion is supplied by the Southern California Gas company, which provide emergency preparedness and gas line maintenance information to the community. Gas lines can be retrofitted to resist small landslides, however due to the linear nature of the pipelines, they may be unable to be retrofitted to withstand changes in geologic conditions created by a landslide (Harp 2008).	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Railway		Landslides could damage the tracks or destroy a station, which could prevent rail cars from passing through the station in either direction. This could limit transit opportunities and movement of goods and services within the region.	IM3	Rail lines can be hardened and protected from some landslides. However, if a landslide does occur, rail lines can be severally damaged and repairs would have to include slope stabilization and rail repairs, which is expensive and could take time.	AC1
V4	Residential structures		Communities such as Murrieta, Temecula, and Banning are within landslide prone areas, including residential structures. Residential structures can be damaged or destroyed by landslides, causing them to become uninhabitable and displace those who were living in them.	IM3	Homes can be reconstructed after a landslide, and funding assistance if often available. However, these funds may not cover all of the expenses needed for the repairs. Repeated damage from landslides and mudflows can cause homes to become uninhabitable.	AC1

SEVERE WEATHER

Severe weather includes strong winds, hail, and lightening, and is usually caused by intense storm systems, although types of strong winds, such as the Santa Ana Winds, can occur without a storm. Severe weather can cause injuries or death to sensitive populations and damage buildings and infrastructure. In the Western Riverside subregion, most severe weather is linked to high winds and thunderstorms. Climate change is expected to cause an increase in intense rainfall, which is usually associated with strong storm systems (OPR, CNRA, CEC 2018).

In the Western Riverside subregion, sensitive populations are the most vulnerable, specifically those populations that do not have access to permanent shelter or live in mobile homes. Individuals with chronic illnesses are also highly vulnerable due to the potential for power outages during severe weather, which can cause life support systems to fail if they rely solely on electricity from the grid. Power outages can be caused by high velocity winds that cause damage to transmission lines and substations.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						
V5	Homeless persons		Homeless persons often lack permanent, or even temporary, shelter, leaving them more exposed to severe weather. Homeless persons have increased risks of injury or other hardships due to increased exposure to severe weather.	IM4	Persons experiencing homelessness can find shelter in homeless shelters throughout the WRCOG subregion. Riverside has various homeless shelter locations that can provide shelter from severe weather conditions. However, homeless persons may not have adequate communication to know about them or may be unable to travel to those locations.	AC1
V4	Individuals chronically ill		Severe weather may cause power outages in the Western Riverside subregion, which can affect the life support systems that persons with chronic illnesses may depend on.	IM3	Individuals with chronic health problems can obtain back-up generators or batteries that can prevent life support systems from shutting off. However, these may be expensive and not always possible for all needs.	AC1
V4	Persons in mobile homes		Mobile homes are generally not as resilient as permanent structured homes, making them more susceptible to damage from severe weather. Damage to mobile homes can cause injury to those living within the structures. Mobile homes that are not well maintained have a higher risk of damage from severe weather.	IM3	Persons living in mobile homes can retrofit the structure and protect the surrounding property, including regular maintenance of the building. However, those living in mobile homes may have lower or fixed incomes which can impact the ability to make appropriate retrofits or repairs.	AC1
Buildings and Infrastructure						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Energy transmission /delivery infrastructure		Electricity lines and substations can be damaged or destroyed by high velocity winds and hailstorms. This can cause secondary impacts such as sparking, in addition to cutting off power to regions within WRC. Damage to substations can cause overloading of power lines and additional power outages in the region.	IM3	Electricity lines can be shut off to reduce damage to the SoCal Edison system and communities within the region, however critical facilities may not have backup power generation which could impede on government and health services. Electricity lines can also be undergrounded; however, this is expensive and would require extensive construction to complete. Electrical substations may be able to be retrofitted or redesigned to resist impacts from severe weather. However, these retrofits can be expensive and may not be possible for all substations within Western Riverside subregion.	AC1
Important Economic Assets						
V4	Agricultural lands		High winds, hail, and thunderstorms can decimate agricultural operations. Crops and vineyards can be flattened by high velocity winds and food crops can be damaged by hail (Motha 2011). This can severely damage the agricultural economy in the WRCOG Subregion and bring economic hardship to farm owners in that area.	IM3	Some crop types may be more resistant to severe weather effects. However, agricultural operations may not be able to adequately prepare or recovery from high intensity storms if crops are damage or destroyed.	AC1
Key Community Services						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Electricity		High winds and hail can damage energy infrastructure and cause disruptions to SoCal Edison's energy delivery system within the WRCOG subregion. This can directly harm the economy, government operations, and public safety.	IM3	Energy infrastructure can be retrofitted or placed underground to protect energy delivery from severe storms. However, this process can be expensive and may disrupt other services.	AC1

