PLACEWORKS

MEMORANDUM

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SUBJECT Climate Change Vulnerability Assessment – Climate Stressors

Introduction to Climate Stressors

Climate stressors are a condition or trend related to climate variability and change, such as decreased precipitation or warmer temperatures, which can exacerbate natural hazards.[1] Climate stressors can be divided into two categories: primary climate stressors and secondary climate stressors.

As greenhouse gas emissions build in the atmosphere and global temperatures continue to rise, primary climate stressors at the local level are likely to become more severe, including changes in air temperature, precipitation, and sea level rise. These primary climate stressors can lead to secondary climate stressors, or *hazards*, which are events or physical conditions that have the potential to cause or may already cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss. These hazards consequently create *impacts,* or effects (especially negative effects) of a hazard or other condition associated with climate change, to the populations and assets within Santa Barbara County. Populations and assets may already be subject to *non-climate stressors* or trends unrelated to climate that can exacerbate climate change hazards.[2]

The following sections describe the four primary climate stressors, ten secondary climate stressors, the compounding or cascading effects that may occur in Santa Barbara County, and the non-climate stressors that populations or assets face. For each climate stressor, we provide metrics, trends, and projected changes where data is available, in addition to providing an overview of the impacts created by the primary climate stressors and hazards. Where data is available, projected changes have been broken into three sub-regions in the county: 1) North County, 2) Cuyama Valley, and 3) South Coast. For each of these sub-regions we selected unincorporated census designated places that were centralized in each of the sub-regions to gather projection data. These include Los Alamos for North County, New Cuyama for Cuyama Valley, and Montecito for South Coast. These are examples by region to illustrate general trends and some locations in a region may see different numbers.

The conclusion offers an overview of how this information will be integrated into the Climate Change Vulnerability Assessment scoring and report.

Primary Climate Stressors

In Santa Barbara County, the four primary climate stressors are 1) air temperature changes, 2) precipitation changes, 3) sea level rise, and 4) ocean acidification. These stressors are direct effects of a rise in global temperatures due to increases in greenhouse gas levels in the atmosphere. The following sub-sections define each stressor, describe the metric to measure the trend in the stressor, and explain how the stressor is projected to change in the future.

AIR TEMPERATURE

Air temperature in Santa Barbara County is projected to rise substantially during the next century, compared to historic levels, as global temperatures continue to increase.[3] This is measured through annual average minimum and maximum temperatures.

- Historically, Santa Barbara County's countywide historic annual average minimum temperature is 43ºF. It is projected to increase by 3.4ºF by 2030, 5.1ºF by 2060, and 7.3ºF by 2100.[4]
- Maximum temperatures are projected to have a similar upward trend. The countywide historical annual average temperature of 68.7ºF is expected to increase by 3.3ºF by 2030, 5.4ºF by 2060, and 7.4ºF by 2100.[5]

Table 1 shows the annual average minimum temperature change countywide and in the three sub-regions of Santa Barbara County[1], and **Table 2** shows the annual average maximum temperature change. Note, that these projections are averages and do not illustrate extreme heat days.

Table 1. Historic and Projected Annual Average Minimum Temperature (ºF)

Sub-Region	Historic	2030	2060	2100
Countywide	43.0	46.4	48.1	50.3
North County	43.8	47.1	48.9	51.1
Cuyama Valley	40.7	44.7	46.7	49.0
South Coast	46.8	49.9	51.6	53.7

Source: California Energy Commission. 2018. "Annual Averages". https://cal-adapt.org/tools/annual-averages/.
Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.

[1] To download data from Cal-Adapt.org, the Project Team used unincorporated communities within the three sub-regions of the county that are central to the sub-region. These locations include Los Alamos for North County, Cuyama for Cuyama Valley, and Montecito for South Coast.

Table 2. Historic and Projected Annual Average Maximum Temperature (ºF)

Sub-Region	Historic	2030	2060	2100
Countywide	68.7	72.0	74.1	76.0
North County	68.7	71.6	73.7	75.6
Cuyama Valley	73.6	77.8	80.1	82.1
South Coast	67.8	70.8	72.6	74.5
Source: California Energy Commission. 2018. "Annual Averages". https://cal-adapt.org/tools/annual-averages/. Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.				

The increase in annual average temperature will cause or worsen hazards throughout the county, such as agricultural pests and diseases, extreme heat, fog, human health hazards, and wildfire. The following list provides an overview of the impacts caused by changes in air temperature.

- Pests and diseases, for both crops and humans, are more active during warmer temperatures. Therefore, an increase in average annual air temperature may increase diseases in crops or livestock or vector-borne illnesses in humans.
- Higher air temperatures are directly correlated to extreme heat days and warm nights, which are likely to become more frequent as the annual average minimum and maximum temperatures continue to rise.
- Fog, which naturally cools the air, may become less frequent as higher temperatures prevent the right conditions for fog to form.
- Higher air temperatures can exacerbate drought events, drying out vegetation and causing water to evaporate faster from reservoirs, making ideal conditions for a wildfire to burn land in Santa Barbara County quickly.

