Southern California Climate Overview

An Important Note About this Document: *This document summarizes existing climate information for southern California from the scientific literature. The aim of this document is to provide an overview of historical, current, and projected climate changes in the region, and to provide a foundation for assessing habitat vulnerability to changing climate conditions.*

Temperature

In California between 1918-2006 the average minimum temperature (Tmin) increased at a rate of +0.17°C per decade and the maximum temperature (Tmax) increased by +0.07°C per decade; this warming trend became most pronounced during the last ~40 years (Cordero et al. 2011). During the period from 1970-2006, maximum and minimum temperature warming trends were substantially larger (Tmax: +0.27°C per decade, Tmin: +0.31°C per decade) than the period between 1918-2006, which is comparable to global warming trends and indicative of anthropogenic influence (Cordero et al. 2011). However, changes in climate vary spatially and temporally; in California, the southern region is experiencing significantly more warming (Tmax: +0.41°C per decade, Tmin: +0.37°C per decade) than the rest of the state with the greatest warming occurring in the spring (March, April, and May) (Cordero et al. 2011). In addition, heat wave activity increased across California between 1950-2010, with humid, nighttime events increasing more rapidly than daytime events (Gurshunov and Guirguis 2012). Peak heat wave season occurs in late July for inland areas, while coastal areas have a longer heat wave season that peaks around September, as Santa Ana winds bring hot desert air from the Great Basin to the coast (Gurshunov and Guirguis 2012). Increased frequencies of heat waves are more prominent in urban areas due to urban heat island effects (Mishra et al. 2015). In southern California, urban areas experienced a higher frequency of extreme heat (> 99^{th} percentile) temperatures compared to non-urban areas between 1972 and 2012 (Mishra et al. 2015). Urban heat island effects also contributed to decreased wind events, further exacerbating temperature extremes and likely contributing to the comparatively higher temperatures experienced at night as a result of the reduced ameliorative effects of wind on temperature and humidity (Mishra et al. 2015).

Considerable uncertainty exists when estimating future climatic changes even at large scales. Further uncertainty is incorporated into estimates when models are downscaled to gain insight into regional climatic impacts. Because of this, few models have attempted to predict climatic changes for California, and those that have present a broad range of potential changes (Sawyer et al. 2014). To ameliorate the varied 21^{st} century climate change projections provided by many models, Dettinger (2005) combined six popular models and produced a projection distribution function to identify the most common, and presumably most likely, increase in temperature by 2100. Dettinger (2005) found that the most common temperature increase for California by 2100 was approximately +5°C, but spread between +2.5 to +9°C. Heat wave conditions (3 or more days with temperatures above 32°C) are projected to occur more frequently in California by the end of the century (Gurshunov and Guirguis 2012), and are expected to last longer, feature higher temperatures, and affect larger geographic areas (Gershunov et al. 2013). Humid nighttime heat waves are projected to show a greater increase in frequency than daytime events, particularly in coastal areas including southern California (Gurshunov and Guirguis 2012).

Precipitation

Southern California receives a majority of its precipitation between October and April (Hughes et al. 2009). In comparison to other Mediterranean climates around the globe, southern California has the most severe summer drought, with only 5% of annual precipitation occurring during summer months (Cowling et al. 2005). In general, California experiences large inter-annual variations in precipitation compared to the rest of the U.S.; precipitation patterns are linked with large-scale climatic forcings such as the El Niño Southern Oscillation (ENSO) and the Pacific/North America Pattern (PNA) (Dettinger et al. 2011; Berg et al. 2014 and citations therein), and subsequent shifts in the jet stream and storm tracks (Neelin et al. 2013; Berg et al. 2014). El Niño phases and positive phases of the Pacific Decadal Oscillation (PDO) are typically associated with wetter than average conditions (Dettinger et al. 2011; Berg et al. 2014 and citations therein). The majority of annual precipitation in southern California falls during a few (5-15) wet days per year, resulting in high 3-day storm totals (Dettinger et al. 2011). Atmospheric rivers are responsible for 20-50% of California's annual precipitation (Dettinger et al. 2011), and atmospheric 'blocking' episodes, which divert storms over southern California, usually result in heavy rains (Carpenter et al. 2007).

Complex topography also contributes to precipitation variability in southern California. The coastal mountains feature significant orographic enhancement of precipitation; higher elevations typically receive more precipitation than lower elevations, and a rain shadow exists on interior slopes (Hughes et al. 2009). However, orographic blocking events, where warm air is forced to rise before the topography changes, can increase precipitation volumes in low elevation coastal areas and in interior basins of southern California (Hughes et al. 2009).