WILDFIRE

The anticipated effects of climate change include warmer temperatures and a decline in precipitation levels, which are expected to lead to an increase in the number of wildfires due to more dry vegetation and favorable atmospheric conditions. Parts of the Western Riverside subregion are already at elevated fire risks, primarily in the forested mountain regions. The risk of wildfires in the subregion is anticipated to increase moderately by 2039, and some locations in the subregion may see the wildfire risk rise by up to 6 percent. The greatest increase in risk is expected to occur in the Santa Ana and San Jacinto mountains.

In addition to the direct risk to people, property, and biological communities from the flames, wildfires can also result in a number of indirect risks. Smoke can cause or exacerbate respiratory problems for sensitive individuals, and the fine particles in smoke can damage machinery or ground airplanes. Without vegetation to help hold the ground together, recently burned areas may also be at greater risk from landslides. People without access to medical care or those that have pre-existing conditions that make it difficult to evacuate or cope with increased smoke conditions are highly vulnerable to wildfires. Buildings and infrastructure, such as older structures, evacuation routes, and electricity lines are also susceptible to damage or destruction from the flames of wildfires.

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
Populations						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V5	Homeless persons		Homeless persons lack permanent, and often temporary shelter, and are thus more exposed to smoke and ash from wildfires. This can lead to reduced lung function, pneumonia, asthma, and cardio-vascular-related morbidity (Hall, 2018).	IM4	Persons experiencing homelessness can seek shelter from wildfires and the smoke created by wildfires. However, persons experiencing homelessness may not be aware of homeless shelters in their area or receive notifications of wildfires in the area, and may be unable to seek shelter or evacuate when needed.	AC1
V5	Senior citizens living alone		Seniors living alone, like other seniors, are more susceptible to poor air quality created by smoke, which can exacerbate health conditions and cause respiratory impacts such as asthma, acute bronchitis, chronic obstructive disease, and pneumonia (Hall 2018). Seniors living alone may be less able to receive information about impending wildfire conditions due to lack of access to communication methods or sensory disabilities associated with age that can lead to greater risk of injury or death from wildfires.	IM4	Seniors living alone can stay inside and run the air conditioning to filter smoke out of the air and seek medical attention if needed. However, if a wildfire is nearby, seniors living alone may not be able to evacuate because of mobility issues.	AC1
V4	Children <10		Children are more likely to be affected by wildfires due to the smoke and ash that they produce. Because their airways are still developing, children breathe more air per pound of body weight than adults (CDC 2018). Children also spend more time outside compared to adults, which can also cause children to breathe is more smoke and existing respiratory illnesses, such as asthma, can severely worsen.	IM3	While adaptation measures are feasible and schools or care centers can take precautionary measures during smoke and wildfire events, children may have a lower level of awareness about the need to stay indoors when wildfires reduce the air quality. Children with pre-existing conditions may have a difficult time recovering from inhaling smoke and ash from wildfires.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Householders age >65		Older adults (>65) are more likely to have susceptibility to poor air quality, and reduced mobility (problematic for evacuation planning). In addition, many retirement aged residents are on a fixed income, and thus less able to afford defensible space/building material retrofits as well as recover if wildfire causes health problems or property damage.	IM4	Older adults (>65), especially those living alone, have lower adaptive capacity because they may have less connectivity with the larger community news and events. In addition, they may be unable to evacuate quickly if needed, and may have less social safety nets of places to stay. They also tend to be on fixed income and less able to recover financially with lost property or injury. Depending on the community, some older adults may have significant assets in place and may be highly resilient.	AC2
V4	Households in poverty		Houses of persons in poverty may be subject to greater damage from wildfires, as financial limitations can make it challenging for these households to maintain defensible space around their homes. Persons in poverty may also be disproportionately impacted by wildfire smoke due to limited medical care.	IM3	Households may not be able to seek medical attention from health impacts of smoke inhalation and may not be able to afford an air purifier to clean the air in their homes. Existing financial burdens may create significant challenges in taking protective steps. These individuals are also less likely to have access to transportation, which can make evacuations more challenging.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Individuals chronically ill		Individuals with compromised immune systems or other chronic illness have limited mobility due to increased frailty, and dependence on medications or large and electronic devices. This makes evacuation more difficult or impossible without significant assistance. Wildfires can create smoke that travels 50-100 miles of the fire, which can exacerbate illnesses that persons with chronic illnesses have and cause asthma, acute bronchitis, chronic obstructive disease, pneumonia (Hall 2018).	IM3	Individuals with compromised immune systems or other chronic illness can try to limit outdoor activities, obtain mobile oxygen, or use indoor air purifiers. However, this may be insufficient for particularly sensitive persons, who may require medical attention during fire events. Ability to adapt to situations requiring evacuation are extremely limited.	AC1