These secondary hazards are discussed in more detail below.

PRECIPITATION

Two distinct metrics measures precipitation: 1) annual average precipitation and 2) seasonality. Countywide historic annual average precipitation was 17.6 inches per year. It is projected to increase slightly but fluctuate by 2.8 inches per year by 2030, 1.2 inches per year by 2060, and 3.9 inches per year by 2100.[6] **Table 3** shows the annual average precipitation change countywide and in the three sub-regions of Santa Barbara County. Changes in average precipitation due to climate change are also expected to vary substantially in different regions of the county. For instance, the eastern areas of the county in the Los Padres National Forest are projected to see increased annual averages, and the areas in the Santa Maria Valley and the Cuyama Valley will likely see a decrease in annual average precipitation. Although there will likely be a slight increase in precipitation throughout the 21st century, the seasonality (e.g., timing during a given year) may change. There will likely be more rain during periods of precipitation (e.g., storms with higher rainfall totals), fewer total days with precipitation, and an increase in year-to-year variability. This means that more rain may fall during fewer storms throughout the year.

Table 3. Historic and Projected Annual Average Precipitation (inches per year)

Sub-Region	Historic	2030	2060	2100
Countywide	17.6	20.4	18.8	21.5
North County	16.7	19.2	17.6	19.7
Cuyama Valley	7.2	7.7	6.9	8.4
South Coast	21.8	25.5	23.9	27.9
Source: California Energy Commission. 2018. "Annual Averages". https://cal-adapt.org/tools/annual-averages/. Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.				

Changes in precipitation patterns can, directly and indirectly, cause or worsen hazards in the county, such as drought, inland and coastal flooding, landslides, severe weather, and wildfire. The following list provides an overview of the impacts caused by changes in precipitation patterns.

- Longer periods without precipitation can cause droughts, dry out vegetation, and strain water supplies in the county for agricultural, domestic, and nonresidential uses. This can lead to wildfire conditions and a lack of water to fight wildfires.
- On the opposite end, more precipitation falling in fewer storms throughout the year can increase inland and coastal flooding as stormwater systems become overwhelmed with peak runoff conditions.
- Heavy rainfall is also a type of severe weather, which can be accompanied by high winds, lightning, and hail.
- Soils can also become saturated with water during periods of heavy rainfall, which can lead to landslides, especially after wildfires burn supportive vegetation.
- Wildfires can cause soils to become hydrophobic, leading to debris flows during periods of heavy rainfall. This most notably occurred after the Thomas Fires in 2017, as debris flows started in the Santa Ynez Mountains and flowed through much of the Montecito community and Carpinteria foothills, blocking Highway 101 for several weeks and portions of State Highway 192 for several months due to bridge and culvert damage.

These secondary hazards are discussed in more detail in the next section.

Sea Level Rise

Sea level rise is one of the direct results of climate change. As global temperatures rise, glaciers and other land ice near the north and south poles melt. As this water flows into the ocean, sea levels increase across the globe. High average temperatures can also cause ocean water to expand, causing further rises in sea levels.

Sea level rise is measured in inches of sea level rise. In California, guidance from the California Coastal Commission suggests that sea levels will increase in most places by 6 to 10 inches by 2030, 13 to 23 inches by 2050, and 41 to 83 inches by 2100.[7] However, it is possible that sea levels could rise faster than these projections.

The County of Santa Barbara Coastal Resiliency Project, completed in 2017 and adopted by the Board of Supervisors, projects sea levels to rise approximately 10.2 inches by 2030, 27.2 inches by 2060, and 60.2 inches by 2100.[8] The Ocean Protection Council's sea level rise guidance, published in 2018, projects sea levels to rise approximately 8.4 inches by 2030, 30 inches by

2060, and 79.2 inches by 2100.[9] **Table 4** shows the sea level rise projections from these sources. The Climate Change Vulnerability Assessment uses the Ocean Protection Council's projections to be consistent with the most up-to-date sea level rise projections for the California coastline.

Table 4. Sea Level Rise Projections for Santa Barbara County (in inches)

Source	2030	2060	2100
Coastal Resiliency Project	10.2	27.2	60.2
Ocean Protection Council	8.4	30.0	79.2

Sources: County of Santa Barbara. 2017. County of Santa Barbara Coastal Resiliency Project: Sea Level Rise & Coastal Hazards Vulnerability Assessment.
Ocean Protection Council. 2018. State of California Sea-Level Rise Guidance – 2018 Update. https://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

Sea level rise is a gradual process, taking place over years or decades, but unlike many other hazards is a chronic and permanent issue. The following list provides an overview of the impacts caused by rising sea levels.