Historical records of precipitation throughout California contain a high degree of variability, making it difficult to measure comparative changes in annual means between recent and historical periods (Thorne et al. 2012; Flint et al. 2013; Sawyer et al. 2014). This data is also sensitive to differences in time-slice interval selection by researchers, creating seemingly contradictory conclusions of historical precipitation changes reported in the literature (Thorne et al. 2012; Flint et al. 2013; Sawyer et al. 2014). For example, Sawyer et al. (2014) found that large-scale models (PRISM) indicate a general decline in annual precipitation by up to 250 mm in southern California since the early 1900s (1930-2000), but selected site-specific data show no trends. Whereas Flint et al. (2013) and Thorne et al. (2012) measured the change in annual precipitation for the latter half of the century and found that since 1950, annual precipitation has increased up to +13% in southern California. Concurrent to the high variability of precipitation regimes, the number of extreme precipitation events in southern California showed a slight increase between 1950-2009 (Mass et al. 2011); these events also show high local variability in frequency and intensity (Carpenter et al. 2007; Mass et al. 2011).

Precipitation projections in southern California are uncertain and range from substantial declines to moderate increases (Tague et al. 2009; Berg et al. 2014). It is likely that shifts in mean precipitation by the end of the century will be minor compared to the natural inter-annual variability of this study region (Berg et al. 2014). However, the most significant change may be in the form in which precipitation arrives. There seems to be a consensus that winters will experience more rain and summers will be drier (Field et al. 1999 and Gabet and Dunne 2003 cited in Sawyer et al. 2014), but temperature increases may drive shifts from snow to rain, especially at lower elevations (Hayhoe et al. 2004; Sun et al. 2013). In addition, shifts in jet stream strength and positioning could significantly affect the direction and magnitude of precipitation patterns in the study region; increased jet stream strength off the southern California coast and/or eastward and poleward shifts in jet stream positioning would likely lead to regional increases in winter precipitation (Neelin et al. 2013; Berg et al. 2014).

Snowpack & snowmelt

The majority of regional snowfall in southern California occurs from December to March (Sun et al. 2015). The snowline lies around 1200 m, and snowfall increases with elevation and along mountainous westward slopes (Sun et al. 2015). Significant snowfall and accumulation can occur at or above 2000 m in mountainous portions of southern California, while high elevation desert regions may see episodic snowfall, but rarely have accumulation (Sun et al. 2015).

In areas that experience snowfall, there are significant declining trends in annual snowfall amounts (Sawyer et al. 2014). In the western United States annual snowpack and spring runoff are declining and snowmelt and runoff are occurring earlier (Mote et al. 2005). In a study by Flint et al. (2013), mean April 1st snow-water equivalent (SWE) in southwestern California declined -17% between 1981-2010 compared to the baseline period (1951-1980).

Relative to 1981-2000, mountain areas in southern California are, on average, projected to see a 30% reduction in snowfall by mid-century (2041-2060) and a 50% reduction of snowfall by the end of the century (2081-2100) under a “business-as-usual” emissions scenario (Sun et al. 2015). Snowfall loss is projected to be greatest at lower elevations; low-lying areas under 1500 m are projected to lose 50% of their snowfall by mid-century, while high elevation areas (above 2500 m) are projected to lose only 10% of their snowfall during the same time period (Sun et al. 2015). By the end of the century, however, low elevations are projected to see an 80% reduction in snowfall, while mid-elevation and high-elevation sites may lose 50% and 20%, respectively; it is likely that there will also be a reduction in the total area experiencing snowfall (Sun et al. 2015). In addition, Sun et al. (2015) hypothesize that by mid-century, spring snowmelt may occur 1-3 weeks earlier on average in mountainous areas of southern California.

Stream flows

High stream flow volumes in southern California are linked with both precipitation (Carpenter et al. 2007; Dettinger et al. 2011) and snowmelt (Berg et al. 2014). Precipitation falling during atmospheric river events accounts for ≥ 50% of overall stream flow volume in coastal California basins, and 30-50% of overall stream flow volume in more inland basins (i.e., in the Peninsular Range) (Dettinger et al. 2011). Further, stream flow rates during atmospheric rivers are twice the mean rates for the same time of year in the absence of precipitation events (Dettinger et al. 2011). Flash floods are common during extreme precipitation events, especially in coastal mountain ranges with thin soils and steep topographies (e.g., San Gabriel Mountains, San Bernardino Mountains) (Carpenter et al. 2007).

