LA County Climate Vulnerability Assessment

October 2021

Our County

Contents

Foreword

Dear Friends,

Just over two years ago, the Los Angeles County Board of Supervisors unanimously adopted the OurCounty Sustainability Plan, which set forth a bold, people-centered vision for making our communities healthier, more equitable, economically stronger, and better prepared for the future. The OurCounty plan directed the preparation of this Climate Vulnerability Assessment to help understand the risks and challenges that a changing climate will bring to people living in Los Angeles County.

Throughout this report, we identify communities of concern—places that are not only at high risk of exposure to climate threats but also have an elevated risk of bad outcomes from that exposure. Unsurprisingly, many of those highly vulnerable communities are where Black and/or Latinx people live. The reasons for this are myriad but stem directly from both the legacy of and ongoing racist policies and practices that have created disparities in education, housing, nutrition, health, and many other aspects of our lives. As we seek to avoid the worst impacts of climate change, we must also simultaneously acknowledge and actively work to overcome systemic racism.

A key finding in this report is that essential workers are the linchpin of making our society and infrastructure function, especially as we face climate threats. The centrality of workers was made abundantly clear over the past 20 months during the pandemic and is emphasized in new ways in this assessment, which articulates how the people who repair our power lines, operate our transit systems, or tend to those who are ill are crucial members of society.

There is always a danger in preparing a Climate Vulnerability Assessment like this one—the projected impacts could be mistaken for established facts of what will happen in the future. In conducting this assessment, we looked at the best available science on climate projections. The results are frightening but not inevitable. We still have the power to create a safer and healthier future by taking bold and aggressive action to reduce emissions today. And, doing so, we will help clean up our air and water, create good jobs, improve our neighborhoods, and address some of our most intractable environmental justice issues.

As you read this report, please keep this in mind. Join us to support meaningful actions to reduce greenhouse gas emissions, and help us ensure that our communities are better prepared for the impacts of climate change. By working together, we can all be more resilient.

Gary Gero
Los Angeles County Chief Sustainability Officer

Executive Summary

Report goals and structure

In recent years, LA County has experienced record-breaking high temperatures, prolonged drought, and more intense wildfires. Each unprecedented event strains our communities, directly harming our health, infrastructure, and the natural resources we rely on. Such climate hazards are projected to become increasingly severe and frequent in the coming decades. This report, the LA County Climate Vulnerability Assessment (CVA), fulfills a commitment outlined in the OurCounty Sustainability Plan, identified by stakeholders as a top priority: to assess how people and infrastructure in LA County may be vulnerable to the changing climate. The County's vision of sustainability demands that we work to understand increasingly dangerous threats.

High climate vulnerability is generally defined as a combination of **increased exposure** to climate hazards; **high sensitivity**, or susceptibility, to negative impacts of exposure; and **low adaptive capacity,** or ability to manage and recover from exposure. A map of social sensitivity, which shows the geographic distribution of LA County residents with heightened susceptibility to climate hazards, is shown in Figure 1.

Social Sensitivity

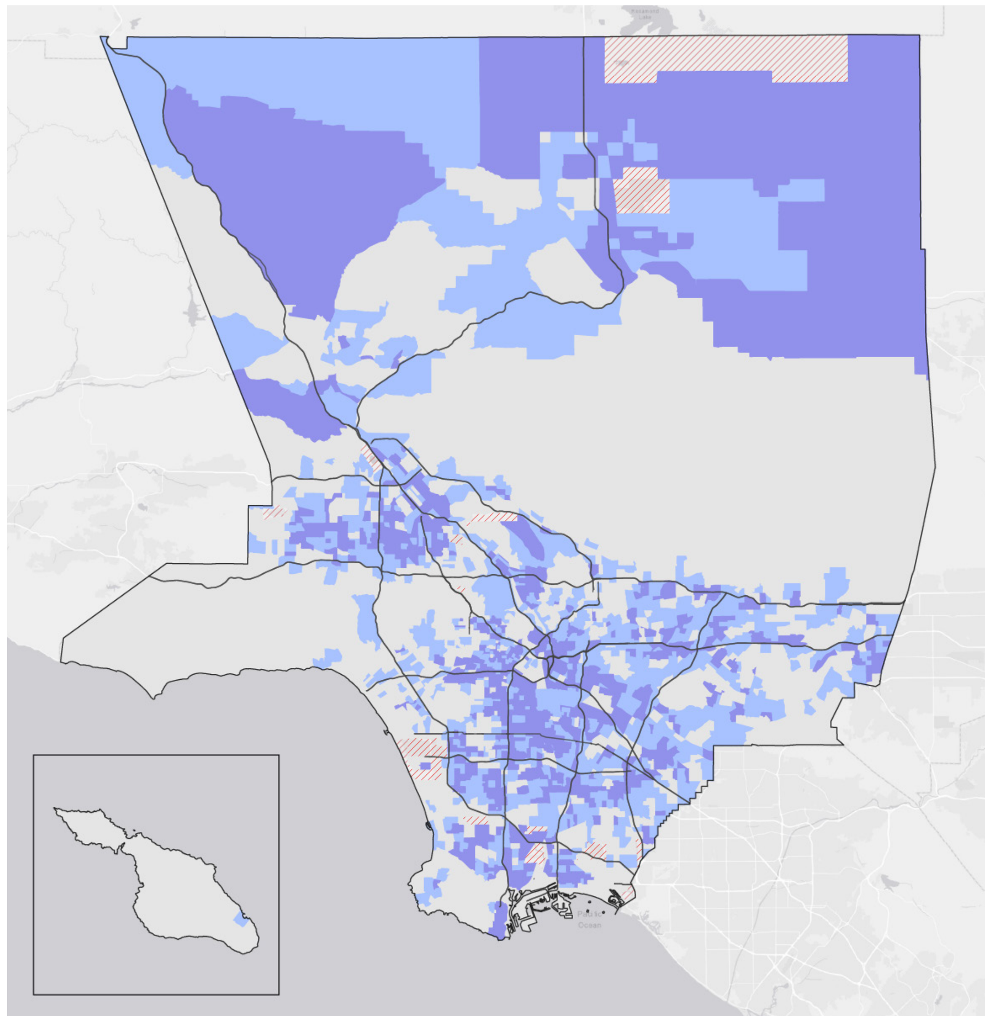

Figure 1: Map of Social Sensitivity in LA County

Relative Sensitivity Level

- Low, bottom third in sensitivity score
- Moderate, middle third in sensitivty score
- High, top third in sensitivity score
- No Population

0 5 10 15 mi

Sources: United States Census Bureau, CEHTP and OSHPD, Los Angeles County ISD, SCAG.

Report goals and structure

The CVA builds on a solid foundation of climate research to analyze vulnerability in LA County—examining climate risks to the County's diverse people and places, including populations with heightened susceptibility to climate impacts, across unincorporated communities and 88 municipalities.

Developed by the Chief Sustainability Office in collaboration with a wide range of partners, this report includes four key components:

The Climate Hazard Assessment (CHA) evaluates potential changes in the frequency and severity of specific climate hazards (extreme heat, wildfire, extreme precipitation and inland flooding, coastal flooding, and drought) resulting from climate change in the coming decades.

The Social Vulnerability Assessment (SVA) looks at the level of risk across communities and populations and identifies groups and places that are highly vulnerable to climate hazards—these groups and places experience high susceptibility and likelihood of increased exposure to climate hazards.

The Physical Vulnerability Assessment (PVA) examines how physical infrastructure and facilities across the County face risk of damage from climate hazards and outlines how damage to highly vulnerable facilities could affect people and society.

The Cascading Impacts Assessment explains how infrastructural systems rely on one another and how harms to one type of infrastructure can affect other facilities, related services, and the people who rely on those services.

Equity is the core focus of this report. *Vulnerability*, in the context of this discussion, does not signify any kind of innate individual weakness; to understand how climate hazards and adaptation strategies may impact people differently, we looked at structural inequities and other factors that put some people at greater risk of negative impacts. We used qualitative and quantitative methods to create a combined approach that highlights the voices, stories, and experiences of frequently excluded, highly vulnerable groups.


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Extreme heat

Extreme heat will increase in frequency, severity, and duration—with up to a tenfold increase in the occurrence of heat waves by mid-century. The largest increases will occur in the Santa Clarita and San Fernando Valleys. Rising temperatures can jeopardize health and well-being in many ways, such as by worsening respiratory and heart conditions. It can cause significant damage, repair costs, and service interruptions to our physical infrastructure. We are particularly concerned about parks and energy infrastructure, both of which play critical roles in helping people to keep cool during extreme heat but which are themselves highly vulnerable to extreme heat.

Wildfire

Wildfires will become larger, more frequent, and more destructive—especially in the San Gabriel Mountains, where the wildfire burn area may increase up to 40 percent by mid-century. Although much of the additional destruction will likely occur in unpopulated areas, more than a million housing units in the wildland-urban interface will continue to be at risk. Furthermore, wildfire smoke will continue to affect people across the County, with 40 percent of residents already reporting that they have avoided going outside because of air quality impacts.[1] Wildfire also jeopardizes water quality and energy assets serving residents across the County.

Inland flooding and extreme precipitation

Rainfall patterns will change, with drier springs and summers and wetter winters. The concentration of rainfall over short periods will increase the likelihood of inland flooding and subsequent landslides and mudslides. It is not possible to calculate the amount of increased risk using existing data; data gaps and outdated floodplain maps belie a history and potential future of devastating floods. Energy infrastructure, again, is one of the physical assets at highest risk, along with medical facilities, transportation, and water systems.

Coastal flooding

A rise in sea level of up to 2.5 feet by mid-century will lead to more frequent and severe coastal flooding, especially in low-lying areas unprotected by natural bluffs. Low-income communities will find it particularly difficult to prepare for and recover from flooding events, and the events may have an outsized impact on the local economy because of the concentration of key industries along the coast, including tourism, shipping, and select energy assets.

Drought

Drought and mega-drought will also become more likely because of rising temperatures and shifting precipitation patterns. Lack of water will not only harm water supply and treatment systems but other infrastructure and physical assets that rely on water—notably, power plants and parks. Communities that rely on single-source or small water service providers could lose direct access to clean water. Additionally, drought may increase the level of dust in the air in desert communities, a change that would be especially harmful to people with respiratory conditions or who spend a lot of time outside.

Throughout this report, we identify specific communities that are vulnerable to climate hazards. Some examples, out of more than 47 communities highlighted in the report, include

- **North Lancaster**, **Hi Vista**, and **Roosevelt** in the Antelope Valley, at risk of exposure to both extreme heat and inland flooding, which have high proportions of children and/or older adults;

Takeaways

- **Reseda** and **Winnetka** in the San Fernando Valley, at risk of exposure to extreme heat, which have high proportions of limited-English households and people with preexisting health conditions;
- **Santa Clarita**, at risk of exposure to both extreme heat and wildfire, which has a high proportion of older adults living alone and low transit access;
- **Montebello**, at risk of exposure to extreme heat, which has a high proportion of people with disabilities and low vehicle access;
- **Westlake** and **Crenshaw** in the Central and South Central parts of LA City, both at risk of inland flooding, which have large proportions of people without access to vehicles or informational resources (e.g., internet and libraries);
- **Long Beach** and **San Pedro**, at risk of flooding from extreme precipitation and/or sea-level rise, which have many low-income households;
- **East LA**, **South Gate**, and **Bellflower** in the east and southeast parts of the County, where limited tree canopy, buildings with poor temperature control, and lots of pavement magnify the impacts of even modest increases in temperature.

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Takeaways

We also highlight concerns about people whose risks may be underrepresented in spatial analyses, such as:

- **People living in mobile homes**: the majority of mobile homes are located in high hazard areas, and they are more susceptible to damage and overheating than fixed houses or larger buildings.

- **People who depend on electrically powered medical devices**: the high vulnerability of energy infrastructure is a problem for all County residents, but power outages have especially acute and urgent impacts on people who need electricity to stay alive, like those with health conditions requiring oxygen equipment.

- **People experiencing homelessness**: even relatively low levels of exposure can be hazardous to people who lack physical shelter from climate hazards.

- **People who are climate-exposed at work**: for extreme heat in particular, exposure at work may be compounded by an inability to recover in the home environment, among climate-exposed workers, like landscapers who both work and live in places with no or poor thermal regulation.

- **Native populations**: adding to historical trauma and ongoing injustice that puts these populations at greater risk of negative impacts, the reduction of the region's natural biodiversity decreases access to traditional foods and culturally significant plants. Climate events like wildfire, high winds, and sea level rise, can destroy cultural sites and sacred land.

We demonstrate throughout the report that many of these vulnerabilities are highly racialized; policies rooted in racial oppression and discrimination have created racial inequities across all facets of society, such that people of color are overrepresented within and among many of the highly vulnerable communities and populations.

Our cascading impacts analysis shows that climate-related threats to our energy supply are pervasive. Because energy infrastructure is connected to every other type of infrastructure and energy assets are vulnerable to many hazards, addressing these risks must be a top priority. Furthermore, the analysis found that workforce availability is central to the operation of every infrastructure system—a point that was underscored by the workforce-related challenges of the COVID-19 pandemic, which were observed during this report's development.

Adobe Stock Image

Takeaways

Lastly, perspectives and experiences shared by community members revealed that many of the vulnerabilities just articulated will intersect with, and exacerbate, the ongoing housing affordability crisis and broader economic inequality in LA County. In 2018, nearly one-third of all households in Los Angeles County were severely housing cost-burdened, meaning that they spent more than half of their income on housing. Climate hazards may render some of the existing housing stock uninhabitable, further shrinking the overall housing supply and forcing people to relocate to safer areas, possibly outside of LA County. Additionally, actions to mitigate climate hazards could, without precautionary measures, lead to gentrification of low-income areas and financially driven displacement.

Any type of displacement is disruptive to social connections, which are important to a person's ability to survive future disasters. However, many stakeholders also shared that their social connections extend beyond their neighborhood and into regional networks of shared backgrounds, occupations, or characteristics. These connections are sustained by organizations or institutions that are well-positioned to help people understand and prepare for climate risks. These trusted organizations can play a critical role in developing and disseminating culturally relevant information and resources for climate hazards.

Acting on this information

As a technical assessment, this report does not outline a climate adaptation plan or recommend specific steps to prepare for the changing climate. However, the County has committed to using the findings of this assessment to inform a range of County-led climate adaptation, emergency preparedness, community resilience, and other efforts. We also encourage other local jurisdictions to use the CVA for their own decision-making processes, and we hope that communities and groups at risk of harm will find it helpful in advocating for equitable changes in policies, practices, and investments.

Metro - Los Angeles

Introduction

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The urgency of climate change

We cannot stop the realities of climate change. But we can act collectively to mitigate and adapt to this new reality, slow down the pace of climate change, and dictate how well we endure the consequences.

Extreme climate events and stressors threaten the health and safety of the people of Los Angeles County. Each year brings unprecedented events that put stress on our health, our natural resources, and the facilities and infrastructure that provide critical services. Hot, dry weather, combined with the area's fire-prone natural landscape, accelerates wildfires severe enough to potentially displace vulnerable communities and fill the region with smoke. Projected increases in extreme heat days create health issues for LA County's most vulnerable, including children, older adults, people experiencing homelessness, and those with health conditions. Increased demand to cool buildings during high heat days can overwhelm energy systems. Coastal and inland flooding pose risks for vital community assets and infrastructure. Prolonged periods of drought threaten our water supply and rich biodiversity.

These events do not occur in a vacuum. They create ripple effects with cascading social, political, and economic consequences. Power outages impact residents, businesses, and the operations and services of other critical infrastructure. Relocations disrupt critical social networks and exacerbate the region's existing housing affordability and availability issues. Physical and mental distress from experiencing a climate emergency can create long-lasting trauma. Outdoor-based industries risk losing jobs and revenue. Changing environments inhibit the ability of Native communities to engage in cultural practices.

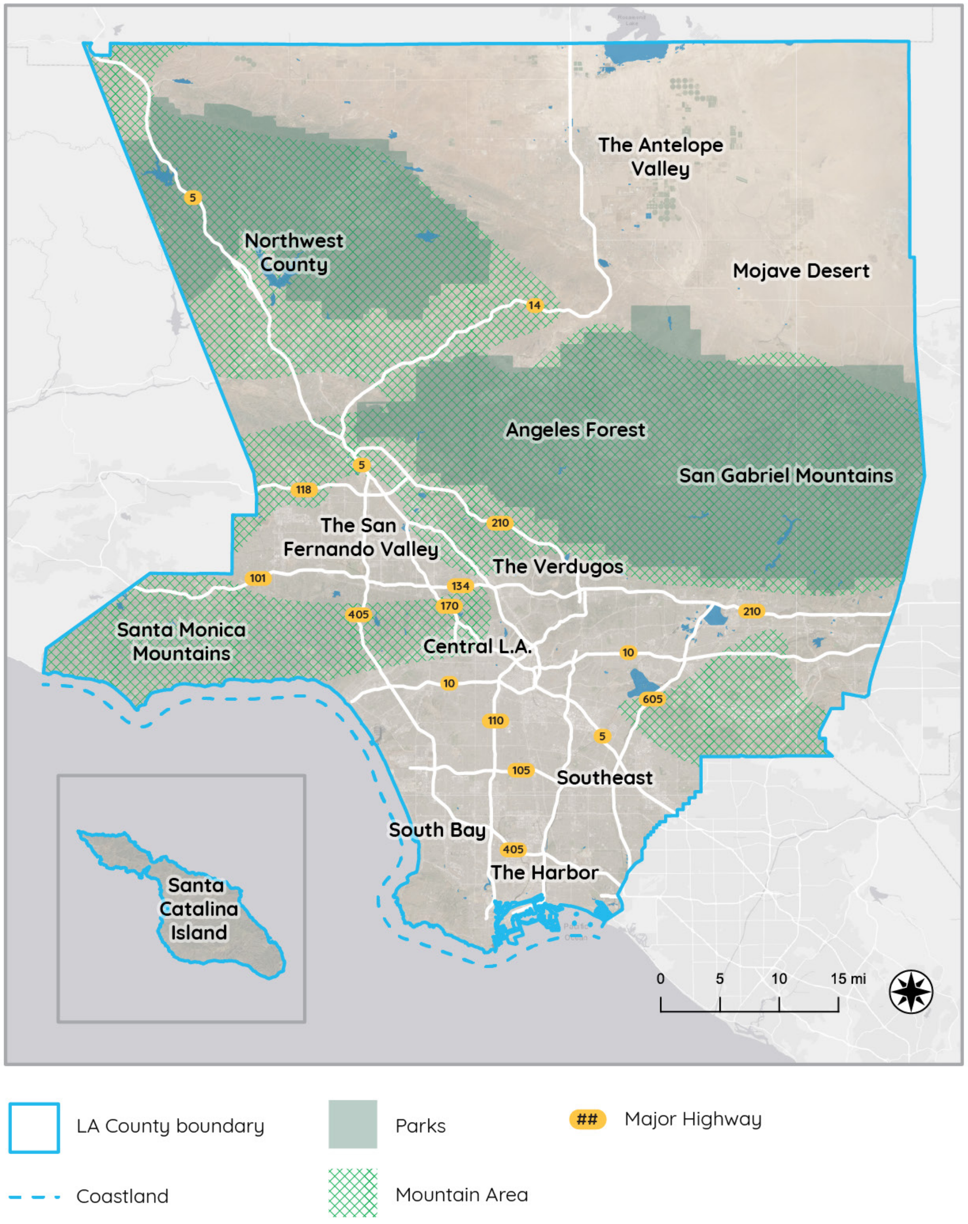
Climate projections paint a picture of more-frequent and severe extremes in the future. Climate action today can help both to curb and to prepare for climate change. Understanding who and what is most vulnerable to these climate hazards can help us prioritize climate adaptation interventions that can reduce the impact to the Los Angeles region and its communities.

We must act today to make our natural, built, and social environments resilient in the face of these shocks and stresses.

Bolstered by the OurCounty Sustainability Plan, the County is well positioned—and on its way—to take the lead in climate action. Responding to climate change requires strong collaboration among municipal entities, industry, community-based organizations, and the public. Our history of banding together to support those most closely affected by wildfires and flooding, curb water usage during times of extreme drought, and offer community refuge during heat waves demonstrates our strength in the face of these challenges.

A resilient LA County would have more redundancy in its utilities and resource systems, thriving parks and open spaces, energy-efficient buildings and facilities, and strong social networks and communities to keep us connected and informed. As we work to achieve climate resilience, we must center those who are disproportionately affected by the consequences of climate change and systemic racism that compound the hardships experienced by Native communities and communities of color.

It is critical to act now as our climate hazards notably strengthen and intensify. Resilience projects take time and effort to realize, and many opportunities are related to large, interconnected systems that require care and planning to change. Decisions made today will set a positive path forward for action that will mitigate some impacts. By comprehensively identifying LA County's physical and social vulnerabilities, this report, the LA County Climate Vulnerability Assessment (CVA), will provide a solid foundation from which the County and other local municipalities and organizations will be able to more effectively plan for a resilient, sustainable, and equitable future for all.



Los Angeles County

4,084 sq miles in LA County

2,638 sq miles of unincorporated area

88 Cities

Over **10,000,000 residents**

75 miles of coastland

1,875 sq miles of mountain area

Figure 3: LA County snapshot map

The LA County Climate Vulnerability Assessment

In 2019, the LA County Board of Supervisors unanimously approved the OurCounty Sustainability Plan following a robust stakeholder engagement process. Two of the actions in OurCounty, Actions 28A and 28B (shown in Figure 2) highlight the need for evaluating and understanding climate vulnerability across LA County.

To address these actions, the LA County Chief Sustainability Office (CSO) developed the CVA. It aims to examine LA County's social and physical vulnerability to climate hazards like extreme heat, wildfire, and flooding, which are projected to become more frequent and severe in the coming decades. The CVA also highlights equity implications of the assessment findings, including how climate vulnerabilities are distributed across different communities and populations in LA County.

The findings of the CVA will guide a range of climate adaptation, emergency preparedness, and community resiliency efforts. Additionally, the LA County CVA aims to increase awareness and climate literacy for cities, community-based organizations (CBOs), and local communities to inform their own adaptation and resilience actions. The assessment can be the foundation of endeavors to support vulnerable populations in advocating for relevant policy changes or investments, provide information for local organizations and jurisdictions to receive grant funding to support adaptation work, and identify infrastructure needs and funding opportunities to build climate resilience in LA County.

Finally, the LA County CVA will also support cities and unincorporated areas in the County in assessing local climate vulnerability for Senate Bill (SB) 379, which requires all cities and counties to update the safety elements of their general plans with climate adaptation and resilience strategies. Updates must include a vulnerability assessment, goals and policies based on that assessment, and implementation strategies. As of this writing, the LA County Department of Regional Planning has started the process of updating LA County's safety element and general plan as a result of the findings of the LA County CVA for unincorporated LA County.

Figure 2: OurCounty actions 28A and 28B

Action 28A:

Conduct a countywide climate vulnerability assessment that addresses social vulnerability and use it to guide priorities for investments in public health preparedness, emergency preparedness and response planning, and community resiliency.

Horizon	Short time
Sphere of influence	Direct, Indirect
Lead County entity	Chief Executive Office
Partners	DPH, DPR, FIRE, LASD, OEM, PW, County Counsel
Topic Tags	Air Quality, Climate, Economy & Workforce, Energy, Equity, Housing, Landscapes & Ecosystems, Public Health, Resilience, Transportation, Waste & Resource Management, Water

Action 28B:

Conduct a countywide climate vulnerability assessment that addresses physical vulnerability and use it to guide priorities for investments in building upgrades, infrastructure improvements, and zoning and code changes.

Horizon	Short time
Sphere of influence	Direct, Indirect
Lead County entity	Chief Executive Office
Partners	DBH, DPH, DPR, FIRE, LASD, Metro, OEM, PW, County Counsel, Utilities
Topic Tags	Air Quality, Climate, Economy & Workforce, Energy, Equity, Housing, Landscapes & Ecosystems, Public Health, Resilience, Transportation, Waste & Resource Management, Water

What is climate vulnerability?

Climate vulnerability represents an elevated risk to the adverse effects of climate hazards, due to both physical (e.g., infrastructure) and social factors (e.g., demographics). This term is inclusive of three key concepts: exposure, sensitivity, and adaptive capacity.

- **Exposure** is the nature or degree to which a system or population is exposed to climate hazards. For example, a coastal town in an area projected to experience a rise in sea level faces higher exposure to coastal flooding than does an inland community.

- **Sensitivity** is the degree to which a system or population is affected by climate change. For instance, older adults and children can have difficulties regulating their internal body temperatures, making them more physiologically sensitive to extreme heat than others.

- **Adaptive capacity** is the ability of a system or population to adjust to, moderate potential damages of, or cope with the consequences of climate change. For example, a municipality that develops an extensive, multilingual emergency telecommunications strategy has increased its adaptive capacity to manage an earthquake.

Vulnerability is a function of how exposure and sensitivity to a particular climate risk align with adaptive capacity. For a community with high exposure and high sensitivity to wildfire, investing in resources, infrastructure, and social services that increase its adaptive capacity to address a future wildfire can lower its overall vulnerability.

Vulnerability is influenced by environmental, institutional, political, economic, and cultural factors. This includes systemic discrimination experienced by marginalized communities based on race, ethnicity, income, age, ability, sexual orientation, or gender expression. The long-term social and economic implications of these historic injustices can directly impact a population's exposure, sensitivity, or adaptive capacity, thus increasing its vulnerability. Climate vulnerability is not an indication of individual weakness or agency but rather a measure of how these external forces contribute to susceptibility to climate risks. Identifying and addressing these inequities is a crucial step in realizing the vision for a resilient Los Angeles County. For more key terms and definitions, refer to *Appendix C: Glossary*.


CEO Countywide Communications

Summary of approach

The rise of climate hazards and extreme weather events across California prompted state, county, and local jurisdictions to focus on climate change adaptation and mitigation in their planning efforts. California is a leader in climate policy and planning, producing several key documents to guide municipalities through planning a resilient future. The first step in conducting a comprehensive climate vulnerability assessment is to review and synthesize existing materials. The LA County CVA builds upon a solid foundation of climate research and assessments to provide an analysis specific to LA County's 88 municipalities and unincorporated areas.

Relevant plans

National Oceanic and Atmospheric Administration - *Assessing the Geographic Variability in Vulnerability to Climate Change and Coastal Risks in Los Angeles County*: Using stakeholder feedback and census data, National Centers for Coastal Ocean Science researchers adapt their Integrated Vulnerability Assessment Framework to analyze Los Angeles County's vulnerabilities to coastal climate hazards.

Southern California Association of Governments - *Regional Climate Adaptation Framework:* The Southern California Association of Governments developed this framework to support local climate adaptation efforts in Southern California, in compliance with SB 379 and SB 1035.

***OurCounty: Los Angeles Countywide Sustainability Plan*:** The OurCounty Sustainability Plan outlines the County's vision for a resilient, sustainable Los Angeles County, including the two actions (Action 28A and Action 28B) that prompted the creation of this CVA.

2019 County of Los Angeles All-Hazard Mitigation Plan: In accordance with the Federal Emergency Management Agency's (FEMA's) Disaster Mitigation Act of 2000, this plan is a comprehensive assessment of the hazards, climate-related and otherwise, projected to affect Los Angeles County.

California's Fourth Climate Change Assessment: This report presents climate science and information on a state and local level to help jurisdictions identify climate-related priorities and inform adaptation strategies across the state.

Overview of methodology

In accordance with SB 379 requirements, the [2020 California Adaptation Planning Guide] suggests a framework for mapping physical and social vulnerabilities to climate hazards. The five-step process was adapted to form the methodology used in this report.

Identify level of exposure to climate hazards.

Los Angeles County has a diverse natural landscape, encompassing mountains, beaches, coastal plains, valleys, deserts, and islands. The climate hazards that affect LA County are similarly varied. Exposure is a measure of the nature or degree to which an asset or population is exposed to a climate hazard. This report uses historical data and climate projections through mid-century (2050), highlighting five key climate hazards: extreme heat, wildfire, drought, inland flooding and extreme precipitation, and coastal flooding. See the ***Climate Hazard Assessment (CHA)*** for detailed descriptions of each of these hazards and their areas of impact.

Identify key populations and physical infrastructure.

The LA County CVA considers both social and physical vulnerabilities to climate change. Certain demographic factors, like health disparities and income levels, influence a population's vulnerability to climate hazards. ***The Social Vulnerability Assessment (SVA)*** grounds its analysis in an understanding of these key social indicators. ***The Physical Vulnerability Assessment (PVA)*** prioritizes infrastructure that is owned or operated by the County or that plays a critical role in emergency response, public health and safety, or social services for vulnerable populations.

Consider sensitivities of infrastructure and populations to different hazards.

Sensitivity is the degree to which infrastructure or a population is affected by a climate hazard. The key populations and physical infrastructure identified in the SVA and PVA are evaluated for their sensitivity to extreme heat, wildfire, drought, inland flooding, and coastal flooding. The methodology for this analysis differs across the two sections. For the **SVA**, the County examined the geographic distribution of residents who are highly susceptible to climate hazards in order to identify highly sensitive communities where those residents are overrepresented, and gathered information from stakeholders on additional sensitive populations. The **PVA** assigned each infrastructure type a sensitivity value of "High," "Moderate," and "Low" for each climate hazard, depending on the severity of damage or service disruption caused by that climate hazard. Detailed descriptions of these scoring methodologies are found in the ***LA County CVA Technical Methodologies Resources.***

Determine vulnerability to individual hazards.

For this CVA, the combination of an infrastructure system's or population's exposure and sensitivity determines its vulnerability to climate change, regardless of adaptive capacity. For example, high exposure and high sensitivity indicate high vulnerability. Combining these measures into a single vulnerability score clearly illuminates areas to be prioritized for future investment and targeted support. However, a low vulnerability score does not mean no vulnerability. Climate change is a powerful force, and different people and infrastructure will respond differently to climate hazards.

Consider the effect of adaptive capacity.

Adaptive capacity is the ability of a system or population to manage or adapt to climate hazards. Adaptive capacity comes in many forms, from building-retrofit policies to green infrastructure to social services for vulnerable populations. Although a critical aspect of climate vulnerability, it is rare that adaptive capacity on its own is sufficient to eliminate climate hazard threats. For this reason, adaptive capacity does not play a role in the quantitative vulnerability scores in this CVA. However, information on progress across LA County toward building adaptive capacity and resilience is integrated throughout the SVA and PVA.

State climate legislation

Over the past decade, California has pushed cities and counties to address climate vulnerability through legislation. Bills and executive orders that set the legislative and policy context for the CVA include the following:

SB 535 (2012) directs at least 25 percent of proceeds from the Greenhouse Gas Reduction Fund to projects that benefit disadvantaged communities, with at least 10 percent of funds allocated to projects within those communities.

AB 2139 (2012) authorizes the State Coastal Conservancy to address the real and potential impacts of climate change on resources within its jurisdiction and to award grants for this purpose to public agencies and organizations, giving priority to projects that maximize public benefits.

EO B-30-15 (2012) directs state agencies to consider climate change in their planning and investment decisions, prioritizing actions that both build climate preparedness and reduce greenhouse gas (GHG) emissions, incorporate flexible adaptive approaches, protect the state's most vulnerable populations, and prioritize natural infrastructure.

AB 691 (2013) requires local trustees of public trust lands with revenues in excess of $250,000 to submit an assessment of how they propose to address sea-level rise to the State Lands Commission for public access and dissemination.

SB 379 (2015) requires all cities and counties to update the safety elements of their general plans with climate adaptation and resiliency strategies, including a vulnerability assessment, goals and policies based on that assessment, and implementation strategies.

SB 246 (2015) creates the Climate Action Team under the direction of the Secretary for Environmental Protection and requires the team to be responsible for meeting the state's climate change goals and to update the Climate Adaptation Strategy and the Safeguarding California Plan every five years.

SB 1000 (2016) requires all cities and counties to include an environmental justice element to their general plans that outlines objectives and policies to reduce the health risks for disadvantaged communities in their jurisdiction.

AB 1550 (2016) modifies the investment minimums established by SB 535 to require at least 25 percent of Greenhouse Gas Reduction Fund proceeds go to projects both within and benefiting disadvantaged communities and at least an additional 10 percent for low-income communities.

AB 2722 (2016) creates the Transformative Climate Communities Program, which awards grants to development and infrastructure projects that achieve major environmental, health, and economic benefits in disadvantaged communities.

SB 30 (2018) creates the Department of Insurance and requires it to identify, assess, and promote investment in natural infrastructure to reduce climate change risks, lessen dangers to communities, and provide mitigation incentives for private investment in natural lands.

SB 100 (2018) requires that renewable energy, and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045.

SB 1035 (2018) requires, after 2022, the safety element to be reviewed and updated upon each revision of the housing element or local hazard mitigation plan to address climate adaptation and resiliency and identify new information regarding flood and fire hazards.

SB 1072 (2019) creates the Regional Climate Collaborative Program to give disadvantaged communities funding for activities related to climate action, like building capacity, convening stakeholders, and developing plans.

Overview of methodology

Data limitations

This report uses a combination of existing research, climate change projections, census data, stakeholder feedback, and community input to inform its findings. However, there are gaps and limitations in these data. Major gaps include missing data associated with climate hazards, namely inland flooding and extreme precipitation. Only inland flooding data via historical FEMA floodplain maps are available, and future projections of flood risk are not available. Extreme precipitation data are available based on precipitation averages but do not capture the extreme events that characterize climate change's impact on precipitation. Improved data and information on these hazards are important for understanding the risk. As these data gaps are filled, the CVA will need to be updated.

Although the LA County SVA projects into the future, the scoring methodology assumes that demographics will remain constant now through 2050. The social vulnerability scores rely on census data, which have their own complications. Census data are static: they provide a snapshot of a population at a specific point in time. An unforeseen environmental or social trend may alter a system or population's exposure or sensitivity. Additionally, limitations in data collection during the census can leave certain communities, particularly undocumented individuals and Native and Tribal communities, underrepresented in the data set. Furthermore, quantitative data can fail to capture the nuances and lived experiences of vulnerable populations. We sought to partially address this limitation by gathering qualitative data from six key populations: outdoor workers, people without reliable access to transportation, people with disabilities or access challenges, rural communities, Tribal and Native communities, and people experiencing homelessness.

Physical infrastructure assets are based on existing, publicly available data sets. If data sets are not available for certain assets, for the purposes of the CVA, we did not seek to create them. Information about assets specific to a single jurisdiction may also be absent from countywide data sets. Therefore, it is critical to use this report as a starting point for future area-specific vulnerability analyses. Local jurisdictions and organizations know their communities best, and this contextual knowledge will help adapt the CVA's findings to a climate resilience strategy that best fits the needs raised by local stakeholders.

CEO Countywide Communications

Components of the CVA

The CVA is made up of four primary components: the Climate Hazard Assessment (CHA), Social Vulnerability Assessment (SVA), Physical Vulnerability Assessment (PVA), and Cascading Impacts Assessment. Each of these components has its own unique approach and findings that contribute to a complete picture of climate vulnerability in LA County.

The Climate Hazard Assessment

identifies climate hazards and evaluates present-day and projected changes in exposure where data are available. The CHA assesses climate hazard distribution across LA County now and through the end of the century. From the CHA, climate hazard exposure for extreme heat, wildfire, inland flooding and extreme precipitation, coastal flooding, and drought are used as the basis for the social and physical vulnerability assessments. Key findings from the CHA related to mid-century projections are provided in the "Hazards" section of the CVA, while the full CHA is available as an appendix.

The Social Vulnerability Assessment

evaluates the climate vulnerabilities of different population groups and communities across LA County. The SVA overlays climate hazard exposure with social sensitivities, like preexisting health conditions, age, and income, to determine where higher social vulnerability is present. The SVA also highlights the inequities in access to resources that help communities adapt to climate change.

The Physical Vulnerability Assessment

evaluates the climate vulnerability of different physical infrastructure and facilities across LA County. The PVA overlays climate hazard exposure with physical sensitivities, like the ability of extreme heat to warp and damage pavement, to determine areas with higher physical vulnerability. The PVA highlights infrastructure systems that are most vulnerable to climate hazards and require priority focus because of their use in adapting to climate change.

The Cascading Impacts Assessment

evaluates the ripple effects of climate-related infrastructure disruption. Climate hazards affect not just the asset where the hazard first strikes but also the people and infrastructure that depend on that asset. The Cascading Impacts Assessment highlights the social impacts of interdependent infrastructure failure and the need to develop adaptation measures that prioritize not just the direct impact on physical infrastructure but also downstream impacts on linked infrastructure sectors, the services those sectors support, and the people who rely on those services.


CEO Countywide Communications

Overview of stakeholder engagement

Building upon deep engagement for the OurCounty Sustainability Plan, the LA County CVA continued momentum to engage local government, utility and business entities, nonprofit organizations, CBOs, and neighborhood groups. The stakeholder engagement process occurred from August 2020 through July 2021—a tough year for many, given climate disasters, racial-justice uprisings, and a pandemic-induced widening of racial inequities. These circumstances centered real-life context as we gathered qualitative data for the CVA. The project team and partners were also challenged to find creative ways to engage hundreds of stakeholders virtually. We used platforms like Zoom, Mentimeter, Google Jamboards, and Miro to reach more than 400 stakeholders who participated in the CVA development process.

The stakeholder engagement process for developing the CVA included a range of activities, including public workshops, a cities summit, Advisory Committee meetings, listening sessions cohosted by trusted community leaders, and stakeholder interviews.

Public workshops

To begin the project, the team hosted a kickoff workshop. At this virtual workshop, 120 participants heard presentations from the CSO team and climate vulnerability stories from Nancy Zúniga from the Instituto de Educación Popular del Sur de California and Fiahna Cabana from the City of Long Beach. Attendees provided feedback on the impacts of climate hazards via eight breakout groups on Mentimeter and Google Jamboards. A word cloud generated during this workshop is shown in Figure 4 - attendees were asked "what comes to mind when you hear climate vulnerability?"

Toward the end of the project, the team hosted a closing workshop attended by 190 participants. The event showcased the CVA findings on how climate change will impact infrastructure and populations. It featured an introduction from California Insurance Commissioner Ricardo Lara and guest speakers Nurit Katz from UCLA and Sona Mohnot from the Greenlining Institute, who all highlighted ways that organizations could use the CVA to spark climate resiliency efforts. Attendees gave feedback on how the County should use the CVA and described how they would use the information in their own efforts.

Cities summit

CSO annually hosts a cities summit to provide a forum for local government staff to convene to advance sustainability. In 2020, CSO hosted its first virtual cities summit, where 50 local government staff representatives engaged in conversations about the need to increase cities' capacity to address the increasing threats from climate change generally and more specifically to ensure that the most vulnerable in their communities are prepared. Kate Gordon, director of the Governor's Office of Planning and Research and senior adviser to the governor on climate, provided opening remarks on state-level climate actions and the important role of local governments.