V4	Individuals with disabilities		Persons with disability could have limited mobility and could be medically dependent on electric devices. They may not be able, or are less willing, to evacuate in emergencies due to dependence on devices. If evacuation is required, they are more likely to suffer physical injury and to lose their medication and assistive devices, and have care-giving support disrupted or lost. Physically disabled individuals may have limited mobility in case of an evacuation and breathing problems could be aggravated by smoke. Mentally disabled individuals may not be fully aware of resources and procedures.	IM3	Mobility is a major concern for people with disabilities. Although some technology and devices can increase mobility, these individuals may still be severely limited. These individuals also may be limited in the places and living environment in order to receive the care they need. Those who choose to/can afford to live in a group living environment could have more resources and support on hand.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Individuals without access to lifelines		Individuals without access to lifelines have less notification of events and may be unable to evacuate quickly if needed. The lack of vehicle access may make it difficult for such individuals to run errands during poor air quality events. Individuals without access to communications may not be aware of evacuation notifications, closures, or other vital news in the event of a local fire.	IM3	Individual without access to important transportation and communication lifelines will very likely need assistance if evacuation is necessary. Individuals may set up their own support network that could offer transportation in case of poor air quality or evacuation. However, those with limited social networks could not adapt in this way. In these cases, individuals will be fully reliant on emergency services.	AC1
V4	Outdoor workers		Approximately 10% of the sub region work in outdoor-oriented fields such as agriculture, forestry, and construction. Individuals that work outdoors are likely to have more direct and extended exposure to smoke in the air quality caused by wildfire.	IM3	Without action by employers or regulators, outdoor workers ability to adapt without risk to employment is low.	AC1
V4	Persons in mobile homes		Mobile homes, similar to most homes, are at risk of being burnt by wildfires. Mobile homes may not be built to the same fire safe standards as other homes older mobile homes may not be well-maintained, which can increase the susceptibility to wildfire damage.	IM3	Creating defensible space around mobile homes may be difficult depending on the location, home placement, and the rights that residents have to the land around their homes. Persons living in mobile homes are more likely to have lower income levels, which can make it more difficult for them to mitigate their homes or take preventative action.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Seasonal residents / Migrant workers		Seasonal workers are typically lower income and less aware of community resources and safety nets. They also have less control over their living environment. Additionally, these workers tend to be outdoor workers and therefore are more susceptible to poor air quality that typically accompanies wildfire events.	IM3	Without action by employers or regulators, migrant workers ability to adapt without risk to employment is low.	AC1
Buildings and Infrastructure						
V4	Energy transmission /delivery infrastructure		High voltage transmission lines run through moderate to very high fire hazard severity zones within the WRCOG subregion. Electrical lines and the poles that support them can be damaged or destroyed by the flames and high temperatures created by wildfires. This can cause residents and businesses within the region to lose power if the electricity lines fail, causing economic hardship and potential public safety concerns.	IM3	Substations are usually surrounded by defensible space, and power lines too (to a lesser extent). State law requires utility companies to keep set distances between power lines and vegetation, depending on the line's voltage. These measures provide a reasonable degree of protection but may not be sufficient for all blazes.	AC1
V4	Evacuation routes		Many evacuation routes are located within the wildland urban interface or areas with high fire threats. Wildfires can block evacuation routes, rendering them impassable for those who depend on them to evacuate during mandatory evacuations.	IM3	Evacuation routes can be cleared for defensible space and redundant roads can be created to ensure that people can evacuate safely. However, this may not always be possible, especially for the routes that are located in the mountains on single access roads.	AC1