Trends in annual average runoff over the past 30 years generally show increased runoff for the central coast, the Mojave Desert, and the Sonoran Desert, but disagree in runoff trends for southwestern California (Thorne et al. 2012; Flint et al. 2013). For example, Flint et al. (2013) found that mean runoff declined -3% in southwestern California from 1981-2010 compared to baseline measurements (1951-1980). Alternatively, Thorne et al. (2012) found that runoff increased 37% in southwestern California between 1971 and 2000, and was higher than mean runoff during previous time periods (1911-1940 and 1941-1970). From 1948-2002, the spring pulse onset and the center mass of annual flow occurred earlier in southern California study sites compared to historical timing due to elevated spring temperatures (Stewart et al. 2005). Over the past 100 years in the San Joaquin basin, annual runoff has decreased by -19% as a result of the earlier onset of snowpack melt (Moser et al. 2009).

Although California hydrology models vary by basin, there is an overall consensus among future projections that increasing temperatures driven by climate change will lead to an earlier and shorter spring snowmelt and an increase in winter runoff (Vicuna and Dracup 2007), with implications for flood risk (Blickenstaff et al. 2013). Within the Los Angeles Basin, annual storm water runoff volume is projected to increase between +4 and +37% by the end of the century, while peak flow rates could increase by +6 to +48% over the same time period (Alexanderson and Bradbury 2013). Similarly, projections for the Santa Ana River watershed indicate increased flood risk, with increased 200-year flood magnitudes and shorter recurrence intervals (Blickenstaff et al. 2013). However, runoff and hydrological projections are highly variable among climate models, making future runoff projections uncertain (Vicuna and Dracup 2007; Thorne et al. 2012; Alexanderson and Bradbury 2013; Blickenstaff et al. 2013).

Soil moisture & groundwater recharge

Due to the combination of altered timing and quantity of snowpack, spring runoff, and spring and summer precipitation coupled with increasing temperatures and evapotranspiration, groundwater recharge is occurring earlier in the spring, leading to earlier and longer dry periods in the summer (Hamlet et al. 2007). Between 1981-2010, mean climatic water deficit (a measure of soil moisture) increased by +1 to +3% across California compared to baseline conditions (1951-1980), mirroring increases (+2 to +3%) in potential evapotranspiration (Flint et al. 2013). Groundwater recharge occurs when soil moisture storage is exceeded and surface water is converted to runoff or percolates into bedrock (Flint et al. 2013). Groundwater recharge was more variable between 1981-2010, with southwestern California experiencing declines (-5%), the central coast experiencing slight increases (+4%), and the Mojave and

Sonoran Desert regions experiencing significant increases (+26% and +35%, respectively) (Flint et al. 2013). More recently (2010-2014), however, groundwater levels have decreased across the state with some areas experiencing a decline of 30 m (100 ft) or more below previous historical lows (California Department of Water Resources 2014). Because topographic and geologic variability influence soil moisture at local scales, some areas may be more resilient to increasing temperatures and soil moisture loss (e.g., north-facing slopes and areas with deeper soils may retain more moisture) (Flint et al. 2013).

Modeling by Thorne et al. (2012) project that loss of snowpack, an earlier onset of spring snowmelt, warmer air temperatures, and increased potential evapotranspiration will lead to increases in climatic water deficit in California by the end of the century, regardless of changes in mean precipitation. Recharge projections are more variable. For example, southwestern and central western California could experience slight recharge increases under a warmer, wetter scenario (PCM) or significant decreases under a warmer, drier scenario (GFDL) (Thorne et al. 2012).

Drought

California is currently experiencing a severe drought, which began in 2012. Studies report contradictory results on the record-breaking status of the drought from 2012-2014, due in part to differences in the metrics used to report drought severity. However, multiple studies found that 2014 was the most severe drought year recorded (Griffin and Anchukaitis 2014; Williams et al. 2015), and additional records were broken regionally in coastal regions (Williams et al. 2015). Precipitation has been low but not unprecedented; however, high temperatures have exacerbated the current drought (Griffin and Anchukaitis 2014; Williams et al. 2015), accounting for 8-27% of the drought during the 2012-2014 period and 5-18% of the 2014 drought year (Williams et al. 2015). In fact, years with low precipitation are twice as likely to become drought years when temperatures are high (Diffenbaugh et al. 2015).