- Ultimately, sea levels may rise enough to inundate low-lying areas along the coastline of the county permanently.
- Economically disadvantaged populations may be unable to prepare or retrofit their homes to withstand inundation from sea level rise.
- Roadways connecting single access neighborhoods or isolated populations may be inundated, affecting access to and from these neighborhoods and communities.
- Sea level rise can worsen secondary climate stressors, such as coastal flooding and dune and bluff erosion.
- Rising sea levels can cause seawater to move farther inland during storms or king tides, increasing coastal flooding. This can also increase erosion along bluffs and dunes within the county.
- Sea level rise can increase saltwater intrusion into groundwater basins, changing the salinity of groundwater used for domestic and agricultural purposes.
- Sea level rise can also exacerbate non-climate -related hazards, such as tsunamis, which can travel farther inland with the rise in sea levels.

Secondary hazards are discussed in more detail below.

Ocean Acidification

Ocean acidification is a consequence of the ocean absorbing carbon dioxide from the atmosphere, making seawater more acidic as the pH level decreases as a direct result of climate change. This increase in acidity, measured on a scale from 0 (acidic) to 14 (basic), can make it more difficult for many marine organisms to form shells and similar parts. The ocean naturally absorbs approximately 30 percent of atmospheric carbon dioxide, meaning that a rise in atmospheric carbon levels will cause the ocean to absorb more of the gas, leading to a more acidic environment. The following list provides an overview of the impacts caused by ocean acidification.

- Affected ecosystem assets would be aquatic, sandy beaches and coastal dunes, and slough and coastal marsh ecosystems, as well as Marine Protected Areas.

- Ocean acidification could cause a decline in the biodiversity of these ecosystems as ocean water becomes more acidic and calcifying species cannot survive.
- Coastal and marine recreation and tourism could decline or change, as some visitors may be deterred from traveling to the coastal areas of the county.
- Workers in the commercial and recreational fishing industry may be impacted if commercial fishing stocks and other marine life populations decline.

Secondary Climate Stressors – Hazards

As described above, primary climate stressors can contribute to the formation of secondary climate stressors or hazards. This section defines 10 distinct climate change hazards, the metric used to measure the trend in the hazards, and how the hazards are projected to change in the future. These 10 secondary climate stressor or climate change hazards, described in more detail in this section, include:

1. Agricultural pests and diseases
2. Coastal hazards
3. Drought
4. Extreme heat
5. Inland flooding
6. Decreased fog
7. Human health hazards
8. Landslides and debris flows
9. Severe weather
10. Wildfire

Agricultural Pests and Diseases

According to the *2019 County of Santa Barbara Crop Report*, agriculture and livestock had total gross production of over $1.6 billion in 2019, with strawberries being the largest grossing crop. Agricultural pests and diseases can affect crop plants, vineyards, and livestock throughout Santa Barbara County. This hazard is measured by the occurrence of pests and diseases, which is likely to increase as higher temperatures allow for insects to reproduce more rapidly.

These pests and diseases, such as the light brown apple moth, white peach scale, Asian citrus psyllid, pacific mealybug, avian influenza, and other pests and diseases, can cause plants and animals to grow more slowly, damage them so that their products are less appealing and harder to sell, or even kill them.[10] Many pests and organisms that carry diseases are most active during warmer months, so the threat of infection or infestation can be higher during this time of year. 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 activity window for pests and diseases. The following list provides an overview of the impacts caused by agricultural pests and diseases.

- Agricultural pests and diseases can harm the economic stability of the agriculture, agritourism, and livestock industries, in addition to the outdoor workers, isolated and rural communities, and undocumented persons who rely on the agriculture industry.
- Agritourism, including wineries, is highly dependent on agricultural production, and therefore could experience a decrease in visitors if fewer or poorer-quality crops and wine grapes are viable year to year.

- Agricultural workers and rural communities could experience economic hardships if agricultural pests and diseases harm crops and livestock.
- It also may be difficult for populations, listed in Table 10 below, to find alternative work if agricultural production declines.

COASTAL HAZARDS

Coastal hazards are secondary hazards strengthened by increases in air temperatures and sea level rise, such as coastal flooding and dune and bluff erosion. Coastal storms and flooding are measured by inches of coastal inundation during a 100-year storm, which floods the shoreline more frequently and severely. Because ocean levels are higher during normal conditions due to sea level rise, shoreline floods such as king tides can reach further onto land. For example, a storm with a one in ten chance of occurring in a given year (known as a ten-year storm) can create a temporary increase in sea levels of approximately 28 to 30 inches. Higher sea levels can also give a "boost" to smaller storms that would not have been large enough to flood dry land during normal conditions, making shoreline flooding more frequent. Along the Santa Barbara County coastline, a 100-year coastal storm is projected to increase high tide levels by 48.4 inches by 2030, 70 inches by 2060, and 119.2 inches by 2100, including sea level rise.[11] The following list provides an overview of the impacts caused by coastal hazards.