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Older residential structures		Older homes in the urban/wildlands interface, may lack fire-resistant features found in more modern buildings. Only 18% of county-wide homes were built before 1970. 51,875 acres of residential land in the WRCOG sub-region currently lies within an elevated fire risk area, which is expected to increase to 107,749 acres around 2039, but decline to 60,439 acres by 2099. It is unknown how much of this acreage is comprised of older homes, but given the relatively new nature of homes in Riverside County, it is reasonable to assume that older homes are the minority.	IM3	Structures can be retrofitted to be more fire resistant, and defensive space can be created. However, such efforts may not be economically feasible for some homeowners. Over 80% of the homes in Riverside County were built after 1970, and such homes may already incorporate defensive features. Homes are required to have 100 feet of cleared brush around them, but enforcement may be challenging.	AC1
V4	Public open space and protected land		Public space & protected lands are located within the mountainous of hillside regions of the WRCOG subregion, which are also within high or very high fire hazard severity zones. A wildfire can destroy park buildings and infrastructure that may be on the land, in addition to the natural vegetation within the open space.	IM4	Public land and open space can be managed to reduce the fuel load and overall risk of wildfire. If left to recover, over time these areas can typically recover to functioning recreation areas or preserves.	AC2
V4	Residential structures		Houses near high fire areas are at increased risks of burning. 1,875 acres of residential land in the WRCOG sub-region currently lies within an elevated fire risk area, which is expected to increase to 107,749 acres around 2039, but decline to 60,439 acres by 2099.	IM4	Homeowners can take a number of steps to reduce their vulnerability to fires, including using fire-resistant building materials, and creating and maintaining defensible space. Homes are required to have 100 feet of cleared brush around them, but enforcement may be challenging.	AC2
Biological Resources						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V5	Riparian scrub, woodland, and forest		Historically, riparian areas acted as natural fire barriers due to the high-water content of foliage. The recent invasion of non-native species (salt cedar, arundo) has greatly increased fire fuel loads and disrupted the fire barrier function of riparian corridors.	IM4	Invasion by exotic species has decreased the adaptability of riparian communities to fire. These invasive are able to recover quickly and expand their range post-fire, thus increasing fuel loads, leading to a destructive cycle. Native trees are less tolerant of direct exposure to fire. Succession of riparian areas from exposed alluvial soil to mature riparian forest and woodland may take 50 to 75 years or more.	AC1
V4	Montane coniferous forest		Montane coniferous forests have been naturally/historically subjected to small, relatively frequent lightning fires. This community typically experiences fewer large fire events than communities at lower elevations. Fire suppression practices have resulted in higher risk conditions for severe fires. Higher risk conditions include an increase in accumulated fuel load in the form of leaf litter and dead/dying trees.	IM4	Many species in montane coniferous forests are dependent upon fires for reproduction. For example, knobcone pines and Tecate cypress will only release seeds from their cones in the presence of fire. Montane coniferous forests are adapted to small, relatively frequent fires. For example, Jeffrey pine forests are adapted to fire intervals of approximately 26 years, which is enough to burn accumulated fuel loads, encourage seedbed growth, stay relatively small in size, and result in few crown replacements. Fire suppression has increased fuel loads and results in severe fires that are fatal to trees. In addition, fire suppression leads to reduced recruitment of large trees due to competition with shade tolerant understory trees.	AC2

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Woodland and forests		Historically, woodland areas were subject to low intensity passing fires. Similar to other communities, the invasion of non-native annual species has greatly increased the risk of severe fire events.	IM4	Woodland and forests in the region are adapted to infrequent, less intense passing fires. Many trees have thick bark, making them resistant to low intensity fire events. Many species are able to reroute following more intense fires; however, severe fires are often fatal. Following fire, shrubs rapidly repopulate, competing with oak seedlings. Junipers are susceptible to extirpation following severe fires due to slow reproductive process.	AC2
Important Economic Assets						
V4	Renewable energy		Hydro-electric facilities and wind farms are within high fire hazard severity areas. Fires can harm these renewable energy facilities and cause them to not function properly. Smoke from wildfires may also impact the effectiveness of solar arrays.	IM3	Defensible space and fire suppression can be created surrounding hydro-electric and wind farms. However, this may be expensive to complete or not always possible on steep hillsides. Solar arrays may generate less energy if smoke persists.	AC1
Key Community Services						