Advisory Committee meetings

The County established an Advisory Committee to guide the CVA project development and inform the process. Fifteen representatives participated in four meetings to inform the CVA's data needs, equity framing, stakeholder engagement process, desktop review, physical and social vulnerability key findings, cascading impacts, and usability of the report. Advisory Committee members came from the following organizations across various sectors: Active San Gabriel Valley, Association of Rural Town Councils, BizFed Institute, Communities Actively Living Independent & Free, the Greenlining Institute, Instituto de Educación Popular del Sur de California, Los Angeles County Department of Public Health, Los Angeles County Department of Regional Planning, Los Angeles Regional Water Quality Control Board, the LA Mayor's Office of Resilience, Prevention Institute, Sacred Places Institute for Indigenous Peoples, Southern California Edison, UCLA Sustainability, and USC Sea Grant.

Listening sessions

The County cohosted six listening sessions with community leaders and organizations to reach 66 stakeholders from hard-to-reach climate-vulnerable populations or those who have barriers to—or have been excluded from—engaging with decision-making processes. These targeted groups included people experiencing homelessness, people without reliable transportation, people with disabilities and access challenges, outdoor workers, Tribal and Native communities, and rural communities. These community experts were engaged to share their communities' experiences with climate hazards, strategies for coping and adapting, and gaps in government responses to climate hazards.

Stakeholder interviews

The project team conducted more than 25 interviews with staff from County departments, academic institutions, and nonprofit organizations to inform data sets that were used for the CVA and to gather information on infrastructure and population sensitivities, cascading impacts, and ongoing research efforts across the region and state.

The CVA's stakeholder engagement contributed to a human-centered approach to the CVA findings. Throughout the stakeholder engagement process, the County heard stories or firsthand experiences from people who coped with past heat waves, flooding, drought, and wildfire hazards. The testimonies will help local organizations use the CVA findings to advocate for their communities or present to people they serve.

Figure 4: "What comes to mind when you hear climate vulnerability?" Word Cloud from Stakeholder Engagement

How to use the CVA

The LA County Climate Vulnerability Assessment is presented in various formats, each serving a different purpose. The CVA can be explored as the report itself along with its accompanying appendices, an online mapping tool, or one-page summaries. All formats are available to the public to help spread awareness and increase education around local climate vulnerabilities.

The **CVA report** is the main way to communicate the process and findings of the effort. The report contains findings across the Social and Physical Vulnerability Assessments and the Cascading Impacts Assessment. It is accompanied by a set of appendices that include a glossary and full technical methodologies.

The **CVA online mapping tool** aims to be a user-friendly resource to dig into the LA County CVA findings so more localized data and information can be highlighted. The tool will support local jurisdictions with their planning projects and provide an extra level of transparency of the CVA data and findings.

A series of **one-page summaries** is tailored for different target audiences: rural communities, advocates, city department staff, and elected officials. These documents are meant to help readers navigate the CVA and the mapping tool, aid cities in adaptation planning, and provide more localized information on climate risks to make the case for climate action and adaptation, respectively.

Climate Hazards

CEO Countywide Communications

Introduction

Los Angeles County faces challenges driven by a rapidly changing climate. LA County comprises diverse landscapes and is subject to a range of climate hazards. A statewide study of climate-related social vulnerability found that while 27 percent of the state's population lives in Los Angeles County, it is home to 40% of the state's highly vulnerable population – roughly 5 million people.[2] Presently and in the future, these hazards pose risks to communities, infrastructure, and natural systems in LA County. The LA County Climate Vulnerability Assessment (CVA) explores five climate hazards.

Some climate hazards will affect LA County as discrete extreme events, like a flood or wildfire. These climate hazards are commonly referred to as *shocks*, because they occur quickly and forcefully. Other hazards like extreme heat or drought are commonly referred to as *stressors*, because severity and consequences build up over time.

For centuries, LA County has been impacted by extreme weather events. However, in recent years, climate hazards have intensified. Seven of the ten largest wildfires in California's history have occurred since the start of 2017.[3] In the County's history, two of the five largest wildfires have occurred since the start of 2018, burning more than 38,800 and 46,500 hectares.[4] LA County experienced its hottest temperatures ever recorded during the September 2020 heat wave, with temperatures reaching 121°F in some areas.[5] In addition, the extremely wet 2016–2017 winter following the 2012–2016 drought signaled increasing volatility of climate hazards that are impacting the region.

A serious challenge of climate change is when climate hazards occur simultaneously or overlap. Such occurrences are referred to as *compound climate events* —the combination of multiple drivers and/or hazards that contribute to societal or environmental risk.[6] There is ongoing research to better understand the impacts of compounding events, but from what we have seen, such events can multiply consequences. For example, simultaneous wildfire conditions and extreme heat may compound risks for those with existing respiratory problems.[7] When drought and heat waves coincide, impacts to the agricultural sector, energy infrastructure, and natural ecosystems may be exacerbated. During these periods, water demands increase while water availability drops. This can also increase the likelihood of wildfires.[8]

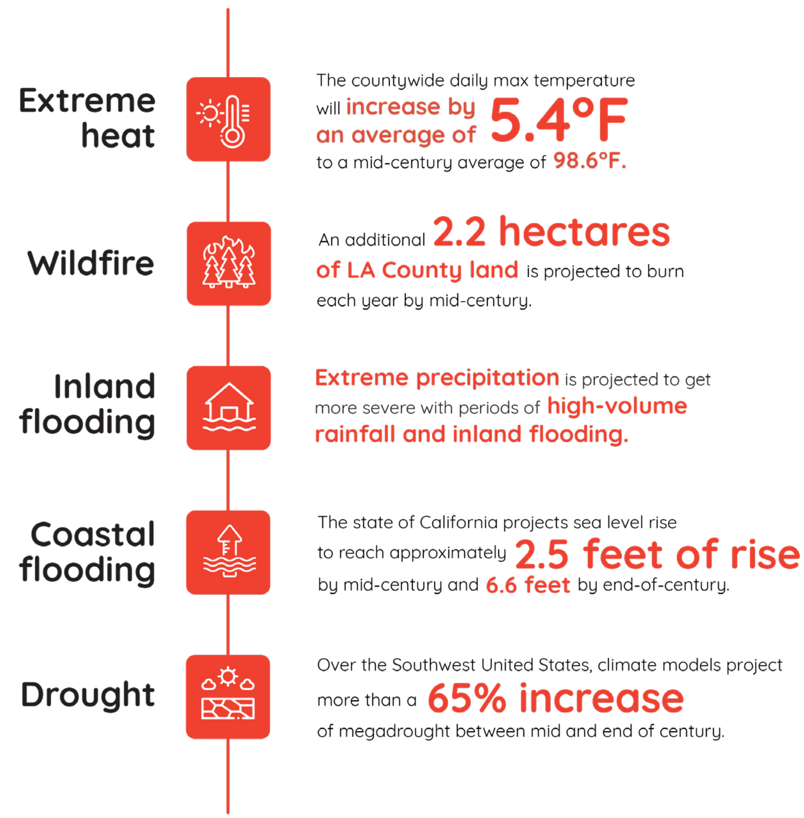


Figure 5: Climate hazard projections in LA County

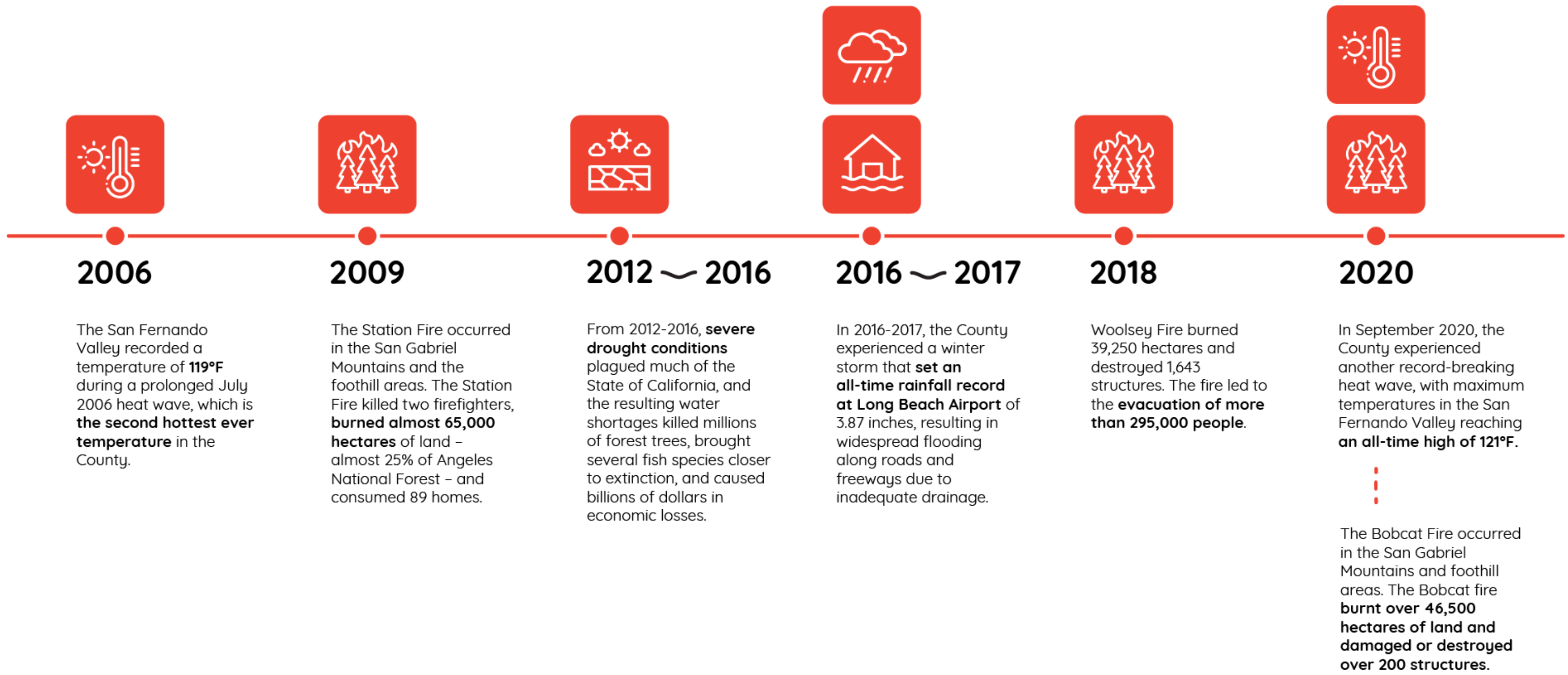


Figure 6: Past climate events in LA County

The degree to which climate hazards will change and intensify over time depends on our global efforts to reduce greenhouse gas (GHG) emissions now and into the future. Climate models use different scenarios to understand potential future climate trends. These scenarios are based on global GHG emission projections, which lead to changes in climate. Two common climate model scenarios include a high GHG emissions future (Representative Concentration Pathway [RCP[9]] 8.5), where GHG emissions continue to rise through the 21st century, and a reduced GHG emissions scenario (RCP 4.5), where action is taken to reduce GHG emissions over time, limiting global temperature increase to 1.8°C by 2100.[10] For the CVA, the County evaluated the RCP 8.5 scenario for a worst-case evaluation of how climate hazards may worsen over time.

In addition to the emission scenarios, the County evaluated climate hazard projections at multiple time intervals. A 30-year period from 1976 to 2005 was used to provide a baseline historical average that minimizes climate variance and anomalies. Future projections for mid-century represent an average of modeled conditions during years 2036 to 2065. The County selected mid-century as the primary future planning time horizon, because it is within a manageable time frame to study, plan, and act to better adapt people and infrastructure in LA County to climate hazards. Evaluating LA County's climate hazards through mid-century under an RCP 8.5 scenario provides a look into the future, illustrating how each climate hazard is expected to change and intensify by mid-century. For more information on climate hazards and projections for LA County, refer to the *LA County Climate Hazard Assessment*.

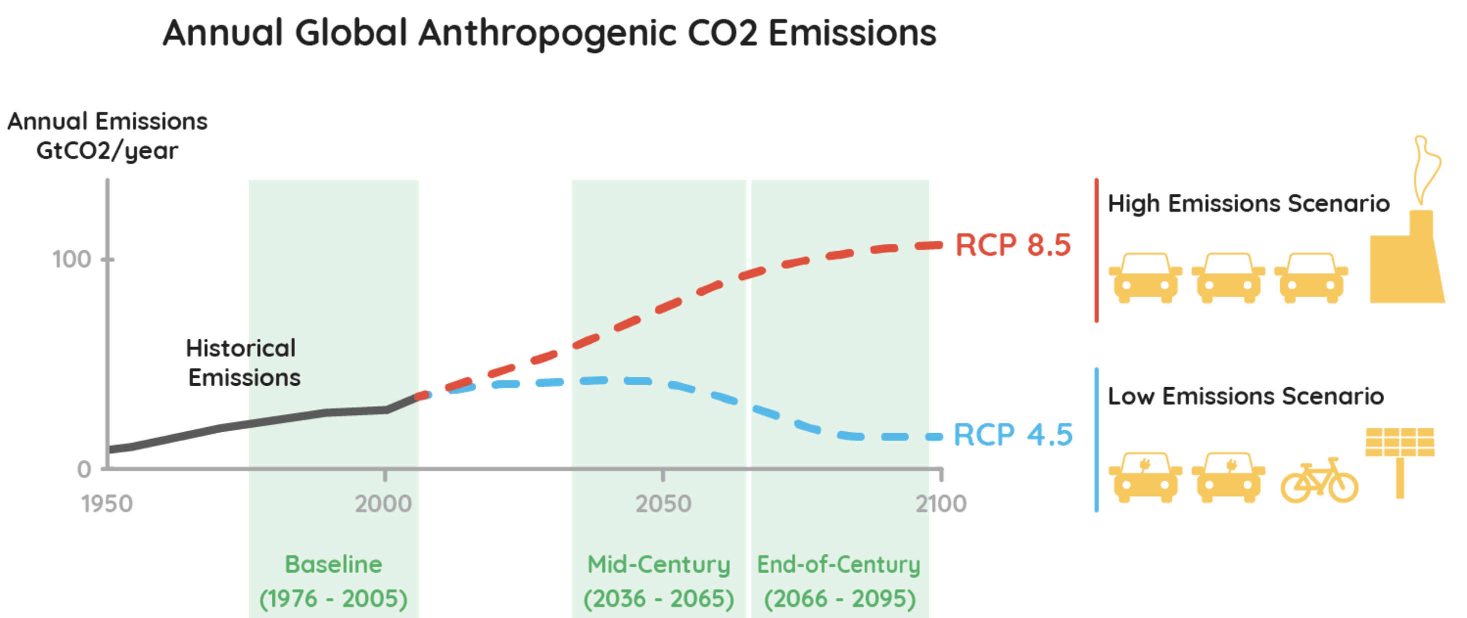


Figure 7: Annual global anthropogenic CO_2 emissions and RCPs[11]

Extreme heat

A primary climate-related concern in LA County and across the country is rising temperatures. For the CVA, the County evaluated historical baseline and projected 95th-percentile daily maximum temperatures—or the temperature threshold at which 95 percent of all days in a year have cooler maximum temperatures. Using the 95th-percentile daily maximum temperature reveals the relative severity of extreme heat across the County. For example, coastal parts of the County historically experience 95th-percentile daily maximum temperatures of about 85˚F, while the San Gabriel Valley historically experiences 95th-percentile daily maximum temperatures of about 100˚F. The countywide 95th-percentile daily maximum temperature will increase by an average of 5.4°F, from an historical baseline of 93.2°F to a mid-century average of 98.6°F.

Extreme heat is projected to increase in frequency, severity, and duration, with the largest increases occurring in the Santa Clarita and San Fernando Valleys. The diverse landscape in LA County includes coastal, mountain, desert, and urban environments. This variety drives climatic variance in the region (see Table 1). Seasonal temperatures can be most extreme in the northern areas of LA County, where 95th-percentile daily maximum temperatures of over 100˚F are common during the summer months.

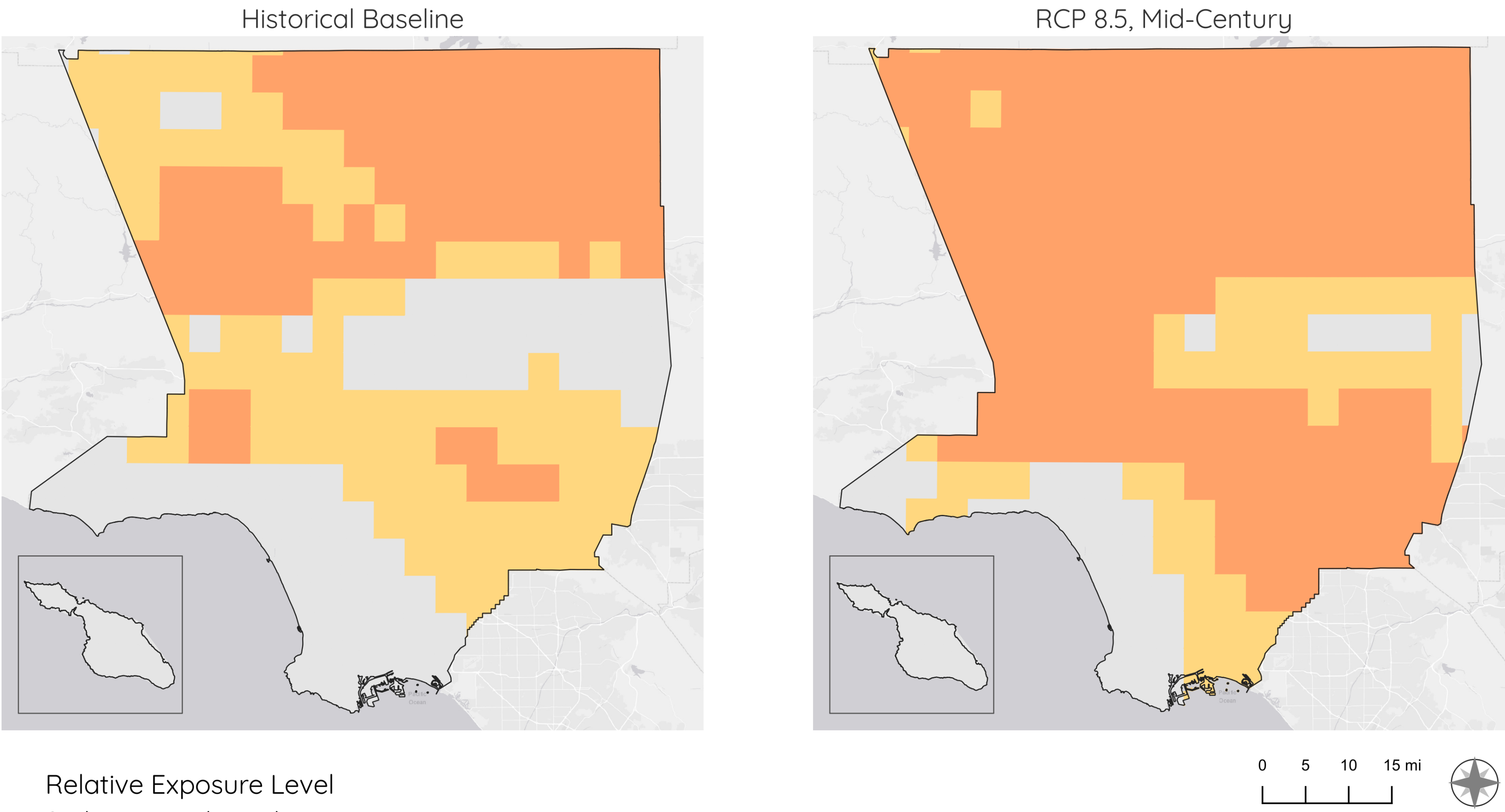
In addition to hot days, extended periods of extreme temperature, known as heat waves, can multiply the impacts of extreme heat. LA County has begun to experience more frequent, longer, and more severe heat waves. The San Fernando Valley experienced a heat wave in July 2006 that saw 21 consecutive days over 100˚F, which was the longest stretch of extreme heat ever recorded since recordkeeping began in the Valley in 1949.[12] More recently, in September 2020, LA County experienced another record-breaking heat wave, with maximum temperatures in the Valley reaching an all-time high of 121˚F.[13] Countywide heat waves are projected to increase in frequency and duration by mid-century. Modeled projections show that the annual average number of heat waves in LA County will increase tenfold by mid-century (in this context, a heat wave is at least four consecutive days of daily maximum temperature above the 98th percentile for the County, or 94.4°F, under an RCP 8.5 scenario). By mid-century, LA County is projected to experience upward of five heat waves per year, compared with less than one heat wave a year during the observed historic period.[14]

Table 1: Representative 95th Percentile Daily Maximum Temperatures Across LA County

Community	Baseline	Mid-Century Projection	Change
Lancaster	100.8°F	106.8°F	6.0°F
Santa Clarita	97.9°F	104.3°F	6.4°F
Reseda	97.6°F	103.7°F	6.1°F
Baldwin Park	97.8°F	103.2°F	5.4°F
East Los Angeles	93.8°F	99.1°F	5.3°F
Malibu	86.2°F	91.0°F	4.8°F
Venice	80.5°F	84.8°F	4.3°F

By mid-century, projections suggest that most of the County will likely shift to moderate or high exposure to extreme heat, with the majority of LA County in high exposure by mid-century. Traditionally cooler communities like those along the coast, will likely experience an increase in heat by mid-century. even though they remain in low exposure per the CVA analysis (see Figure 8). It is also likely that these communities may not be prepared for the increases in temperatures, given their historically mild climate.

Exposure to Extreme Heat



Relative Exposure Level
95th Percentile Daily Maximum Temperature

- Low, < 86.4 °F
- Moderate, 86.4 °F - 94.2 °F
- High, > 94.2 °F

Sources: Cal-Adapt, UC Berkeley, Scripps Institution of Oceanography - UC San Diego, University of Colorado, Boulder.

Figure 8: Map of exposure to extreme heat in LA County

Wildfire

Hot and dry summer weather, followed by low moisture and strong Santa Ana winds in the fall and winter, combined with a fire-susceptible landscape, often creates severe wildfire conditions across LA County. For the CVA, the County evaluated historical baseline and projected annual hectares burned to represent wildfire exposure. Although the projections used for the CVA do not include the influence of wind patterns, research points to a relationship between strong winds and larger fires.[15] For more information on wildfire and the influence of wind on wildfire, refer to the *LA County Climate Hazard Assessment.*

The San Gabriel Mountains, largely covered by the Angeles National Forest, have the highest degree of wildfire risk. On average, the San Gabriel Mountains are projected to experience an increase in wildfire burn area of approximately 40 percent and 50 percent in 2050 and 2080, respectively, under the RCP 8.5 scenario. By mid-century, wildfire events in LA County and across the state are projected to be considerably larger, more frequent, and more destructive. As shown in Figure 9, exposure to wildfire in LA County is expected to grow, and many areas will be in the high-exposure range by mid-century. Areas particularly exposed include the mountainous band of LA County near the Angeles National Forest.

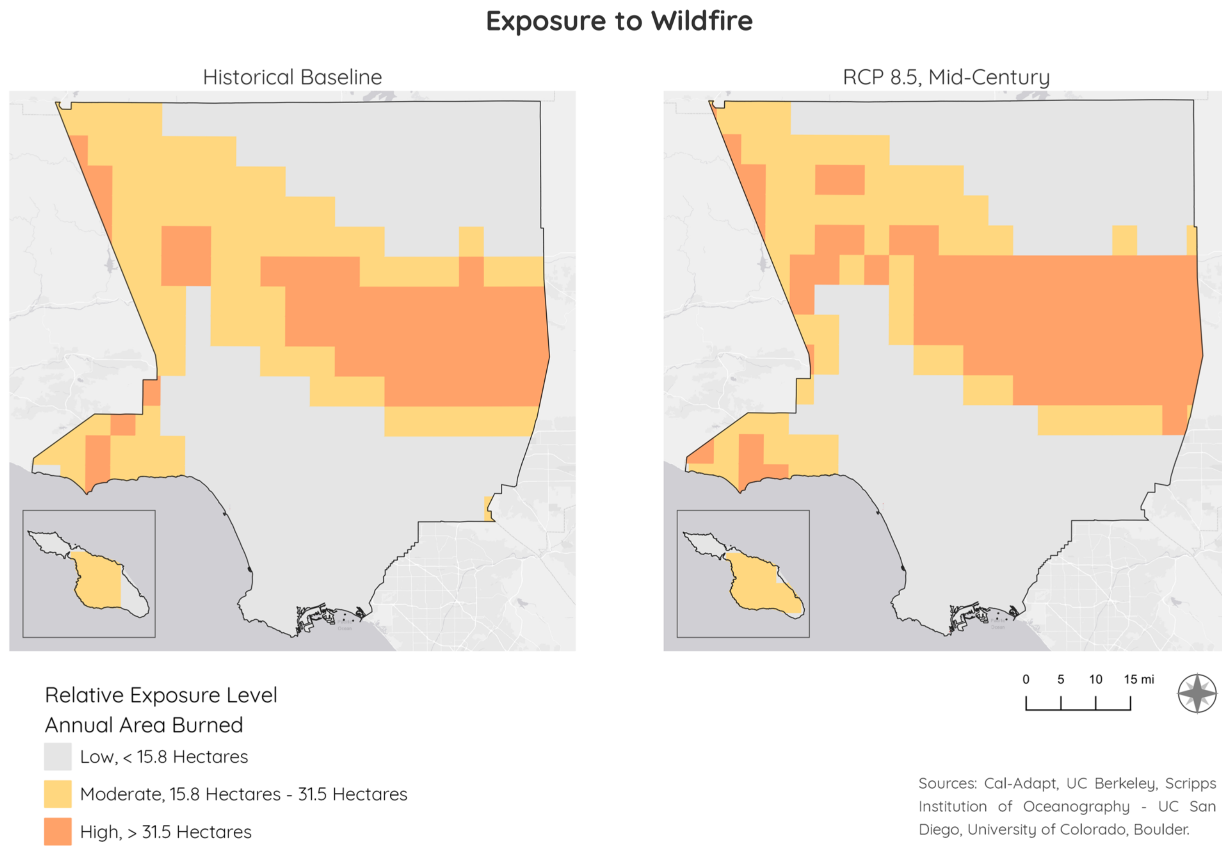


Figure 9: Map of direct exposure to wildfire in LA County

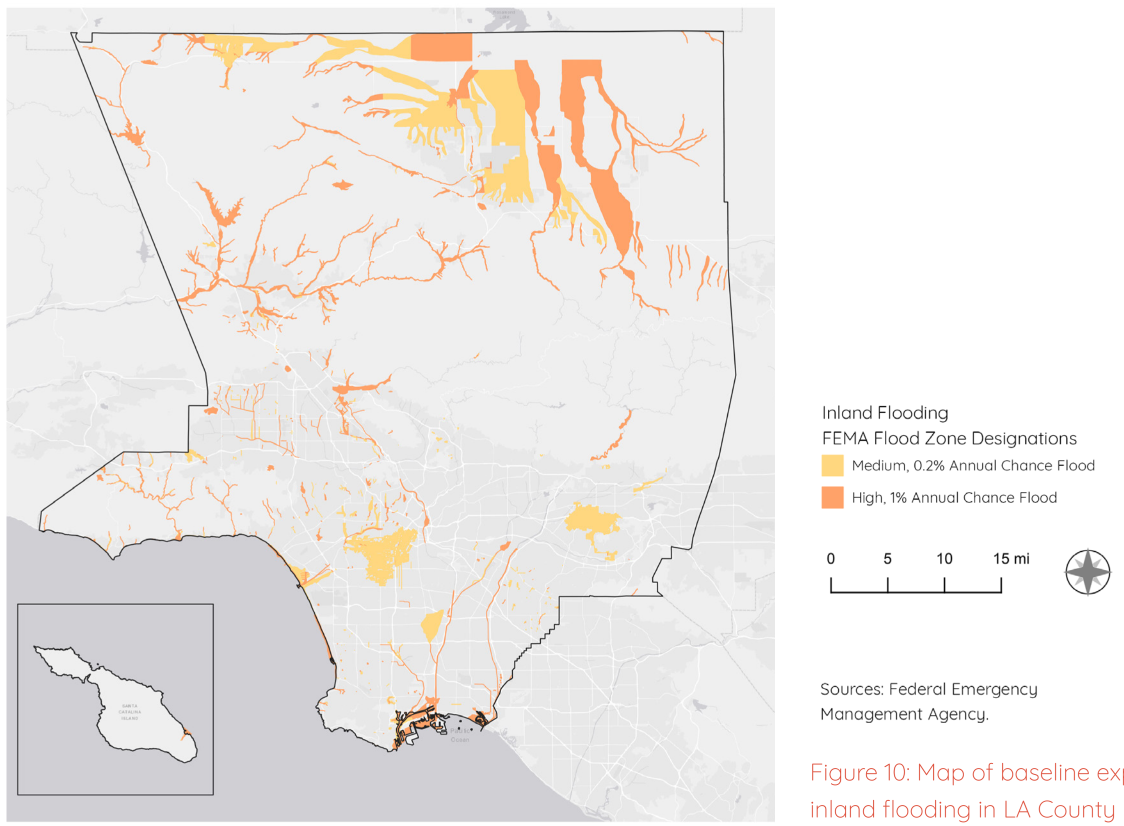
Inland flooding and extreme precipitation

Inland flooding in LA County results from heavy or intense precipitation events that create flows large enough to overtop natural waterways or exceed the capacity of stormwater infrastructure. Flood-prone zones include areas within river floodplains or adjacent to drainage systems, low-lying areas where heavy rainfall can collect, and areas with inadequate storm drain infrastructure. Inland flooding can be exacerbated by high amounts of impermeable surfaces.

Climate projections for inland flooding that account for such factors as land use, stormwater management infrastructure, and topography were not available at the time of this assessment. This represents a critical gap for understanding climate vulnerability in the County. As of this writing, the only countywide data available on inland flooding are Federal Emergency Management Agency (FEMA) floodplain maps, which are representative of current, or baseline, likelihood of severe flooding and do not account for likely increases in severe flooding resulting from climate change. The LA County CVA includes these data to represent current inland flooding vulnerability, however, the County notes that climate-informed projections are critical to understanding future flood risk and should be prioritized. For the CVA, inland flooding exposure was categorized as areas with a 1-percent chance of annual flooding occurrence or 0.2-percent chance of annual flooding occurrence (see Figure 10). There are approximately 182 square miles in LA County that face a 1-percent chance of annual flooding. As just noted, because of the limitations of these data sets, estimates of flood risk in the CVA should be considered conservative.

Extreme precipitation is a contributing factor to inland flooding and was evaluated for the Climate Hazard Assessment using the 95th-percentile daily precipitation threshold (in inches)—or the threshold at which 95 percent of all rain days in a year have smaller amounts of precipitation. Across LA County, the baseline 95th-percentile daily precipitation threshold is 1.1 inches, which is projected to increase to 1.2 inches by mid-century, or an average of a 0.091 inch increase. Existing data are based on precipitation averages but do not capture the extreme events that define climate change's impact on precipitation. For this reason, inland flooding is used as a proxy for understanding exposure to both inland flooding and extreme precipitation. However, it is acknowledged that both data sets have gaps and should be investigated further for a better understanding of LA County vulnerability. It is also important to understand that inland flooding and extreme precipitation can and do occur independently and can have discrete impacts

Exposure to Inland Flooding



Sources: Federal Emergency Management Agency.

Figure 10: Map of baseline exposure to inland flooding in LA County

on people and infrastructure. For more information on extreme precipitation, refer to the *LA County Climate Hazard Assessment*.

Inland flooding, both in terms of frequency and extent, will likely increase in the future because of changes in extreme precipitation.[16] Rainfall patterns are expected to change in the future, with drier springs and summers and wetter winters throughout the state. Moreover, precipitation may become more concentrated over short periods, resulting in extreme rain events and heavier rainy seasons that occur after periods of very dry weather.[17] In addition, increasing urbanization has already exacerbated flood risk in LA County, and the continuation of this trend may worsen future floods if climate-resilient development strategies are not prioritized.[18]

Coastal flooding

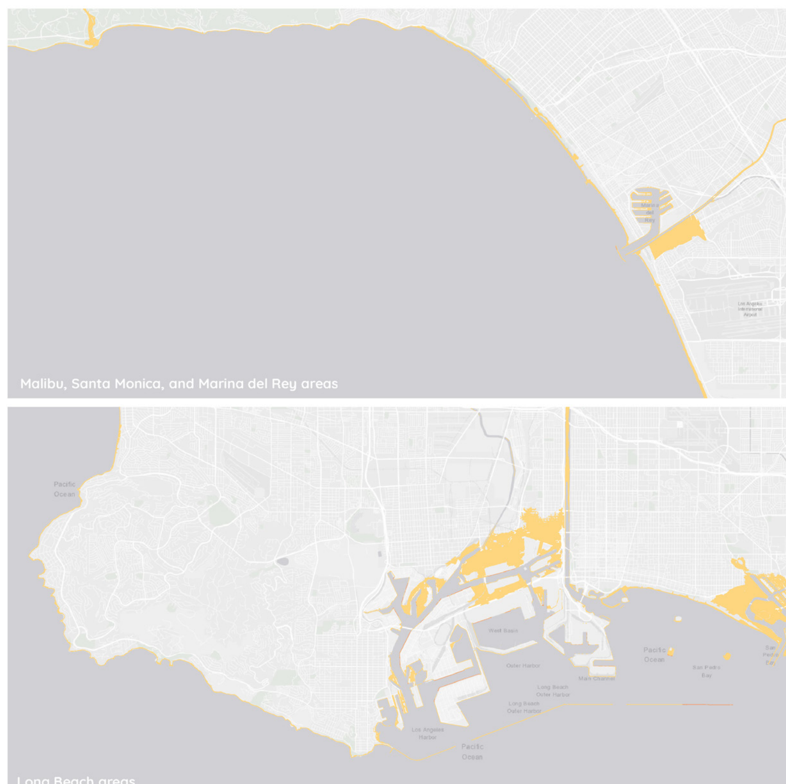
Much of the LA County coastline is characterized by wide, sandy beaches and steep cliffs, as well as infrastructure like roadways and bike or pedestrian paths, homes and businesses, and recreational spaces. Other areas of the coast are more developed, with major infrastructure like ports and marinas. Sea-level rise poses a risk to low-lying areas of LA County and exacerbates inundation during high tides and coastal storms. Additionally, sea-level rise may result in rising inland water tables (i.e., “shoaling”), especially in areas with shallow groundwater, increasing the severity of flooding.[19]

For the LA County CVA, the projected increase in sea-level rise, in conjunction with a 1-percent chance of annual flooding occurrence, was evaluated to represent storm-induced coastal flooding exposure. There is currently minimal sea-level rise to contribute to coastal flooding and, thus, current conditions serve as the baseline as part of the CVA.

Sea-level rise within LA County is projected to accelerate through the 21st century. The state of California projects sea-level rise under an extreme scenario, assuming accelerated mass loss from the West Antarctic Ice Sheet over the 21st century, to reach approximately 2.5 feet by mid-century and 6.6 feet by end of century. Combined with a 1-percent chance of annual flooding occurrence, the depth of inundation can be much greater. Coastal flooding events may become more frequent and severe, even with small increases in sea level rise.

By mid-century, all of LA County’s coastline will experience at least moderate exposure to coastal flooding (see Figure 11). Some areas around the Ports and on Santa Catalina Island will experience high exposure to sea-level rise, combined with extreme storms that result in flood heights greater than 3.9 feet. However, these high exposure areas are minimal compared to moderate exposure along the coast, and therefore are difficult to discern in the zoomed-in maps.

Exposure to Coastal Flooding



Relative Exposure Level
2.5 Foot Sea Level Rise and 1% Annual Chance Storm
Moderate, 0 - 3.9 feet
High, > 3.9 feet

0 1.5 3 mi

Source: USGS Coastal Storm Modeling System (CoSMoS).

Figure 11: Map of exposure to coastal flooding in LA County

Drought

Drought is a regional hazard characterized by prolonged dry periods that can lead to shortages in water supply, increased wildfires, and impacts to air quality including dust. Drought is a climate hazard for which census tract-level mapping is not possible. For the LA County CVA, drought and its impacts are discussed qualitatively.

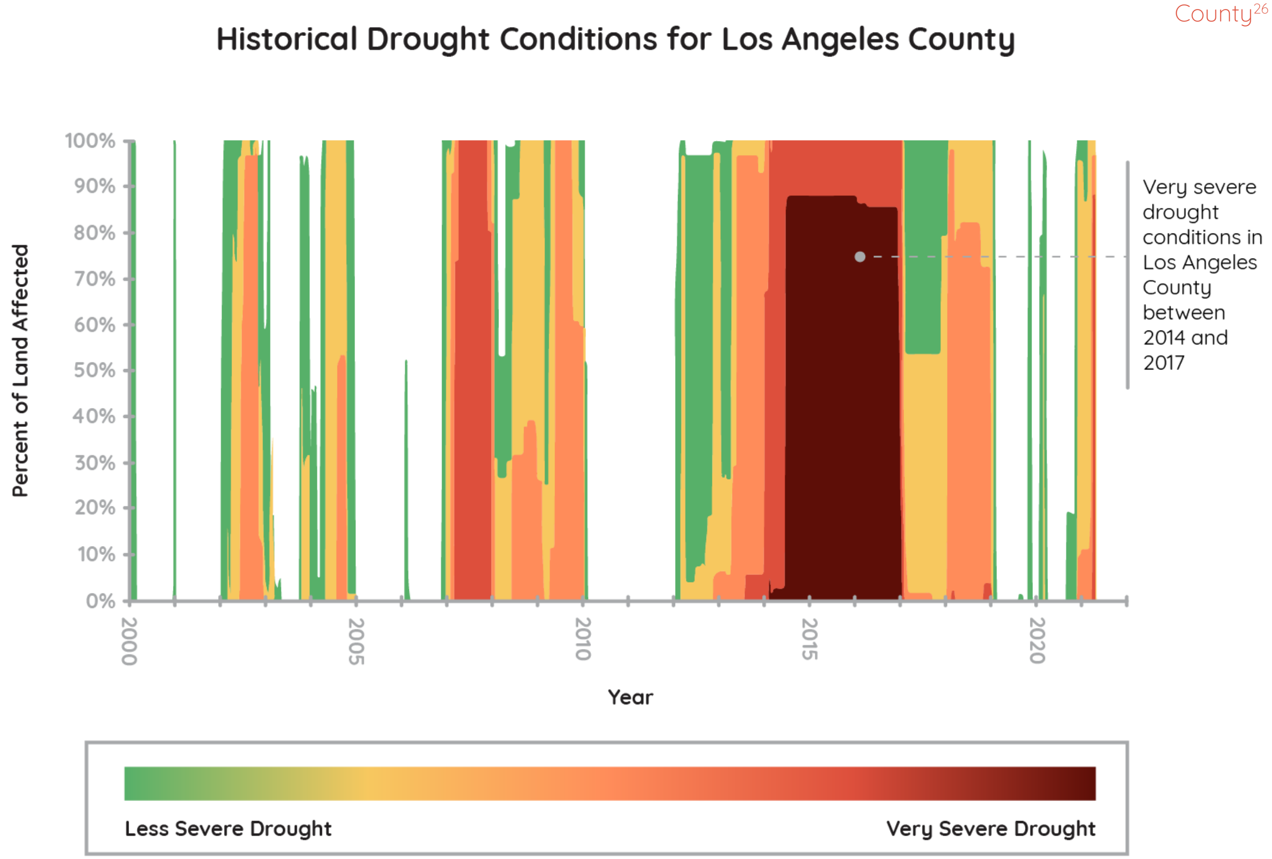
Climate change is projected to increase the likelihood of coincident low precipitation and warm years throughout California, which will increase the risk of severe droughts.[20] Across the southwestern United States, drought is projected to occur more frequently, more severely, and over increasingly prolonged periods of time. In this same region, climate models project a significant increase in the chance of a multidecadal drought—or a mega-drought—which can lead to extensive impacts.[21]

Additionally, because Southern California is heavily reliant on water supplies imported from the Owens Valley, Bay Delta region, and the Colorado River, drought impacts on these watersheds, including reduced snowpack, will affect water supply in Southern California. Changes to snowfall patterns can influence water supply and drought conditions. Snowpack in the Sierras may largely disappear below 6,000 feet by end of century, particularly in the northern portions of the mountain range, reducing mountain system recharge.[22]

Although the average amount of annual precipitation in California is not projected to change significantly, annual variability is expected to increase, with drier springs and summers and wetter winters creating water storage challenges. The increase in frequency of transition between wet and dry extremes—or *precipitation whiplash*—makes the drought-flood cycle more dramatic.[23] More intense droughts are caused by high temperatures, strong winds, and clear skies, which cause an increase in radiation from the sun.[24] This phenomenon can quickly remove moisture from the soil, leading to compacted soil. [25] In the case of a severe rain event, compacted soil will not allow for infiltration and can lead to flash floods.