- Nearly all populations living or working in coastal areas in the county would be affected by coastal storms.
- Coastal storms can increase flooding in low-lying areas, directly damaging property and cause mold and mildew to grow in homes and other buildings, impacting the health of populations that live and work in these buildings.
- Economically disadvantaged populations are more likely to live in less resilient structures, which could be damaged by coastal flooding.
- Floodwaters could also damage roadways and other infrastructure that populations depend on daily, disrupting transportation routes and harming economic assets such as coastal recreation and tourism.
- Essential infrastructure such as commercial airports, bridges, electrical substations, and water and wastewater infrastructure can be damaged by high-intensity waves and storm surge.
- Coastal floodwaters can damage building foundations, and standing water that remains may directly damage property and cause mold or mildew to grow in these structures.
- Damage to buildings and infrastructure may cause economic harm, as visitors may be less likely to travel to the area for recreation and tourism or to visit historical sites. Also, employees may not be able to travel to their workplace if major roads and highways are damaged.

Erosion along the coastline is the process by which local sea level rise, high tides, and wave action wear down and carry away rocks and sand or soil.[12] Dune and beach areas of the county, such as Refugio State Beach and Rancho Guadalupe Dunes Preserve, also rely on accretion, which is the process of sediment accumulating on the beach from a river or other alluvial or oceanographic systems. Dunes have natural erosion and accretion processes that can change the extent and shape of the sandy areas. Erosion severity is measured by the inches or feet that dune and bluff erode, and erosion is projected to increase. In bluff areas of the county, such as Isla Vista and Gaviota, accretion typically does not occur, and erosive processes slowly eat away at the foundations of the bluffs.

Bluff erosion projections include at least 16 feet (5 meters) from existing conditions, with 0.03 feet per year (0.01 meters per year) to 9 feet per year (0.23 meters per year) based on the amount of sea level rise and the geology of the bluff tops.[13] In bluff areas of the county, such as Isla Vista and Gaviota, accretion—the gradual accumulation of sand and other sediment along sandy beaches—typically does not occur, and erosive processes slowly eat away at the foundations of the bluffs. In these areas, higher sea levels and eroding bluffs can cause beaches to disappear, because they are not built up by accretion and not able to migrate inland due to bluffs and cliffs. An average of 623 feet of dune erosion and 177 feet of bluff erosion is projected to occur by 2100.[14]

The following list provides an overview of the impacts caused by dune and bluff erosion.

- Those living or working along the bluffs or coastal dunes of the county, which includes several frontline communities, would be impacted by dune and bluff erosion.
- Dune and bluff erosion can also disrupt key ecosystems and recreation areas. These disruptions include the loss of sand supply, beach wrack which is important to the beach ecosystem, and other impacts to near shore ecosystems.
- Dune and bluff erosion can also undermine the foundation of Highway 101, railways, single access roadways, and buildings along the coastline.
- Evacuation routes, as well as services that rely on Highway 101 and other major roadways, such as public transit, vital goods delivery, and emergency services, could be impeded if erosion damages or destroys roadways.
- Bluff erosion could undermine the foundations of important buildings, such as UC Santa Barbara, commercial centers, homes, and schools. This could disrupt major employment centers, coastal recreation and tourism, the oil and gas industry, State and federal land recreation and tourism, and operations at the Vandenberg Air Force Base.
- Essential services that rely on roadways or underground infrastructures, such as natural gas lines and water lines, could be disrupted if the foundations for this infrastructure are compromised.
- Ecosystems most affected by dune and bluff erosion include coastal bluffs and sandy beaches and coastal dunes, as storm surges may eat away at bluffs and cause inward migration of dune habitats.

DROUGHT

A drought occurs when conditions are drier than normal for a long period of time, making less water available for people, agricultural uses, and ecosystems. In addition to the use of local groundwater and surface water supplies, unincorporated Santa Barbara County receives water supplies from the State Water Project that is stored in Lake Cachuma. This supply depends on precipitation and snowpack in the Sierra Nevada Mountains. Snowpack levels in the Sierra Nevada decreased by 25 percent during the 2011 to 2016 drought, and average springtime snowfall is expected to drop 64 percent by 2100.[15] The following list provides an overview of the impacts caused by increased drought periods.

- Communities in Santa Barbara County may experience water shortages during drought conditions, which could lead to water restrictions for both domestic and agricultural purposes.
- Farmers may need to cut back on irrigation activities, and other businesses and residents may need to change water use behavior.

- Less precipitation could lower water levels or decrease water quality in streams, groundwater basins, and lakes, which can affect both natural habitats and recreation activities.
- Where rivers and creeks meet the ocean along the coastline, water can become more saline and brackish as freshwater levels decline and high tides push further upstream.
- Droughts can increase the use of groundwater to meet water demand, which can lower groundwater levels more quickly than they can be replenished, reduce the water quality of groundwater, and cause subsidence of the land above the groundwater basin.

Droughts are a regular occurrence in California and are measured by the timing and length of the drought. However, in the past 50 years, there have been four major statewide droughts, plus smaller regional droughts.[16] Due to changes in precipitation patterns discussed above, droughts will likely last longer and occur more frequently due to more variability in precipitation extremes. Base flows in rivers and creeks in the county's coastal and inland areas are projected to decline significantly, in the North County and South Coast sub-regions of the county, in an early- and late-century extended drought scenario shown in **Table 5**.