Vulnerability Score	Sensitivity	Sensitivity Type	Impact Explanation	Impact Score	Adaptive Capacity Explanation	Adaptive Capacity Score
V4	Electricity		Wildfires can damage or destroy energy delivery infrastructure, which can cause power outages that can last for days or weeks depending on the severity of the event. This can directly harm the economy, government operations, public safety, and hinder wildfire recovery efforts.	IM3	SoCal Edison, who manages the electricity lines, can clear vegetation around powerlines to ensure that energy delivery is not disrupted. In many areas, it would be extremely difficult and expensive to underground powerlines, especially high voltage lines that go through the hillsides. Substations can be cleared of vegetation and retrofitted with fire retardant materials, but this may not be effective at maintaining the capacity of all substations during a wildfire.	AC1
V4	Water delivery		Wildfires in the WRCOG subregion could impact the reservoir water sources. Water quality can be degraded due to ash content or fire retardants that make their way into surface water storage. This may reduce the overall quantity of water that the water districts have to supply agricultural, commercial, and residential demands.	IM3	Contaminated water supplies can be filtered to remove contaminants from drinking water. Treatment plants can also be upgraded to clean this water. However, this may be expensive and may take weeks or months to complete after a fire occurs. Additional water supplies come from groundwater, which may be limited in supply due to regional laws and drought conditions.	AC1

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SUMMARY OF VULNERABILITY ASSESSMENT RESULTS

POPULATIONS AND ASSETS	AGRICULTURAL PESTS AND DISEASES	AIR QUALITY	DROUGHT	EXTREME HEAT	FLOOD	HUMAN HEALTH HAZARDS	LANDSLIDES	SEVERE WEATHER	WILDFIRE
POPULATIONS									
Children age <10		V4		V4		V2			V4
Ethnic communities/non-English speakers		V2		V2	V1	V2		V3	V2
Healthcare workforce (doctors, nurses)				V1	V1	V3		V1	V2
Homeless persons		V5	V3	V5	V4	V5		V5	V5
Household renters		V2	V3	V2	V2		V2	V3	V2
Householders age >65		V3		V4	V3	V3	V4	V2	V4
Households in poverty		V4	V4	V4	V4	V3	V3	V3	V4
Households overpaying for housing (>30% of income)		V3	V2	V2	V3	V1	V2	V1	V2
Individuals chronically ill		V4	V1	V4	V3	V5	V3	V4	V4
Individuals uncertain about available resources because of citizenship		V2		V2	V2	V2		V3	V2
Individuals with disabilities		V2		V3	V3	V2	V3	V3	V4
Individuals without access to lifelines		V3		V3	V4	V3	V3	V3	V4
Low-income individuals		V3	V4	V4	V4	V3	V2	V2	V3
Outdoor workers	V3	V5	V4	V5	V2		V1	V3	V4
Overcrowded households		V2	V1		V2	V2		V1	V2
Persons in mobile homes		V3		V3	V4	V1	V4	V4	V4
Pregnant or nursing women		V4		V3	V1	V5		V1	V2

POPULATIONS AND ASSETS	AGRICULTURAL PESTS AND DISEASES	AIR QUALITY	DROUGHT	EXTREME HEAT	FLOOD	HUMAN HEALTH HAZARDS	LANDSLIDES	SEVERE WEATHER	WILDFIRE
Seasonal residents/migrant workers		V5	V4	V4	V2	V2	V2	V3	V4
Senior citizens living alone		V4		V5	V4	V4	V5	V3	V5
BUILDINGS AND STRUCTURES									
Adult residential care facilities							V2	V1	
Airports				V2	V4			V1	V3
Bridges					V3		V3	V3	V2
City Halls and government offices					V2		V1	V1	V2
Commercial structures					V4		V1	V3	V3
Communication infrastructure				V1	V2		V2	V2	V2
Community gathering areas					V1		V1	V1	V2
Dams					V1		V4	V1	V1
Emergency Systems					V1			V1	
Energy generation infrastructure		V2	V2		V2		V3	V2	V3
Energy transmission/delivery				V4	V3		V3	V4	V4
Evacuation routes					V3		V3	V2	V4
Fire stations					V1		V2	V1	V1
Flood control center					V2			V1	V1
Foster homes					V3			V3	V3
Fueling infrastructure and pipelines				V1	V3		V3	V2	V3
Healthcare facilities				V1	V2		V1	V2	V3
Industrial structures					V3		V4	V3	V2