In addition to direct impacts on water supply, drought creates dry conditions that can lead to secondary impacts – including but not limited to: increased wildfire risk, reduced evapotranspiration (and thus less ability to mitigate periods of extreme temperatures), damage to habitats and vegetation, and higher volumes of dust. Collectively, these will contribute to decreased air quality and increased public health issues across LA County.

Figure 12: Historical Drought Conditions for Los Angeles County[26]



Climate hazards also play a role in worsening environmental conditions and driving secondary impacts to human and natural systems in LA County. For example, extreme precipitation that followed the Camp and Woolsey Fires triggered potentially deadly mudslides in recent wildfire burn areas in Southern California, forcing evacuations.[27] Additionally, climate hazards worsen air and water quality, increase the transmission of vector-borne diseases, and reduce biodiversity. These environmental impacts are projected to increase in frequency and severity because of climate change.

Air quality

Climate change is projected to exacerbate poor air quality in the Los Angeles region, which already experiences some of the worst air quality in the country. Ozone and particulate matter are the primary air pollutants in the region.

Extreme heat increases ground-level ozone production both by speeding up the chemical reaction that forms it and by increasing rates of biogenic volatile organic compound (VOC) emissions, which can be a precursor for ground-level ozone. In addition, increases in wildfire activity result in higher particulate matter (PM) concentrations, particularly PM 2.5, or particulate matter smaller than 2.5 micrometers. Wildfire smoke can also contain other toxic air pollutants like nitrogen oxides, VOCs, carbon monoxide (CO), ozone, and black carbon.[28, 29, 30] Extreme precipitation and flooding may lead to excess moisture in homes, potentially worsening indoor air quality through mold growth. Increasing frequency and severity of drought may dry out soils and increase dust levels. Each of these factors worsen outdoor and indoor air quality and can create or exacerbate human respiratory illnesses.

By 2050, ozone concentrations in Los Angeles could increase between 5 to 10 parts per billion (ppb), and the number of days with ozone at more than 90 ppb (considered unhealthy for sensitive populations) could increase to 22–33 days.[31] The U.S. Environmental Protection Agency (EPA) sets the National Ambient Air Quality Standards standard for ground-level ozone levels at no more than 70 ppb to protect public health.[32]

Water supply and quality

Water quality and supply in LA County is at risk from high temperatures, drought, and flooding. Water quality can suffer from pollutants like excess nutrients, bacteria, algae, and, salinity and sedimentation that may be spurred by climatic events.

Higher water temperatures in lakes and reservoirs can remove dissolved oxygen, lead to excess nutrient production, and alter water chemistry, promoting the growth of bacteria, algae, and parasites.[33, 34, 35] Decreases in precipitation, from drought, and evaporation, caused by higher temperatures, may increase the concentration of pollutants and salinity in streams, reservoirs, and groundwater. Increased precipitation and wildfires can also transport more contaminants to surface waters.[36] Increased carbon dioxide concentrations can also lead to acidification.

Water in LA County is already a precious resource, and climate change poses significant challenges to maintaining supplies both for humans and the environment. More frequent and intense periods of drought could reduce the availability of imported water and drive an increasing use of groundwater. If not managed sustainably, groundwater overdrafts can permanently diminish aquifer capacity.[37] Higher temperatures may increase evaporation and thereby reduce water supply. Furthermore, because of the changes in snowpack in the northern Sierra Mountains, the April snow-water equivalent—an indicator of water resource availability—may decrease by up to 80 percent by mid-century.[38] This reduced storage of water in snowpack, as well as more extreme seasons (i.e., drier springs and summers and wetter winters), also pose a challenge to water capture and storage.

Biodiversity

Los Angeles County predominantly features a Mediterranean climate and encompasses a range of ecosystems, including desert, mountain, and coastal zones. There is high biodiversity, with more than 4,200 distinct species (over 1,200 of which are native), and with even the most urbanized land areas containing more than 200 native species.[39, 40]

Increasing temperatures, changing precipitation patterns, and other climatic events will likely lead to a shift in plant and animal habitats toward higher elevations and northward in LA County. In the oceans, a similar trend is expected: fish populations will move northward, and more subtropical species will enter the region because of rising water temperatures.[41] Rising concentrations of carbon dioxide will also drive ocean acidification, threatening marine ecosystems throughout the California coast.[42] More generally, changes in temperature and precipitation can lead to a decline in biodiversity, particularly for some species that might have trouble adapting to the changing climate. Some of these same changes may also favor the proliferation of invasive species, which will place further stress on native biodiversity.[43, 44] In the case of sea-level rise, the sea can submerge wetlands and can potentially remove the feeding habitat for seasonal, migratory birds.[45]

About two-thirds of California's local species may experience an 80-percent reduction in their geographic distribution. Almost half of the protected land area currently home to these species may be devoid of them by mid-century under RCP 8.5.[46]

Disease vectors

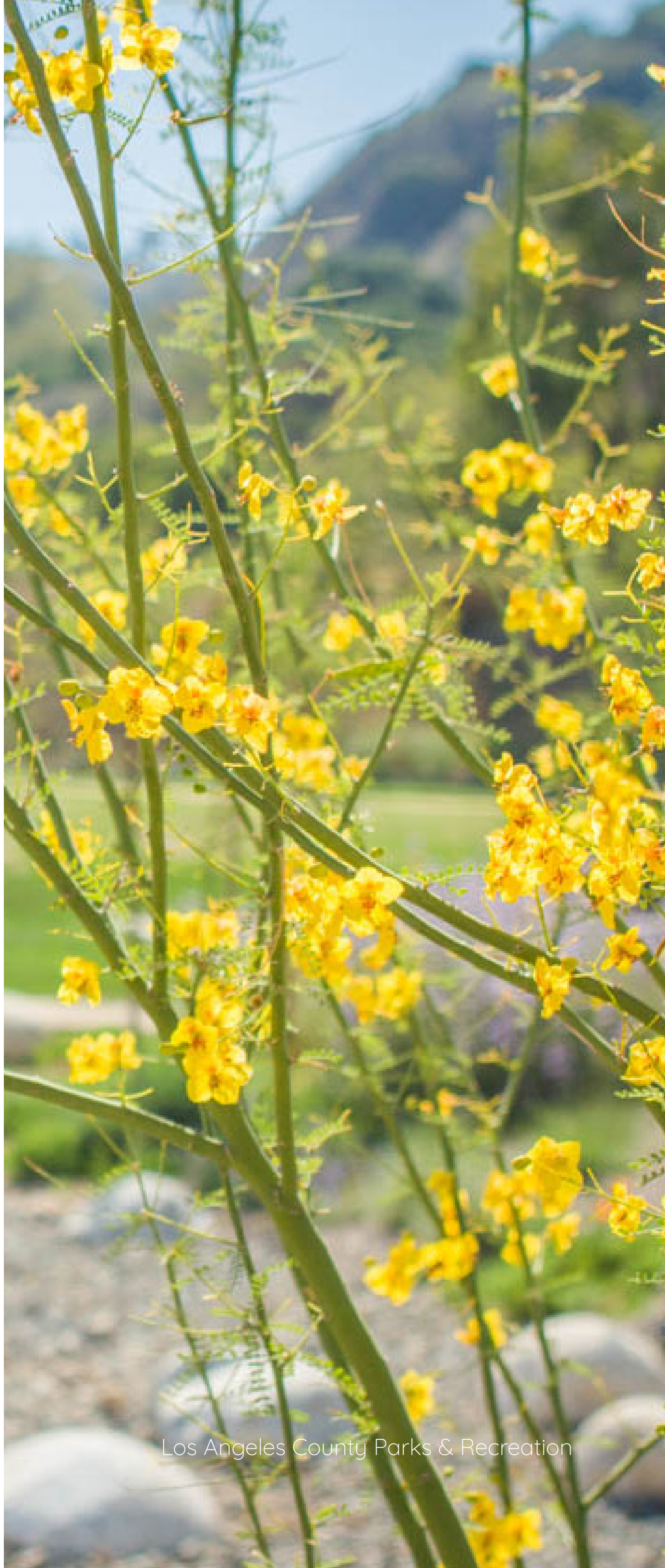
Vectors are living organisms that can transmit infectious pathogens between humans, or in some cases from animals to humans. Vectors can transfer parasites, viruses, or bacteria and can cause vector-borne diseases in humans, like malaria or yellow fever.[47] Extreme heat, extreme precipitation, and flooding create conditions conducive to the proliferation of mosquitos, potentially increasing the prevalence of West Nile Virus and other diseases throughout LA County.[48]

Increasing temperatures and precipitation also provide favorable conditions for invasive Aedes mosquitos, which are vectors for dengue fever, Zika virus, and chikungunya virus elsewhere in the world, although these viruses are not currently endemic in LA County. Aedes mosquitos first appeared in LA County in 2011[49,50] and are now found in most communities. Climate change will likely continue to facilitate the spread of Aedes mosquitos, although it is unclear to what extent this will occur in the Los Angeles region.[51]

Mudslides and landslides

Mudslides and landslides, which contain significant amounts of water, are frequently triggered by extreme precipitation, especially following wildfires.[52] Because of their nature, mudslide and landslide susceptibility is highest in the mountainous areas of LA County.

Future changes in precipitation patterns, coupled with more frequent and severe wildfires, are projected to increase landslide and mudslide risk across LA County. Climate models indicate that the region will experience more intense and prolonged periods of rainfall in the future, which will saturate soils and potentially trigger mudslides and landslides.[53] Wildfires exacerbate these risks, as they can produce impermeable layers of ash and hydrophobic soils. Consequently, instead of penetrating surfaces, runoff from heavy precipitation in these areas will pick up sediment and debris as they flow down slopes, contributing to and initiating mudslides.



Los Angeles County Parks & Recreation

Social Vulnerability Assessment

For guiding priorities in public health preparedness, emergency preparedness and response planning, and community resiliency

CicLAvia | Jon Endow


Los Angeles County Parks & Recreation

What is social vulnerability?

The OurCounty Sustainability Plan took a people-centric approach to sustainability. This LA County Climate Vulnerability Assessment (CVA) furthers that commitment by diving deeply into social vulnerability to climate change. Social vulnerability encompasses the conditions that affect people's sensitivity and exposure to the impacts of climate change. Vulnerability, in this context, is not an indicator of an individual's weakness or incapacity to cope, but rather an indicator of the factors (almost all of which are outside of their control) that put them at greater risk for negative impacts. Climate hazards pose a risk to all County residents, but various factors can make certain populations more susceptible than others. These factors include, but are not limited to

- **inequities in infrastructure and access** to the benefits of education, living wages and income, economic opportunity, social capital, healthcare, and/or other services;
- **institutionalized bias** or exclusion from political and decision-making power;
- inequities in **environmental and living conditions** and health status; and
- differences in individual **health**, **age**, and **ability**.

Los Angeles County is committed to advancing equity. As expressed in the OurCounty Sustainability Plan, equity is "an end state in which all groups have access to the resources and opportunities necessary to improve the quality of their lives." Historical and ongoing injustices, including housing discrimination, segregation, and gentrification, have created environmental conditions that make frontline communities susceptible to climate hazards today. Rectifying these harmful policies is key to creating a safe, resilient future for all County residents.

The County seeks to support climate resilience not only through its own policies and programs, but also by proactively fostering cooperation among our 88 municipalities and collaboration with communities. This comprehensive CVA integrates countywide exposure projections with social sensitivity indicators and adaptive capacity information to examine the relative level of vulnerability across LA County. Future climate adaptation actions and related investments in infrastructure and services will need to incorporate the analysis of present and future social vulnerabilities to best address the needs of the communities most at risk.

Measuring social vulnerability

Capturing the nuances of social vulnerability is not easy. Social vulnerability can be assessed qualitatively, quantitatively, or by using a combination of qualitative and quantitative methods. We conducted a quantitative analysis to understand the geographic distribution of people with specific characteristics (like old age or poverty) that increase susceptibility to climate hazards. This resulted in the social sensitivity index described below. This method helps us understand which geographic areas are disproportionately populated by people who have high social vulnerability and where to prioritize community-scale interventions. However, some of the factors affecting susceptibility do not have high geographic variation, and there are many factors affecting susceptibility that are simply not well documented in research or existing data sets.

A recent technical brief from the UCLA Center for Neighborhood Knowledge points out that communities with lower rates of internet subscriptions, higher rates of limited English-speaking households, and/or higher percentages of noncitizen residents are less likely to respond to the census—our main source of quantitative data.[54] Furthermore, our quantitative data do not capture the role that community-led efforts play in adaptive capacity or provide insight on people's experiences and perspectives.

For these reasons, the LA County Social Vulnerability Assessment used qualitative methods, along with quantitative methods, for a combined approach—one where the voices, stories, and experiences of typically underrepresented groups played a critical role in both the process and findings (see below for a brief description of these methods). A full methodology for the Social Vulnerability Assessment is available in LA County CVA Technical Methodologies Resources.

Quantitative approach

Our primary quantitative approach for assessing social vulnerability was to evaluate geographic variation in **exposure to climate hazards** and **social sensitivity**. For extreme heat, we also evaluated geographic variation in **community-scale adaptive capacity** through characteristics of the built and natural environment that can support a community's ability to respond or adapt to a climate hazard. This additional layer provides a look at how adaptive capacity can be influenced by the physical environment around us. We evaluated adaptive capacity to other hazards qualitatively.

Climate hazard exposure scoring

We collected and evaluated climate hazard exposure data as part of the Climate Hazard Assessment (refer to *Appendix D* for the full Climate Hazard Assessment). The County developed geographical layers for the five primary climate hazards: extreme heat, wildfire, inland flooding, coastal flooding, and drought. These layers are the foundation of the Social Vulnerability Assessment.

Social sensitivity scoring

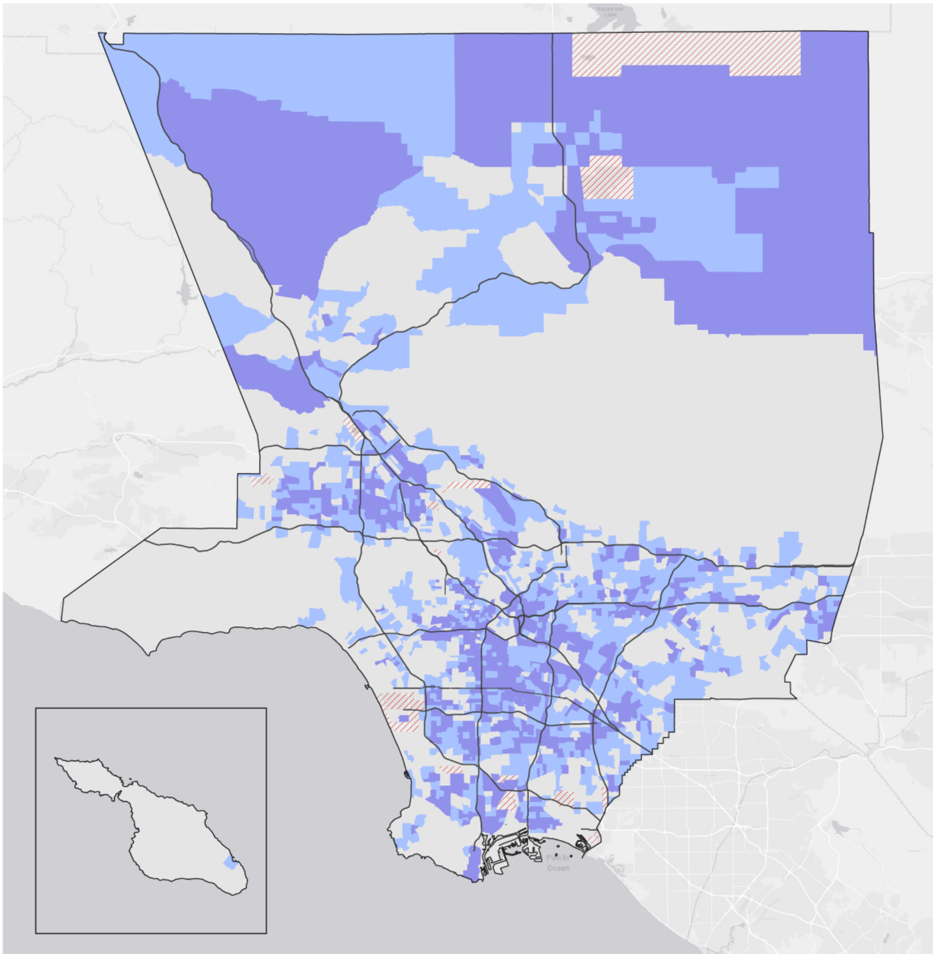
We developed a social sensitivity index for LA County using 29 data indicators. Each indicator represents a characteristic that increases a person's sensitivity to climate hazards. There are ten categories of social sensitivity indicators: age, community and language, education, health, housing, income and wealth, occupation, transportation, access to information, and race/ethnicity (see Table 2 for full list, and refer to *Appendix D* for a full description of the social sensitivity scoring methodology).

Table 2: Social sensitivity indicators

Age: children, older adults, older adults living alone
Community and language: foreign-born, female, female householder, library access, voter turnout rate, limited English proficiency
Occupation: outdoor workers (including workers in agriculture, fishing, mining, extractive or construction occupations), unemployment
Education: no high school diploma
Health: disability, asthma, cardiovascular disease, no health insurance
Housing: living in group quarters, mobile homes, cost-burdened, renters
Income and wealth: median income, poverty
Race / Ethnicity: Black, Asian, Hispanic/Latinx, Indigenous
Access to information: no internet subscription
Transportation: households without vehicle access, transit access

We used the index to analyze where people who may be climate-sensitive live. This helps us understand which geographic areas in the County have high proportions of climate-sensitive residents—or "high social sensitivity," as illustrated in Figure 13. The map of countywide social sensitivity is the second layer to factor into social vulnerability, on top of climate hazard exposure.

Social Sensitivity



Relative Sensitivity Level
Composite Score of 29 Indicators

- Low, bottom third in sensitivity score
- Moderate, middle third in sensitivty score
- High, top third in sensitivity score
- No Population

0 5 10 15 mi

Sources: United States Census Bureau, CEHTP and OSHPD, Los Angeles County ISD, SCAG.

Figure 13: Map of social sensitivity in LA County

To create the index, we selected indicators based on their inclusion in similar assessments and best-practice methodologies. Some of these indicators represent characteristics that increase a person's physiological sensitivity to climate hazards, while others relate to a person's ability to prepare for or recover from climate hazards. Some indicators may relate to both physiological sensitivity and resilience.

It is important to note that the social sensitivity data offer a static picture based on recent demographics. Because we are unable to predict or project demographic changes, we use the same data to represent mid-century demographics. The County's older adult population is one noteworthy and anticipated change that is not included in this CVA. The current older adult population is predominantly white, a demographic group that will likely decrease as the younger, more diverse generations age. For example, today, Latinx individuals make up 39.4 percent of California's population. However, when looking at members of the population that are under 18 years old, Latinx people make up 51.6 percent.[55] This change in composition of older adults has potential implications for climate risks and could lead to more widespread social sensitivity to climate hazards in the future.

Throughout the Social Vulnerability Assessment, we assume that social sensitivity is consistent across hazards. For example, older adults are more sensitive not only to heat but also to wildfires, floods, and other consequences of climate change—even if for different reasons. We assume all sensitivities are relevant to the full range of climate hazards and climate events.

Social vulnerability scoring

High vulnerability is the product of the intersection of high sensitivity and high exposure to a hazard. Moderate vulnerability is represented as any combination of moderate and moderate-to-high sensitivity and exposure. Finally, low vulnerability includes any intersections where exposure or sensitivity is low.

Note that low vulnerability here does not mean no vulnerability. To be clear—communities that experience low and moderate vulnerability still include some individuals who could be categorized as highly vulnerable and are nonetheless at risk to climate impacts. We are all exposed to climate change effects to some degree and have varying degrees of sensitivity and accessibility to resources. We are all a part of the climate emergency and have a role to play in protecting ourselves, and each other, from it and preparing for the future it will bring us.

Throughout the Social Vulnerability Assessment, we provide countywide maps of social vulnerability. These maps use the colors shown in the grid in Figure 14 to illustrate the level of sensitivity and exposure in a given

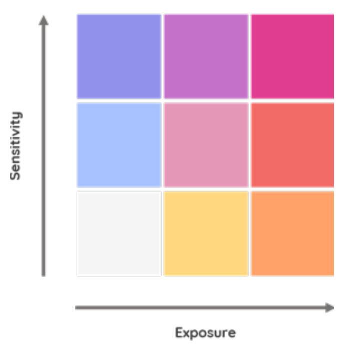


Figure 14: Social vulnerability matrix

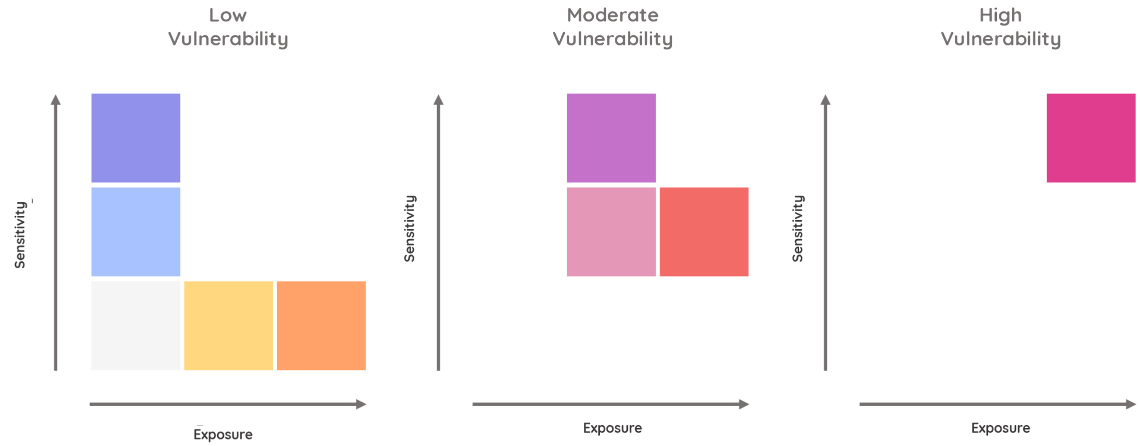


Figure 15: Social vulnerability matrix by level

census tract. In Figure 15, the respective colors are grouped into low, moderate, and high vulnerability. The third image shows that highly vulnerable census tracts are displayed in magenta.

Qualitative approach

The County conducted qualitative research to learn how climate change is affecting populations that are underrepresented in our quantitative data and understand the nuances of people's lived experiences and priorities. As the primary data collection method, we held six listening sessions to learn how climate hazards impact people experiencing homelessness, climate-exposed workers, people with disabilities and access challenges, people without reliable transportation, people living in rural communities, and Tribal and Native communities. Of course, no one can be defined by a single trait; the listening sessions also gave us opportunities to learn how traits like age, health status, immigration status, language, economic status, and race intersect with other social sensitivity factors to further affect a person's overall vulnerability.

Each listening session featured eight to ten participants who brought insight from their lived experiences and/or their experiences working with the target population. We partnered with organizations that are trusted among the target populations; they cohosted the sessions to facilitate discussion. This dynamic was intended to create a welcoming environment and to help participants feel comfortable sharing personal stories. During each session, we asked how these groups currently experience, manage, and adapt to climate hazards. Listening sessions summaries can be found in *Appendix D: LA County CVA Stakeholder Engagement Summary*, and relevant findings are mentioned throughout the report.

Our qualitative research also included an assortment of interviews with public sector, private sector, and academic experts; interviews with LA County departments; group discussions with the CVA Technical Advisory Committee; and public workshops.

Racism, discrimination, and vulnerability

The LA County Social Vulnerability Assessment explores and brings out the strong role that structural racism plays in the impacts of climate hazards. Structural racism describes a system in which public policies, institutional practices, cultural representations, and other norms work to reinforce and perpetuate racial group inequity.[56] Past and present policies rooted in the oppression and discrimination of people of color contribute to and create inequities across all facets of society: the economy, health care, education, housing, and beyond. The consequences of these inequities have endured for generations. Climate vulnerability is no exception; these racial inequities make people of color disproportionately susceptible to climate hazards, and climate hazards can further exacerbate the inequities.

In particular, Black communities have suffered from racist practices and policies, including but not limited to slavery, Jim Crow laws, racial covenants, and redlining. Structural racism has created steep economic inequality; in 2019, the homeownership rate for Black households was 40.6 percent, while white households had a 73.1 percent homeownership rate.[57] Black people are highly segregated in low-income areas with polluting industries and infrastructure, limited green infrastructure, food deserts, and other environmental concerns. This segregation results in and contributes to environmental injustic and racial inequities that manifest as disproportionately higher rates of respiratory and cardiovascular disease, as well as worse overall health outcomes. In the aftermath of climate disasters, Black households suffer greater wealth losses than do white households, illustrating how existing policies and practices, like the unequal or insufficient distribution of post-disaster recovery funds and assistance, continue to worsen historic inequities.[58]

Unless government intervenes in a way that intentionally reduces racial inequities, these inequities will only grow deeper as a result of climate change. Throughout the Social Vulnerability Assessment, we examine ways in which people of color are disproportionately burdened by climate risks and impacts.

Climate change and Native populations

Los Angeles County is located on the ancestral lands of the Tongva, Tataviam, Chumash, and Kizh tribes, all of which are landless and though they are not federally recognized, they are recognized by the State of California. LA County is also home to more Native American/Alaskan Natives than any other county in the United States—at around 141,000 people—in large part due to federal relocation programs.[59] Colonial violence, including attempted cultural erasure and forced migration of Native people, has reverberated through to the present, leading to both high rates of poverty and a deep sense of distrust in U.S. government institutions among these communities.

Native and Tribal communities in LA County are particularly vulnerable to climate change because of compounding stresses from historical events and contemporary conditions that pose economic, political, legal, environmental, and health challenges. For members of these communities in rural areas, there is increased risk of wildfire and drought. Gaps in data collection efforts and community outreach can leave Tribes that are affected by wildfire excluded from accessing recovery resources. Limited access to medical facilities in under-resourced areas of LA County raises concerns about proper medical care during extreme climate events. Climate change also poses a threat to cultural practices. The reduction of the region's natural biodiversity decreases access to traditional foods and culturally significant plants. Furthermore, climate events like wildfire, high winds, and sea-level rise can destroy cultural sites and sacred land.

Through stories, Native and Tribal communities often pass down climate-related information, knowledge, and expertise that, while not necessarily measurable, are otherwise observed and learned. Traditional ecological knowledge is unique to each Tribe and underpins many Tribes' approaches to environmental management and community and economic development approaches. Understanding and incorporating practices crafted from centuries of Tribal land stewardship into climate adaptation and resilience policies and interventions, in partnership with Native and Tribal communities, can improve County environments for the benefit all County residents. Building a relationship rooted in trust and collaboration provides an opportunity for reciprocity.

Extreme heat

Introduction

Average temperatures are steadily increasing across LA County because of our changing climate. In addition to changes in average temperatures, extreme heat is projected to increase in both severity and frequency by mid-century. Although there are many ways to define and track extreme heat, the CVA uses the 95th-percentile daily maximum temperature metric. The 95th-percentile daily maximum temperature identifies the threshold temperature that is exceeded only by 5 percent of the hottest daily maximum temperatures in a year. For example, a countywide 95th-percentile daily max temperature of 98.6°F means that 5 percent of days will have daily highs that exceed 98.6°F. This measure of extreme heat is relative and location-specific, highlighting the fact that different communities in LA County may have different thresholds for understanding extreme temperatures and thus experience the same temperature differently. For specific information on extreme heat projections in LA County, refer to *Climate Hazards*.

Impacts of extreme heat on people

Extreme heat accounts for more annual deaths than any other single weather-related hazard.[60] It can trigger heat-related illness, like heat stroke, and exacerbate other medical conditions. More severe heat waves have coincided with increases in region-wide excess deaths.[61] Cardiovascular disease and preexisting respiratory diseases, like asthma, increase sensitivity to extreme heat and increase the likelihood that an individual will experience heat-related health risks.[62] Extreme heat also exacerbates other medical conditions, like kidney disease, and leads to an increase in emergency room visits and hospitalizations.[63, 64] Furthermore, extreme heat can cause uncomfortable and even dangerous conditions for outdoor physical activity, making it harder for people to get the recommended amount of exercise and potentially leading to increased risk of long-term health effects related to a sedentary lifestyle.

During CVA listening sessions, several local assistance organizations for people with disabilities noted that individuals with skin conditions and traumatic brain issues can be very sensitive to extreme temperatures. People with disabilities can have difficulties regulating their internal temperatures, leading to discomfort or significant health complications during a heat wave. Additionally, people with developmental disabilities or autism can have a more difficult time regulating their behaviors with the rise in temperature. To adapt to these challenges, advocates explained that people with disabilities often rely on resources like 211 LA, a 24/7 call line and resource hub for local health, human, and social services in the County. Local nonprofits and caretakers can reach out to clients via telephone during a heat wave with information on how to respond. However, certain barriers still persist, like the lack of backup power for medical devices and refrigerated medication storage, that pose a significant challenge to adaptation.

Extreme heat can also impact pregnancies and infant health. A systematic review of 57 studies, covering a total of more than 32 million births nationwide, found a correlation between extreme heat and maternal and infant health. The review concluded that 80 percent of studies found a median increase of 15.8 percent in preterm births, and 100 percent of studies found a median increase of 31.0 percent in infants with low birth weights as temperatures increased.[65] Black mothers are particularly at risk of delivering infants with low birth weights.[66] As extreme heat events increase in frequency and severity, LA County faces serious implications for the health and safety of its newborns, infants, and future generations.

Extreme heat also impacts mental health. One study evaluated correlations between social media language choices and temperature. The authors found that depressive thoughts and expressions increased during periods of higher temperatures.[67] During warm seasons in California, a 10°F increase in same-day mean apparent temperature was associated with increased risk of emergency room visits for mental health disorders (4.8-percent increase), self-injury and suicide (5.8-percent increase), and intentional injury/homicide (7.9-percent increase).[68]

Hotter days and heat stress can also lead to insomnia and impact cognitive function. One study observed a group of students during a 12-day heat wave and found that students who lived in air-conditioned dormitories had better cognitive function than another group that lived in non–air-conditioned dormitories.[69] These impacts on cognitive function can have implications for well-being and productivity.

Social vulnerability by climate hazard - extreme heat

People experiencing homelessness face challenges in avoiding the health impacts associated with extreme heat. As local homelessness services organizations noted during the stakeholder engagement sessions, design disparities across LA County leave some neighborhoods with limited spaces for protection from extreme heat. One organization noted that some of their clients would forgo appointments to access housing or health care just to maintain their camping spot in the shade. These organizations also reported that people experiencing homelessness rely heavily on privately owned spaces, like bathrooms in local businesses, for hydration and cooling. Parks and beaches are also valued public cooling spaces.

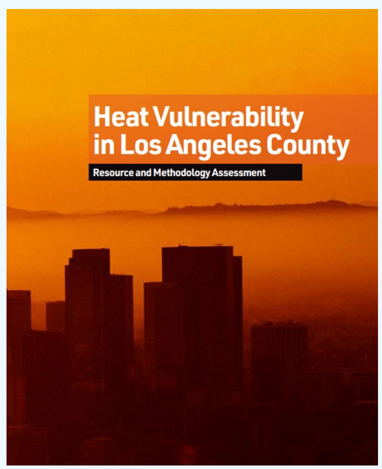
The impacts of extreme heat are especially pronounced for outdoor workers. A study focusing on outdoor workers in Los Angeles County found that heat events disproportionately affect communities with more residents who work in construction, agriculture, or other outdoor occupations. These communities had higher rates of hospitalizations and emergency department visits during summer extreme heat events.[70]

Heat waves are particularly worrying when nighttime temperatures do not cool off, leaving communities without relief from the day's high temperatures. Research indicates that human health strongly benefits from the ability to cool down and recover at night.[71] Warm nights have been associated with increased risk to persons with chronic ischemic diseases, like coronary heart disease. Historically, LA County has had an average of eight warm nights a year (as defined by Cal-Adapt as nights above 66.4°F, or the 98th-percentile temperature). The number of warm nights is projected to increase to 44 by mid-century under the RCP 8.5 scenario.[72]

Extreme heat and human safety, human health, and human productivity are inextricably linked. In this section, we explore the social vulnerability of LA County communities to extreme heat, identifying locations where people are most vulnerable and particularly sensitive to rising temperatures.

Extreme heat: tools and resources

A growing number of tools and resources to understand extreme heat vulnerability in LA County have been published. In 2020, the County worked with Columbia University's Center for Resilience Cities and Landscapes on an assessment that evaluated several tools and resources that are publicly available to planners. Many of these same tools and resources influenced the methodology used in this CVA.




Los Angeles County Parks & Recreation

Social Vulnerability to Extreme Heat

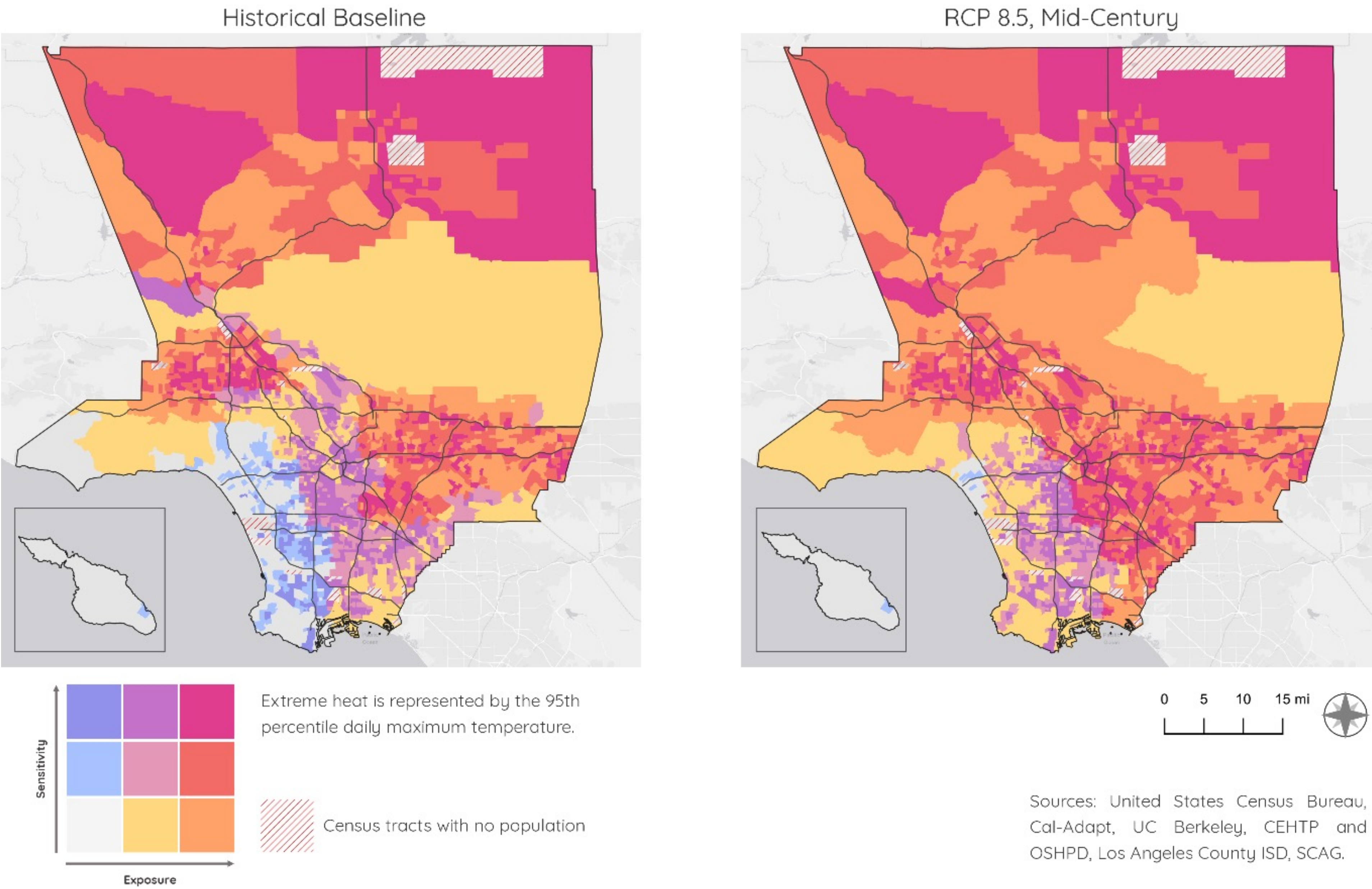


Figure 16: Map of social vulnerability to extreme heat

Social vulnerability by climate hazard - extreme heat

Key takeaways

Extreme heat already has far-reaching impacts on communities throughout LA County. Over the next several decades, LA County residents will experience both hotter maximum temperatures and more days of extreme heat. By mid-century, nearly 98 percent of LA County's population will face at least moderate exposure to extreme heat. A total of 2.2 million people are expected to reside in areas of both high exposure and high social sensitivity (resulting in high social vulnerability) by mid-century, an increase of 87.3 percent from baseline conditions as shown in Figure 17. For these highly vulnerable communities (shown in magenta in Figure 16), expected changes in 95th-percentile maximum temperatures range from 5.1°F to 6.5°F by mid-century—meaning they will only grow more vulnerable.