Droughts have always been common in southern California, including periods of time during the Dust Bowl, 1950s, 1970s, and late 1980s (Griffin and Anchukaitis 2014). Based on paleoclimate reconstructions using tree ring records, mega-droughts lasting for decades or centuries occurred in the Southwest and Central Plains during the Medieval Warm Period between 900 and 1300 CE (Cook et al. 2015; MacDonald et al. 2008).

Over the coming century, the risk of drought is expected to increase dramatically, as warming temperatures continue to exacerbate conditions in years with low levels of precipitation, causing more severe droughts than have previously been observed in even the driest Medieval centuries (Cook et al. 2015). Over the next several decades, drought is twice as likely to occur (Diffenbaugh et al. 2015). For the late 21st century high-emissions scenario, the risk of decadal or multi-decadal drought occurrences are 80%; under medium-emissions scenario the risk is reduced but still significant (Cook et al. 2015).

Wildfire

Across the western United States, warmer and drier conditions have increased wildfire frequency and intensity in recent years (Westerling et al. 2006; Westerling and Bryant 2008). This is particularly acute in lowland chaparral-grassland ecosystems, which represent more than a third of National Forest land in southern California (Fried et al. 2004 cited in Sawyer et al. 2014). Although wildfire has always been an important ecological driver in southern California, the combined influence of warming temperatures, variable precipitation patterns, extreme wind events, and increased anthropogenic ignitions, have resulted in decreased fire return intervals in lowland ecosystems (Pinol et al. 1998, Riera et al. 2007 cited in Sawyer et al. 2014). Historically, chaparral-grassland dominated systems of southern California had fire return intervals of 60-100 years (Keeley and Fotheringham 2001). Although changes in fire size and the proportional area burned by large fires in southern California is debated (Sawyer et al. 2014), there is consensus that fire frequency has increased, reducing the fire return interval to its current rate which may be as low as 10-20 years in chaparral-grassland systems, potentially furthering their expansion (Safford 2007).

In contrast to low- and mid-elevation chaparral-grassland ecosystems, fire return intervals at higher elevations in southern California have increased relative to pre-Euroamerican settlement periods (Sawyer et al. 2014). Historically, fires occurred frequently in conifer forests of southern California, however, fire suppression efforts beginning around 1900 have decreased the frequency of burning (Safford 2007). The lengthening of fire return intervals as a result of fire suppression tactics allowed for the accumulation of fuels in forest stands, creating conditions that favor intense, large-scale, stand-replacing wildfires, the effects of which have become increasingly apparent in recent years (Keeley et al. 2009; Sawyer et al. 2014). Consequently, stand-replacing fires are facilitating a compositional shift of conifer forests towards fire-tolerant species and systems such as chaparral-grassland (Minnich 2007; Westerling and Bryant 2008).

Under most future climate scenarios in California, fire activity is projected to increase due to increased fuel growth from increased carbon dioxide, decreased fuel moistures from warmer temperatures, and increased thunder cell activity (Price and Rind 1994, Miller and Urban 1999, Lenihan et al. 2003, 2008, Westerling and Bryant 2006 cited in Sawyer et al. 2014). Due in part to altered atmospheric circulation patterns that control the timing and extent of Santa Ana winds, more frequent high wind events occurring during the critical late fire season, combined with increased frequency of anthropogenic ignitions, will likely prolong the fire season and increase the frequency and intensity of wildfires (Miller and Schlegel 2006; Sawyer et al. 2014). Additionally, coupled with increasingly frequent fires, the conversion from shrublands to grasslands will likely create conditions for larger, more frequent fires as well (Sawyer et al. 2014). However, lower moisture availability may limit fine fuel production and contribute to decreased fire risk in parts of southern California (Westerling and Bryant 2008).

Vegetation shifts

Kelly and Goulden (2008) found that the average elevation of dominant plant species in the Santa Rosa Mountains in 2006-2007 was roughly 65 m (213 ft) higher than in 1977, and attributed this elevational shift to regional climate variability. Shifting temperatures, precipitation, fire regimes and climatic water deficit, as well as non-climate stressors (i.e., invasive species) are likely to affect species ranges in the future (Lenihan et al. 2008; Thorne et al. 2012; Sawyer et al. 2014). Lenihan et al. (2008) project a decline in evergreen conifer forests, mixed evergreen woodlands, and shrublands in California by the end of the century, with increases in mixed evergreen forests and grasslands. Desert vegetation may increase in extent under drier conditions, or decrease in extent under wetter conditions (Lenihan et al. 2008).