Table 5. Historic and Projected Changes in Baseflow during Early- and Late-Century Extended Drought Scenarios (inches per year)

Sub-Region	Historic	Early-Century	Late-Century
Countywide	2.1	1.4	1.3
North County	1.4	1.2	1.2
Cuyama Valley	0.4	0.4	0.4
South Coast	4.1	2.6	2.6

Source: California Energy Commission. 2018. "Extended Drought Scenarios". https://cal-adapt.org/tools/extended-drought/.
Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.

EXTREME HEAT

Extreme heat occurs when temperatures rise significantly above normal levels and is measured by the number of extreme heat events per year and heat wave duration. "Extreme heat" is a relative term—temperatures of 100 degrees are normal in locations like Palm Springs, but almost unprecedented in coastal areas of Santa Barbara County. Santa Barbara County has different extreme heat temperatures in different regions of the county. An extreme heat day is where temperatures reach at least 88.7 degrees in Los Alamos, 101.3 degrees in Cuyama, and 87 degrees in Montecito.[17] Although temperatures are lower in the coastal areas of the county, it is still dangerous when temperatures are higher than usual for people and assets that are not accustomed to them and may not have the resources to cope with the warmer temperatures.

Historically, Santa Barbara County has experienced an average of four extreme heat days a year. This is expected to increase by eight extreme heat events per year by 2030, 15 extreme heat events per year by 2060, and 30 extreme heat events per year by 2100.[18] **Table 6** shows the number of extreme heat days projected to occur in the three sub-regions of the county. The duration of heat waves is projected to increase countywide from 2.7 days historically, to 4.3 days by 2030, 5.6 days by 2060, and 9.4 days by 2100.[19] **Table 7** shows the increase in heat wave duration by sub-region in the county.

Table 6. Historic and Projected Number of Extreme Heat Days by Sub-Region

Sub-Region	Historic	2030	2060	2100
Countywide	4	12	19	34
North County	4	7	11	19
Cuyama Valley	4	22	31	46
South Coast	5	7	11	21

Source: California Energy Commission. 2018. "Extreme Heat Days and Warm Nights". https://cal-adapt.org/tools/extreme-heat/.
Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.

Table 7. Historic and Projected Length of Heat Waves by Sub-Region

Sub-Region	Historic	2030	2060	2100
Countywide	2.7	4.3	5.6	9.4
North County	2.6	2.7	3.9	5.2
Cuyama Valley	2.2	6.9	9.0	14.7
South Coast	2.4	2.5	3.5	5.3

Source: California Energy Commission. 2018. "Extreme Heat Days and Warm Nights". https://cal-adapt.org/tools/extreme-heat/.
Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.

When the daily minimum temperatures remain significantly above normal levels, warm nights can worsen an extreme heat day because people and assets may not get relief from the high temperatures. A warm night is when temperatures remain above 56.3 degrees in Los Alamos, 62.8 degrees in Cuyama, and 60.1 degrees in Montecito.[20] **Table 8** shows the number of warm nights projected to occur in the sub-regions of the county.

Table 8. Historic and Projected Number of Warm Nights by Sub-Region

Sub-Region	Historic	2030	2060	2100
Countywide	4	26	51	88
North County	4	20	52	93
Cuyama Valley	4	16	30	52
South Coast	4	23	47	81

Source: California Energy Commission. 2018. "Extreme Heat Days and Warm Nights". https://cal-adapt.org/tools/extreme-heat/.
Note: Projections are an average of the four state-recommend climate models (HadGEM2-ES, CNRM-CM5, CanESM2, MIROC5), averaged for 2030-2050, 2050-2070, and 2070-2099. For more details, see the hazards summary dated July 7, 2020.

The following list provides an overview of the impacts caused by an increase in extreme heat days, warm nights, and the length of heat waves.

» Extreme heat and warm nights can cause heat-related illnesses, such as heat cramps, heat exhaustion, and heat stroke.
» These temperatures can harm animals and plants, including livestock and agricultural crops that are not adapted to these conditions.

- Some types of infrastructure, including power lines and roadways, face more significant stresses during high temperatures, which make materials unstable and failure more likely.
- Very high temperatures make people less likely to venture outside, hurting recreation and tourism economic sectors that depend on outdoor activities.
- Extreme heat can also increase wildfire conditions by drying out plant material, and prolonged high temperatures can contribute to drought conditions.

Inland Flooding

A flood occurs when there is too much water to be held in local water bodies, carried away by creeks and rivers, or to soak into the soil. All flooding is a breakdown in conveyance, as water can build up and wash into normally dry areas and cause significant harm to buildings, people, and ecosystems. Floods can be caused by heavy rainfall or long periods of moderate rainfall or block off drainage areas during periods of rainfall. A break in a dam, water pipe, or water tank can also cause flooding in rare instances. Floods that develop very quickly are called flash floods; they are especially dangerous because they give little or no warning. Floodwaters can be deep enough to drown people and may move fast enough to carry away people or heavy objects, such as cars. In some cases, floods can be strong enough to lift buildings off their foundations. Inland flooding is measured by the areas flooded per year, which is expected to increase as more precipitation is falling in fewer storms, as discussed above.