Historical baseline is the average of a 30-year period from 1976 to 2005.

Mid-century is the average of a modeled climate under a high emissions scenario for 2036 to 2065.

Percent of LA County Population by Level of Vulnerability to Extreme Heat

	Baseline	Mid-Century	% Change
High Vulnerability	11.8%	22.1%	+87.3%
Moderate Vulnerability	45.6%	45.8%	+0.4%
Low Vulnerability	42.6%	32.1%	-24.6%

Figure 17: Percentage of LA County population by level of social vulnerability to extreme heat

CEO Countywide Communications

Social vulnerability by climate hazard - extreme heat

Communities of concern that experience extreme heat are listed in Table 3. The northwestern portion of LA County, from the San Fernando Valley to the Lancaster/Palmdale area, is expected to experience the largest increase in temperature. **More than 1 million people in Los Angeles County live in areas where the 95th-percentile maximum temperature will be over 6°F hotter by mid-century.** These same areas will experience approximately 30 additional extremely hot days above today's 95th-percentile daily maximum temperature. People impacted by these particularly large changes live in some of the communities highlighted specified in the table.

Table 3: Extreme heat communities of concern

Community[a]	Number of highly vulnerable census tracts	Supervisorial District	Population in highly vulnerable census tracts[b]	Baseline	Mid-Century	Change[c]	Additional days above baseline[d]
Los Angeles - Reseda	9	3	52,502	97.6 °F	103.6 °F	6.0 °F	29.4
Santa Clarita	9	5	50,457	97.1 °F	103.5 °F	6.4 °F	28.9
Los Angeles - Winnetka	8	3	39,661	98.4 °F	104.4 °F	6.0 °F	28.8
Los Angeles - Pacoima	7	3	28,307	94.5 °F	100.6 °F	6.1 °F	29.8
Los Angeles - Canoga Park	6	3	27,137	98.4 °F	104.4 °F	6.0 °F	28.8
Los Angeles - Sylmar	5	3	20,767	93.9 °F	100.0 °F	6.1 °F	31.8
Los Angeles - Northridge	4	3	16,518	96.7 °F	102.8 °F	6.1 °F	30.0
Los Angeles - Tarzana	2	3	8,344	98.5 °F	104.5 °F	6.0 °F	27.9
Los Angeles - Encino	1	3	5,618	98.5 °F	104.5 °F	6.0 °F	27.9
Unincorporated - North Lancaster	1	5	5,399	101.1 °F	107.1 °F	6.0 °F	33.4
Unincorporated - Castaic	1	5	5,387	95.5 °F	101.7 °F	6.2 °F	29.5
Los Angeles - Reseda Ranch	1	3	5,270	97.4 °F	103.5 °F	6.1 °F	29.7
San Fernando	1	3	4,556	94.4 °F	100.5 °F	6.1 °F	31.4
Unincorporated - Del Sur	1	5	3,985	100.3 °F	106.4 °F	6.1 °F	32.6
Los Angeles - Mission Hills	1	3	3,959	94.4 °F	100.5 °F	6.1 °F	32.2
Los Angeles - Woodland Hills	1	3	3,268	99.7 °F	105.9 °F	6.2 °F	26.4

a. Communities listed represent those that include the most highly vulnerable census tracts and population; data represent values and averages of the highly vulnerable census tracts.

b. 2018 population.

c. Change in temperature represents the change from the baseline to 2050 in the 95th-percentile daily maximum temperature. Communities shown are those that will experience a change of 6.0°F or more.

d. This column represents the projected additional number of days a community is expected to experience above the historic baseline 95th-percentile threshold by 2050. For all areas of LA County, days above the 95th-percentile at baseline is around 18 days (or 5 percent of all days in a year).

Social vulnerability by climate hazard - extreme heat

Hispanic and Latinx people make up the majority of residents in communities highly vulnerable to extreme heat in LA County. On average, Hispanic and Latinx people make up 48.5 percent of LA County's population, but, in communities with high vulnerability to extreme heat, Hispanic and Latinx people make up 66.9 percent of the population.

The history of discriminatory housing practices and diverted investment from communities of color is connected to the extreme heat risks experienced by these communities today. Researchers revealed in an analysis of 108 urban areas across the United States that land surface temperatures in formerly redlined neighborhoods are approximately 2.6°F warmer than in non-redlined neighborhoods.[73] The lack of tree canopy, lack of access to park space, and/or presence of high-asphalt infrastructure in these areas inhibit the ability of these neighborhoods to mitigate extreme heat.

The health risks associated with exposure to extreme heat are intensified when compounded with other demographic factors. Hispanic and Latinx people are overrepresented in other vulnerable populations, like outdoor workers and undocumented individuals. Across highly vulnerable census tracts, over 8.5 percent of the population are outdoor workers, nearly 60 percent higher than the countywide average of 5.4 percent. Outdoor workers have increased sensitivity to extreme heat because of their extended exposure and outdoor working conditions. For undocumented individuals who may also live in these highly vulnerable communities, there are additional considerations, like limited worker protections and linguistic isolation, which can make accessing information difficult.

Sensitivity indicators that drive community-level vulnerability

Communities with high vulnerability to extreme heat are characterized by higher-than-average representation of residents who are children, older adults and older adults living alone, people with cardiovascular disease, people with asthma, and outdoor workers. People in these groups who are living in highly exposed communities will be especially vulnerable to rising temperatures in LA County.

Children and older adults

Numerous communities that are highly vulnerable at baseline conditions have particularly high percentages of older adults and/or older adults living alone. These areas include parts of the City of Los Angeles (like Woodland Hills), La Verne, Cerritos, and unincorporated Hi Vista and Roosevelt. By mid-century, additional communities, like Chinatown, will join this list because of increased exposure. Adults over 65 years old are consistently cited as one of the most sensitive groups to adverse health effects and mortality from extreme heat and heat waves. This can be especially true for older adults who live alone, because of social isolation and lack of access to nearby assistance.[74] A comprehensive literature review of heat and mortality concluded that "infants, young children, and the elderly should be specifically targeted in future studies to prevent heat related mortality."[75]

Several highly vulnerable communities have relatively high percentages of children. At baseline, these areas include North Lancaster, incorporated and unincorporated Pomona, and Palmdale, and by mid-century they will also include Watts, Vernon Central, and Central Los Angeles. Children who are under five years old and school-aged children (5–18 years old) are sensitive to the impacts of extreme heat. Children under five years old are especially vulnerable to health impacts caused by extreme heat because they are rapidly growing and are not able to thermoregulate as effectively as adults.[76] Extreme heat also impacts learning and cognitive function in school-aged children, especially if their schools do not have air conditioning. Because schools that lack air conditioning are disproportionately located in communities of color, these impacts could contribute to an academic opportunity gap already perpetuated by centuries of systemic racism in the United States.[77]

Pre-existing health conditions

Air pollution is linked to asthma and cardiovascular disease, both of which increase vulnerability to extreme heat. Extreme heat can contribute to and exacerbate the formation of ground-level ozone, which triggers asthma attacks. Furthermore, high temperatures can place extra stress on the cardiovascular system, increasing the chance of heart attacks and other heat-related health issues.[78] Lancaster and the surrounding unincorporated areas (North Lancaster, Lake Los Angeles, Roosevelt, and Hi Vista) have much higher rates of emergency room visits for both asthma and heart attacks than other parts of LA County. By mid-century, additional communities with high prevalence of preexisting health conditions, including Long Beach and Watts, will become highly vulnerable because of increases in exposure.

Unpacking the demographic conditions of these communities underscores the connection between racial health disparities and climate vulnerability. Black and Native populations are overrepresented in these communities, which experience a high prevalence of preexisting health conditions: our analysis shows that Black people account for more than 18 percent of the total population with a high prevalence of preexisting conditions (compared with the 7.9 percent countywide average), and Native people make up 0.34 percent of the population (compared with the 0.2 percent countywide average). Recent data (2018) from the Centers for Disease Control and Prevention show a similar picture nationwide, with Black and Native people having the highest rates of asthma. Communities already susceptible to adverse health outcomes because of their environmental pollution burden will experience compounding health effects as extreme heat increases in both frequency and severity.

Outdoor workers

Communities whose vulnerability is characterized by having a proportionately greater number of outdoor workers at baseline conditions include Palmdale, Lancaster, and Pomona. Because of changes in exposure, this list will expand to include East Los Angeles and Van Nuys by mid-century. Communities with the highest percentage of residents who are outdoor workers include unincorporated Llano and Hi Vista.

Outdoor workers are highly vulnerable to extreme heat in LA County. They are much more likely to have prolonged exposure during extreme heat events and have physically demanding jobs. For many workers, the decision to not work or the inability to work in extreme heat or another climate hazard can result in lost wages and mental stress. Furthermore, outdoor workers who do not have personal vehicles may experience additional exposure and risk to extreme heat during their commute. Because many outdoor workers are compensated by the hour, they are incentivized to work without necessary breaks, making them even more susceptible to heat-related illnesses.

Extreme heat can also lead to productivity losses, which in turn can impact the economic livelihood of outdoor workers and relevant industries. Organizations representing day laborers and domestic workers noted that workers often rely on daily payment to make ends meet, so taking time off or going home because of heat illness is not a viable option.

Workers' rights organizations highlighted various physical and social interventions used to combat extreme heat. Street vendors use phone trees to share information ranging from updates on regulations to weather and environmental conditions. Nonprofits serving day laborers operate worker centers that provide access to hydration, sanitation, and shade. Community education on health and safety is provided by trained *promotoras*, or community health workers. Worker resilience comes in the form of repurposing and adapting objects for use in various situations, like using clothing for masks or shade cover.

Respite from heat is critical to outdoor workers to mitigate the potential health impacts of extreme heat. For this reason, both place of residence and place of occupation are important in understanding the overall risk. This section focuses on where outdoor workers live, while the *Workers and jobs* callout box more closely examines the relationship among climate hazards, location of work, occupation type, and employer provisions.

Temperatures inside shipping containers at the Port of Los Angeles can be 20°F hotter than the outside air on an extreme heat day. Workers spend all day inside these containers lifting heavy objects; a local stakeholder reported that workplaces can get so hot, a worker's sweat will sizzle when it hits the container. Worker protections that can prevent heat illness include access to water and rest periods.

Social vulnerability by climate hazard - extreme heat

Other indicators of social sensitivity and adaptive capacity to extreme heat:

No health insurance: Individuals without health insurance are less likely to regularly visit a doctor who can diagnose preexisting conditions and/or receive care for any injury/illness that occurs from or during extreme heat.

Mobile homes: Mobile homes are usually less equipped to deal with extreme heat and lack adequate thermal envelopes. More than 56 percent of mobile home residents are in high heat exposure areas, compared with 38 percent of all County residents.

Households without vehicle access or transit access: Lack of vehicle or transit access makes it more difficult to access cooling centers and other shelter from heat during extreme heat. Across LA County, more than 54 percent of people who lack access to transit currently live in high extreme heat exposure areas. Comparatively, only 38 percent of all residents live within these high hazard regions. Local transit advocacy organizations highlighted how a lack of bus shelters, tree canopy, and hydration sources increases risk of heat stress for public transit riders. Additionally, vehicles can act as a source of shelter from extreme heat if the vehicles have working air conditioning.

Income and poverty: Low-income households are less able to pay for air conditioning during extreme heat, even if their home has air conditioning equipment. Many low-income neighborhoods are also overburdened by high levels of environmental pollution, contributing to respiratory and cardiovascular health impacts among residents.

Sources:

1. *Raval, Amee, et al. Mapping Resilience: A Blueprint for Thriving in the Face of Climate Disasters. Asian Pacific Environment Network, 2019.*

2. *Rhoades, Elizabeth K., et al. Your Health and Climate Change in Los Angeles County. Climate and Health Series, Report 1, Los Angeles County Department of Public Health, Division of Environmental Health, Aug. 2014.*

3. *Cooley, Heather et al. Social Vulnerability to Climate Change in California. CEC-500-2012-013, Pacific Institute, Jul. 2012.*

Workers and jobs

Climate vulnerability assessments often illustrate a static snapshot of vulnerability based on where people live. However, for many workers, their workplace and residence are not in the same area, and both locations may have differing climate exposures and adaptive capacity resources. Understanding the potential impacts to workers can be especially important for hazards like extreme heat and air pollution, where the built environment and employer provisions, like shade, air conditioning, air filtration, and worker protection policies, significantly affect worker health and safety. For example, exposure to extreme temperature is correlated with surges in workplace injuries.[79] It is also important in terms of economic performance and potential disruptions to employment and livelihood. Studies have shown that air pollutants, like ozone and particulate matter, negatively impacts worker productivity, especially in cases of prolonged exposure.[80, 81]

A recent survey completed by the USC Dornsife Center shed some light on typical workplace conditions and employer provisions within LA County. Of workers who are highly exposed to heat, more than 1 in 4 reported getting neither paid sick leave nor extra break time on hot days.[82] Local labor advocates highlighted that street vendors often spend long hours in areas with high heat, low tree canopy, and high surface area of dark pavement, further raising the ambient temperature. Vendors who attempt to use umbrellas or awnings for shade coverage discussed the risk of incurring government fines.

Workers and jobs, continued

Heat-related adverse impacts don't only apply to outdoor workers, like those in agriculture and construction occupations. Other climate-exposed workers, like those who work in manufacturing, transportation, and warehousing, are also impacted. People in these occupations may not spend much time outdoors and be directly exposed to weather, but they often work in very hot or cold temperatures, open vehicles, or indoors but without environmental controls.[83] Local labor representatives raised that indoor temperatures in non-air-conditioned warehouses sometimes exceed outdoor temperatures, creating a dangerous working environment for strenuous activity. Lack of health care and exclusions from certain Cal/OSHA protections compound the issue of heat stress on these communities. Local workers' rights organizations expressed a common fear of retaliation from employers for voicing concerns about heat stress in these conditions.

Areas with higher concentrations of outdoor and climate-exposed workers tend to be along major roads and freeways and be more industrialized, as shown in Figure 18. Many of these areas have fewer residents but larger worker populations who may be at risk throughout their workday. One example of such a location is Vernon. Although very few people live in Vernon, it has more than 39,000 workers, 55 percent of whom are considered to have occupations in which they are climate-exposed. Although many industries are captured in our analysis, we do not capture informally employed workers, self-employed workers, and uniformed military.

Within Los Angeles County, the City of Industry, Santa Fe Springs, Vernon, Long Beach, and Carson have the most climate-exposed workers. Our analysis reveals that all these locations have lower-than-average tree canopy cover and permeable surfaces. Some locations, like Vernon and the City of Industry, are also below LA County averages in heat refuge and park access. This lack of built environment and natural resources means that workers have fewer safety nets and protections during climate events and may be more at risk as climate shifts intensify. In targeting these areas for adaptation resources, the County can also address and repair long-standing environmental justice issues.

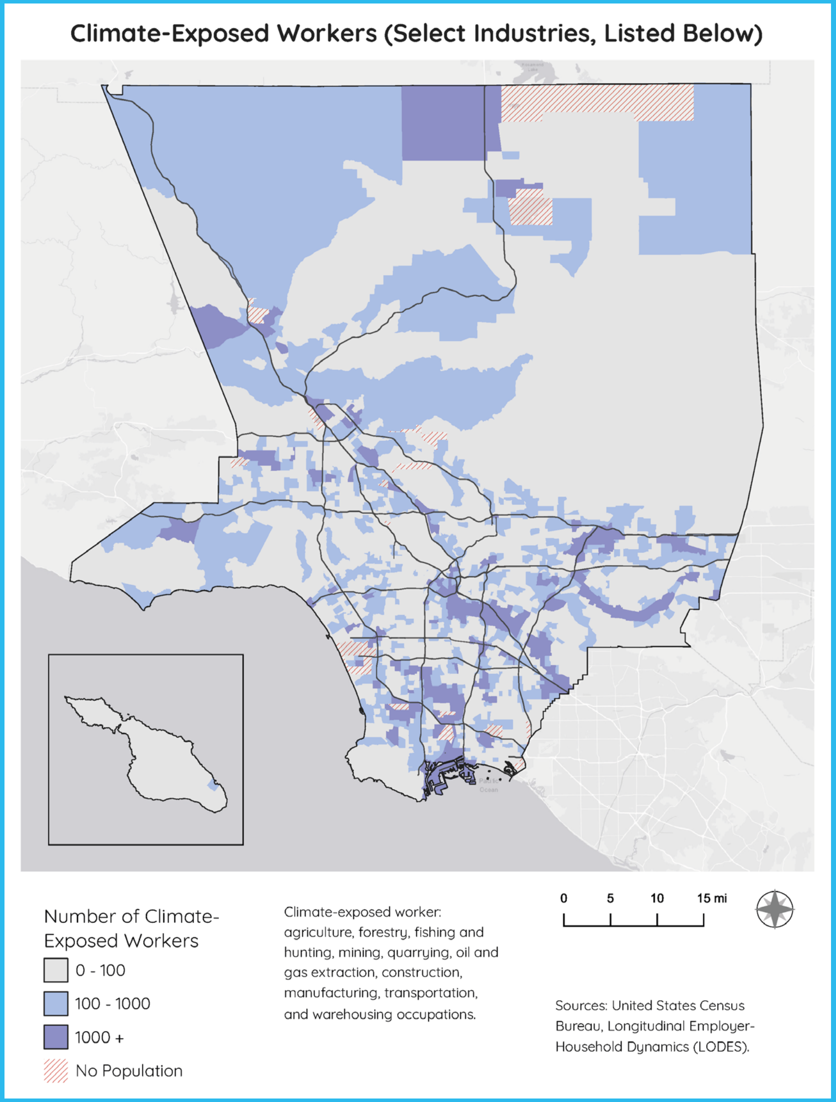


Figure 18: Climate-exposed workers in LA County

Community-scale adaptive capacity

In addition to social sensitivity, the built environment and natural systems that surround us greatly influence our ability to react and respond to climate hazards. We analyzed data on specific built environment and natural systems that represent community-scale adaptive capacity and that can provide relief during extreme heat to identify where in LA County these resources are lacking. Specifically, we examined the following indicators: proximity to heat refuge, park access, thermal building performance, and tree canopy. These resources allow us to adapt to extreme heat and provide ways to reduce heat islands.

Household-level resources like air conditioning can greatly support people's ability to respond to rising temperatures; however, data, such as on the availability, affordability, or use of air conditioning, are not available at the census-tract level. As illustrated in this example, the evaluated list of indicators is not inclusive of all resources available for managing extreme heat.

Heat refuge[84]

As the number of extreme heat days increases, the demand for accessible heat refuges increases. Heat refuges, which include official cooling centers and other cool indoor public and private locations (like libraries, museums, indoor shopping malls, or movie theaters), act as safe places for people to escape the heat. Heat refuges are especially critical for those who do not have reliable air conditioning at home. A few hours away from intense heat can be crucial in reducing the health consequences of heat stress. Heat refuges can also serve as central locations for disseminating public information or navigating visitors to any other County resources they may need.

Park access[85]

Parks can provide critical cooling infrastructure by reducing localized ambient air temperatures and providing no-cost shaded spaces where people can spend time shielded from the sun. These areas are particularly important for communities without air conditioning or other heat refuges. Many parks have drinking fountains, which allow people to stay hydrated and are essential for physical health during heat events. Parks also have additional public health co-benefits: access to green space is shown to reduce feelings of anxiety and depression, increase levels of physical activity, and lower risk of heat stress.[86] Furthermore, parks can act as outdoor community resources, providing spaces for social connectedness and public assembly.

Tree canopy[87]

Dense tree canopy cover improves a community's respiratory health by capturing particulate air pollution. As a form of green infrastructure, tree canopy cover reduces the urban heat island effect and can provide natural habitat for local wildlife, while providing cooling refuge for residents using sidewalks and/or public transportation.

Thermal building performance[88]

Modern building codes mandate insulation standards that separate the interior flow of heat from the exterior flow of heat. The components of a building that work together to shield the indoors from the outdoors are known as the thermal envelope. Buildings constructed before these codes were enacted often have looser thermal envelopes, meaning that they can easily leak cool air from the inside. Older buildings both heat up faster during heat events and are less effective at remaining cooler than outdoor temperatures. Because of this, people living in older buildings are at an increased risk of heat stress and spikes in utility costs during extreme heat events. Reflective building materials help improve thermal performance. In 2018, the County enacted a cool roof ordinance, implementing rigorous standards for new construction and building retrofits.

Permeable surfaces

Permeable surfaces can include green spaces and other high albedo, or cool, ground surfaces that help protect against localized heat gain and reduce the contribution to the urban heat island effect. Permeable surfaces can lower temperatures through evaporative cooling—or when water is infiltrated into the ground then evaporated back into the ambient air.[89]

Social vulnerability by climate hazard - extreme heat

Key takeaways

Across LA County, there are spatial differences in communities' access to the built environment and natural resources that can help people cope with extreme heat. Areas with limited access should be prioritized for adaptation action, because they are less equipped or prepared to deal with extreme heat risks. Even marginal increases in frequency, severity, and/or duration of extreme heat events may cause more serious impacts in these communities.

Combining our built environment and natural system indicators (heat refuge, park access, tree canopy, thermal building performance, and permeable surfaces) and mapping them across LA County provides a view of which communities have limited access. The maps shown in Figure 19 illustrate the 20 percent of LA County census tracts that have the least access to built and natural resources for managing extreme heat, on top of their vulnerability to extreme heat.

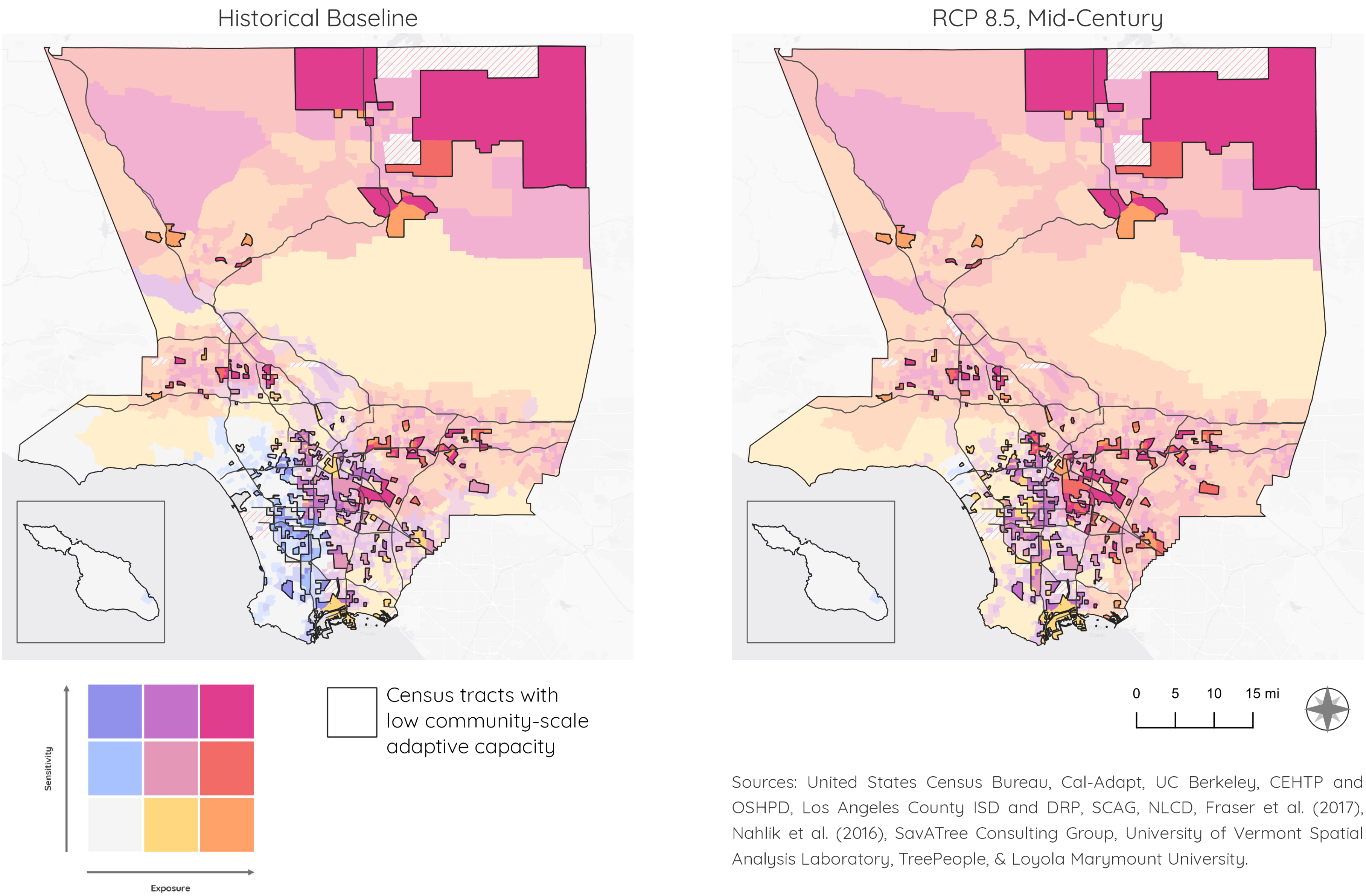
The communities where limited access to community-scale adaptive capacity coincides with high vulnerability to extreme heat include areas of Baldwin Park, Montebello, and parts of City of Los Angeles (Van Nuys, North Hollywood, and Winnetka). For these communities, heat refuge, park access, and tree canopy cover are all below the countywide average.

We also identified communities with low community-level adaptive capacity that are expected to become more vulnerable to extreme heat by mid-century because of increases in exposure. These include unincorporated East Los Angeles, South Gate, Huntington Park, Bellflower, and Los Angeles (Melrose). For these communities, thermal building performance, tree canopy cover, and percentage of permeable surfaces are all well below the countywide average.

In observing communities with low community-level adaptive capacity, it is clear that many of the highlighted areas occur along major freeways. Communities along freeways traditionally receive less public investment and resources that directly benefit the local population. Also, because of their proximity to continuous vehicle traffic, these communities frequently experience worse air pollution and associated health impacts.


Flickr | Boyce Duprey

Social Vulnerability + Community-Scale Adaptive Capacity to Extreme Heat



Sources: United States Census Bureau, Cal-Adapt, UC Berkeley, CEHTP and OSHPD, Los Angeles County ISD and DRP, SCAG, NLCD, Fraser et al. (2017), Nahlik et al. (2016), SavATree Consulting Group, University of Vermont Spatial Analysis Laboratory, TreePeople, & Loyola Marymount University.

Figure 19: Map of social vulnerability to extreme heat overlaid with community-scale adaptive capacity

Wildfire

Introduction

Climate change has been linked to increases in wildfire activity and longer wildfire seasons across California.[90] Increasing temperatures, earlier snowmelt, mega-droughts, and precipitation whiplash events are all contributing factors.[91, 92] However, wildfire activity and its associated impacts vary depending on factors, like land use, ecology, topography, and active forest management. Wildfire events occur in more rural areas of LA County, particularly in the northern areas, or along the wildland urban interface (WUI). Because of the location of these events, people who live directly in the path of wildfires are typically fewer in number than the populations impacted by other hazards. However, the severity of the impact on these residents can be particularly high. For more information on wildfire and the WUI, refer to *Wildfire and extreme precipitation: high risk communities and mudslides.*

Wildfire smoke can travel great distances and affect people far from a wildfire's location. By mid-century, in LA County, the total number of smoke waves, average intensity, and length of season are projected to increase significantly.[93]

Impacts of wildfire on people

Wildfire events have the potential for disastrous outcomes and long-lasting impacts. People who live near or have to respond to wildfire can become injured or die; furthermore, wildfires can cause major community-wide disturbances, like evacuations, power outages, economic losses, road and school closures, losses to biodiversity and the natural environment, and disruptions to recreational activities. Power outages are particularly harmful to individuals who rely on electricity for medical devices, do not have a personal vehicle, lack transit access, and/or have preexisting medical conditions. In recent years, local wildfires, as summarized in Table 4, have caused devastating damage and led to major evacuations, electricity interruptions, and closures of roadways, schools, and recreational activities. In listening sessions with organizations representing older adults and people with disabilities, participants explained that evacuations can be particularly difficult for these populations. Swift communication methods are not well established. Limited resources for moving, storing, and charging mobility devices, like electric wheelchairs and scooters, and the general lack of transportation options were all cited as challenges. Lastly, concerns were expressed that temporary shelters are not set up to provide adequate caregivers for older adults and people with disabilities.

Wildfires can cause wide-reaching and long-lasting impacts to communities as people are displaced. In some extreme cases, like the recent Camp Fire in Northern California, entire communities were destroyed, and people were forced to relocate. Six months after the Camp Fire, more than 1,000 families were still looking for housing as neighboring communities struggled to accommodate the displaced population.

For some people, evacuation and displacement may not be temporary. Property loss is a major risk of wildfires and can leave people and families without permanent shelter. In the 2018 Woolsey Fire, roughly 900 homes were destroyed in LA County, while about 395,000 people evacuated the area.[94] Rebuilding is not an option for everyone, because many may have underinsured or uninsured properties or lack the financial resources to bring their homes back to a habitable state. Wildfire insurance coverage for homes can be costly, and many may not obtain the insurance coverage because of financial strain, putting them at risk for displacement and financial uncertainty. Households without proper coverage will suffer the most from property damage and loss.

Another implication of displacement is the impact on personal identity and social cohesion, leading to increases in anxiety, depression, and post-traumatic stress disorder (PTSD).[95] For Native and Tribal communities in LA County, wildfire can mean damage to cultural sites, sacred lands, gathering areas, and agricultural resources.[96] These losses can be detrimental to the spirituality, sense of community, and health and wellness in these communities. During CVA listening sessions, Tribal and Native representatives cited community mutual aid networks as extremely helpful for coping in the aftermath of a wildfire.

Research has barely begun to explore the wide range of mental health impacts from wildfire. A recent paper by the UCLA Center for Healthy Climate Solutions found that exposure to wildland smoke may have mental health impacts, like PTSD and depression, particularly

Table 4: Past major wildfire events and their impacts

Wildfire Event	Date	Area Burnt (hectares)	Area Impacted	Buildings Destroyed / Damaged	Additional Impacts
Bobcat Fire	September 2020	46,860	Angeles National Forest	170 / 47 [100]	Threats to biodiversity, evacuations [101, 102]
Lake Fire	August 2020	12,581	Angeles National Forest	12 / 3 [103]	Impacts to recreation activities, highway closure [104, 105]
Tick Fire	October 2019	1,868	Santa Clarita Valley	22 / 9 [106]	More than 50 schools and colleges closed, power outage to more than 25,000 residents, freeway closure [107, 108, 109]
Saddleridge Fire	October 2019	3,561	San Fernando Valley	25 / 88 [110]	More than 100,000 residents evacuated, cardiac arrest related death, freeway/highway closure [111]
Woolsey Fire	November 2018	39,234	Santa Monica Mountains, Malibu, parts of Ventura County	1,643 / 364 [112]	Estimated repair costs of $6 billion, 3 deaths, 395,000 evacuated, closure of parks and trails, freeway closure, damage to historical locations and filming locations [113, 114]
Creek Fire	December 2017	6,321	Kagel Canyon, Angeles National Forest	123 / 81 [115]	115,000 residents evacuated, smoke advisories in San Fernando Valley, school closures, livestock killed on nearby ranches [116, 117]
Rye Fire	December 2017	2,448	Santa Clarita Valley	6 / 3 [118]	Highway closure, evacuations, TV/movie production halts, electricity interruptions to greater than 8,500 customers [119, 120]

in episodes of chronic and persistent smoke events.[97, 98] A newly identified emotion, *solastalgia*, describes the pain experienced from lack of solace, particularly due toa transformation in one's environment. However, this phenomenon is not yet well understood.[99]

The Climate Resolve report *Lessons from the Woolsey Fire* , points out that many sensitive and underrepresented community members are often forgotten during wildfire events. These people include caretakers, housekeepers, day laborers, farmhands, and landscapers. The impacts of wildfire on these populations can mean loss of a job or housing. Without proper attention or assistance, these impacts can be devastating. During a CVA listening session, the Instituto de Educación Popular del Sur de California (IDEPSCA), a community-based organization that represents day laborers and domestic workers, reported that many workers had to evacuate on foot down the Pacific Coast Highway during the Woolsey Fire. Some day laborers were also contracted as first responders to fight fires in private backyards, acknowledging that their place of work and wages were at stake. The same organization reported that workers experienced discrimination coming in and out of affected wealthy neighborhoods as they tried to evacuate and were subsequently excluded from post-recovery services.

Social vulnerability by climate hazard - wildfire

Climate story: IDEPSCA and wildfire

Through direct outreach in the Woolsey Fire area, IDEPSCA was able to speak to more than 500 day laborers, domestic workers, restaurant workers, and other low-wage workers. Many workers were, in a sense, trapped in that area during the fire. The majority of communications about the fire were on Twitter in English, making it inaccessible to most workers. These individuals found out about the fires by being on-site or by seeing road closures as they were trying to get to their place of work.

Some homeowners and workers decided to stay past evacuation orders. Some workers had to evacuate on foot or via public transportation, which could take hours, many faced being exposed to wildfire smoke, and some were even exposed to racial profiling from police while trying to get in and out of evacuation areas. Power dynamics and citizenship status within these employment situations added to worker vulnerability, forcing difficult choices between immediate safety and longer-term economic survival.

For example, some workers were even hired by Malibu residents to act as first responders. One worker, Eladio, was paid around $700 to protect a group of homes in Malibu with a hose. He told us at the time he needed the work, but, thinking back, he understands he was putting his life at risk. Lost work has a huge impact on these workers, and, in terms of relief, they were left out completely. Most relief and support went to homeowners directly, while leaving out businesses and domestic workers.

It is important to think about the intersection of who is in these areas, what their experiences are, and how we can take an equitable approach that is inclusive. In our experience, partnerships with United Way LA, American Red Cross, and immigrant worker centers are key to providing financial relief directly to those impacted but otherwise left out of any support.

Moreover, lack of health and safety protections for workers who are gardeners, nannies, and house cleaners in private homes also meant, that during the fires, immigrant workers were not provided any personal protective equipment (PPE), like an N95 mask, or any education or training on what to do in case of an emergency, like wildfires, which are so commonplace in these areas. Post-Woolsey, we learned that many immigrant domestic workers have survived several fires with no training, financial relief, or PPE.

You can read more in IDEPSCA's Woolsey 1 year anniversary statement [here](#).

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Air quality and health

Wildfires are big contributors to air pollution in the western United States and are responsible for an estimated 70 percent of PM 2.5 emissions during periods when fine particulate matter pollution levels are above the EPA standard (35.5 ug/m^3).[123] Wildfires primarily produce fine and ultrafine particulate matter, which disperse, linger, and are more harmful to health than coarse particulates.[124] However, smoke produced from wildfires also includes a complex array of additional air pollutants, like nitrogen oxides (NOx), VOCs, carbon monoxide, ozone, and black carbon.[125, 126, 127]

Wildfire-generated particulate matter are linked to respiratory complications like asthma, chronic obstructive pulmonary disease, pneumonia, bronchitis, and other infections.[128, 129, 130] In addition, wildfire smoke has been linked to cardiovascular issues, including ischemic heart disease, heart failure, and cardiac arrest.[131] Wildfire smoke impacts can even affect fetal health. After a 2003 California wildfire event, infants who had been exposed to smoke in utero were born at a lower birth weight than those not exposed to smoke.[132] This is in line with broader studies that have repeatedly shown associations between exposure to PM 2.5 and increased risk of both preterm birth and low birth weight.[133] Furthermore, wildfire smoke has the potential to cause both long- and short-term detrimental issues in children.[134] A survey of health-related impacts from wildfire smoke on children found that the smoke was associated with higher reported levels of doctor visits, asthma medication use, respiratory symptoms, and missed school days.[135]

Beyond more acute public health concerns, wildfire smoke may hinder people's ability to exercise or even spend time outdoors. A quarterly survey of Los Angeles residents, administered by USC, revealed that around 40 percent of respondents said that they avoided going outside because of poor air quality due to wildfire.[121] As discussed during CVA listening sessions, not all Angelenos have the option to avoid bad air quality. Air quality can affect homeless service providers' ability to conduct outreach and disproportionately exposes people experiencing homelessness to adverse health outcomes. Representatives from Communities Actively Living Independent & Free reported that air pollution can negatively affect those with muscular dystrophy and asthma who do not have access to air purifiers.

Wildfire can have grave impacts on people's livelihoods, homes, and health. We explore the social vulnerability of LA County communities to wildfire in this section, identifying locations where people are most vulnerable and particularly sensitive to wildfire events.