POPULATIONS AND ASSETS	AGRICULTURAL PESTS AND DISEASES	AIR QUALITY	DROUGHT	EXTREME HEAT	FLOOD	HUMAN HEALTH HAZARDS	LANDSLIDES	SEVERE WEATHER	WILDFIRE
Major roads and highways				V3			V3	V2	V3
Military facilities									V1
Natural gas facilities					V2		V4		V3
Old residential structures				V2	V3		V3	V3	V4
Parks	V1		V1	V2	V2		V3	V3	V2
Police/sheriff stations					V2			V1	V1
Private recreational sites	V1		V2	V2	V1		V2	V2	V2
Public housing					V3			V3	V3
Public open space and protected land	V2		V3	V1	V1		V2	V3	V4
Public works corporation yards					V1			V1	
Railway				V4	V4		V4	V3	V2
Residential structures					V4		V4	V2	V4
Road signals/traffic control centers					V1		V2	V2	V3
Schools and childcare centers					V3		V3	V2	V2
Senior care centers					V3		V2	V1	V3
Sidewalks, bikeways, trails					V2		V3	V1	V2
Transit infrastructure					V3		V2	V3	V2
Transportation facilities and infrastructure				V1	V3		V2	V2	V3
Wastewater treatment plant and collection infrastructure			V2	V1	V4		V3	V2	V1
Water treatment plant and delivery infrastructure			V1	V1			V3	V2	V1

POPULATIONS AND ASSETS	AGRICULTURAL PESTS AND DISEASES	AIR QUALITY	DROUGHT	EXTREME HEAT	FLOOD	HUMAN HEALTH HAZARDS	LANDSLIDES	SEVERE WEATHER	WILDFIRE
BIOLOGICAL RESOURCES									
Chaparral	V3		V3	V3			V2	V2	V3
Coastal sage scrub	V2		V2	V3	O		V3	V1	V3
Desert scrub	V1		V1	V1			V1	V1	V3
Grassland	V2		V3	V2	O		V2	V2	V2
Meadows and marshes	V2		V5	V4	O			V2	V2
Montane coniferous forest	V4		V5	V3			V2	V2	V4
Playas and vernal pools	V1			V3	O			V2	V2
Riparian scrub, woodland, and forest	V3		V4		O		V3	V3	V5
Riversidean alluvial san sage scrub	V2		V3		V1		V1	V1	V3
Woodland and forests	V4		V3				V3	V2	V4
IMPORTANT ECONOMIC ASSETS									
Agricultural lands	V4	V2	V4	V4	V4		V3	V4	V3
Renewable energy		V2	V1	V1	V1		V1	V2	V4
State and federally owned land	V2		V3	V3	V1	V2	V3	V1	V3
Tourism	V1	V3	V2	V2	V2	V3	V2	V2	V3
KEY COMMUNITY SERVICES									
Communications				V2	V1		V1	V2	V3
Electricity			V2	V4	V2		V3	V4	V4
Emergency medical response				V1	V2	V2	V2	V2	V2
Government administration		V1			V1	V1			V1

POPULATIONS AND ASSETS	AGRICULTURAL PESTS AND DISEASES	AIR QUALITY	DROUGHT	EXTREME HEAT	FLOOD	HUMAN HEALTH HAZARDS	LANDSLIDES	SEVERE WEATHER	WILDFIRE
Healthcare service delivery		V2		V1	V1	V3	V1	V1	V1
Natural gas							V3		V3
Public safety				V1	V2	V2	V3	V2	V3
Transit access				V3	V2		V2	V3	V2
Wastewater treatment			V3	V2	V4		V2	V3	V3
Water delivery			V4	V2			V3	V1	V4

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GLOSSARY OF TERMS

Adaptation – Adjustments in natural or human systems in response to actual or expected climate changes or their effects which minimize harm or take advantage of beneficial opportunities (California Natural Resources Agency 2009).

Adaptive Capacity – The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences (California Natural Resources Agency 2009).

Adaptation Strategy – An action taken to protect an asset or community from climate change impacts.

Arizona Crossing – A type of road crossing, also known as a ford, that allows a small waterway to pass over the roadbed. Arizona crossings are common in desert environments, where waterways usually do not contain enough water to affect traffic.

Atmospheric River – An atmospheric river is a narrow section of the atmosphere that transports large amounts of water vapor, which often turns into precipitation when the atmospheric river travels over land (NOAA 2015).