Although climate change is expected to increase the frequency and intensity of droughts, scientists also project that it will increase the frequency and intensity of inland flooding in Santa Barbara County, although precipitation levels are expected to increase only slightly. Up to half of California's precipitation comes from a relatively small number of intense winter storms, which are expected to become more intense with climate change. For example, what is currently a 200-year storm, or one that has a 1 in 200 chance of occurring in a given year, by 2100 would increase in frequency by 40 to 50 years (to a 1 in 150/160 chance in a given year).[21] This means that the 100-year and 500-year floodplains may expand, and the current floodplains may become 40- to- 50-year floodplains. The following list provides an overview of the impacts caused by inland flooding.

- Heavy rainfall following dry periods increases runoff, which can cause flooding and lead to a higher risk of landslides and flash floods.
- Damage to homes and essential infrastructure can isolate or permanently displace households or communities.
- Transportation routes, such as Highway 101, can be flooded, preventing residents and visitors from evacuating or employees from traveling to work.
- Damage to water and wastewater infrastructure can cause them to malfunction or spill raw sewage into surrounding areas.
- Ecosystems near rivers, creeks, and other water bodies can experience increased erosion and higher levels of sedimentation after flood events.
- Local, regional, and intra-state commerce can be disrupted by inland flooding that blocks or damages transportation routes.

Decrease in Fog

Fog is a very low cloud that usually is low enough to touch the ground, and that forms when the air near the Earth's surface reaches the right temperature for water in the air to condense into a cloud. Fog is measured by the number of fog days per year, which is expected to decrease, although the future of fog is uncertain. In Santa Barbara County, fog forms along the coast as it flows in from the Pacific Ocean toward warmer temperatures on land. The cool air brought in by fog is necessary for cooling off the inland areas of the county. The following list provides an overview of the impacts caused by changes in fog conditions.

- A reduction in coastal fog could decrease the water supply for ecosystems such as chaparral and scrub habitats and grassland environments, causing vegetation to dry out more often and/or a decrease in plant productivity.
- Coastal bluffs and sandy beaches and coastal dune environments may have shallow-rooted species or lichen that may not obtain sufficient amounts of water in the absence of coastal fog.
- Coastal fog naturally cools down coastal areas in the summer months, and higher temperatures may occur more frequently in the absence of fog.
- Alternatively, if heavy fog increases due to warmer temperatures, traffic accidents are more likely to occur as drivers may have reduced visibility.

Human Health Hazards

Human health hazards are bacteria, viruses, parasites, and other organisms that can cause diseases and illness in people. These diseases are carried by animals such as mice and rats, ticks, and mosquitos, which are usually regarded as pests even if they do not cause infections. Changes in temperature and precipitation can increase the activity of the animals that carry diseases, as they are more active during warmer weather. Warmer temperatures earlier in the spring and later in the autumn can cause these animals to be active for longer periods, increasing the time for the disease to be transmitted. This hazard is measured by the occurrence of health hazards, which is likely to increase as temperatures allow for insects and other pests to reproduce more rapidly. The following list provides an overview of the impacts caused by human health hazards.

- Some of these diseases may only cause mild inconvenience, but others are potentially life-threatening. Examples include hantavirus pulmonary syndrome, Lyme disease, West Nile virus, and influenza, which can be debilitating or fatal for some people.
- Other hazards that affect human health include extreme heat (discussed above), poor air quality, and smoke created from wildfires in the region, which can cause additional or exacerbate existing cardiovascular and respiratory illnesses.
- Pandemic scale human health hazards can also harm several economic sectors within the county.

Landslides and Debris Flows

Landslides occur when a hillside becomes unstable, causing soil and rocks to slide downslope. Landslides are most common on steep slopes made up of loose soil and other material, but they can also occur on shallower slopes. Hillsides commonly absorb water, which increases the instability of the slope, leading to increased slope failure, which is likely to occur more frequently as more precipitation falls during fewer storms throughout the year (discussed above). 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). Higher temperatures, wildfires, and droughts can clear vegetation that holds soil in place and dry out soil making it unable to absorb as much water and creating a risk of landslides when heavy rains return.

Debris flows-fast moving flows of mud, rock, boulders, trees, and other debris-can also occur in or below areas with steep topography that have recently burned. High-intensity wildfires strip areas of vegetation and causes soils to become hydrophobic, preventing water from percolating into soil during a high-intensity precipitation event, as occurred in the 2018 Montecito debris flow. Similar conditions have led to numerous documented landslide and debris flow events along the South Coast throughout the 19th, 20th, and 21st centuries. This hazard area may shift after a debris flow or landslide or other hazards have affected an area, such as wildfire, flooding, or drought. Debris flow and landslides 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. The following list provides an overview of the impacts caused by landslides and debris flows.