Key takeaways

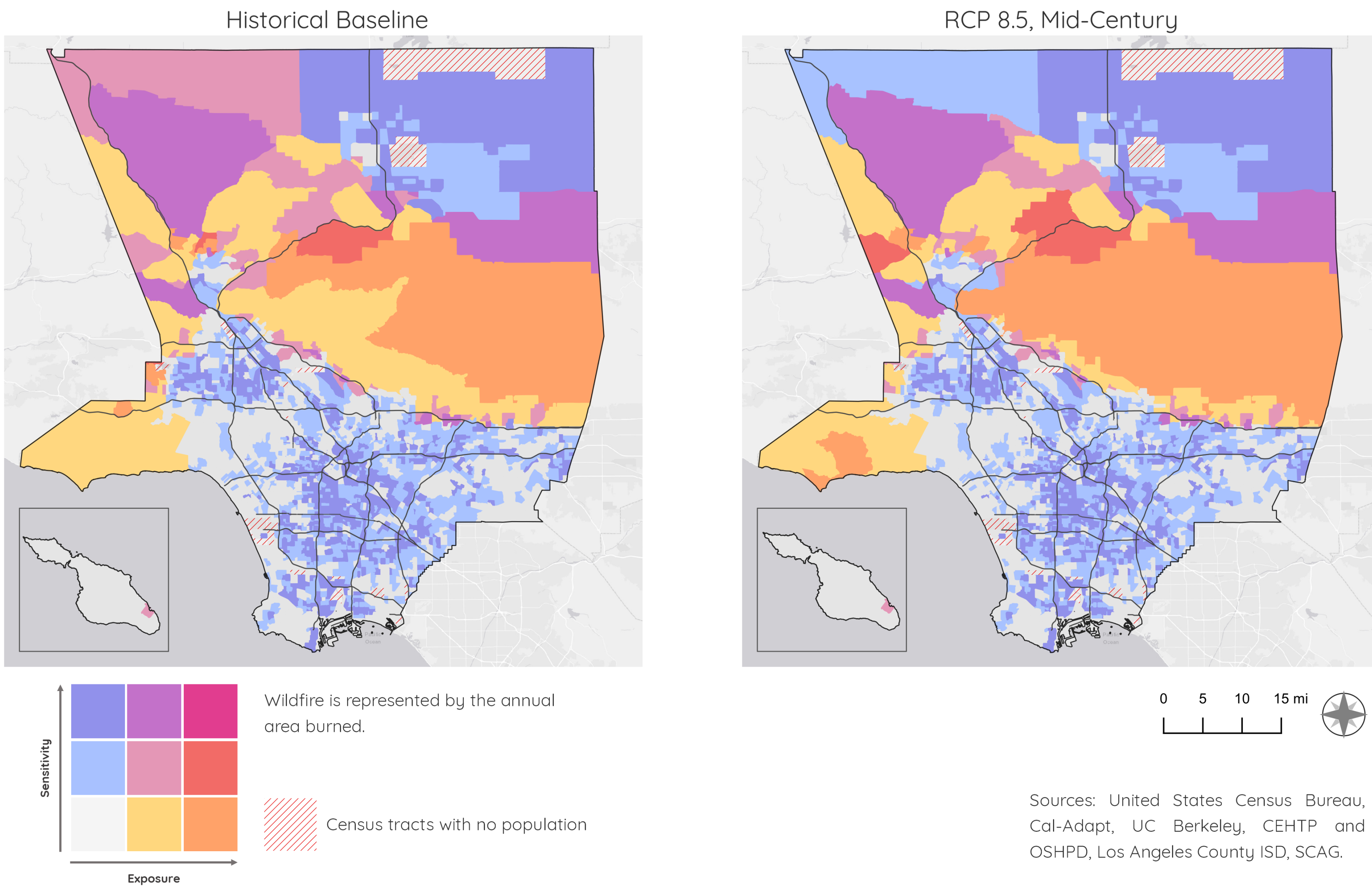
Wildfire is, and will continue to be, a major concern for LA County and the western United States through mid-century. In LA County, areas of high social sensitivity do not overlap with high direct wildfire exposure, as shown in Figure 21 and quantified in Figure 20. Most of the areas that are highly exposed to wildfire are forested, with low populations, and therefore do not appear in

Percent of LA County Population by Level of Vulnerability to Direct Impacts from Wildfire

	Baseline	Mid-Century	% Change
High Vulnerability	0%	0%	0%
Moderate Vulnerability	3.4%	2.6%	-23.5%
Low Vulnerability	96.6%	97.4%	+0.8%

Figure 20: Percentage of LA County population by level of social vulnerability to direct impacts from wildfire

Social Vulnerability to Wildfire



Sources: United States Census Bureau, Cal-Adapt, UC Berkeley, CEHTP and OSHPD, Los Angeles County ISD, SCAG.

Figure 21: Map of social vulnerability to wildfire in LA County

the Social Vulnerability Assessment. At the same time, there are smaller areas within communities or census tracts that may be especially exposed or vulnerable to wildfire. More granular analysis is needed to identify the nuances in direct wildfire vulnerability within these regions.

The northern portion of LA County is most at risk to direct impact from wildfire and will experience the largest change in wildfire exposure through mid-century. Many areas in northern unincorporated LA County and some cities in the foothills of the San Gabriel Valley, as detailed in Table 5, are moderately vulnerable. Indirect impacts from regional wildfires will likely affect the entire County. In the Western United States, communities within 100 miles downwind of a wildfire have historically had significantly elevated air pollution levels, five to 15 times worse than typical levels.[122]

Table 5: Wildfire communities of concern

Community[a]	Number of Moderately Vulnerable Census Tracts	Supervisorial District	Population in Moderately Vulnerable Census Tracts[b]	Baseline (hectares)	Mid-Century (hectares)	Change (hectares)
Santa Clarita	2	5	11,216	25.7	20.9	-4.8
Duarte	2	5	10,153	25.7	27.3	1.6
Los Angeles—Tujunga	2	5	7,811	20.2	22.5	2.3
Monrovia	1	5	7,087	24.8	24.5	–0.3
Unincorporated—La Crescenta-Montrose	1	5	5,763	23.6	19	–4.6
Glendora	1	5	5,605	14.8	17	2.2
Azusa	1	1	5,448	17.1	19.2	2.1
Unincorporated—Castaic	1	5	5,387	27.5	28	0.5
Unincorporated—Acton	1	5	4,687	37	43.6	6.6
Los Angeles—Sunland	1	5	4,456	23.8	26.1	2.3
Unincorporated—Llano	1	5	4,380	24.5	29.3	4.8
Unincorporated—Agua Dulce	1	5	4,074	28.8	34.7	5.9
Unincorporated—Val Verde	1	5	3,573	29	35.5	6.5
Arcadia	1	5	3,519	22	17.4	-4.6
Unincorporated—Anaverde	1	5	1,367	20.8	19.1	–1.7

NOTE: Because there are no highly vulnerable census tracts for wildfire, this table includes information for census tracts that have either high sensitivity and moderate exposure or moderate sensitivity and high exposure.

a. Communities listed are representative of those that include the most highly vulnerable census tracts and population; data represent values and averages of the highly vulnerable census tracts.

b. 2018 population.

People of color, particularly Black and Native populations, are highly burdened by chronic illnesses that are exacerbated by extreme heat and poor air quality. For example, asthma rates among both children and adults in Native communities are higher than among the general population.[137] These individuals are therefore at increased risk of negative impacts from extreme heat and wildfire smoke.[138]

Sensitivity indicators that drive community-level vulnerability

Communities that are most vulnerable to wildfire have higher-than-average representation of older adults living alone, people with cardiovascular disease, and people with low transit access. In many cases, vulnerable communities have high representation with respect to not only one of these characteristics, but even multiple or all. Where social sensitivities and low adaptive capacity to wildfire are compounded, the risk to people and their livelihoods is greatly elevated. People belonging to these groups and living in vulnerable communities will be especially sensitive to the direct impacts of wildfires in LA County.

Older adults living alone

Older adults living alone are particularly sensitive to wildfire events. Because of their age, they are more likely than other residents to have a variety of health conditions, mobility limitations, and/or communication challenges. Older adults with respiratory conditions are especially susceptible to wildfire-induced smoke, and those with limited mobility may be unable to evacuate quickly. Additionally, those who live alone may struggle to find information on evacuation details or locate assistance to help during emergencies. Communities with relatively high representation of older adults living alone and higher than average wildfire exposure by mid-century include Duarte, Santa Clarita, Arcadia, unincorporated La Crescenta-Montrose, and unincorporated Castaic.

People with cardiovascular disease

Wildfire smoke and air pollution are known causes of cardiovascular disease.[136] In LA County, areas with relatively high cardiovascular disease prevalence and higher wildfire exposure include Santa Clarita, Los Angeles—Tujunga, and unincorporated Val Verde. These communities face the brunt of wildfire impact and smoke and will experience higher risk of wildfire that will exacerbate and worsen health concerns. Health impacts are particularly problematic for people who lack health insurance or easy access to medical facilities, because they may not receive timely treatment.

People with low transit access

During a wildfire evacuation, transportation is critical. Many households in LA County can evacuate with a private vehicle, but households without access to one are more likely to rely on public transit, like buses. During wildfire and other extreme events, public transit systems are sometimes strained, delayed, or unavailable because of power outages and increased demand. People who rely on public transit sometimes spend prolonged time outdoors during these events, exposed to smoke while waiting for their ride. In LA County, communities with low transit access and high vulnerability to wildfire include Santa Clarita, Duarte, unincorporated Val Verde, unincorporated Castaic, unincorporated Acton, and unincorporated Agua Dulce.

Community-scale adaptive capacity

There are many ways that policymakers and property owners can design the built environment and natural systems to support a person's or community's ability to adapt or respond to wildfire. Homes can be built or retrofitted to better withstand wildfire, spaces around homes can be designed as intentional breaks to decrease fire behavior, indoor spaces can be equipped with air-quality monitors and filters to combat wildfire smoke, and proper forest management and collaboration with LA County's Tribal populations can reduce the impacts of wildfire.

Starting in 2008, the state of California began integrating wildfire protections and material requirements into building codes to ensure that newly constructed buildings or major renovations meet certain safety standards. Although these code requirements do not nullify the potential risks, these standards minimize the potential impacts on a building and its occupants. Communities in LA County with high wildfire exposure and old buildings have high risk of wildfire damage. These include Azusa, Glendora, Arcadia, Monrovia, and Sierra Madre – all communities along the San Gabriel Valley foothills. In these communities, an average of

Social vulnerability by climate hazard - wildfire

only 2 percent of the building stock is newer and was built after 2008, when new building codes began being enforced.

Finally, a critical path for the County to curb wildfire impacts and better manage and prepare for wildfire is to engage with local Tribal communities. Local Tribes in LA County have generations of experience with managing the land sustainably. These communities can be valuable partners in better managing and controlling wildfire in LA County.

Other indicators of social sensitivity to wildfire

No health insurance: Individuals without health insurance are less likely to regularly visit a doctor who can diagnose preexisting conditions and/or to receive care for any injury or illness that occurs as the result of or during wildfire events.

Mental health: Trauma from past wildfires can be serious. About one-quarter of people who have experienced wildfire in the past five years may suffer mental health disorders at about twice the rate as the general population.

Children: Wildfire smoke may hinder cognitive abilities for children and can even cause respiratory-related absences.

Foreign born / limited English proficiency: Limited English proficiency can hinder protective behaviors during wildfire events by limiting access to or understanding of health warnings, evacuation routes, and other important emergency communications of wayfinding materials.

Sources:

1. Raval, Amee, et al. Mapping Resilience: A Blueprint for Thriving in the Face of Climate Disasters. Asian Pacific Environment Network, 2019.

2. Rhoades, Elizabeth K., et al. Your Health and Climate Change in Los Angeles County. Climate and Health Series, Report 1, Los Angeles County Department of Public Health, Division of Environmental Health, Aug. 2014.

3. Cooley, Heather et al. Social Vulnerability to Climate Change in California. CEC-500-2012-013, Pacific Institute, Jul. 2012.

4. Gibbs, L., et al. Beyond Bushfires: Community Resilience and Recovery Final Report. University of Melbourne, Nov. 2016.

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Extreme heat and wildfire: electricity-dependent populations

Extreme heat and wildfire are major concerns in LA County. When these two hazards intersect, it can be particularly dangerous. Extreme temperatures strain the electrical grid (read more in the *Physical Vulnerability Assessment*), potentially causing outages; wildfire conditions can also lead to Public Safety Power Shutoff events and power supply challenges. In January 2021, Southern California Edison cut off power to 17,900 residents in Los Angeles County to prevent wildfires caused by strong Santa Ana winds.[139] Power outages caused by extreme heat or wildfires can greatly impact people in LA County. These conditions are particularly risky for populations dependent on electricity for health and medical needs.

Medicare is a federal insurance program that covers older adults and people with disabilities. There are over 62 million Medicare beneficiaries in the US. Figure 22 shows the number of Medicare beneficiaries that are electricity-dependent by zip code. While this data do not provide a comprehensive view of electricity-dependent people across the County, it does provide an idea of the scale of people that are already sensitive to climate change impacts and have electricity-dependent medical needs.

Regions in the unincorporated Northeast Antelope Valley have relatively large numbers of people who are highly exposed to extreme heat and medically dependent on electricity (see Figure 22). Power outages may be particularly problematic for people living in rural areas outside Lancaster and Palmdale, where there are fewer medical facilities. For wildfire, moderate dependency on electricity overlaps with high wildfire exposure near Santa Clarita and parts of the Angeles National Forest. These vulnerable areas may need outside resources and support during extreme heat and/or wildfire events and power outages.

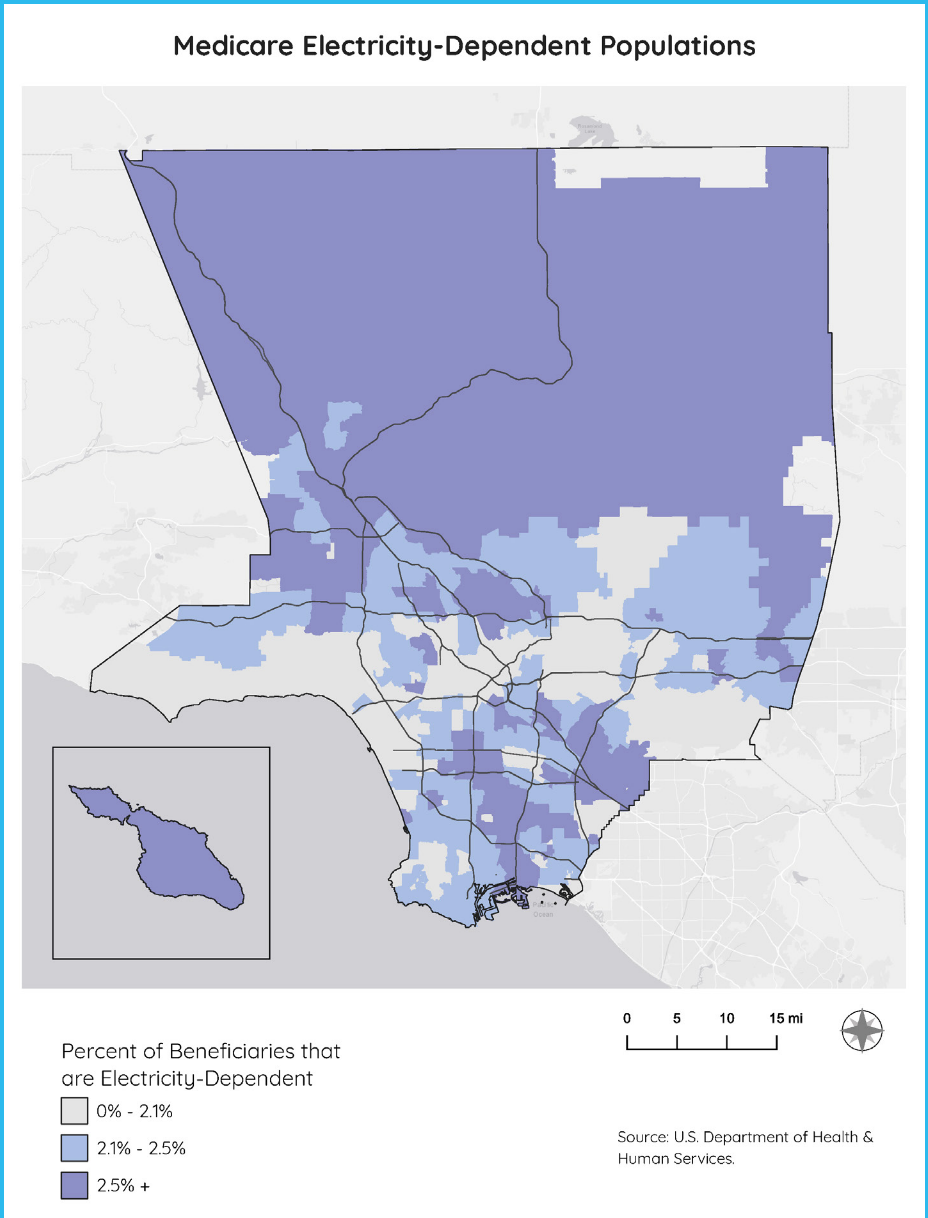


Figure 22: Medicare electricity-dependent populations in LA County

Inland flooding and extreme precipitation

Introduction

In LA County, climate change brings with it wetter, more intense storm events. Although the total amount of rainfall is not projected to change significantly by mid-century, rainfall events will become more severe. The increase in rainfall volumes in short periods of time can lead to inland flooding across LA County and serious impacts to people and property.

Data on exposure to extreme precipitation are limited to annual rainfall averages and do not capture the extreme precipitation events that can cause the most damage. Because of this data gap, this section primarily explores the impact of inland flooding on communities. Exposure to inland flooding is based on mapping of floodplains created by FEMA. For the purposes of the CVA's exposure assessment, communities in the 500-year floodplain have a 0.2-percent annual chance of flooding, and communities in the 100-year floodplain have a 1-percent annual chance of flooding. Floods that have a 1-percent chance of annual occurrence, or a 0.2-percent annual occurrence, are major destructive events that can cause harm to infrastructure and people.

As with extreme precipitation data, inland flooding data have their limitations. FEMA floodplain maps do not account for future climate change but instead provide a picture of areas that are more likely to face flooding based on historical conditions. Given the data gaps described, the future vulnerability to flooding—and the number of people impacted—is likely greater than what can be assessed here. For these reasons, these exposure predictions should be considered conservative estimates of risk, and should not be compared to vulnerabilities from other climate hazards for which future projections do exist. It is critically important for the County to update the CVA analysis as additional precipitation and flood risk analysis and modeling for LA County becomes available. For more information on the Climate Hazard Assessment, available data, and data used for the CVA, refer to *Appendix D*.

Impacts of inland flooding and extreme precipitation on people

Inland flooding risks are widespread across LA County. The most serious floods can destroy homes and lead to loss of life. The ability of a property owner to recover from the destruction of property is heavily influenced by flood insurance. Households that are located in

"It's important to think about how extreme events could potentially affect our unhoused clients. In one instance, a flooding event prevented the El Monte Multidisciplinary Team (MDT) at Union Station Homeless Services from providing services, many of which are critical on a day-to-day basis, and can have repercussions for our clients' food security, health, and housing outcomes."
- Jim Goodwin, MDT program at Union Station Homeless Services

Union Station Homeless Services

Social vulnerability by climate hazard - inland flooding and extreme precipitation

> **"Those experiencing unsheltered homelessness are the most vulnerable due to their exposure and lack of resources. Particularly, poor air quality and extreme temperatures greatly impact the health and well-being of people experiencing homelessness who are already very health-compromised."** - Colleen Murphy, Los Angeles Homeless Services Authority

areas with 0.2-percent annual chance of flood are not required to purchase flood insurance as a prerequisite for federally backed mortgages, whereas households within areas with a 1-percent annual chance of flood are required to do so. Furthermore, many households rent their homes and may lack insurance-related resources for recovery.

During a period of extreme precipitation or a flood, even buildings that have little visible damage may start accumulating mold. Mold will grow in any moist environment; it is commonly found indoors in places where there have been flooding or leaks, like at roofs, windows, or pipes. Mold can irritate the eyes, throat, or skin, and can trigger asthma attacks. People with suppressed immune systems or underlying lung disease are more susceptible to fungal infections, and those with chronic respiratory disease may have difficulty breathing. The impacts of mold are most concerning for those with preexisting conditions or those who spend time in buildings without proper ventilation or access to dehumidifiers.


LAHSA

For sensitive populations, the health consequences associated with a flooding event can last for years after the original disaster. Researchers compared birth outcomes and pregnancy risk factors before and after a catastrophic flooding and found a higher prevalence of low birth weight, preterm birth, and pregnancy complication after a disaster.[140]

Representatives from homelessness services organizations highlighted the difficulties that their clients face while protecting their shelter and belongings from extreme precipitation. In particular, the Los Angeles County Department of Health Services noted that encampments can lack proper waterproof protection, increasing the exposure to water and subsequent mold. The Los Angeles Homeless Services Authority tries to prepare highly vulnerable communities by providing warnings to encampments closest to riverbeds before a storm.

Beyond impacts to buildings, shelters, and occupants, inland flooding and extreme precipitation have the potential to impact transit and road infrastructure, causing service delays or shutdowns and road closures. These impacts disrupt access to essential services, jobs, and education in the short term and, in severe cases, the long term. Generally, people with lower income are less able to pay for the various resources needed to respond to and recover from flooding, like cars or hotel rooms. In listening sessions, organizations representing people without reliable transportation reported that inland flooding can exacerbate transit accessibility. Waterlogged bus stops force riders to stand elsewhere on the street, resulting in missed buses. Adjusted transit routes resulting from street blockages can cause riders to miss work entirely. Union Station Homeless Services shared that a flooding event recently prevented outreach workers from visiting an encampment, leaving residents cut off from services until the flooding subsided.

For those with disabilities and mobility challenges, navigating sidewalks becomes more difficult during times of extreme precipitation. Representatives of these communities reported that litter and debris can clogs storm drains, flooding the sidewalks and, in turn, limiting accessibility for the blind, visually impaired, and physically disabled.

People who experience stressful flood events and loss are at greater risk of mental health outcomes, like depression.[141] Support during recovery can be important, because those with stronger social networks and support systems are more resilient to adverse mental health effects.[142]

Key takeaways

Based on FEMA floodplain maps, there are many communities are at risk to inland flooding throughout LA County (see Figure 23). These communities represent close to 720,000 people in danger of being impacted by flood events. In LA County, approximately 480,000

Social Vulnerability to Inland Flooding

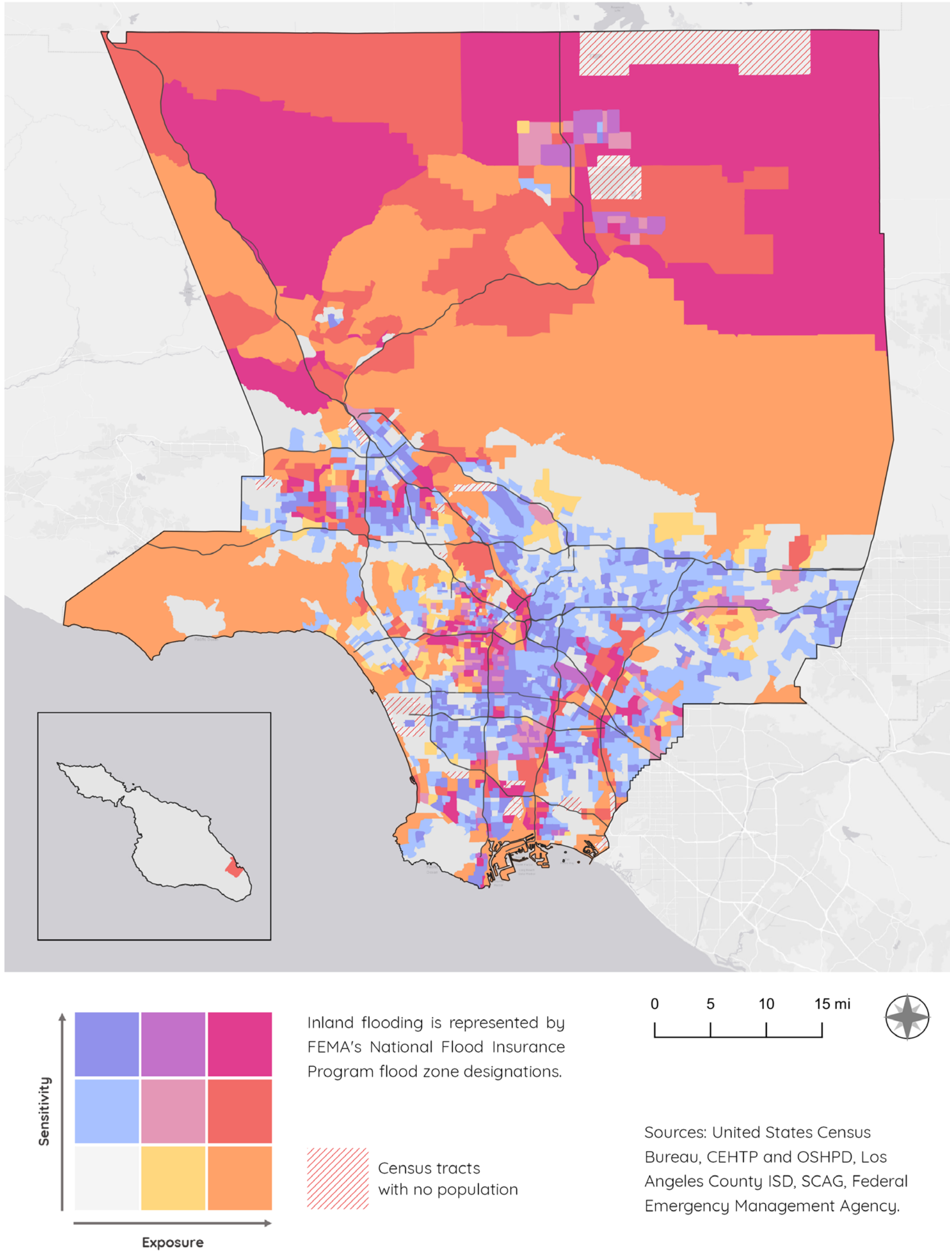


Figure 23: Map of social vulnerability to inland flooding in LA County

Social vulnerability by climate hazard - inland flooding and extreme precipitation

Table 6: Inland flooding communities of concern

Community[a]	Number of Highly Vulnerable Census Tracts	Supervisorial District	Population in Highly Vulnerable Census Tracts[b]	Inland Flooding	Extreme Precipitation, 95th-Percentile Daily Max	
				1% Annual Chance Flood Exposure (Percentage Area)	Baseline (in)	Mid-Century (in)
Long Beach	7	4	29,455	22.3%	1.0	1.1
Los Angeles—Melrose	5	3	18,587	13.7%	1.3	1.4
Los Angeles—Sun Valley	4	5	12,992	17.0%	1.2	1.3
Los Angeles—Crenshaw District	2	2	9,452	19.0%	1.2	1.3
Los Angeles—Country Club Park	2	2	8,118	26.1%	1.2	1.3
Los Angeles—Little Bangladesh	2	2	6,704	13.9%	1.3	1.4
Lynwood	1	2	7,231	25.3%	1.2	1.3
Unincorporated—Lake Los Angeles	1	5	5,783	18.9%	0.5	0.5
Unincorporated—North Lancaster	1	5	5,399	16.6%	0.6	0.6
Los Angeles—Exposition	1	2	4,563	15.3%	1.2	1.3
Los Angeles—Mid-City	1	2	3,993	15.6%	1.2	1.3
Unincorporated—Del Sur	1	5	3,985	29.2%	0.6	0.7
Los Angeles—St. Elmo Village	1	2	3,949	25.2%	1.2	1.3
Los Angeles—Westlake	1	1	2,942	35.1%	1.3	1.4
Unincorporated—Roosevelt	1	5	1,151	35.1%	0.5	0.5

a Communities listed are representative of those that include the most vulnerable census tracts and have greater than 10 percent of the area within 1-percent annual chance flood hazard exposure; data represent values and averages of the vulnerable census tracts.

b 2018 population.

people live in census tracts with at least 10 percent of the area exposed to a 0.2-percent annual chance of flood, and nearly 141,000 live in census tracts with at least 10 percent of the area exposed to a 1-percent annual chance of flood. As noted above, these should be considered conservative estimates of both risk as well as number of communities impacted.

Low-lying areas or areas in and around watersheds throughout LA County are at a higher risk of inland flooding. Communities that face higher risk of flooding are shown in Table 6. In some of the most flood-prone communities, up to 35 percent of the land area is exposed to a 1-percent annual chance of flooding. One area of particular concern is along the LA River, as approximately 1,000,000 people live within a mile of it.[143]

Redlining and historical development practices have led to higher concentrations of people of color in flood-prone areas. Furthermore, low-income neighborhoods tend to have less protective or poor-quality infrastructure to manage stormwater and mitigating flooding. For these reasons, many low-income communities and communities of color will be disproportionately impacted by inland flooding events.

Additionally, redlined and other communities that have experienced environmental injustice are often adjacent to heavy industrial and hazardous facilities. During an extreme precipitation or flooding event, people living in these areas can have an increased risk of exposure to polluted runoff and dangerous conditions.

Sensitivity indicators that drive community-level vulnerability

Communities with high vulnerability to inland flooding are characterized by higher-than-average representation of mobile homes, households without vehicle access, households with low library access, people with asthma, and households without an internet subscription. Many of the communities that are most vulnerable to flooding have high representation with respect to not only one of these characteristics, but even multiple or all.

Mobile homes

Compared with the countywide average, census tracts identified as highly vulnerable to flood events have more than twice as many people who live in mobile homes. Several unincorporated communities, including North Lancaster, Del Sur, and Roosevelt, have higher-than-average numbers of people living in mobile homes. Mobile homes have been shown to be more sensitive to the impacts of flooding because of susceptible water and wastewater systems; in some cases, mobile homes may not be permanently secured to a foundation, putting them at risk of movement and damage.[144] Mobile home parks represent a concentration of sensitive people who are underserved by disaster response and preparedness programs.[145] For example, mobile homes are harder to insure through FEMA's National Flood Insurance Program than fixed homes.

Households without vehicle access

Access to a personal vehicle may be important for mobility during and/or immediately after extreme precipitation and flooding events, especially if sidewalks and other pedestrian avenues are blocked or damaged. A handful of communities at risk of flood in the City of Los Angeles have populations with below-average access to personal vehicles. These areas include Westlake, Little Bangladesh, Melrose, Crenshaw District, and St. Elmo Village. And although these communities all have populations with 100-percent access to public transit systems, the lack of redundancy, speed, and efficiency of these services during evacuation can put them at greater risk. Furthermore, a lack of transportation options and redundancy can impact people getting to work during extreme events. Without reliable transportation or private vehicle flexibility, these households could face wage losses and financial stress due to climate change.

Low library access and low internet subscription

Internet-enabled devices (like smartphones or computers) and libraries are important sources of social connection and information, facilitating access to news and emergency alerts. Communities with high exposure to flooding and lower-than-average rates of internet subscription include Lynwood and unincorporated Roosevelt, as well as Westlake, Crenshaw District, and St. Elmo Village in the City of Los Angeles. Many of the unincorporated areas with high exposure to inland flooding also have low access to libraries. These communities include Roosevelt, Del Sur, and North Lancaster.

Social vulnerability by climate hazard - inland flooding and extreme precipitation

Asthma

People with asthma have greater susceptibility to the mold that can result from flooding and extreme rain events. Mold can cause irritation of the eyes, throat, or skin, and for those with preexisting respiratory conditions like asthma, it can trigger more serious attacks.

Community-scale adaptive capacity

Built environment and natural systems can be critical for a person's or a community's ability to adapt or respond to flooding. One indicator of an area's potential for flooding is its ratio of permeable surfaces to impermeable surfaces. *Permeable surfaces* allow water to infiltrate into the ground rather than pooling or running down a surface area. Undeveloped natural lands are highly permeable and can absorb lots of water, but most types of pavement are *impermeable*. When land is paved for roads, buildings, and parking lots, the proportion of permeable surface typically decreases. Maintaining as much permeable surface as possible by using permeable materials for new development can help ensure that stormwater will be absorbed into the ground and will filter through the soil to replenish groundwater. Many urbanized areas, particularly in and around downtown Los Angeles, have limited permeable surfaces, making stormwater more likely to pool and accumulate on streets and sidewalks.

Green infrastructure projects are one way to expand permeable areas and reduce flooding potential in LA County. Green infrastructure, like bioswales, rain gardens, and green roofs, can be installed along rights of way or in yards to collect, slow down, and passively treat stormwater. Building design can also affect a community's vulnerability to flooding; buildings with electrical, heating, and/or cooling equipment that are raised above flood elevation levels are better able to maintain standard functions, like air conditioning during flood events.


LA Waterkeeper

Wildfire and extreme precipitation: high risk communities and mudslides

Across LA County and the region, areas that reside on the border between urbanized land and undeveloped wildland vegetation are collectively referred to as the wildland urban interface (WUI). These areas often sit within LA County's High and Very High Fire Hazard Severity Zones (see Figure 24) and are at particular risk of wildfire events. In LA County, 19 percent of residents live in Very High Fire Severity Zones.[146] When people build new housing or infrastructure in these areas, they must follow certain requirements to limit the potential impacts of wildfire to their property. Despite this, they are still at much higher levels of potential exposure than more urbanized areas of LA County. In the state of California, at least 25 percent of the state's population lives in the WUI, and developers continue to build in these areas despite wildfire concerns.

Landslides and mudslides are a second type of risk in WUI areas at the foothills of mountain ranges, where there may be steep slopes. The congruence of post-wildfire debris and extreme precipitation in these sloped areas can have devastating impacts on developments in the down-slope areas. For more information on post-wildfire debris flow and physical vulnerability, refer to *Physical vulnerability by climate hazard: Inland flooding and extreme precipitation.*

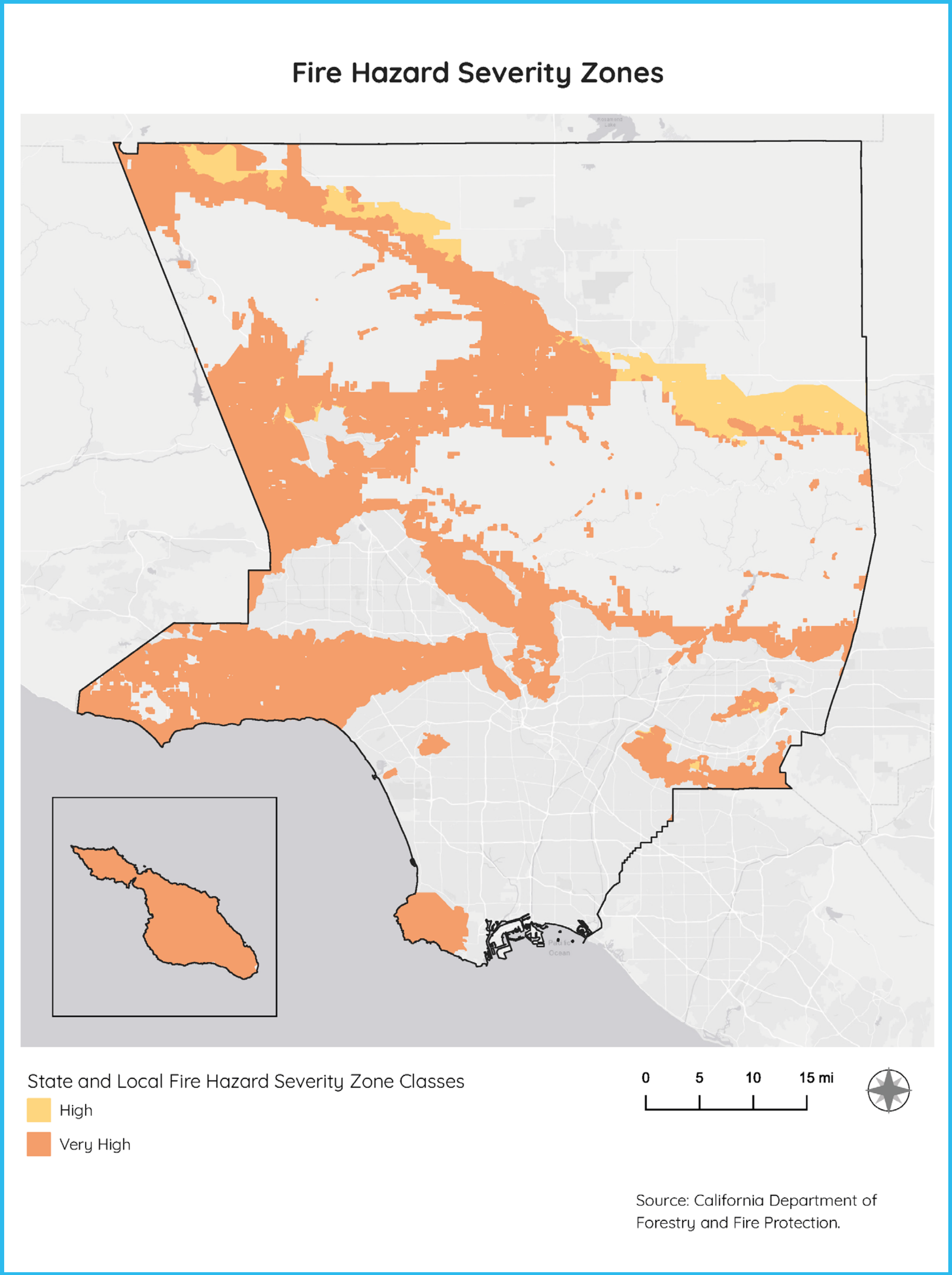


Figure 24: Fire hazard severity zones in LA County

Coastal flooding

Introduction

Sea-level rise, combined with a 1-percent annual chance of flooding, will pose significant risks to the coastal communities in LA County. Although most areas along the coast have steep cliffs that guard against sea-level rise, multiple low-lying areas will experience coastal flooding. The extensive business and tourism activity in these areas, and their status as a recreational space for LA County visitors and residents alike, may be jeopardized. Coastal flooding is likely to have a significant impact on coastal industries and communities in LA County by mid-century.

Impacts of coastal flooding on people

Many areas along LA County's coastline are dedicated to tourism, retail, and entertainment and are active focal points for Southern California communities. Impacts from sea-level rise and coastal flooding could damage and close some businesses and reduce the activity in and visitation to these areas. Shifts in activity and damage to these areas may cause financial losses for businesses and workers.

Furthermore, people visit LA County beaches and nearby community spaces to find respite from heat and stress and to participate in social and cultural activities. Sea-level rise and coastal flooding put the availability of these resources at great risk. As sea levels rise, the amount of beach and park area will shrink, **and it is very likely that many County beaches will disappear by end-of-century**. One model suggests that Southern California could lose up to 67 percent of its beaches by end-of-century.[147] The loss of beaches and public spaces along the coast would be devastating for LA County communities and local culture.

Native sacred and cultural sites are at risk of being diminished through coastal erosion.[148] During CVA listening sessions, Native and Tribal representatives reported that they continue to advocate to protect sacred spaces and be involved in habitat restoration and wetlands preservation along the coastline as a response to coastal flooding and sea-level rise. They also emphasized the need to uplift Native knowledge like building *tomols* and *ti'ats* (Native canoes) to paddle in traditional waters, or working with elders to practice Native language, prayer, and song. This education can cultivate a deeper linkage among people, land, and ecological systems.

It is not possible to prevent sea-level rise through mid-century. Methods for preventing the associated flooding are limited. Given these circumstances, people who live in low-lying coastal areas may need to migrate inland to stay safe. Inland migration can be especially challenging for low-income households without available resources. Governmental policy that facilitates this type of migration is often called *managed retreat*.