Recommended Citation

EcoAdapt. 2016. Southern California Climate Overview. Version 1.0. EcoAdapt, Bainbridge Island, WA.

This document is available online at the EcoAdapt website (http://ecoadapt.org/programs/adaptation-consultations/socal).

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Summary of Climate-Related Changes in Southern California

Climate variable	Historical changes	Direction and range of projected future change	Seasonal patterns of change	Confidence
Air temperature	Since 1970 in southern California • Average maximum temp increased +0.41°C per decade • Average minimum temperatures increased +0.37°C per decade[1] Between 1950-2010, heat wave activity increased across California • Humid, nighttime events increased more rapidly than daytime events[2] Urban heat island effects have: • Enhanced extreme high temperatures during heat waves • Reduced ameliorating wind events, further exacerbating heat wave events[3]	Most likely projections for statewide temperature changes by 2100 include: • A +5°C increase, but model estimates range between +2.5°C and +9°C[4] • Increased frequency of heat wave events2 above with a greater relative increase in frequency of humid nighttime heat waves ○ Coastal areas will be particularly susceptible[2]	Historically, warming trends are: • Most pronounced during spring (Mar, Apr, May) • Least pronounced during winter (Dec, Jan, Feb)[1]	There is a consensus among downscaled GCM models that the temperature in California will warm in the 21st century[1,4,5] The degree of warming, however, is less certain due to chaotic inputs from the global system and future anthropogenic mitigation measures
Precipitation	Between 1930-2000 in southern California mean annual precipitation declined by as much as 250 mm[6] • The majority of precipitation fell during a few (5-15) wet days per year, resulting in high 3-day storm totals[4] • Higher elevations typically received more precipitation than lower elevations, creating interior rain shadows[7] Between 1950-2009, extreme precipitation events increased slightly, but were variable by location in southern California[8,10] In general, southern California precipitation experienced large inter-annual variability Precipitation patterns were linked to large-scale climatic forcing systems (e.g., ENSO, PNA, PDO)[4,9]	Overall, precipitation estimates for California are uncertain: • Late century estimates range from substantial declines to increases[9,10] More precipitation will fall as rain rather than snow,[5] especially at lower elevations[11] Mean precipitation shifts by the end of the century will likely be minor compared to the natural inter-annual variability of this study region[9]	There is a consensus across models indicating that winters will experience more rain and summers will be drier[6]	Overall changes in future precipitation are uncertain It is likely that California will be drier irrespective of precipitation patterns due to warmer temperatures, reduced snowpack and earlier snowmelt, and increased evapotranspiration.[12]

Climate variable	Historical changes	Direction and range of projected future change	Seasonal patterns of change	Confidence
Snowpack and snowmelt	Across California: • Snowpack and runoff are declining and snowmelt and runoff are occurring earlier in the spring[6,13] In southern California: • Areas that receive snow have experienced significant declines since 1930[13] Mean April 1st snow-water equivalent (SWE) declined 17% between 1981-2010 compared to the baseline period (1951-1980)[14]	Compared to baseline conditions (1981-2000), "business-as-usual" emission scenarios for the southern California mountains project: • A 30% reduction in snowfall by mid-century (2041-2060) and 50% reduction by (2081-2100) • Snowpack may decline by an additional 15-20 percentage points at low and middle elevations (e.g., 45-50% by 2060), and by 5 percentage points at high elevations • Spring snowmelt will occur 1-3 weeks earlier by mid-century[11]	Temperature increases will drive shifts from snow to rain during winter months, particularly at lower elevations[4,11]	Although there is uncertainty associated with the magnitude of projected snowfall loss due to downscaling of global climate models, this uncertainty generally diminishes with increasing elevation[11]
Stream flows	Between 1951-1980 and 1981-2010, mean runoff decreased by 3% in southwestern California, but increased in central western California (11%), the Mojave Desert (25%), and Sonoran Desert (17%)[14] From 1948-2002, in southern California the onset of snowmelt runoff occurred earlier due to elevated spring temperatures[15] Over the past 100 years, annual runoff has decreased by 19% in the San Joaquin basin due to earlier onset of snowpack melt[16]	Although California hydrology models vary by basin, there is an overall consensus among future projections that: • Increasing temperatures driven by climate change will lead to an earlier and shorter spring snowmelt and an increase in winter runoff in California[17] Various basins will exhibit increases in storm water volume and peak flows and reductions in flood return intervals[18,19]	The greatest impacts on stream flow will likely occur during the spring and late summer season due to earlier snowmelt and runoff and earlier and longer dry periods in the summer[5,12]	Runoff and hydrological projections are highly variable among climate models, creating uncertainty among future runoff projections[12,17,18,19]