- Landslides can block or damage roadways and bridges, preventing residents and visitors from evacuating, in addition to disrupting communication and energy delivery services.
- Debris flows can damage homes and essential infrastructure, isolating households or communities.
- Oil and gas infrastructure can be damaged by these events, potentially causing hazardous materials to be released into the soil, air, or water.
- These hazards can also damage or destroy lands supporting recreational activities in both inland and coastal areas of the county, which may deter visitors from traveling to the county for these activities.
- In aquatic and riparian ecosystems, landslides can cause streams to be blocked and can lead to increased sedimentation, harming aquatic plants and wildlife.
- Post-wildfire landslides and debris flows can damage facilities that economic sectors depend on to function, as well as increase stress and anxiety for residents and businesses that have experienced them in the past.

Severe Weather

Severe weather includes strong winds, hail, lightning, and heavy rainfall. Severe weather is usually caused by intense storm systems, although types of strong winds, such as sundowners, can occur without a storm. Severe weather is measured by the number of severe weather events per year, which is likely to increase on average every year. Severe winds can damage or destroy buildings, knock over trees, and damage power lines and electrical equipment. This includes sundowner winds, which can reach over 120 degrees Fahrenheit with speeds of up to 60 miles per hour in some areas.[22] The following list provides an overview of the impacts caused by each type of severe weather.

- Hail can damage buildings and ecosystems, and lightning can spark fires, injure people, or cause fatalities.
- Heavy rainfall can lead to flooding in both rural and urban areas of the county.
- Severe weather can damage homes and essential infrastructure that can isolate households or communities.
- Severe winds can also cause power outages and Public Safety Power Shutoff (PSPS) events. The uncertainty of Public Safety Power Shutoffs during severe wind events can trigger stress and anxiety for residents and business owners.
- Severe winds, especially sundowner winds, often co-occur during wildfire conditions, causing rapid growth of wildfires.
- Sudden oak death, which harms a variety of oak species, can be more easily spread through high velocity winds.

- Severe winds and hail can flatten agricultural crops, harming agriculture, winery, and agritourism based economies.
- Severe weather at Vandenberg Airforce Base may postpone rocket launches and other key operations.
- Heavy rainfall caused by severe weather can cause dam erosion increasing the risk of dam failure that can flood areas below the dams.

WILDFIRE

Wildfires are a regular feature of the landscape in much of California and the county. The Mediterranean-type climate and ecosystems found throughout most of the state, including Santa Barbara County, are especially fire-prone. Winter rains support plant growth, and the summer dry season, droughts, and extreme heat events dry out vegetation, increasing the potential for ignition during the late summer and autumn when temperatures are high for several months without precipitation. Wildfires can be sparked by lightning, malfunctioning equipment, vehicle crashes, or many other causes. Most wildfire ignition is human caused. High winds can then spread wildfires quickly over the terrain. Wildfires are fires burning in natural areas, although they can easily spread into the developed areas between urban and wildland zones, known as the wildland-urban interface.[23,24] The wildland-urban interface can expose people and property to the flames, increasing the risk of injury, death, and property damage or destruction. Wildfires can be linked to landslides and debris flows on steep slopes within the county, as seen after the 2017 Thomas Fire.

Wildfires as a secondary climate stressor are measured by the number of acres per year, which is expected to increase in the 21st century. Historically, an annual average of 17,681 acres burned per year in the county, although some years have seen significantly more burnt acres. A projected increase in annual average precipitation can lead to an increase in the amount of fuel growth available for wildfires to burn. Due to higher annual average temperatures and the increased frequency and intensity of droughts, annual average acres burned is expected increase to 23,040 acres per year (30 percent increase) by 2030, 25,782 acres per year (46 percent increase) by 2060, and 24,050 acres per year (36 percent increase) by 2100, compared to historical baseline conditions (1961 to 1990).[25] **Table 9** shows the annual average acres burned in the communities within Santa Barbara County.

Table 9. Historic and Projected Number of Average Annual Acres Burned (acres per year)

	Historic	2030	2060	2100
Santa Barbara County	17,681	23,040	25,782	24,050
Source: California Energy Commission. 2018. "Wildfire". https://cal-adapt.org/tools/wildfire/. .				

Nearly all populations and assets assessed in the vulnerability assessment will be directly or indirectly affected by wildfires, especially as winds and extreme heat increase wildfire conditions in Santa Barbara County.

Cascading and Compounding Hazards

As described above, four primary climate stressors and secondary climate change hazards can have cascading or compounding effects throughout the county. Cascading hazards are extreme events that link together hazards over days, weeks, or months, resulting in multiplied effect that cause secondary and possibly tertiary damages, exceeding those from the initial hazard event. Cascading hazards tend to hit hardest in the social, economic, and infrastructure vulnerabilities caused by human interaction with the natural environment, such as buildings and infrastructure located in hazard- prone areas. The destruction caused by the 2017 Thomas Fire and loss of life in the subsequent 2018 Montecito debris flow, followed by the disruption when US 101 closed, is an example of a cascading disaster. **Table 10** describes the cascading and compounding effects that can occur in Santa Barbara County due to climate change.