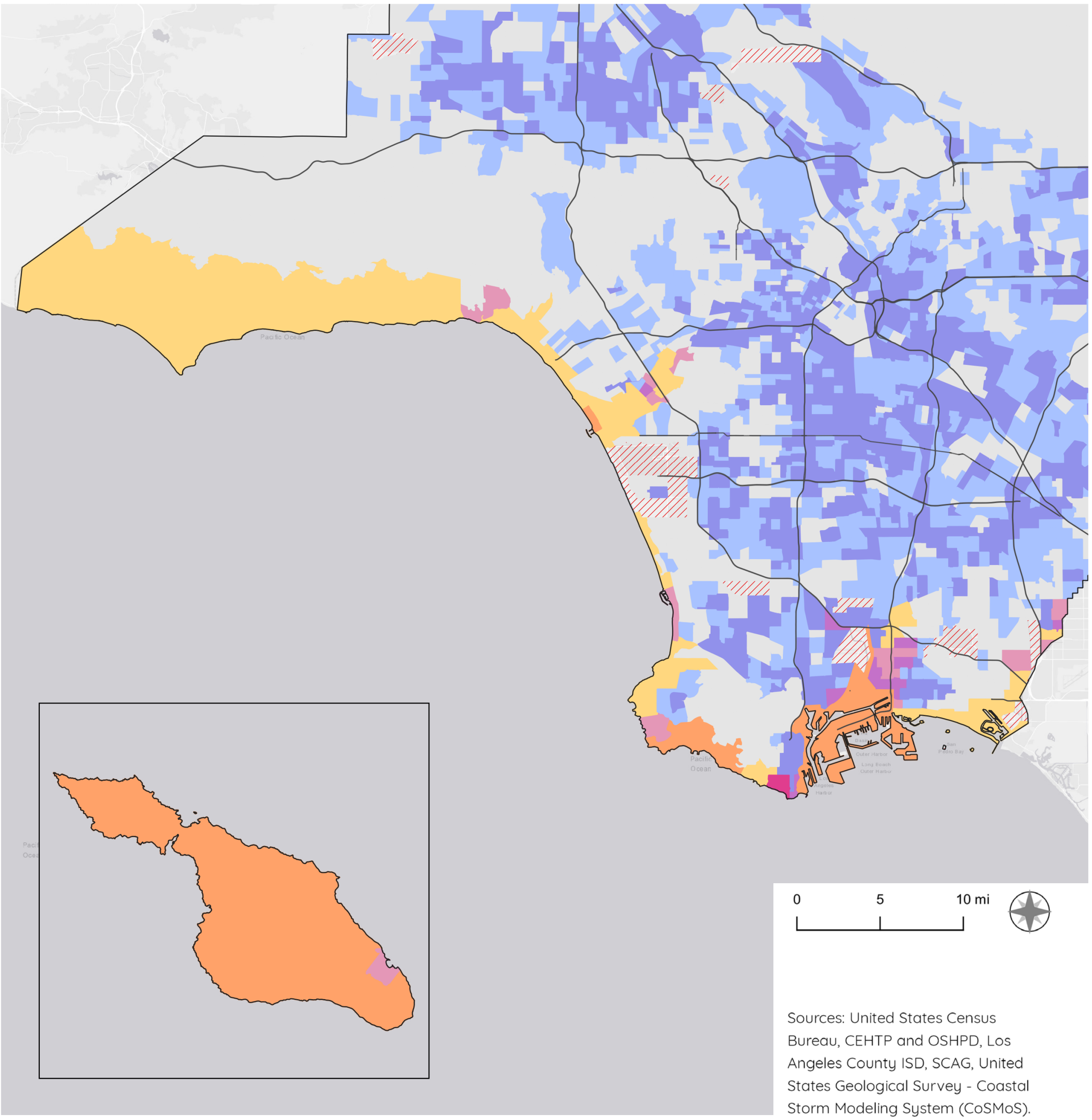
Key takeaways

By mid-century, sea-level rise and coastal flooding will impact almost all of LA County's coastline (see Figure 25). These projections illustrate the urgent need to plan for and adapt to these changes now. Across Los Angeles County, there is relatively limited overlap between highly sensitive residential communities and high exposure to sea-level rise. However, coastal flooding will impact commercial areas, workplaces, and other community resources, like parks and open space, that will affect people beyond the communities mentioned in this assessment.

Across the LA County coast, there are roughly 47,000 people at risk of coastal flooding by mid-century; these people live in the communities listed in Table 7. The people in these communities and many more will be affected by the loss of recreational activity or business.

As with many areas in LA County, vulnerable communities on the coast are disproportionately comprise low-income people and residents of color. At times, these residents are excluded from adaptation planning and thus do not receive information about government resources and programs. For example, the 2010 floods in San Pedro and Wilmington affected mostly Hispanic/Latinx residents, many of whom were undocumented and some of whom did not speak English. Rather than use a Red Cross shelter setup to accommodate flood victims, many of these residents turned to a local nonprofit that was trusted by the community. The Red Cross shelter, seeing low turnout, closed prematurely. To ensure that affected residents get the support they need in the future, it is important to frame community outreach with the appropriate local context.

Social Vulnerability to Coastal Flooding

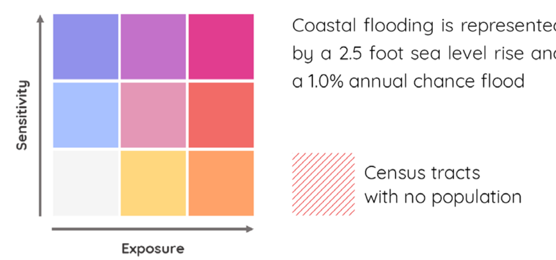


Sources: United States Census Bureau, CEHTP and OSHPD, Los Angeles County ISD, SCAG, United States Geological Survey - Coastal Storm Modeling System (CoSMoS).

Sensitivity indicators that drive community-level vulnerability

Communities with relatively high vulnerability to coastal flooding are characterized by higher-than-average representation of people living in mobile homes, people experiencing poverty, households with low median incomes, and people without a high school diploma. Many of the communities with the highest vulnerability to coastal flooding also have high representation with respect to not only one of these indicators of sensitivity, but even multiple or all. People represented by these groups and living in vulnerable regions will be especially sensitive to the impacts of coastal flooding in LA County.

Figure 25: Map of social vulnerability to coastal flooding in LA County



NOTE: Because Santa Catalina Island consists of only two census tracts, the map shows most of the Island experiencing coastal flooding by mid-century, when in actuality, some areas are unlikely to flood because of the elevation on the island.

Mobile homes

Compared with the countywide average, census tracts identified as highly vulnerable to coastal flooding have more than two and a half times as many people who live in mobile homes. Similar to the risks of inland flooding, mobile homes may be more sensitive to the impacts of coastal flooding because of susceptible water and wastewater systems, compounding socioeconomic factors and political barriers to recovery.

Poverty, median income, and educational attainment

Households with lower median income and people living in poverty are less likely to have protections against extreme weather events like coastal floods. This includes property or flood insurance or the financial ability to repair damaged property or deal with resulting health consequences. Lack of education, and specifically not having a high school diploma, is another indicator that is often associated with broader impacts to health and well-being and socioeconomic status. Economic prosperity allows for access to resources that can mitigate climate impacts. Poverty, however, is linked to a range of adverse health outcomes, like shorter life expectancy, higher infant mortality rates, and higher death rates for the 14 leading causes of death.[149, 150] Poverty can limit access to proper nutrition, healthy foods, proper shelter, safe neighborhoods, clean air and water, and other resources that support a healthy lifestyle.[151] Regions in Los Angeles County with exposure to coastal flooding and higher-than-average rates of poverty, low median income, and lack of educational attainment include Del Rey and Wilmington in the City of Los Angeles and parts of Long Beach.

Table 7: Coastal flooding communities of concern

Community[a]	Number of High or Moderately Vulnerable Census Tracts	Supervisorial District	Population in High or Moderately Vulnerable Census Tracts[b]	Coastal Flooding[c]		Extreme Precipitation, 95th-Percentile Daily Max	
				Moderate (Percentage Area)	High (Percentage Area)	Baseline (in)	Mid-Century (in)
Long Beach	6	4	21,870	16.2%	0.0%	1.0	1.1
Los Angeles—San Pedro	2	4	8,104	0.9%	0.0002%	1.0	1.1
Los Angeles—Del Rey	1	2	5,478	3.6%	0.0%	1.1	1.2
Hawaiian Gardens	1	4	4,849	5.5%	0.0%	1.1	1.2
Carson	1	2	3,670	0.01%	0.0%	1.0	1.1
Los Angeles—Wilmington	1	4	3,229	0.2%	0.0%	1.0	1.1

NOTE: Because there is only one highly vulnerable census tract (San Pedro) for coastal flooding, this table also includes information for census tracts that have high sensitivity, and moderate exposure

a Communities listed are representative of those that include the most highly vulnerable census tracts and population; data represents values and averages of the highly vulnerable census tracts.

b 2018 population.

c Moderate exposure for coastal flooding is characterized by flooding up to 3.9 feet (during a storm surge and with a 2.5-foot sea-level rise). High exposure areas refer to any flood depth above 3.9 feet.

Drought

Introduction

Drought has the potential to impact many lives across LA County and the southwestern United States. Because of rising temperatures and shifting precipitation patterns, the risk of severe droughts will increase through mid-century. Extended periods of drought, often called *mega-droughts*, will increase the severity impacts on people in LA County, limiting water supply and increasing levels of dust in the atmosphere.

Impacts of drought on people

One of the most critical impacts of drought on people in LA County is the reduction in the availability of clean and affordable drinking water. In the UCLA Luskin Center for Innovation's 2015 analysis of the Los Angeles County water systems, 75 percent of community drinking water systems exhibited at least one indicator of drought vulnerability risk.[152] Drought vulnerability can be exacerbated by single-source dependency, increased groundwater contamination risk, water from small service providers, and location in areas with a projected increase in extreme heat days. For households that fall under the jurisdiction of the most vulnerable water systems, the threat of drought can mean losing direct, easy access to drinking water.

Drought can also impact power generation in the region and lead to high utility costs. California's top two sources of electricity are hydropower and natural gas. The state's driest drought from 2012 to 2016 substantively decreased hydroelectricity generation, such that hydropower as a share of the state's total power generation dropped from 18 percent to just 13 percent in that timeframe.[153] Because of the lower costs associated with hydroelectricity, the increase in natural gas dependence during the drought resulted in higher utility costs for ratepayers.[154] With droughts expected to increase in severity over the next several decades, households unable to manage higher utility costs are at risk of losing access to necessary resources or becoming housing insecure. For low-income households, increased water rates can be detrimental, leading to tough financial choices. Low-income households face these possibilities despite mostly using less water on average than higher-income households, which often have lawns and washing appliances. This leaves low-income households with less room to cut back on water use during drought periods.

Another impact of drought on people in LA County is the increasing prevalence of Valley fever. Valley fever is a disease caused by inhaling fungus spores carried in soil dust.[155] Arid and semiarid landscapes, dust storms, and warmer temperatures all contribute to conditions that lead to increases in Valley fever. The number of reported cases of Valley fever in California has steadily and significantly increased over the past 20 years.[156] In 2020, the California Department of Public Health reported 1,113 cases of Valley fever in LA County.[157] While many who become infected experience no or minimal symptoms, some will develop severe and life-threatening illness that can last a month or more, like pneumonia and meningitis.[158] Populations at greater risk of severe disease from Valley fever include people who are Black or Filipino, older adults, pregnant people, infants, and people with diabetes or conditions that weaken the immune system. People who live or work in areas where soil is disturbed, such near construction, farming, or military operations, are at higher risk of exposure.[159]

Representatives from rural town councils expressed concerns that in addition to the health risks it poses, Valley fever can also impact economic well-being because illness may affect one's capacity to work, and treatment can be expensive. Immigrants or those who live in limited English-speaking households may experience more barriers to educational material and key messaging from employers, government agencies, or other groups about the disease.

Many Native communities rely on the land for sustenance. Drought, coupled with invasive species and reduced soil nutrients, may jeopardize traditional gathering activities. As discussed during the listening sessions, drought can negatively impact plants used for basket-weaving and medicinal purposes and soil quality for food production. Native communities have responded by nurturing land plants and growing food through regenerative agriculture and healthy soils practices.

Drought also impacts job availability and productivity in the agricultural sector, leaving workers with volatile schedules and reduced incomes. Although most of the region's farms and agricultural workers reside outside of LA County, agricultural instability can cause displacement and other economic impacts that have

Social vulnerability by climate hazard - drought

ripple effects across the region. In 2014, the drought cost farmers in the South Coast area of the state nearly $17 million from production losses and additional pumping costs.[160] Low agricultural production can also mean employment losses in food-related industries and higher prices for consumers, all of which can lead to food insecurity.

In 2019, the median household income for Los Angeles County was $68,044.[161] However, disaggregating this figure by race highlights the income instabilities experienced by people of color. Median household incomes for white ($75,422) and Asian ($80,046) householders are higher than those for Black ($48,823) and Latinx ($56,076) householders.[162] Median income is a strong indication of a household's ability to navigate a climate crisis. This is especially true of drought, which brings with it challenges to accessing and affording clean water. During periods of drought, there are domestic water shortages, which can lead to increased charges and concerns over affordability. For example, in Glendale, an average-sized household earning $10,000 per year and using 55 gallons of water per capita per day would pay an additional 1.4 percent of their annual income for drought charges alone, increasing the cost of basic water needs from 5.1 percent to 6.5 percent of their household income.[163]

Physical Vulnerability Assessment

For guiding priorities in policies and investments in building upgrades, infrastructure improvements, and zoning and code changes

What is physical vulnerability?

Physical vulnerability is the susceptibility and limitations of physical infrastructure in the context of climate hazards and extreme events. Climate change has the potential to damage physical infrastructure and disrupt services or limit accessibility. Because resilient infrastructure is one of several important components for a more resilient LA County, the Climate Vulnerability Assessment (CVA) explores the vulnerability of key infrastructure systems to understand how climate change will affect them by mid-century.

In the CVA, climate hazard exposure and infrastructure sensitivities to climate hazards are combined to determine physical vulnerability to climate change. The Physical Vulnerability Assessment (PVA) aims to highlight infrastructure systems that are most vulnerable to different climate hazards and to both prioritize and bring attention to those that should be the focus of pertinent investment and policy decisions.

Measuring physical vulnerability

To evaluate physical vulnerability, we combined climate hazard exposure and physical sensitivity for a set of prioritized infrastructure systems. The exposure analysis is mostly grounded in spatial data sets, and the sensitivity analysis for infrastructure is based on qualitative assessments from research, stakeholder engagement, and other vulnerability assessments. The nature and scale of the countywide PVA means that the assessment findings are not intended to be applied to specific infrastructure assets; individual facilities may have different vulnerabilities than the facility type overall. **Rather, the LA County PVA aims to provide a high-level view of different infrastructure systems across LA County that will face the greatest change in exposure in combination with sensitivity to different climate hazards**.

Infrastructure types

Determining the set of infrastructure systems to be evaluated was the first step in the PVA process. We narrowed down a broad list of infrastructure systems by prioritizing as most critical those facilities that

- **the County directly** owns and operates;
- are important for decision-making on **public health and safety;**
- play a role in **emergency response**; or
- provide an important service for **socially vulnerable populations**.

Using these criteria, the County selected 49 critical infrastructure types that communities throughout LA County rely on to live, work, recreate, and stay safe. Although those selected do not meet all four criteria, each infrastructure type, if damaged or disrupted, could have a negative impact on LA County and its residents and businesses. In the CVA, the 49 infrastructure types are organized into 11 primary categories: communications, community and other facilities, economic centers, emergency response, energy, housing for sensitive populations, medical facilities, natural resources, transportation, waste, and water. Table 8 provides a list of the infrastructure types assessed within each infrastructure category. Refer to the *LA County CVA Technical Methodologies Resources* for a full list of the spatial data sets we used for the PVA.

Table 8: Infrastructure included in the PVA

Communications: cell towers*
Community and other facilities: childcare/child and family services, cooling centers, cultural/historic resources, prisons and jails, schools
Economic centers: job-dense areas
Emergency response: emergency and disaster offices, fire stations, sheriff and police stations
Energy: electricity transmission lines, natural gas transmission and distribution, oil pipelines, oil refineries
Housing for sensitive populations: continuing care, residential care, and nursing facilities; publicly subsidized low-income housing; temporary and supportive housing for people experiencing homelessness
Medical facilities: medical clinics, mental health providers, hospitals and medical clinics
Natural resources: beaches, parks and open space, streams and rivers
Transportation: airports, bridges, bus lines and stops, disaster routes, highways, Metro and Metrolink lines and stations, ports, tunnels
Waste: hazardous waste disposal/Superfund sites, solid waste
Water: active private/permitted wells, dams and debris basins, groundwater recharge basins/ spreading grounds, injection wells, lakes and reservoirs, storm-drain system, wastewater treatment/reclamation facilities, water distribution/ aqueducts, water treatment

*Note that cell tower data are from the U.S. Department of Homeland Security and include only government-owned cell towers.

Climate hazard exposure

Like the SVA, the PVA used climate hazard exposure data from the Climate Hazard Assessment (available in *Appendix D*). However, for the PVA, we used change in exposure from the historical baseline to mid-century for the exposure analysis. This shift toward evaluating change in exposure, as opposed to a historical baseline and mid-century evaluation, highlights areas in LA County where there will be the most drastic increases in severity of climate hazards. Operators who work on infrastructure are continually evaluating infrastructure performance and risks. For this reason, we assumed that owners and/or operators of infrastructure systems are accustomed to and aware of current vulnerabilities and the risks posed by climate change under present-day conditions. Given this assumption, in the case of physical vulnerability it is more important to understand the degree to which exposure might change in the future and how that might impact infrastructure's vulnerability to climate hazards, rather than to provide snapshots of present-day and mid-century vulnerability.

For extreme heat and wildfire, the projected change in exposure is measured for each climate hazard between a historical baseline and mid-century. In the case of inland and coastal flooding, exposure is measured by examining areas within LA County with historical or projected likelihoods of flooding. By contrast, drought is evaluated qualitatively on a regional scale. Most infrastructure types were evaluated using the geographic information system to overlay spatial projections of exposure with critical facility locations. For unmapped infrastructure types, exposure scores were estimated based on location assumptions. Ultimately, based on the exposure analysis, we assigned each infrastructure type an exposure score of low, moderate, or high for each climate hazard.

Many areas across LA County are already exposed to climate hazards, and consequently, there may not be significant change in vulnerability to certain hazards between the historical baseline and the mid-century scenario. Since the analyses within the PVA assess vulnerability based on change, certain areas of the County may not see high vulnerability scores because the degree of change between the baseline and mid-century is not substantial. However, said areas will still be important to address with respect to physical vulnerability and countywide climate resilience

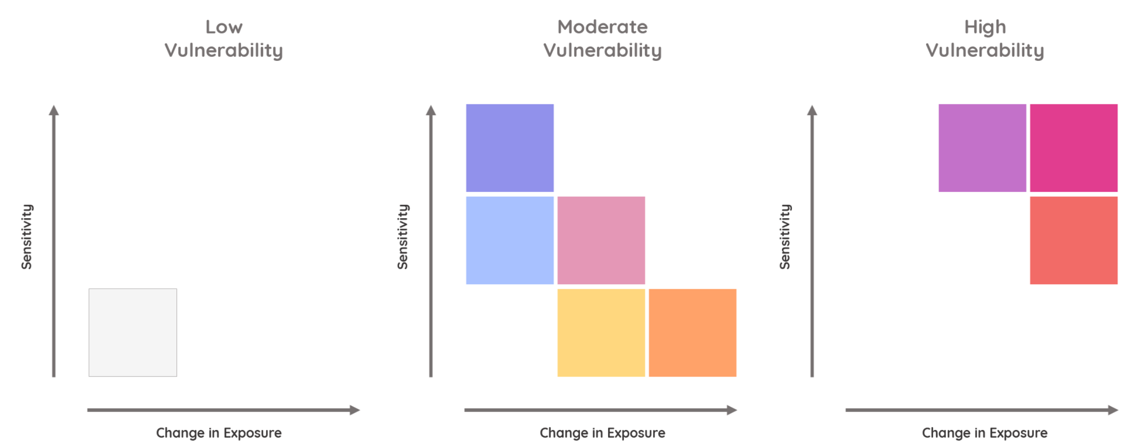
Physical sensitivity scoring

To evaluate physical sensitivity, we conducted desktop research and interviews with infrastructure specialists. We compiled findings from these investigations in a sensitivity matrix, organizing information on physical sensitivities by each infrastructure type and each climate hazard. Based on the information collected on physical sensitivity, we assigned each combination of infrastructure type and climate hazard a sensitivity score of low, moderate, or high.

Physical vulnerability scoring

The County determined physical vulnerability scores based on the intersection of exposure and physical sensitivity scores. For example, high exposure and high sensitivity would result in a high physical vulnerability score. As with social vulnerability, a low physical vulnerability score does not mean no vulnerability. All

Figure 26: Physical vulnerability matrix by level of vulnerability



infrastructure systems will face and respond to climate hazards differently, and we must look to build resilience into all infrastructure systems.

For more information on the PVA methodology and to see the full exposure, sensitivity, and scoring matrices, refer to the *LA County CVA Technical Methodologies Resources*.

Extreme heat

Introduction

LA County already experiences extreme heat events and their associated impacts. For example, in August 2020, a heat wave created electricity demand that exceeded supply, resulting in rotating power outages over a two-day period, during which nearly a half a million California residents lost power.[164] Less than a month later, San Fernando Valley set a new County record of 121°F.[165] Increasing temperatures contribute to dry soils and vegetation, creating prime wildfire conditions near communities at the wildland urban interface.[166] Extreme heat has had and will continue to have a wide range of impacts on infrastructure and facilities across LA County.

Impacts of extreme heat on physical infrastructure

Extreme heat does not typically result in discrete, catastrophic infrastructure failure. However, the widespread, gradual, and ongoing nature of rising temperatures can result in significant damage, repair costs, and service interruptions over time. Still, extreme heat impacts can be catastrophic to human health and test infrastructure capacity. Heat waves can be especially challenging, because high temperatures over many days or weeks can prevent the opportunity to recover. Extreme heat affects infrastructure in a wide variety of ways, including, but not limited to

- power outages can occur during heat events because of increased cooling demand and supply-demand imbalances, which can lead to service disruptions and a host of cascading impacts (see *Cascading Impacts Assessment*);
- materials like rail, transmission, and catenary lines can expand, and pavement can crack and rut, causing damage, potential safety hazards, and service disruptions; and
- water supply and quality are reduced, which, compounded with increases in water demand, contribute to limited water resources for communities.

Key takeaways

Vulnerability to extreme heat will be widespread across LA County's physical infrastructure by mid-century, more so than for other climate hazards examined in the PVA. Because of LA County's high exposure, almost all infrastructure types have moderate or high vulnerability to extreme heat. The infrastructure types that are highly vulnerable to extreme heat are listed in Table 9.

The impacts of extreme heat are closely linked to water and energy systems. Water systems face increased demand and increased system loss as a result of evaporation from aqueducts, lakes, and reservoirs, while energy systems face heat-related equipment damage to transmission lines and power plants along with increased cooling demand. Other infrastructure types, like airports and railways, housing for sensitive populations, and prisons and jails, also face direct infrastructure damage from extreme heat, on top of cascading impacts because of their heavy dependence on water and energy systems. These impacts on infrastructure directly affect County residents in the form of power outages and associated lack of air conditioning, water shortages, delayed or disrupted transportation, and inability to use parks and open spaces for cooling and safe recreation.

Community and other facilities

Prisons and jails

Extreme heat will strain air conditioning systems at prisons and jails and potentially lead to a lack of sufficiently cooled space if systems are not properly sized. Most prisons are not designed with thermal comfort in mind, and some prisons and jails do not have adequately sized air conditioning equipment or do not offer cooling in all areas of the facility. This can be dangerous and deadly for inmates and staff during extreme heat events. As prison populations have limited mobility and access to the outdoors, they have limited

Table 9: Extreme heat vulnerability by infrastructure type

Infrastructure Type		Exposure	Sensitivity	Vulnerability
Community and other facilities	Prisons and jails	H	H	H
Energy	Electricity transmission lines	H	H	H
	Power plants	H	M	H
Housing for sensitive populations	Continuing care, residential care, and nursing facilities	H	M	H
Natural resources	Parks and open space	H	H	H
	Streams and rivers	H	M	H
Transportation	Airports	H	M	H
	Metro lines and stations	M	H	H
	Metrolink lines and stations	M	H	H
Water Systems	Aqueducts and water distribution	H	M	H
	Lakes and reservoirs	H	M	H
	Water treatment plants	H	M	H

options to adapt and respond to extreme temperatures.

Energy

Transmission lines, substations, and power plants

Transmission lines and power plants will be among the infrastructure that is most vulnerable to extreme heat in LA County. Heat can cause transmission lines to sag and lose carrying capacity. Substations will also lose operating capacity because of extreme heat and can be overloaded and tripped as a result of increased demand. Extreme temperatures can also reduce the efficiency and output capacity of both natural gas-fired power plants and solar power plants. Rising air temperatures can impact chiller performance for dry-cooled natural gas plants and combined cycle natural gas plants leading to capacity losses.[167] Solar panels are typically tested at 77°F and decrease in efficiency as temperature increases.[168] Across LA County, distribution of solar power plants is disproportionately higher in moderate and high heat hazard areas. Nearly half of all solar power plants are in regions where change in extreme heat will be relatively high. The average solar plant in high hazard areas is expected to see more than a 6°F increase in 95th-percentile daily maximum temperature by mid-century—up from an already high baseline average of 99°F.

As shown in Figures 27 and 28, the most vulnerable transmission lines and power plants are in the Santa Clarita Valley and northwest areas of LA County, which are expected to experience some of the greatest increases in temperature. Infrastructure located in the cooler coastal areas of LA County will likely be less vulnerable. Of LA County's nearly 1,000 miles of high-voltage transmission lines, 96 percent are in areas that will experience moderate or high change in exposure to extreme heat.

While energy generation and transmission may have reduced capacity, electricity demand is also high because of increased demand for air conditioning and other cooling equipment during extreme heat events, adding more stress to the power grid. This confluence of diminished capacity and high demand poses challenges for meeting residents' needs and threatens grid reliability during extreme heat.

Extreme heat challenges were on display during the August 2020 heat wave, when demand surpassed

Figure 27: Map of transmission lines and substations and extreme heat exposure in LA County

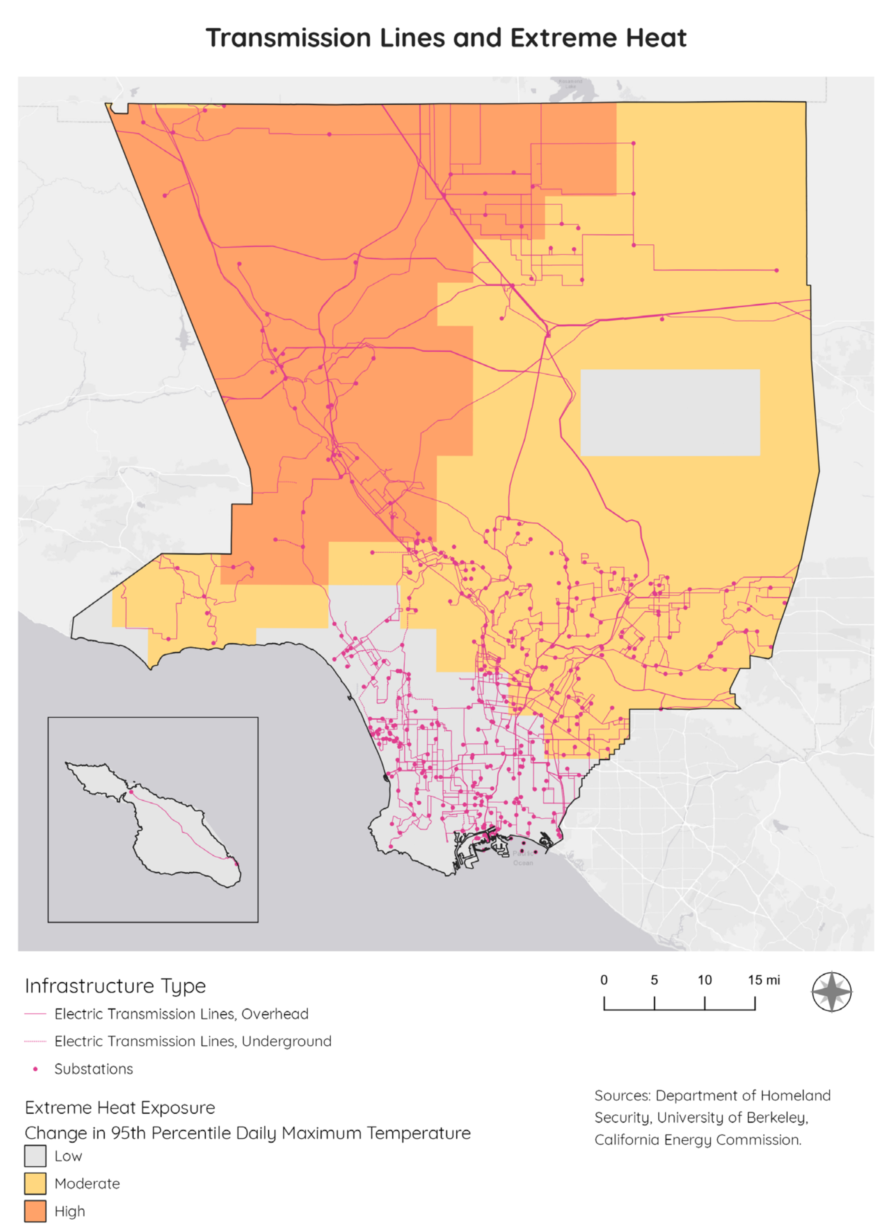
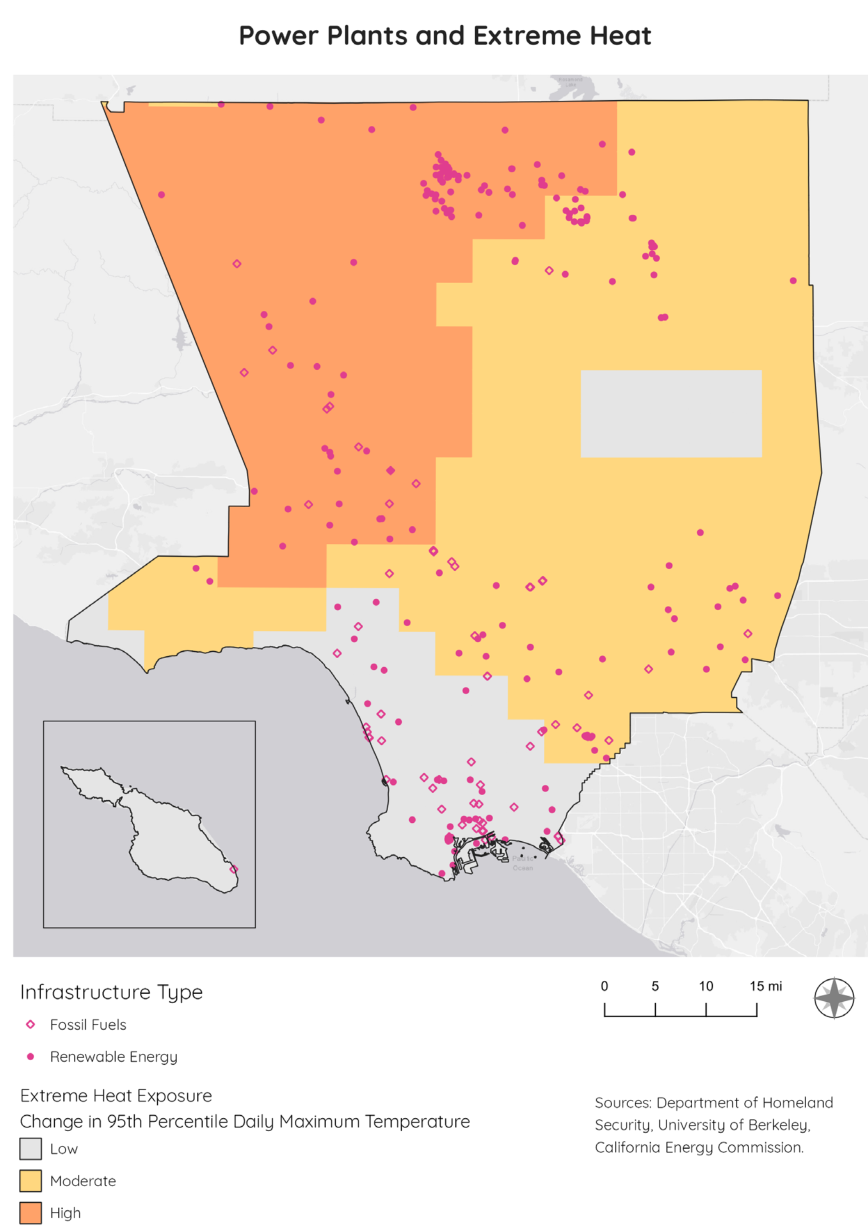


Figure 28: Map of power plants and extreme heat exposure in LA County



Vulnerability and the future of the energy system

The energy system across California is undergoing significant changes as the state enacts initiatives to combat climate change and our reliance on fossil fuels. The shift to renewable energy will likely be integrated with the expansion of battery storage systems, which are at risk of overheating and degradation during extreme heat events.[176] During a transition to renewable energy, the state will see more and more EVs on the road, leading to higher electricity demands. Meanwhile, extreme heat adaptation measures, like expanded use of air conditioning to protect human health and comfort, may also increase demand on an already-strained grid. It is essential that the effect of heat on supply and demand of electricity is a primary factor in planning decisions.

As fossil fuel plants phase out, the location of power production throughout the state continues to change. Fossil fuel plants are sensitive to even small fluxes in temperature; their energy output may decrease during extreme heat even though they are generally concentrated in areas that are not expected to experience dramatic increases in temperature, like coastal areas of LA County.[177]

Energy utility companies, the California Independent System Operator, the California Energy Commission, and the California Public Utility Commission must plan ahead in order to site, design, and/or retrofit energy infrastructure that can withstand projected increases in extreme heat. During the 2020 heat wave, renewable energy production actually exceeded planning targets. Renewable energy generation will continue to play an important role in our energy system, and it is important to ensure that the location and design of these systems consider the future role of climate change and prioritize resilience.

In addition to large-scale renewables that support the larger grid infrastructure, smaller distributed energy sources, like microgrids, can improve local energy resilience. Microgrids can increase energy reliability by balancing supply and demand locally and functioning apart from the larger grid, as needed. However, there are still many questions about how microgrids might interconnect at large scales and provide support when required, such as during a heat wave.[178]

generation-planning targets, resulting in a supply shortfall, rotating power outages, and emergency declarations.[169] In particular, natural gas–fueled resources operated less efficiently, while other power resources, like solar arrays, were impacted by cloud cover and smoke from wildfires occurring at the same

time. On August 14, 2020, alone, 491,600 residents across California experienced power outages that prevented the use of air conditioning, refrigeration, and other critical needs. The heat wave contributed to unhealthy levels of ozone pollution and coincided with a global pandemic and local wildfires, contributing to the dangers and difficulties of managing the impacts of the outage, which included heat-related illness and death.

Adapting energy infrastructure and the electric grid system to heat can be challenging. Strategies for preventing power-related impacts during extreme heat could include cooling solar energy generation equipment to mitigate efficiency losses or increasing temperature ratings for new and existing lines, increasing line tension, or placing lines underground to help reduce transmission losses associated with heat.[170] Beyond physical improvements and technological advances, policy efforts also play a key role. For example, government agencies may create plans and programs to bolster reliability and resilience of local energy supplies. As a starting point, the state's California Local Energy Assurance Plan offers strategies and targets for adaptation planning, energy demand reduction, and sustainability.

Housing for sensitive populations

Continuing care, residential care, and nursing facilities

Continuing care, residential care, and nursing facilities are maintained at cool temperatures year round to ensure a safe, healthy environment for occupants.

Housing and extreme heat

Good housing conditions are critical for preventing the health consequences of extreme heat. Older housing, particularly units constructed before the 1960s, features elements like thinner mass walls, single-pane windows, and limited insulation.[179] These elements lead to poor thermal performance—during hot weather, inside temperatures rise quickly. Homes in LA County have an average build year of 1959, with most older homes concentrated around downtown LA. In particular, homes in the cities of Maywood, Bell, South Gate, and Huntington Park have an average build year of 1941 or earlier.[180] Furthermore, about 30 percent of households across the Southern California Edison service area lack air conditioning; those households without air conditioning are concentrated in low-income communities.[181] Even when homes do have air conditioning, the high utility bills associated with increased use may stop households from running their systems to the degree necessary.

On high heat days, particle pollution and ozone often rise above the acceptable standard for healthy air quality, reaching "very unhealthy" levels on the Air Quality Index.[182] This outdoor pollution can infiltrate into indoor spaces, especially in buildings that lack air conditioning, because windows are more likely to be open for ventilation. Poor air quality can cause chest pain, shortness of breath, and more severe health consequences for those with preexisting respiratory conditions, such as asthma.

The California Department of Community Services and Development (CSD) works with local energy providers to offer weatherization services for low-income homeowners. Community partners perform energy audits, detecting and repairing any flaws in a household's insulation or air conditioning system. CSD also manages the Home Energy Assistance Program, which provides one-time financial assistance to households that spend a large portion of their income on utility bills.

To respond to these issues, the County operates a network of cooling centers to provide relief during extreme heat. Cooling centers are typically public recreation facilities, like community centers and libraries, that serve as an air-conditioned refuge for those without access to such spaces at home.

During periods of extreme heat, cooling systems can be strained, especially if they are undersized, impacting their ability to keep these spaces cool. Residents of these facilities may be more sensitive to extreme temperatures because of age or chronic medical conditions, making these facilities and their operations more vulnerable. Furthermore, in the case of a heat-related power outage, some vulnerable groups, like those reliant on power for medication or medical equipment, may be at increased risk without backup power or other adaptation measures.

Natural resources

Parks and open spaces

Parks and open spaces are essential assets to LA County, providing important recreation opportunities and serving as a cooling resource for individuals seeking relief from heat. They provide mental health benefits, opportunities for social cohesion, stormwater management, and a variety of other services.

These assets are highly sensitive to extreme heat because heat can harm vegetation and increase the likelihood of insect infestations.[171] Trees and plants that are exposed to extreme heat may require additional maintenance and watering to be kept alive. Even with additional maintenance, trees and plants may lose leaves or shrink, reducing the availability of their shade for park visitors. Stressed vegetation also creates conditions for wildfires. Extreme heat threatens biodiversity in parks by limiting or changing the range of species, the timing of their life cycles, and their habitat. Heat may also create unsafe working conditions for outdoor workers, like gardeners and park rangers.