Climate variable	Historical changes	Direction and range of projected future change	Seasonal patterns of change	Confidence
Soil moisture and recharge	Soil moisture recharge is occurring earlier in the spring leading to longer dry periods in the summer[20] In the past 4 years, groundwater declines have reached historical lows[21] Between 1951 and 2010: • Mean climatic water deficit increased by 1-3% in all areas of the study region • Potential evapotranspiration increased 2-3% • Groundwater recharge declined by 5% in southwestern California, but increased in central western California (4%) and the Mojave (26%) and Sonoran Desert regions (35%)[14]	Climatic water deficit will likely increase by the end of the century Groundwater recharge may experience modest increases or significant decreases, depending on regional precipitation[12]	A consensus among models indicates that winters will experience more rain and summers will be drier[6] In areas with snow, lowest climatic water deficits are typically in spring, coinciding with snowmelt[12]	Climatic water deficit is projected to increase under all future precipitation scenarios[12] Recharge projections are more variable, depending on changes in precipitation[12]
Drought	Drought from 2012-2014 broke multiple records for the most severe drought year (2014), lowest accumulated soil moisture, and regionally as the most severe drought in the southern California Central Valley and heavily-populated coastal areas[22,23] High temperatures exacerbated the impact of low precipitation between 2012-2014[22,23] • Anthropogenic warming accounted for 8-27% of 2012-2014 drought, and 5-18% of 2014[23] Droughts are common in southern California; the region has experienced 6 since 1900[22] Within the Southwest and Central Plains, mega-droughts occurred that lasted from decades to centuries in the Medieval warm period (between 900 and 1300 CE)[24]	Droughts are expected to be more severe than those previously experienced in the state[24] Drought years are twice as likely to occur over the next several decades[25] Between 2050 and 2100, the chance of a drought lasting 10 years or more is 80% under a high-emissions scenario (reduced risk in the moderate-emissions scenario, but still significant)[24]	Soil moisture is more likely to be very low in summers following a period of low winter precipitation, increasing the risk of drought	There is uncertainty around precipitation projections, and the metrics used for drought are often not consistent; however, climate models are able to confidently predict longer and more severe drought even when the details are uncertain

Climate variable	Historical changes	Direction and range of projected future change	Seasonal patterns of change	Confidence
Wildfire	Historically, fires in southern California occurred in lowland shrubland ecosystems at a fire return interval of 60–100 years[26] Currently, the fire return interval in shrubland communities has fallen to 10-20 years or less[27] • Fires have become larger and more severe in these ecosystems, however there is disagreement among the scientific community about whether this is accurate[6] In mid- and high elevation conifer stands, fire suppression efforts have increased fire return intervals, allowing fuels to accumulate and leading to conditions favoring high-intensity, large-scale, stand-replacing fires[6,28]	Warmer temperatures, increased fuel loading, increased human ignitions, and altered Santa Ana winds will lead to increased size, severity, and frequency of fires in the future By mid-century in California: • 10-35% increase in large fire risk • 2.5X greater area burned in shrublands[29,30]	Wildfire severity and size will likely increase during the late fire-season period due to increased Santa Ana winds and thunder cell activity[6]	Climate models indicate future conditions will be more conducive to large, more intense wildfires due to: • Increased rate of woody fuels growth • Extended late season dry periods • Increased human ignitions[6]
Vegetation shifts	In the Santa Rosa Mountains, the average elevation of dominant plant species in 2006-2007 was roughly 65 m higher than in 1977, a shift attributed to regional climate variability[31]	By the end of the century in California: • Conifer forest, mixed conifer forest, and shrublands are projected to decline, while grasslands may increase[32] • Mixed conifer may displace conifer forest due to increased productivity of hardwoods[32] • Desert vegetation may increase in extent under drier conditions, or decrease in extent under wetter conditions[32]	None identified	Excluding desert vegetation, projections regarding the direction of change for every vegetation type were consistent across models, although spatial variations in vegetation occurrence varied between models[32]

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