Climate – The long-term average of meteorological conditions (temperature, precipitation, wind, etc.) at a particular location or over a broader area (IPCC 2013).

Climate Change – Any long-term change in average climate conditions in a place or region, whether due to natural causes or as a result of human activity (California Natural Resources Agency 2009).

Climate Variability – Variations in the mean state of the climate and other statistics (such as standard deviations or the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events (California Natural Resources Agency 2009).

Cooling Center – A designated public facility, often air-conditioned, where people may go for relief during periods of extreme heat.

Culvert – A tunnel carrying water under a road or railroad.

Energy Conservation – Saving energy by reducing or going without an energy-using service, such as turning off a light when leaving the room or unplugging an appliance that is not in use (Lawrence Berkeley National Laboratory 2014).

Energy Efficiency – Saving energy by using less energy to provide the same or better service, such as replacing a washing machine with a model that washes clothes as effectively as the previous device but requires less energy (Lawrence Berkeley National Laboratory 2014).

Evapotranspiration – The sum of water lost through evaporation off of surfaces, and water lost through the pores of a plant as part of its normal respiratory cycle (a process called transpiration) (US Geologic Survey 2014).

Exposure – The degree to which a community or asset will experience a climate hazard.

Heat wave – There is no single quantitative definition of a heat wave. The Cal-Adapt online tool defines a heat wave as a period of 4 consecutive extreme heat days or warm nights when the daily

maximum/minimum temperature is above an extreme heat threshold (>98th historical percentile based on historical data from 1961-1990 and between April and October) (CEC 2019).

Hydroperiod – The seasonal pattern of the water level in a particular environment (US Forest Service, n.d.)

Impact – An effect of climate change on the structure or function of a system (California Natural Resources Agency 2009).

Mitigation – In hazard mitigation planning, mitigation means “sustained action taken to reduce or eliminate the long-term risk to human life and property from natural, human-caused, and technological hazards and their effects. Note that this emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery” (California Governor’s Office of Emergency Services 2018).

Renewable Energy – Energy sources that restore themselves over short periods of time and do not diminish. In California, this includes solar, wind, geothermal, biomass, and limited types of hydroelectric generation (California Public Resources Code, n.d.)

Resilience – The ability of a community, natural resource, or system to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC 2007).

Resource Conservation – Reducing the use of a resource (water, electricity, fuel, etc.) by reducing the use of services or devices that require the resource; in short, doing less with less (US Environmental Protection Agency 2014; Lawrence Berkeley National Laboratory 2014).

Resource Efficiency – Reducing the use of a resource (water, electricity, fuel, etc.) by using less of the resource to provide the same service; in short, doing the same or more with less (US Environmental Protection Agency 2014; Lawrence Berkeley National Laboratory 2014).

Risk – The possibility of interaction of physically defined hazards with the exposed systems. Risk is commonly considered to be the combination of the likelihood of an event and its consequences—i.e., risk equals the probability of climate change impact occurring multiplied by the consequences a given system may experience (California Natural Resources Agency 2009).

Sensitivity – A structure, function, or population that could be affected by climate change (Cal OES and CNRA 2012).

Snowpack – A seasonal accumulation of slow-melting snow. In California, the snowpack acts as a reservoir to provide water during drier months (IPCC 2007).

Sustainability – A process in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspiration; sustainability integrates the political, social, economic, and environmental (IPCC 2007). A more common and concise definition of sustainability is a system that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987).

System – A human population or ecosystem; or a group of natural resources, species, infrastructure, or other assets (California Natural Resources Agency 2009).

Urban Heat Island – A phenomenon in which developed areas are warmer than rural zones due to the prevalence of impermeable, dry, and heat-absorbing surfaces (such as asphalt and concrete) in urban areas (Akbari 2005).

Urban-Wildland Interface – The transition area between wild areas and the urban/developed zone (California Fire Science Consortium n.d.)

Vulnerability – A susceptibility to harm or change. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its adaptive capacity (California Natural Resources Agency 2009).

Water Conservation – Saving water by reducing the use of services that require water, such as replacing a lawn with plants that require little or no irrigation (US Environmental Protection Agency 2014).

Water Efficiency – Saving water by using less water to provide the same or better service, such as a faucet with a model that satisfies the same needs as the previous faucet but requires less water (US Environmental Protection Agency 2014).

Weather – The meteorological conditions (temperature, precipitation, wind, etc.) at a specific location and moment (IPCC 2013).