Figure 29 shows parks and open spaces mapped with extreme heat exposure in LA county. Over 80% of parks and open spaces will be exposed to a moderate or high change in extreme heat by mid-century. The parks and open spaces in the northwest, including parts of the Angeles National Forest and parks in the City of Santa Clarita, City of Palmdale, and areas of the San Fernando Valley, are likely to face the greatest increases in heat.

Within the County, there are currently ten public parks located in areas that will face high change in extreme heat exposure. All of these parks are located in the San Fernando Valley and received a "poor" rating for park infrastructure condition in the Department of Parks and Recreation's *Park Needs Assessment*. Per that assessment, *park infrastructure* includes irrigation, vegetation, and landscaping, all of which could be impacted by increasing temperatures. Parks that are both located in high exposure areas and have poor infrastructure conditions may be especially susceptible to adverse impacts, diminishing their ability to act as a beneficial resource to surrounding communities.

Parks and open spaces will also be highly vulnerable to wildfire and drought. Extreme heat and drought stress trees, increasing tree mortality in parks and open spaces; dead trees can then become fuel for fires. Moreover, trees face increasing threats of pest outbreaks, which can be exacerbated by warming and drought. For example, the County-owned Whittier Narrows Recreation Area recently lost hundreds of trees to the combined hazards of drought, extreme heat, and an invasive beetle, and such events could

Parks and Open Space and Extreme Heat

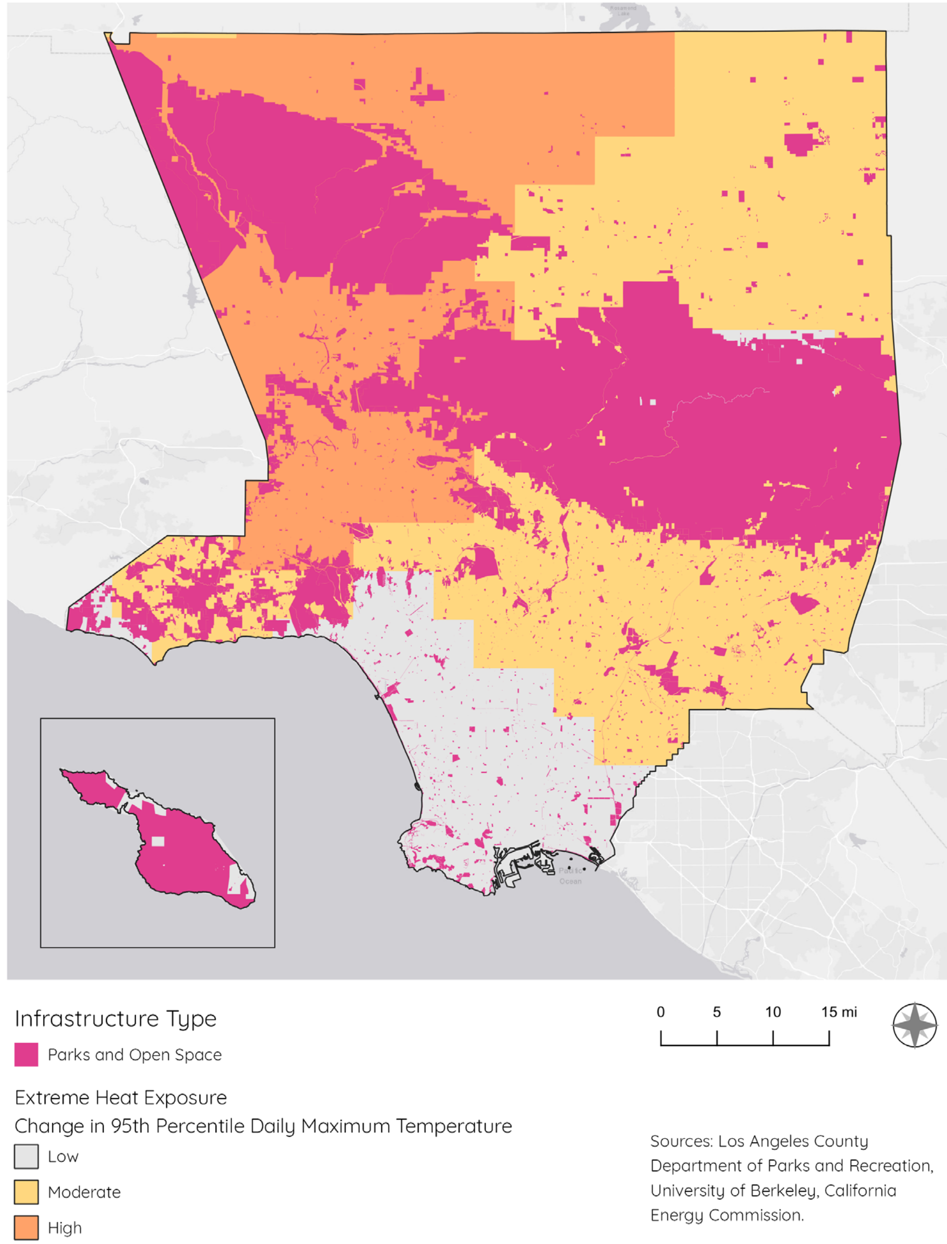


Figure 29: Map of parks and open spaces and extreme heat exposure in LA County

become more common. Managers of parks and open spaces are already mitigating some of these impacts by undertaking efforts to plant and protect native and drought-resistant landscaping.

Streams and rivers

Streams and rivers are threatened by poor water quality during extreme heat. Higher temperatures can increase nutrient concentrations and reduce dissolved oxygen, leading to a process called *eutrophication*. The change in water chemistry can result in harmful algal blooms and impact the animal and plant life in streams and rivers, affecting LA County's biodiversity.

Transportation

Airports

Extreme heat can impact airports in a variety of ways. High temperatures may cause concrete pavement to buckle and non-concrete pavement to deteriorate. Extreme heat and moisture can also decrease air density, reducing aircraft lift and necessitating longer runways or weight restrictions on planes. Aircrafts have different threshold temperatures past which they are not allowed to take off. Some commuter aircraft cannot safely take off at temperatures above 118°F.[172] By mid-century, areas of north LA County may experience temperatures as high as 118°F, meaning that airports in these areas may be particularly vulnerable. Finally, increases in extreme heat could affect cooling systems' ability to adequately cool airport facilities. Lack of sufficient air conditioning can impact workers' and travelers' experiences and put occupant health at risk.

Metro and Metrolink lines and stations

Extreme heat can cause infrastructure damage in the form of buckled rails and sagging catenary lines. This can create safety hazards or disrupt transit service. In recent heat waves, the Metrolink Antelope Valley line experienced major service delays because of repairs of "sun kinks," which occur when the track is warped from extreme temperatures, increasing the risk of derailment.[173] Metrolink and Metro systems rely heavily on electricity, so disruptions in electricity supply could affect their operations. Outages can create mobility concerns by disrupting elevator service at transit stations. Cooling systems in stations and equipment rooms may not be able to adequately cool during extreme heat events, which can cause such impacts as passenger discomfort, driver and passenger safety issues, and reduced ridership. These issues can affect many County residents' ability to get to work, health care facilities, or other critical destinations.

Water

Aqueducts and water distribution

Aqueducts and water distribution systems are essential in providing County residents with adequate water supply. Because LA County relies heavily on imported water, it is crucial to understand the effects of hazards on these systems. For instance, higher temperatures could affect water quality in aqueducts. Extreme heat has been associated with increased chlorophyll and turbidity and decreased dissolved oxygen in water supply, indicating deterioration in water quality and creating potential health hazards for County residents.[174]

Also, water flowing through aqueducts can evaporate into the surrounding air. Especially in hot, dry climates, aqueducts can lose a considerable amount of water per day through evaporation, reducing the water supply for County residents.[175]

Lakes and reservoirs

Surface water sources, like lakes and reservoirs, may be impacted by faster evaporation, growth of toxic algal blooms, and other heat-related changes in water quality. This can limit the use of these water sources and lead to an increased need for and cost of water treatment. These impacts can also disrupt the recreational uses of this infrastructure from fishing to swimming and impact the animal and plant life in these water bodies that are critical for biodiversity.

Water treatment plants

Water treatment plants will be highly vulnerable to extreme heat, primarily because of increased water demand and decreased operational capacity during extreme heat events. High temperatures degrade the plants' electrical infrastructure, decrease the water quality of influent water, and change the rate of engineered biological processes, making treatment more difficult and costly. Demand for water supplies will increase during heat events, because water is required for many types of cooling and other strategies to keep safe in extreme heat. Higher demand for water can stress water treatment plants and contribute to threatened water availability over time.

Wildfire

Introduction

Wildfire is a major threat to Los Angeles County, and it will continue to be a destructive force. In 2020, the Bobcat Fire ignited in the San Gabriel Mountains and foothill areas and burned more than 115,000 acres, becoming one of the largest fires on record in LA County to date. The Woolsey Fire of 2018 burned nearly 100,000 acres, destroyed more than 1,500 structures, caused three deaths, and resulted in an estimated $6 billion in losses.[183 184]

Infrastructure is sensitive not only to wildfire but also to wildfire smoke. Wildfire risks are likely to increase in the future. Many critical facilities are located in urbanized areas, where wildfire is unlikely to occur, but urban facilities may be affected by wildfire smoke and disruptions in the delivery of services (such as electricity) provided by facilities located in rural areas, directly in the path of wildfire. While wildfire poses major risks to the County, fire also plays an important role in many California ecosystems, and cultural burning is a component of traditional knowledge and land stewardship practices for many Native and Tribal communities.

Impacts of wildfire on physical infrastructure

The impacts of a major wildfire event can be widespread and severe. Wildfire affects physical infrastructure in a wide variety of ways, including, but not limited to

- direct damage and loss of trees, vegetation, and buildings and other structures, including homes;
- loss of power and damage to cell towers, which can disrupt communications during and after a wildfire event; and
- increased smoke, which can create health hazards, delay operations, and disrupt daycares, schools, workplaces, and other community facilities.

Key takeaways

LA County is already grappling with significant threats from wildfire. Few areas in the County are projected to have high change in exposure to wildfire; only parks, open space, streams, and rivers meet our criteria for the classification of highly vulnerable. However, regardless of exposure, many infrastructure types have high sensitivity to wildfire. This results in infrastructure types having moderate to high vulnerability to wildfire. Those infrastructure types that are highly vulnerable or moderately vulnerable with relatively high sensitivity are shown in Table 10.

Natural resource infrastructure is most vulnerable to projected change in wildfire. Wildfire can burn forests and other flora in parks and open spaces, making way for invasive plant species that can potentially worsens the effects of future wildfires, and destroying the habitat of local fauna. Streams can experience lowered water quality during and after wildfire events.

Communications, community and other facilities, energy, and water infrastructure are highly sensitive to wildfire, though they have relatively low exposure. Cell towers and electricity transmission lines can experience direct wildfire damage, leading to cellular

Table 10: Wildfire vulnerability by infrastructure type

Infrastructure Type		Exposure	Sensitivity	Vulnerability
Communications	Cell towers	L	H	M
Community and other facilities	Prisons and jails	L	H	M
Energy	Electricity transmission lines	L	H	M
Natural resources	Parks and open space	M	H	H
	Streams and rivers	M	H	H
Water	Lakes and reservoirs	L	H	M

and electricity outages for County residents. Water reservoirs can become contaminated or experience increased sedimentation during and after wildfire events, decreasing the efficiency of the water storage and supply system and potentially requiring additional water treatment. These impacts to infrastructure add to the other types of wildfire risk that County residents face, such as direct health and safety hazards caused by wildfire and smoke. Table 10 provides more detail.

Communications

Cell towers

For the LA County PVA, only government-owned cell towers reported by the U.S. Department of Homeland Security were assessed. Of these facilities, roughly one-third are located in areas of moderate change in wildfire exposure and 2 percent are in areas that will face high change.

Cell towers are particularly susceptible to damage from wildfire as has been observed in past events. In October 2017, 77 cell towers went down during the Sonoma County Complex Fires, and it took days to fully restore service.[185] Stakeholders often cite communications as a critical means to connect to resources, not only for daily communications but also for spreading the word about climate hazards and emergencies. Power outages from wildfire damage or Public Safety Power Shutoffs (PSPS) events can also impact cell towers and communication. The State Communications Division calculated more than 15 million blocked calls in California during wildfire and PSPS events between 2017 and 2019. Loss of dependable communication during a wildfire can

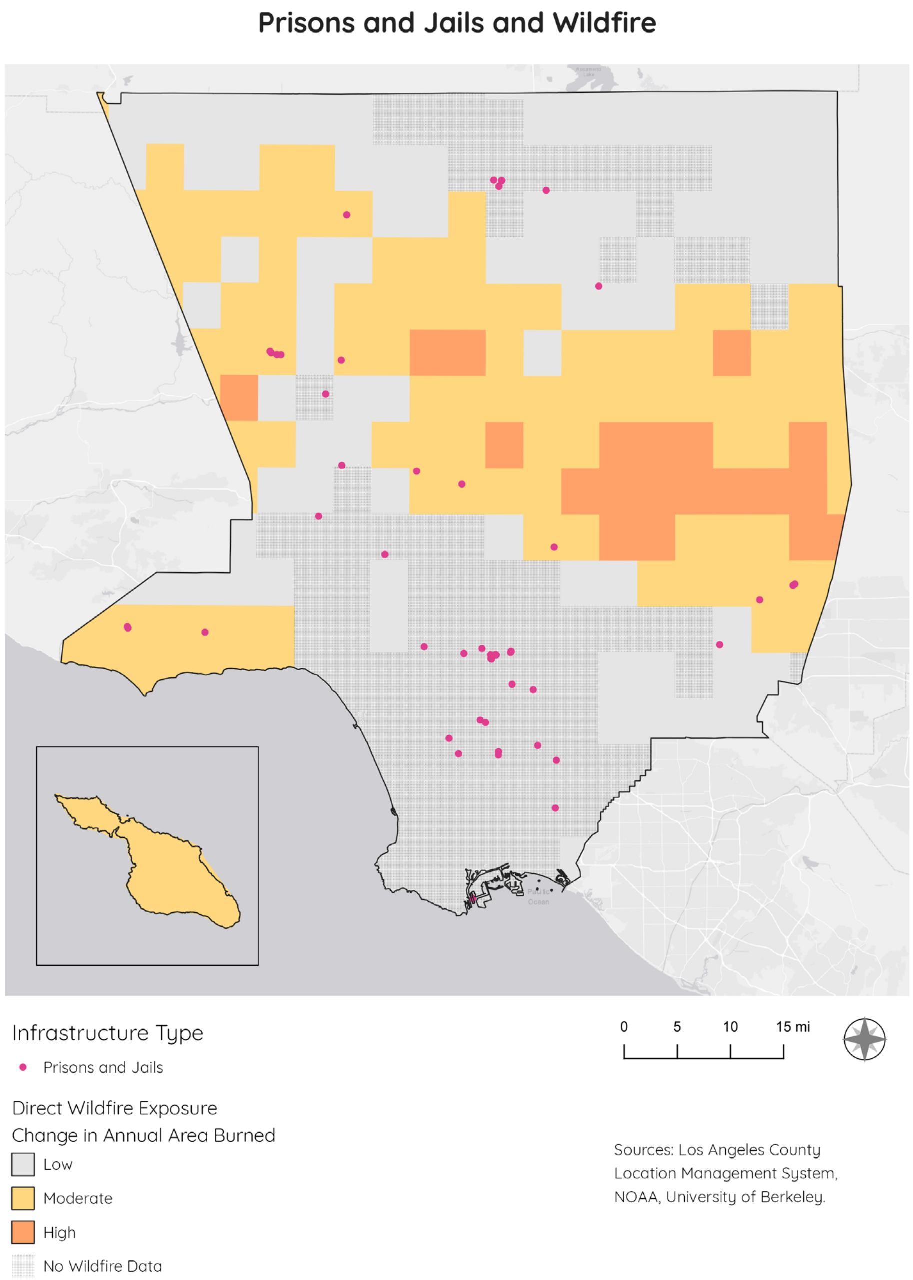


Figure 30: Map of prisons and jails and direct wildfire exposure in LA County

hinder evacuations and firefighting operations, resulting in a loss of lives. In 2018 alone, both the Hill Fire in Ventura County and the Woolsey Fire were responsible for about half a million impacted wireless customers, nearly 500 impacted cell sites, and more than 4 million blocked calls.[186]

Most cell sites nationwide depend on just a single source of power,[187] but the California Public Utilities Commission recently mandated cell carriers to have backup power for a minimum of 72 hours.[188] As an adaptive capacity measure, backup power can reduce the impact of wildfire on communications infrastructure.

Community and other facilities

Prisons and jails

More than one-quarter of all LA County prisons and jails are located in areas of moderate change in wildfire exposure, as shown in Figure 30. This includes the Los Angeles County Sheriff's Pitchess Detention Center and North County Correctional Facilities. The remaining facilities are dispersed throughout the County and are either jails or juvenile detention centers with shorter holding times. Areas with jails and prisons are projected to face wildfires that will burn an additional 0.1 to 9.6 hectares annually between the historical baseline period and mid-century. Wildfire can be destructive to the prison or jail campuses and structures. Furthermore, prisons and jails that are threatened by wildfire face complications in evacuating and relocating prison populations to other high-security locations. Nearby wildfires and poor air quality may also impact any outdoor operations or activities, like outdoor exercise, and the health of inmates and workers.

Housing and wildfire

The increasing frequency and severity of wildfires exacerbate existing housing supply and insecurity concerns. A 2020 report from the U.S. Forest Service found that more than 7 percent of housing—or about 300,000 units—are directly exposed to wildfire in Los Angeles County.[196] The California Department of Forestry and Fire Protection's (CAL FIRE's) strategy for preventing home destruction during a wildfire is two-pronged: (1) keep heat and flames away from buildings and (2) control the spread of burning embers.[197] In most cases, property damage is not caused by direct contact with flames, but rather by the spread of embers ahead of the fire.[198]

The homes most at risk are those built before the implementation of the 2008 update to the California Building Standards Code.[199] The update set new standards for homes in fire-prone regions of the state, requiring fire-resistant roofing, improved attic ventilation, tempered glass for exterior windows, and other related safeguards. When it comes to wildfires, a community is only as strong as its weakest link. Older homes vulnerable to ignition can spread the fire to adjacent homes that are up to code.

CAL FIRE produces Fire Hazard Severity Zone maps, assigning hazard scores based on such factors as vegetation, fire history, ember production, and climate. AB 3074 (2020) requires property owners within or adjacent to a "very high" fire hazard severity zone to maintain 100 feet of defensible space from each side of their structure.[200] Defensible space is a buffer between a structure and nearby landscaping or wildlands. This space slows the spread of a wildfire and provides a safe space for firefighters to defend a home. The 100-foot defensible space is broken up into three zones, each with its own landscaping and maintenance requirements. SB 190 (2019) requires the State Fire Marshal to work with local and state agencies, insurance companies, and the environmental community to develop a defensible space public education program to increase awareness of these requirements.[201]

To help communities prepare for fire, AB 38 (2019) mandates the disclosure of fire hazard severity during a property sale.[202] Additionally, the bill requires the State Fire Marshal to develop and circulate a list of low-cost building retrofits that reduce fire damage risk for homeowners in hazard zones. The 2020-2021 state budget allocates $100 million for the California Governor's Office of Emergency Services and CAL FIRE for a new home-hardening pilot program to help fund home retrofits for vulnerable households.[203] The financial assistance bridges the cost gap for households on a limited income that would be unable to afford such retrofits otherwise.

Many California Department of Corrections and Rehabilitation facilities have precautions and adaptation strategies in place for current and projected wildfires. These include on-site fire departments, wildfire mitigation plans, PSPS protocols, and backup generators.[189]

Energy

Electricity transmission lines

Wildfire can pose a serious threat to a variety of energy assets, resulting in power outages and creating safety hazards. Energy infrastructure is sensitive because wildfire can burn and destroy poles and lines, especially smaller lines that generally have wooden poles. Heat, smoke, and particulate matter may affect a line's transmission capacity in multiple ways, including accumulation of soot in insulators that causes leakage currents; ionized air in smoke that can cause arcing, resulting in a line outage; and by-products of firefighting, such as fire retardant, that can damage lines. Although these sensitivities can result in electricity outages, they are more likely to increase the cost of electrical maintenance and reduce efficiency in transmission lines,[190] which are also significant threats.

It is possible that wildfire impacts to transmission lines and other energy infrastructure could disrupt linkages to imported power from other states and areas of California. For example, the 2019 Saddleridge Fire intersected with three major transmission corridors, reducing imported energy supply by 75 percent.[191] Although the wildfire directly damaged only a small portion of infrastructure, the impacts were large and widespread; had there been high energy demand, rolling blackouts would have been required. Speaking before the Senate Committee on Environment and Public Works, City of Los Angeles Mayor Garcetti used this example to underscore the importance of local power generation as a form of adaptive capacity.[192]

To preempt any damage to energy infrastructure, utilities may shut off power to reduce wildfire risk and minimize the role that energy infrastructure could play in sparking a wildfire. These events, known as PSPS, can especially impact communities that are dependent on power for critical needs, including people who rely on electrically powered medical equipment. Because wildfire exposure is projected to increase by mid-century, PSPS occurrence will likely increase as well. To protect against power outages, distributed energy generation and energy storage can act as adaptation measures.

Natural resources

Parks and open spaces

Parks and open spaces, particularly those in northern LA County, will face high vulnerability to wildfire. For example, natural areas, like the Angeles National Forest in the San Gabriel Mountains, will become more exposed to wildfire by mid-century, and the area burned within the forest may increase by nearly 50 percent. Malibu and the Santa Monica Mountains—coastal areas with canyons and wildland—are also expected to have higher exposure to wildfire in the future. With more frequent wildfires occurring in the same areas over time, native vegetation may not have sufficient time to recover. This could lead to the spread of invasive weeds and other non-native, highly flammable vegetation, which could fuel further wildfires and increase the wildfire risk in nearby communities.

Wildfires can impair the social and ecological functions of forests and other natural spaces. For example, a burned trail may provide less healthy habitat for local fauna and may attract fewer visitors to a park, leading to a drop in tourist dollars for nearby businesses.

As will be discussed later in the section on drought, parks and open spaces are also highly vulnerable to drought. Both extreme heat and drought stress trees, increasing tree mortality in parks and open spaces and creating more potential fuel for fires. Moreover, warming and drought can exacerbate increased threats of pest outbreaks on trees. For example, the County-managed Whittier Narrows Recreation Area recently lost hundreds of trees to the combined hazards of drought, extreme heat, and an invasive beetle, and such events could become more common. These compounding risks to trees in LA County can lead to increased wildfire risk without proper care.

Streams and rivers

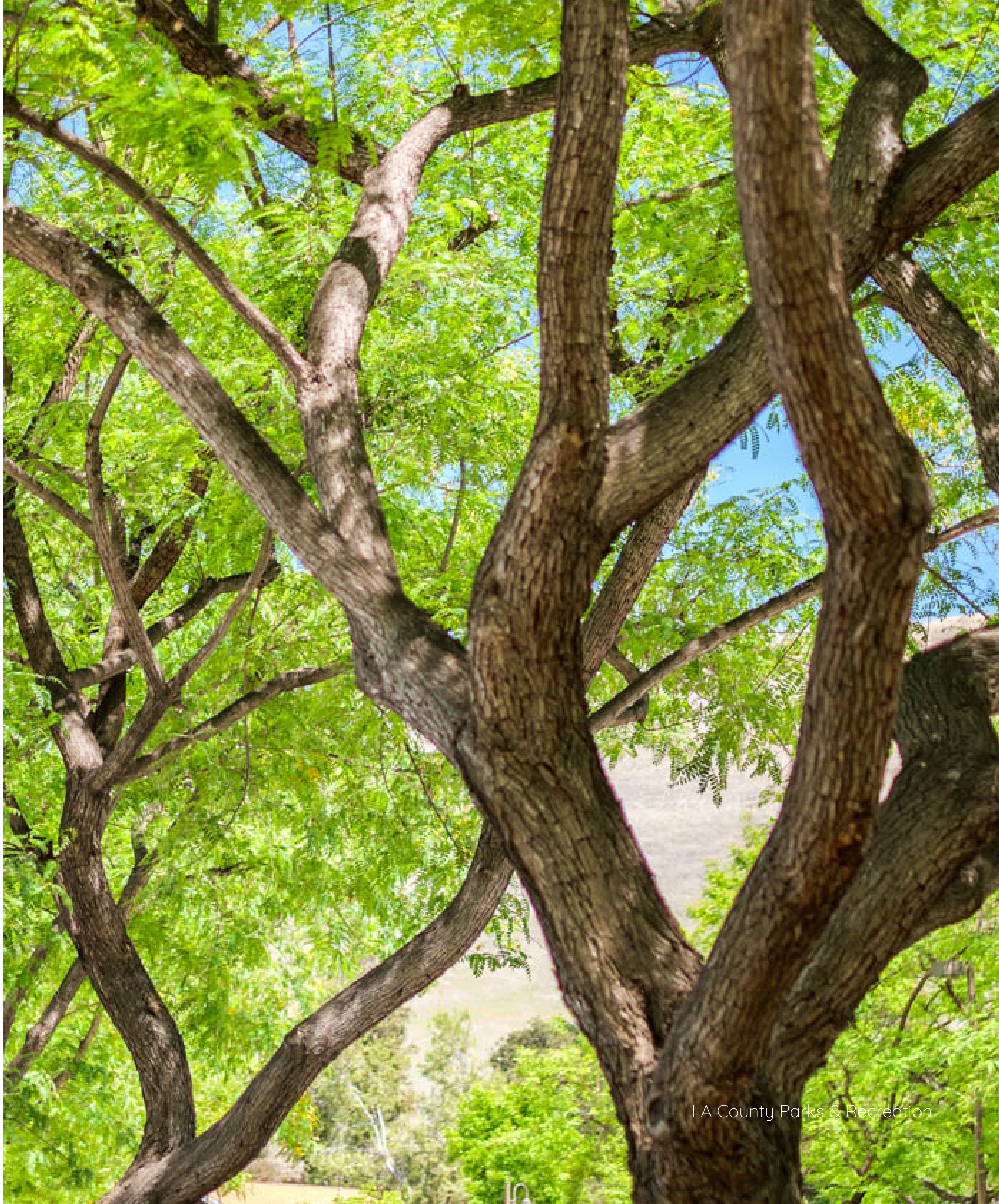
Wildfire may reduce water quality in streams and rivers because of soot, erosion, and sedimentation from debris.[193, 194] Ash flows and toxic chemicals, such as fire suppressants, can contaminate water bodies during or after wildfire events. Poor water quality can impact the wildlife and biodiversity in and around streams and rivers, such as fish populations.

Physical vulnerability by climate hazard - wildfire

Water

Lakes and reservoirs

Like in streams and rivers, water quality in lakes and reservoirs can be impacted by wildfire. Because of the potential for dangerous water contamination from wildfires, downstream water treatment facilities may need to use additional treatment methods to adequately clean the water. Several large bodies of water, including Pyramid Lake, Castaic Lake, Bouquet Canyon Reservoir, Morris Reservoir, and San Gabriel Reservoir, are located in areas with moderate wildfire exposure. Cogswell Reservoir, which sits in the San Gabriel Mountains in the Angeles National Forest, is one of the largest bodies of water located in a high wildfire exposure area. The reservoir is predominantly used for flood control, but it also recharges groundwater and maintains downstream riverine flows. In 2020, the Bobcat fire destroyed much of the vegetation in the surrounding catchment, which led to excessive sediment buildup in that reservoir and in the nearby San Gabriel Reservoir. To avoid additional consequences, such as losing the ability to adequately control floods and conserve water, the Los Angeles County Department of Public Works is currently taking on a multiyear sediment removal project.[195]



LA County Parks & Recreation

Inland flooding and extreme precipitation

Introduction

In the PVA, we look at exposure to flooding and extreme precipitation together, as they are closely related. Spatial data sets and future projections for both hazards have limitations. In the case of flooding, the FEMA Flood Maps—the source of spatial exposure information—do not account for future changes in climate and are based on historical understanding of flood risk. Data on extreme precipitation are based on average precipitation volumes but do not capture the range of extreme precipitation events that define climate change's impact on rainfall. For these reasons, inland flooding is used as a proxy to understand exposure to both inland flooding and extreme precipitation. However, it is acknowledged that both data sets have gaps and should be investigated further to better understand LA County's flood vulnerability. It is also important to understand that inland flooding and extreme precipitation can and do occur independently and can have discrete impacts on people and infrastructure.

Impacts of inland flooding and extreme precipitation on physical infrastructure

Inland flooding can have severe impacts on infrastructure. Many facility types can be damaged by inundation and erosion. Inland flooding and extreme precipitation affect infrastructure in a wide variety of ways, including but not limited to

- damage to buildings, structures, and pavement due to inundation and erosion;
- disrupted access to community or medical facilities and other infrastructure; and
- water pollution because of increased urban runoff and overflow wastewater released into beaches, swimming areas, streams, rivers, lakes, and reservoirs.

Key takeaways

As stated in the Climate Hazards section, FEMA's Flood Maps do not take into account climate projections and as a result do not illustrate the full extent of flooding potential, but rather help highlight areas where flooding is most likely to occur. The PVA did not identify any infrastructure types that are highly vulnerable to inland flooding. However, several types of infrastructure will face moderate vulnerability to inland flooding and have relatively high sensitivity, shown in Table 11.

Several types of energy, medical facilities, transportation, and water systems infrastructure were found to have low to moderate exposure but high sensitivity to inland flooding. Inland flooding can cause equipment damage to electricity generation and distribution systems, impair hospital facilities and equipment, erode road and bridge infrastructure, and overwhelm stormwater systems

Table 11: Inland flooding vulnerability by infrastructure type

Infrastructure Type		Exposure	Sensitivity	Vulnerability
Energy	Petroleum terminals	L	H	M
	Power plants	L	H	M
	Substations	L	H	M
Medical facilities	Hospitals	L	H	M
Transportation	Bridges	L	H	M
	Metro lines and stations	L	H	M
	Metrolink lines and stations	L	H	M
	Tunnels	L	H	M
Water systems	Dams and debris basins	L	H	M
	Storm drain system	L	H	M
	Wastewater treatment and reclamation facilities	L	H	M

and wastewater facilities. According to Flood Factor, a property-level flood risk tool developed by First Street Foundation, about 19 percent of properties in the County are considered at risk of a 0.2-percent annual chance flood. Per the tool, this number is projected to increase up to 19.6 percent by mid-century.[204] These direct impacts to infrastructure affect County residents in the form of power outages or transportation delays and disruption. Inland flooding can also inhibit general mobility and access to community or medical facilities, increasing risks to County residents. Table 11 provides more detail.

Energy

Petroleum terminals

Petroleum terminals are susceptible to inland flooding primarily because flooding can damage equipment and impact operations, leading to downstream impacts on fuel supply and supply chains (e.g., rail access will be shut down when tracks are flooded). In addition to direct impacts to the terminals, flooding of these facilities could lead to spillage of fuel and contamination of waterways, impacting nearby communities and wildlife.

Power plants

During inland flooding events, power plants can be put out of service because of equipment or structural damage or loss of a fuel or water that can impair operation. Periods of heavy rainfall and flooding can also transport debris into power plants, potentially causing additional damage. An inoperable power plant can lead to cascading impacts to the wider energy system. There are currently 12 power plants located in 1-percent annual chance flood hazard areas. Three of the 12 are solar electricity generation facilities in Palmdale and another three are fossil fuel and biomass facilities in Long Beach. The remaining six power plants are dispersed throughout the County, mostly in the north.

Substations

Substations are particularly sensitive to flooding because the submersion of electrical equipment can create electrocution hazards and threaten operations or lead to an emergency shutdown. Although substations are designed to certain flooding standards, if those design criteria are exceeded by a flooding event, damage could be extensive. It can disrupt grid system reliability, such as through loss of HVAC systems, loss of AC (alternating current) station services, and disruptions to DC (direct current) batteries and communication disruptions.[205]

Medical facilities

Hospitals

Inland flooding can damage hospitals, particularly electrical and HVAC equipment, and critical life-saving medical equipment and supplies. A key concern for hospitals during flooding events is access for emergency vehicles and patients. Compounding the impacts, flooding events can also create health and safety hazards, such as increased road collisions, that may lead to increased demand for medical services.

If flooding impacts a hospital facility directly, making the space unsafe to inhabit, evacuations of staff and patients can be challenging to manage and execute in a safe, efficient manner. Furthermore, it can be difficult to locate additional hospital beds to accept evacuated patients. As shown in Figure 31, although no hospitals overlap with high-hazard flood areas, seven hospitals reside in areas with a 0.2-percent annual chance of flood. Of these seven hospitals and medical centers, five are in West Covina and Covina. The remaining two that are in 0.2-percent annual flood chance areas are in the City of Los Angeles.

Historically, U.S. hospitals were often located near water so they could access water for operations and discharge. Many of these hospitals still exist and are still in flood-prone areas. Building maintenance and operations, such as roof repair, mold elimination, and other updates, can protect against damage from extreme precipitation and flood events. Political incentives and guidance can also be important, especially because flood proofing regulations are often passed locally. Adaptation strategies are vital for acute care facilities, which should remain operational despite damaged energy and water infrastructure so they can provide uninterrupted services.[206] Placing key electrical systems and critical patient care functions above the first floor can ensure that direct damage and disruptions from flood are minimized.[207]

Transportation

Bridges

Bridges are particularly sensitive to extreme precipitation and flooding events because water can cause erosion damage to bridge approaches or where the roadway transitions to the bridge deck. Past events have shown the dangers of flooding for bridges, such as the LA River Flood of 1938 that completely destroyed the Lankershim bridge, and extreme storms in 2015 that destroyed the Tex Wash bridge (located outside of LA County). These bridge failures led to several injuries and road closures that forced drivers to take significant detours. Erosion from the extreme precipitation and flash floods damaged the infrastructure of the bridges and the ground supporting them.[208] Bridges with supports in rivers or streams may also face increased erosion because of increased velocity of water flow. Flooding events can also bring debris and wreckage, which can collect on bridge decks and cause damage.

Hospitals and Inland Flooding

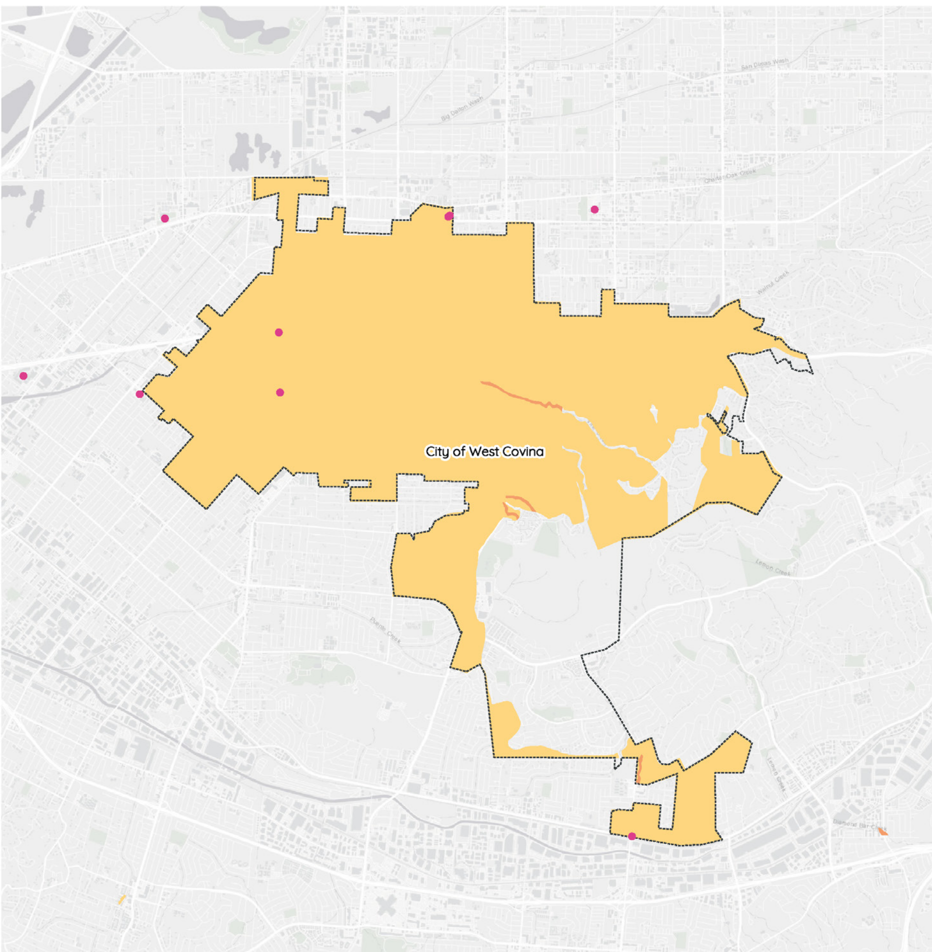


Figure 31: Map of hospitals and inland flood zone designations in LA County

Infrastructure Type
Hospitals

Inland Flooding
FEMA Flood Zone Designations
0.2% Annual Chance Flood
1.0% Annual Chance Flood

0 0.5 1 1.5 mi

Sources: Federal Emergency Management Agency, Los Angeles County Location Management System.

Metro and Metrolink lines and stations

Transportation infrastructure is important not only for daily travel but also to help people access resources or evacuate during a climate emergency. Station structures can be impacted directly by flood damage, limiting access to Metro and Metrolink services. Beyond stations, the larger network of infrastructure can also be at risk. Impacts from flooding can range from weakened ties on railway tracks to inundated electrical equipment that can cause rail sensor failure to flooded subway lines if flooding levels exceed available pump capacity. Erosion of railway support systems, like ballasts, can threaten track stability and impact operations.

Figure 32 shows Metro and Metrolink lines and stations and flood zone designations. Much of the railway beyond Newhall Metrolink Station in Santa Clarita follows along high flood hazard areas, crossing and overlapping flood-prone designated land. Taylor Junction and Mission Junction, just east of Union Station in downtown Los Angeles, are classified as high flood hazard areas. Although few Metro stations and lines overlap directly with high flood hazard areas, more than 10 percent of each are within moderate hazard designations. This is mostly because of the low-lying flood-prone areas across downtown Los Angeles.