Table 10. Cascading Effects in Santa Barbara County

Secondary Climate Hazard	Cascading Effect
Increase in Air Temperature	
Agricultural pests and diseases	• Weakens crops, vineyards, and livestock, causing them to be more susceptible to harm from extreme heat and wildfire.
Extreme heat	• Dries out vegetation, enabling a wildfire to spark or burn more quickly through an area. • Weakens crops, vineyards, and livestock, making them more susceptible to agricultural pests and diseases. • Causes cardiovascular and respiratory illnesses, making people more susceptible to other illnesses and diseases. • Increases evaporation and evapotranspiration rates, worsening drought conditions. • Increases the potential for planned or unplanned electricity blackouts.
Decrease in fog	• Worsens extreme heat days by not providing relief from high temperatures. • Impacts crops that rely on cooler temperatures. • Harms coastal ecosystems can increase dune and bluff erosion. • Can dry vegetation in dune habitats, increasing erosion.
Human health hazards	• Harms economic sectors if people are unable to go to work or perform their jobs.
Wildfire	• Burns vegetation on hillsides, destabilizing the slopes and causing landslides or debris flows. • Increases flooding due to increased lack of vegetation due to previous burned surfaces and debris in watersheds.
Changes in Precipitation Patterns	
Agricultural pests and diseases	• Weakens crops, vineyards, and livestock, causing them to be more susceptible to harm from drought.

Secondary Climate Hazard	Cascading Effect
Drought	• Dries out or changes vegetation, increasing natural fuel sources for wildfires. • Change(s) to or addition of new, permanent, or temporary, local water supplies, for drinking water and irrigation (e.g., increased dependence on groundwater or desalinated water), resulting in increases in the cost of water and/or to products dependent on water. • Increases poor water quality.
Inland flooding	• Contributes to dune and bluff erosion downstream.
Landslides and debris flows	• Debris from landslides can fill water bodies or drainage basins, leading to flooding.
Severe weather	• Heavy rainfall causes inland flooding and worsen coastal flooding. • Lightning can spark wildfires. • Strong winds spread wildfires more quickly and increase the intensity of wildfires. • Strong winds cause the need for Public Safety Power Shutoffs.
Wildfire	• Burns vegetation on hillsides, destabilizing the slopes and contributing to landslides or debris flows.
Sea Level Rise	
Coastal flooding	• Increases inland flooding. • Increases saltwater intrusion into aquifers.
Dune and bluff erosion	• Expose buildings and infrastructure behind dunes, increasing coastal flooding. • Undermines the foundations of buildings along bluffs.

Non-Climate Stressors

As stated above, non-climate stressors are trends unrelated to climate that can exacerbate climate change hazards.[26] These are also known as pre-existing conditions that can affect the adaptive capacity for populations and assets throughout Santa Barbara County. Non-climate stressors are those factors that make populations or assets especially susceptible to harm from hazards, as they may not be able to prepare for, respond to, or recover from hazards due to these stressors. **Table 11** provides a list of non-climate stressors for each population and asset category included in the Climate Change Vulnerability Assessment.

Table 11. Non-Climate Stressors

Populations or Asset Category	Non-Climate Stressors
Populations	• Lack of affordable housing or homeownership. • Financial instability. • Remote location of housing or employment. • Language and communication barriers. • Mobility and/or health issues. • Citizenship status. • Distrust of government programs. • Existing pollution burden. • Poor housing quality. • Lack of air conditioning, cool spaces, or reliable electricity supply. • Lack of community centers and shelters. • Lack of access to healthcare, transportation, or communication. • Educational attainment and availability of educational opportunities.
Buildings & Infrastructure	• Lack of funding for retrofits, repairs, and/or upgrades. • Lack of alternatives or redundancy. • Aging buildings, infrastructure, and technology. • Earthquake and seismic hazards. • Staff capacity for retrofits, repairs, and/or upgrades. • Difficulty in relocating.
Economic Drivers	• Resistance or lack of capital to change in business practices. • Lack of alternative crops, marine life, buildings, or infrastructure. • Lack of employees. • Existing water quality or quantity issues. • Reliance on the ecosystem services. • Difficulty in relocation. • Large scale economic fluctuations: changes to economic sectors or recessions.
Ecosystems and Natural Resources	• Existing poor water, air, and soil quality. • Habitat fragmentation. • Contamination from oil spills.
Key Community Services	• Disruption of services from the failure of buildings or infrastructure during repairs. • Aging infrastructure and technology. • Staff capacity. • Reduced funding. • Reliance on transportation infrastructure.

Conclusion

As described above, Santa Barbara County will experience an increase in four primary climate stressors, air temperature changes, precipitation changes, sea level rise, and ocean acidification, which will cause or worsen ten distinct secondary climate change hazards. These climate change hazards can have compounding or cascading effects on one another, and in some cases, can quickly multiply hazardous conditions in the county. Existing non-climate stressors can prevent populations and assets from adequately preparing for, responding to, and recovering from primary and secondary climate stressors. Climate stressors, cascading and compounding effects, and non-climate stressors will be used during the impact and adaptive capacity scoring phase of the Climate Change Vulnerability Assessment to fully grasp the vulnerabilities of populations and assets in Santa Barbara County.

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