Metro's *2019 Climate Action and Adaptation Plan* outlines several adaptation categories for its system. These include hardening and protecting infrastructure, relocating infrastructure, adjusting operations, and changing behaviors. Specific flood adaptation actions include, but are not limited to, adding erosion and mudslide control measures, updating and improving stormwater management capture and reuse, increasing pump capacity to clear flood waters from underneath tracks, and elevating assets in high hazard areas. Expanding monitoring, response, and data sharing will also support preparedness and response to flooding events.[209] Metrolink recently received investment that paved the way for the Southern California Optimized Rail Expansion (SCORE) Program. As part of SCORE, Metrolink and Caltrans will conduct a climate vulnerability assessment, which will, among other things, inform and identify climate-adaptation strategies for their transit systems. The program includes assessment for both inland flooding and coastal flooding.[210]

Metro and Metrolink and Inland Flooding

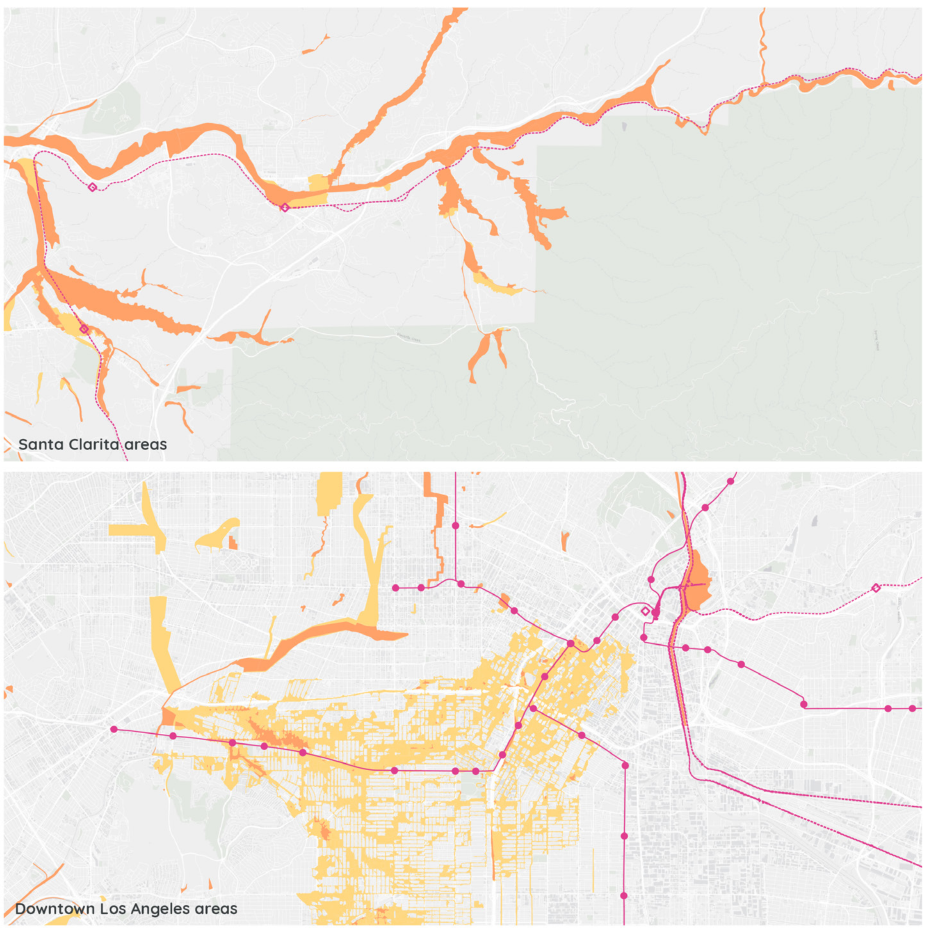


Figure 32: Map of Metro and Metrolink lines and stations and inland flooding designations in LA County

Infrastructure Type
- Metrolink Lines
- Metrolink Stations
- Metro Lines
- Metro Stations

Inland Flooding
FEMA Flood Zone Designations
- 0.2% Annual Chance Flood
- 1.0% Annual Chance Flood

0 1.5 3 mi

Sources: LA Metro, Metrolink, Federal Emergency Management Agency.

Tunnels

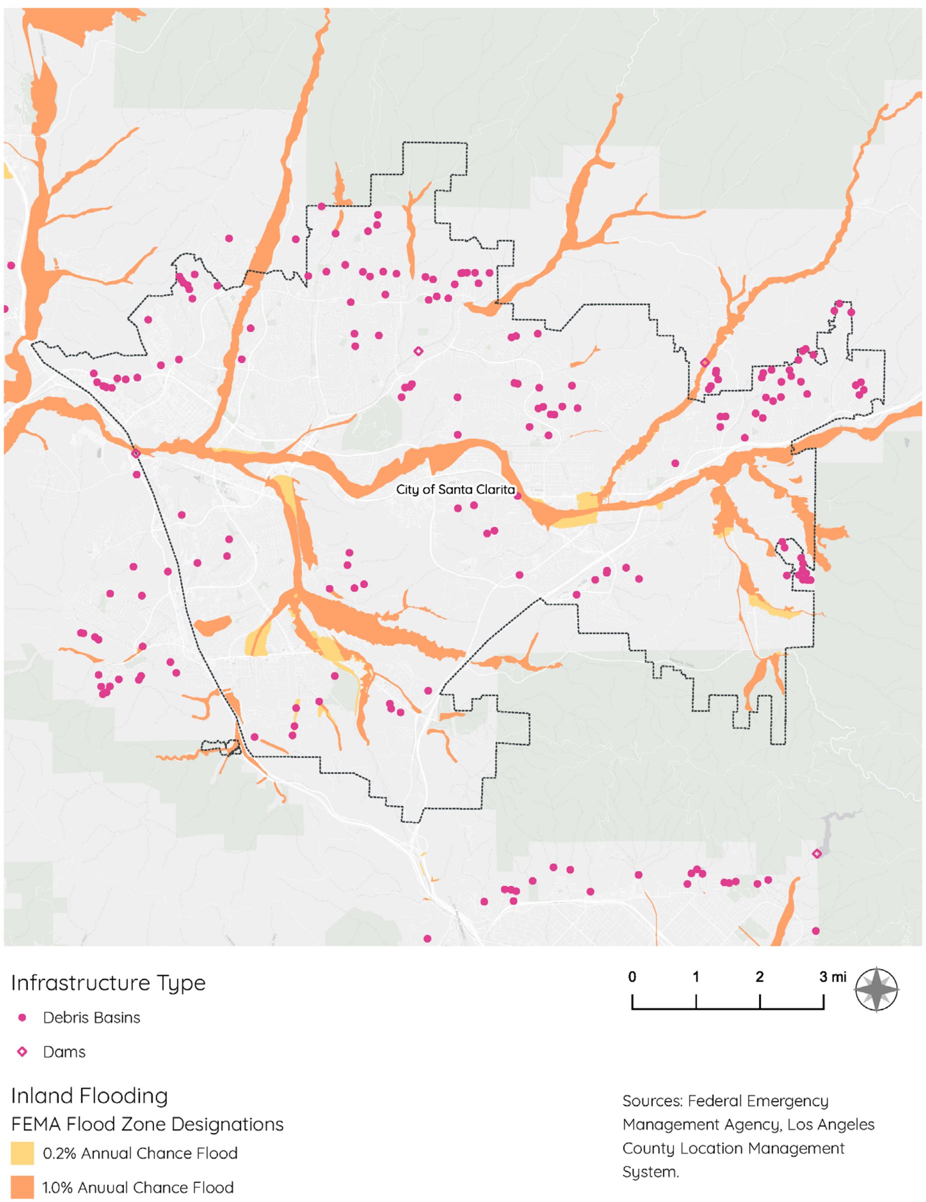
As underground infrastructure, tunnels are especially prone to flooding, which can render them inaccessible and lead to closed roads in the surrounding area. In 2011 and again in 2017, heavy rainfall, combined with debris-clogged storm drains, caused the LAX Sepulveda Boulevard tunnel to flood, increasing traffic and delays at and around the airport.[211] Additionally, hydraulic pressure on tunnel walls may increase as water tables rise, which could lead to tunnel damage or collapse.

Water

Dams and debris basins

Inundated dams may experience more spillway and overtopping events, which occur when dammed water flows over a dam's main wall. When floods result in overtopping, the face of the dam can erode, making the dam more vulnerable to failure. Flooding may also contribute to changing erosion patterns that could increase sedimentation behind dams, reducing their overall storage capacities. Debris basins are designed

Dams and Debris Basins and Inland Flooding



Sources: Federal Emergency Management Agency, Los Angeles County Location Management System.

Figure 33: Map of dams and debris basins and inland flooding designations in LA County

to protect communities against flooding by helping settle out sediment and debris and allowing clarified water to flow through. However, debris basins typically have a capacity of 20,000–70,000 cubic yards, which could be exceeded during extreme precipitation and flooding events, leading to reduced effectiveness.[212]

The debris basins scattered throughout the County lie in areas where hillsides and mountainsides meet more urbanized communities and infrastructure. These areas include the northern and eastern border of the Santa Monica Mountains, the southern portion of the San Gabriel Mountains and Angeles National Forest, and the hillsides north of Santa Clarita (as shown specifically in Figure 33). Communities with multiple debris basins next to flood hazard areas include Santa Clarita and the adjacent unincorporated Stevenson Ranch and Lakeview Terrace, as well as the adjacent Kagel/Lopez Canyons. In the event that multiple debris basins in these areas exceed their capacities or otherwise fail, nearby communities may be at higher risk of flooding.

Dams and debris basins provide essential community-level adaptive capacity through flood control, post-wildfire debris flow mitigation, and water storage. Strengthening storage solutions, updating design requirements, and upgrading aging infrastructure of dams could enhance flexibility and response to more extreme and variable precipitation and flooding events. Debris basins could be retrofitted with improved controls around outflows, especially if they discharge to spreading grounds.[213] Controls would enable debris basins to temporarily store stormwater and release it when appropriate, contributing to overall better management of stormwater.

Roads and post-fire debris flow

When intense rain events take place after wildfires, landslides and mudslides are much more likely. These post-wildfire debris flows occur because of fire-induced changes in soil chemistry and vegetation, which ultimately impact absorption and flow of water. The additional runoff can carry debris, inundate stormwater infrastructure, and/or block or damage roadways. The U.S. Geological Survey mapped the likelihood of post-wildfire debris flow after fire events, estimating that the Getty fire in 2019 contributed to the development of four sediment retention basins. Each of these sediment retention basins have more than a 60-percent probability of debris flow in a design storm—a simulated flood event—with a peak 15-minute rainfall intensity of 24 millimeters per hour.[214] In this scenario, workers were sent to these high-risk areas shortly after the fire to install nets and barriers on the hillside, which allows water to flow through as large boulders and debris are kept from moving downhill toward homes.[215] Without dedicated planning and mitigation action, more extreme wildfire and precipitation events can lead to significant damage.

A statewide assessment of roadway vulnerability concluded that, in a ten-year storm scenario, 60 road miles are currently vulnerable to post-wildfire debris flow, increasing to 444 road miles in a 1-percent annual chance storm. Under the more severe high-emissions scenario (RCP 8.5), a 10-percent annual chance storm would render 254 road miles vulnerable and, in a 1-percent annual chance storm, that vulnerable area increases to 1,104 road miles. Per the assessment, Los Angeles County has clusters of high and extremely high debris flow risk for a 10-percent annual chance flood event in the unincorporated Santa Monica Mountains and Angeles National Forest areas. Researchers working on the assessment recommend a phased approach to addressing this vulnerability, noting the immense scale of the road network in California, but encouraged extending transportation services and committed "to reassessing conditions, technologies, designs, and operations for a future defined by uncertainty."[216]

Storm drain system

When the design capacity of storm drain systems is exceeded by a major storm, or when storm drain infrastructure is unable to function because of debris blockage, these systems can contribute to localized flooding. This can have cascading effects on other infrastructure systems. For example, increases in localized flooding contributes to erosion of roadways and bridges. Because extreme precipitation is anticipated to become more variable and more intense, storm drain systems could face high volumes of stormwater through mid-century.

Wastewater treatment and reclamation facilities

During periods of extreme precipitation, significant leakage of stormwater can enter sanitary sewer systems through maintenance hole covers and cracked pipes which can cause wastewater treatment plant flows to increase and potentially overwhelm systems and lead to sewage spills. Additionally, if the facilities themselves are flooded, the treatment equipment could malfunction or be forced to shut down, impacting the whole water system. There are currently four wastewater treatment and reclamation facilities located in 1-percent annual chance flood zones in LA County. They are the Long Beach Main Pumping Station Plant and Marina #1 Pumping Plant in Long Beach, Suez Water Reclamation in Burbank, and Lancaster Water Reclamation Plant in Lancaster. The State Water Board has begun to encourage and support wastewater treatment plant operators to develop their own climate vulnerability assessments and mitigation plans. These detailed assessments will provide insights into specific vulnerabilities of these facilities and help to inform action to improve their resilience.

Coastal flooding

Introduction

Sea-level rise exacerbates natural hazards that already take place along the coastline, such as high tides, coastal storms, and erosion processes. Sea-level rise can also raise water tables near the coast, increasing severity of flooding and affecting below-ground infrastructure and resources, resulting in saltwater intrusion into coastal aquifers. Southern California has already seen a sea-level rise of 0.8 inches per decade since the early 20th century.[217]

Impacts of coastal flooding on physical infrastructure

For the CVA, coastal flooding is defined as sea-level rise combined with a 1-percent annual flood event. Some impacts from coastal flooding will be more gradual than inland flooding, due to sea-level rise. However, coastal flooding may also lead to magnified impacts during storms. Coastal flooding will also have additional impacts as a result of saltwater corrosion and intrusion into coastal fresh groundwater resources. Coastal flooding affects infrastructure in a wide variety of ways, including but not limited to

- saltwater corrosion and wave scouring of sensitive equipment such as electrical equipment;
- saltwater intrusion into groundwater resources, especially in areas with low-lying groundwater tables; and
- increased sedimentation into coastal water bodies or shipping channels in ports.

Key takeaways

Coastal flooding primarily affects areas directly along the coast. Therefore, overall infrastructure exposure in LA County is relatively low. However, most infrastructure types do face high sensitivity to coastal flooding due to the severity of impacts from sea-level rise and storm surges. Infrastructure types that are most vulnerable to coastal flooding are shown in Table 12. While the PVA evaluates change in exposure from the historical baseline to mid-century, coastal flooding is a climate hazard that will lead to much greater exposure by end-of-century. By mid-century, coastal flooding under a 1-percent annual chance storm will cover approximately 7 square miles of coastline and reach a maximum flood depth of 7.9 feet. By late-century, this same scenario will flood approximately 17 square miles of coastline and reach depths of up to 8.3 feet. This indicates a nearly 2.5-times increase in flooded area from mid- to late-century in LA County.

Energy infrastructure along the coast can become corroded and damaged because of coastal flooding. Beaches may experience increased erosion and land loss. Ports rely on energy infrastructure, channels, and piers that can be damaged as a result of coastal inundation. County businesses and residents may experience these impacts through disruptions in electrical service, impaired access to recreational beach areas, negative economic impacts from supply chain interruptions in the energy and shipping industries, and decreased recreational revenue from beaches.

Energy

Oil refineries and petroleum terminals

There is a significant amount of fossil fuel infrastructure bordering the coastline in LA County and at risk to coastal flooding. While oil refineries and petroleum terminals are particularly sensitive to coastal flooding, existing public policies like Senate Bill 100 require the decarbonization of the energy sector and thus energy infrastructure in California which will begin to make this

Table 12: Coastal flooding vulnerability by infrastructure type

Infrastructure Type		Exposure	Sensitivity	Vulnerability
Energy	Oil refineries	L	H	M
	Petroleum terminals	L	H	M
Natural resources	Beaches	L	H	M
Transportation	Ports	M	H	H

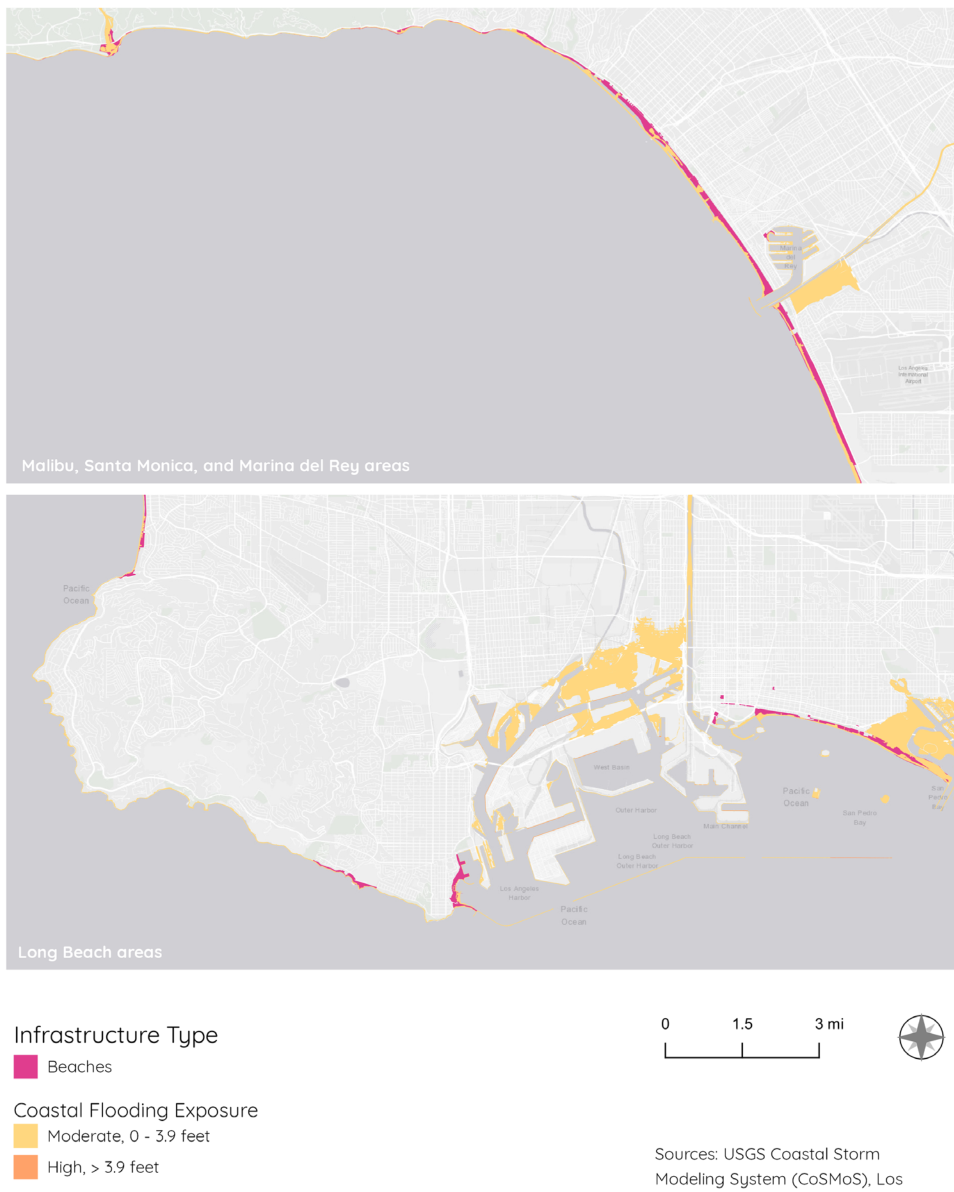
infrastructure obsolete. About 15 percent of petroleum terminals and 11 percent of oil refineries in LA County will face moderate change in coastal flooding exposure—or up to 4 feet of inundation by mid-century. Coastal flooding can cause scour, saltwater corrosion, and damage from debris mobilized during flooding events. Damaged infrastructure can include onsite equipment, like piping, instrumentation, tanks, and control rooms, that can impact operations. Should refineries go out of service because of coastal flooding, it can curtail fuel production and have downstream impacts on infrastructure that require oil to operate. Furthermore, closure of waterways because of wreckage, debris, or petroleum leaks can prevent access to distribution terminals for imports and movement to delivery terminals, halting the supply chain. LA County is still in the process of transitioning from reliance on oil and petroleum, and impacts to this infrastructure can be costly, time-intensive to repair, and disruptive to the local economy.

Natural resources

Beaches

Beaches comprise much of LA County's coastline and play an important role as natural resources and economic and cultural resources. With increased sea-level rise and coastal flooding, beaches may experience more coastal erosion, which can result in land loss and shoreline migration. In Southern California, 3.3 to 6.6 feet of sea-level rise by end-of-century could result in beach loss of 85–135 feet (67 percent of South Coast beaches) and 62–95 feet of bluff retreat.[218] The entire

Exposure to Coastal Flooding



Sources: USGS Coastal Storm Modeling System (CoSMoS), Los Angeles County Department of Parks and Recreation.

Figure 34: Map of beaches and coastal flooding exposure in LA County

coastline of LA County is expected to experience some impact from coastal flooding, including 46 beaches (or 79% of all beaches) identified in the analysis. Beaches are categorized as low exposure because projected mid-century coastal flooding is shown to impact only 23 percent of the total area of beaches. This is partly since some beaches can extend hundreds of feet inland from the present water line.

LA County beaches are popular recreational destinations, and loss of beaches can result in significant economic consequences. For example, the Venice Beach Boardwalk annually sees about 10 million visitors and produces financial benefits from recreation, spending, and tax revenue of about $1 billion. Sea-level rise is expected to decrease benefits at Venice Beach by $89 million in 2100 compared with a 2000 baseline.[219] As shown in Figure 34, much of the coast from Santa Monica to Marina del Rey, as well as parts of Long Beach, are expected to see coastal flooding by mid-century.

Adapting coastal beaches to sea-level rise and storm inundation requires political support and direction, management plans, and granular assessments. The City of Santa Monica's *Climate Action and Adaptation Plan* suggests prioritizing "soft" adaptation strategies over structural ones where possible. Beach nourishment, dune restoration, living shorelines, and managed retreat are some of the listed examples of soft strategies.[220] Improving the monitoring of and projections regarding sea-level rise and tides can also help planning efforts become more effective.

Transportation

Ports

Port infrastructure is, by nature, located along the coastline and serves as an important connection to other areas for goods movement. LA County is a critical component of the global goods movement and is home to the Ports of Los Angeles and Long Beach (Figure 35). Together, these ports are the largest container complex by volume in the United States and are the ninth busiest in the world.[221] The organizations that oversee these ports have each recently developed and published sea-level rise assessments and resilience plans: Port of Los Angeles Sea Level Rise Adaptation Study and Port of Long Beach: Climate Adaptation and Coastal Resiliency Plan (CRP). Across both assessments, potential impacts from coastal flooding include permanent inundation and chronic flooding; damage to port buildings, shipping channels, and piers; overwhelmed stormwater drainage systems; damage and corrosion of electrical systems; and input of debris and sediment into shipping channels, disrupting operations.

The Port of Los Angeles found that its most sensitive assets included various cargo wharves, electrical systems, community and commercial assets, and natural habitats. The port's cargo wharves were found to be vulnerable to temporary flooding in 12–37 inch sea-level rise scenarios that could delay or prevent operations. This would have social impacts, because cargo activities provide one in nine jobs in the area. The Port of Long Beach found that the most sensitive components included electrical and stormwater systems on the pier, rail, roads, and most utility components. It

Coastal highways and coastal flooding

Sea-level rise and storm surges can contribute to coastal flooding on highways, particularly at waterway crossings or low-lying areas of highway along the coast. Flooding on highways can lead to road closures. Flooding can also damage highways by eroding paved surfaces and causing pavement or embankment failure. Highways were evaluated as part of the PVA, but results show they will face low vulnerability to coastal flooding as an entire system, mostly because the highway system in LA County is widespread and only a small percentage of it is near the coast. However, if we focus in on those highways located near the coast, highways will face much higher exposure and risk.

Coastal flooding concentrated in critical areas may affect segments of the highway system, leading to downstream impacts like traffic build-up and rerouting of trips. LA County's highway network is extensive and has built-in redundancy, but, in some instances, a full or partial highway closure can cause serious traffic issues and make some areas hard to access. The Sea Level Rise Vulnerability Study for the City of Los Angeles, prepared by the USC Sea Grant Program, found that coastal flooding impacts on the Pacific Coast Highway (PCH) could result in frequent closures or even structural failure, and that it is uncertain if the highway could continue to function even if partially disabled.[222] Any disruption to the PCH could have severe consequences because the PCH serves as an important transportation connection in the region.

was found that these components, such as conveyors, communications, security systems, lighting, and shore-to-ship power systems, could suffer permanent damage from even a brief period of flooding. These impacts not only damage infrastructure but also lead to strained materials and goods movement and contribute to economic difficulties across LA County.

In these plans, both ports are initiating their adaptation planning and beginning to prioritize such actions as collaborating with highly exposed tenants to evaluate options and better prepare for coastal flooding.

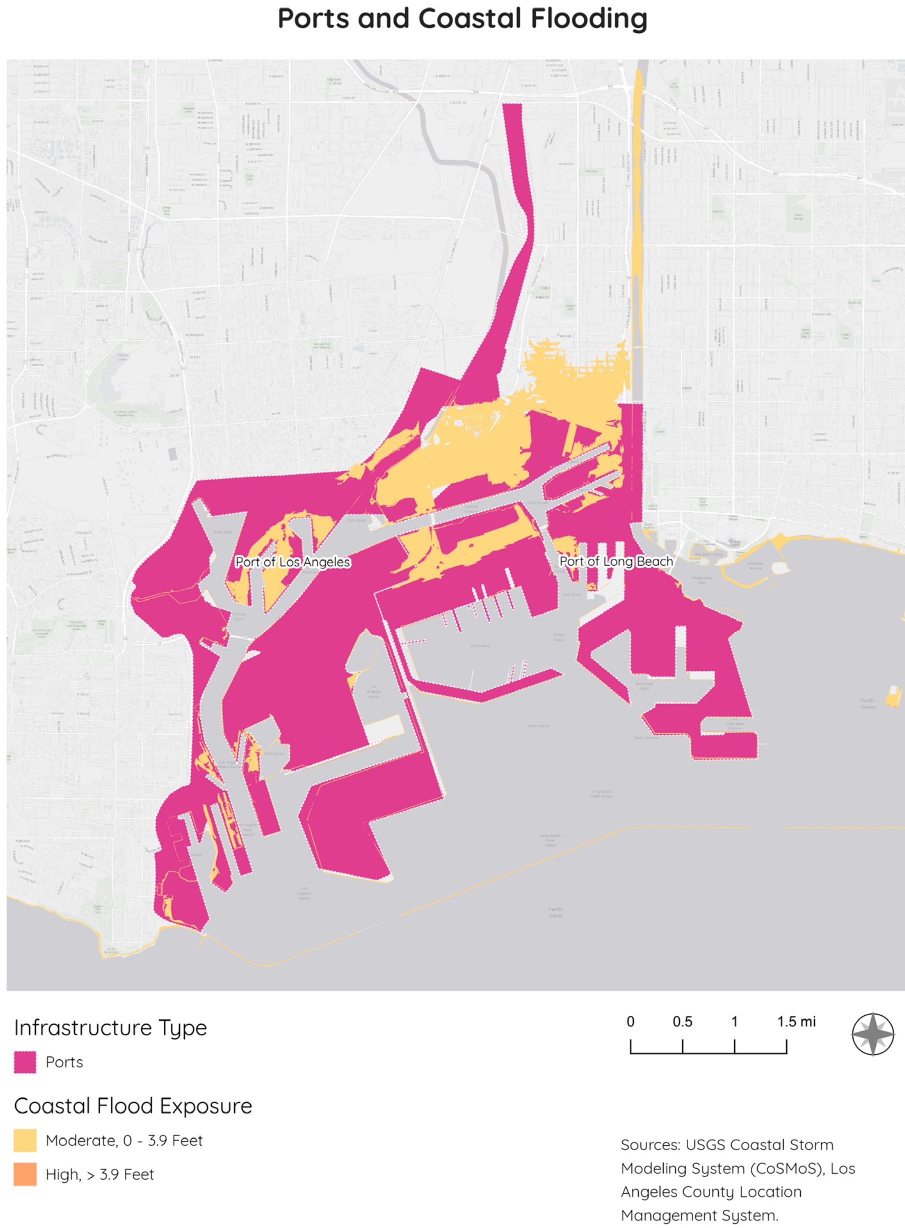


Figure 35: Map of ports and coastal flooding exposure in LA County

Drought

Introduction

Drought is already a risk to LA County, and the impacts can be far-reaching. For example, the recent 2012–2016 drought had major impacts on water resources throughout the state, such as permanently reduced groundwater storage capacity because of land sinking caused by excessive extraction of groundwater.[223] In the future, drought severity, frequency, and length are expected to increase so much so that California may experience long-term droughts at least every decade.[224] A drought spanning multiple decades is 65 percent more likely to occur under RCP 8.5 than under RCP 4.5.[225] Earlier in 2021, as drought conditions worsened in the West, and with California in its second consecutive dry year, the Governor declared a state of emergency.[226] Regional drought emergencies also were declared in areas of California where reservoir levels were at record lows. With Lake Mead at historically low levels, the federal government declared the first-ever water shortage on the Colorado River.[227] LA County heavily depends on imported water supplies from northern California via the State Water Project and from the Colorado River Basin, which are facing these historic drought conditions and are at risk for more severe conditions in the future.[228]

Drought conditions affecting water supplies that flow from snowpack in the Sierras will require changes in the County's water management methods to better store and conserve water throughout the year. Drought also contributes to the production of dust, which can have significant impacts on physical infrastructure and health, as described in the *Social Vulnerability Assessment*.

There are many complex, statewide and multi-state, even international, efforts to maintain water reliability in the face of drought, including the *2016 State Water Project and Central Valley Project Drought Contingency Plan: March 1, 2021–September 30, 2021*, *Sustainable Groundwater Management Act of 2014*, *2020 Water Resilience Portfolio* and *Colorado River Basin Drought Contingency Plans*. While cooperative arrangements between water users can help shift water management practices to better meet water supply needs and water quality requirements, these agreements involve complex negotiations.

Impacts of drought on physical infrastructure

The drought threat can have broad impacts to ecosystems, the regional economy, and communities, particularly rural ones. In the PVA, we focus on how drought impacts physical infrastructure, noting the function of these facilities in the context of these broader systems. Drought affects physical infrastructure in a variety of ways, including, but not limited to

- increased dependency on groundwater and lower groundwater levels, causing increased contaminant concentrations in aquifers and permanently impaired aquifers;
- damage to or loss of vegetation in parks and open spaces, including increased susceptibility of vegetation to invasive pests and wildfire; and
- increased soil cracking and subsidence in areas with low groundwater tables and high plasticity soils (e.g., clay-heavy soils), causing damage to building foundations and façades.

Key takeaways

Drought is a regional hazard for which spatial projection information is unavailable. Therefore, the LA County PVA does not assess exposure to drought spatially. Rather, we assumed moderate change in exposure to drought across all areas of LA County. This means that drought vulnerability is driven by the level of sensitivity in infrastructure systems. Other non-geographic factors, such as policies and legal agreements, can influence water allocations, which can affect who and what is ultimately impacted by drought geographically. Because water is a limited resource, it is important to understand vulnerabilities of various types of infrastructure so that the aggregate impacts can be taken into consideration when addressing how water is managed and used.

Table 13 lists infrastructure types that are highly vulnerable to drought. It shows that natural resources and water infrastructure systems will be most directly and severely impacted by drought. Parks and open spaces can experience degraded soil quality and plant health, potentially increasing the risk of wildfire. Drought will decrease imported water supply and increase the reliance on groundwater basins. This will also mean decreased water for cooling and decreased supply for recycled water and groundwater recharge. County residents may be directly impacted by water shortages during droughts.

Table 13: Drought vulnerability by infrastructure type

Infrastructure Type		Exposure	Sensitivity	Vulnerability
Natural resources	Parks and open space	M	H	H
Water	Active private and permitted wells	M	H	H
	Aqueducts and water distribution	M	H	H
	Groundwater recharge basins and spreading grounds	M	H	H
	Lakes and reservoirs	M	H	H
	Water treatment plants	M	H	H

Natural resources

Parks and open spaces

Parks and open spaces will face high vulnerability to drought. Drought directly impacts the health and quality of soil and plants. It can also make some vegetation more susceptible to invasive pests. Cumulatively, this can result in the loss of biodiversity and habitat in parks and open spaces. Furthermore, adaptation measures, such as water limits and conservation efforts, can result in limited or lack of irrigation water for vegetation.

The County's Department of Parks and Recreation has noted extensive loss of trees because of drought impacts.[229] Furthermore, some streams located in parks have dried up, leading to a loss of biodiversity and natural resources. Drought has also decreased vegetation greenness for chaparral and coastal sage scrub. This trend will likely continue in the future, increasing the risk of wildfire.[230]

Adaptive capacity measures, such as planting drought-resistant vegetation, can mitigate potential impacts of drought. However, these solutions can be expensive and time-intensive to implement across large parks and open spaces. Per stakeholder interviews, the Department of Parks and Recreation is developing biodiversity programming and strategies, acknowledging that it may be difficult or impossible to mitigate vegetation loss because of limited water supply under drought conditions.[231] However, there are efforts underway to protect and enhance biodiversity through the installation of native and drought-resistant landscaping, landscaping training programs, and tree inventories.

Water

Active private and permitted wells

More than one-third of the water systems serving LA County are entirely dependent on groundwater for drinking. Most of these systems serve small communities in northern LA County, such as Palmdale, Azusa, Industry, and Downey.[232] During periods of drought, these communities could face impaired groundwater basins or dry wells, requiring back-up drinking water sources, such as bottled water or storage tanks.[233] Drought can

Small water systems

Small water systems, defined as those that serve 501–3,300 customers, are threatened by extreme heat, wildfire, precipitation, and, most notably, drought. The California Department of Water Resources studied these systems in the *Small Water Systems and Rural Communities Drought and Water Shortage Contingency Planning and Risk Assessment*. From the assessment, small water providers with overlapping and cumulative climate impacts may be at risk of losing the ability to adequately provide water to their customers. Factors such as water source, type redundancies, and monitoring ability play a key role in determining overall vulnerabilities to the system.

In Los Angeles County, more than 250,000 people, mainly located in the northeast and northwest areas of the County, are served by small water systems. Most small water systems service residential areas. However, the second largest number of small water systems serve mobile home parks and roughly 140,000 people, representing 20 percent of all systems. Eight of the most vulnerable water systems in the County serve either mobile home parks or rural areas, putting these communities at particularly high risk to water supply challenges.[236]

also impact water quality in wells, when well water levels decrease and pollutant concentrations increase during drought conditions. For example, concentrations of contaminants, like arsenic and salt, can increase in well water during drought periods; this can result in unsafe drinking water without proper treatment. A lack of clean, sufficient well water can cause financial burden, sanitation concerns, and other issues for communities that rely on active wells for bathing, washing dishes, and other daily needs.

Aqueducts and water distribution

Drought and decreased water in aqueducts may slow the flow of water or cause it to become stagnant. Water stagnation in aqueducts can decrease water quality and increase the potential for mosquitos and other vectors. Finally, compounding problems with water shortage, underground water pipelines that transport water are more prone to damage during drought as soils crack and lose plasticity, resulting in water leaks.

Groundwater recharge basins / spreading grounds

Groundwater sources and the infrastructure we use to recharge groundwater and to draw it from aquifers—including wells, recharge basins, and spreading grounds—will be particularly vulnerable to the effects of drought. During periods of drought, water availability for groundwater recharge in recharge basins and spreading grounds will be at risk. As regional competition for water grows during drought events,[234] groundwater can serve as a dependable source of water. However, this can drive groundwater extraction beyond a sustainable capacity, compounding the issue of decreasing groundwater levels. Overextraction and lower levels of available groundwater can contribute to subsidence, which can impact above-ground structures. Overdrafting groundwater can also permanently reduce groundwater storage capacity in aquifers.

Lakes and reservoirs

Drought can increase the concentration of pollutants in lakes and reservoirs, impairing water quality.[235] Reservoirs in particular are highly sensitive because they are required to regularly release water to meet flow and temperature requirements downstream, even when water is limited. Fluctuating water levels from drought conditions can degrade reservoir containment infrastructure over time. For example, based on stakeholder interviews, recent decreased water levels in a swimming lake in LA County have led to exposure of submerged pipes, making swimming dangerous until water levels rose again.

Water treatment plants

Drought can result in reduced water availability for drinking water systems fed by water treatment plants. Because drought is also likely to impact water quality, water treatment plants may need to work harder to treat water to potable quality. For example, it is likely that water treatment plants will need to use arsenic treatment more frequently to treat groundwater. For treatment facilities using groundwater, facilities may incur additional pumping and related costs. During the 2012–2016 California drought, the LA County Waterworks Districts had to maximize pumping from its groundwater wells.

Water system adaptive capacity to drought

Diminishing snowpack, overdrafted groundwater basins, and more severe and prolonged periods of drought will likely threaten water systems' ability to provide reliable water at affordable prices. Because of this, adaptation planning is becoming more and more critical. Broadly speaking, strategies for improving water system resiliency include recycling and recapture, water conservation, consolidation of small water systems, water source redundancies, and shifting water supplies from being imported to being locally sourced. However, coordination and long-term planning across distinct and often disparate systems can be challenging. For example, small water systems that exclusively rely on groundwater face more risks than larger diversified systems. At the state level, legislation like the *Sustainable Groundwater Management Act* has ensured that moderate- and high-priority groundwater basins are part of plans to foster sustainable management of water supply. The *Water Surplus and Drought Management Plan* outlines a ten-year plan for achieving 100-percent reliability across the Metropolitan Water District of Southern California. In addition to state and regional efforts, more local actions will be required. This may include avoidance of wasteful water practices, water restrictions during periods of drought, leak monitoring and repair, and investments in recovering contaminated water supplies.

Cascading Impacts Assessment

Metro | Steve Hymon

Introduction

Physical and social climate vulnerability are interdependent. People and infrastructure sectors rely on and support one another. Because of these interconnections, the impacts of a climate hazard extend beyond the initial infrastructure disruption.[237] A wildfire that burns down an electrical substation may cause traffic lights to fail, even in areas not directly affected by the fire. The resulting traffic jams make local commuters late, which could impair the functioning of other critical services like health care, transit, and emergency management. These interconnected, or cascading, impacts can heighten the severity of a climate event, sending shocks throughout multiple sectors.[238]

This section examines potential cascading impacts in Los Angeles County, specifically how climate-related infrastructure disruption can affect linked systems and socially vulnerable populations.

Infrastructure interdependencies

Critical lifelines are maintained through a system of interdependent infrastructure. The structure of the metropolitan Los Angeles system was first mapped for California's *Fourth Climate Change Assessment* through interviews and workshops with infrastructure experts throughout the region, including representatives from the water, power, transportation, communications, public health, health services, and emergency services sectors.[239] Figure 36 displays an updated and extended version of this systems map for Los Angeles County. Each node represents a component of the County's critical infrastructure, organized by sector. The arrows indicate dependencies. For example, A->B means that when A goes up, B goes up, or, for dotted arrows: when A goes up, B goes down.

To develop this updated map, 37 people from local, regional, and state government and public agencies, industry associations, and nonprofits participated in stakeholder engagement exercises. Participants were asked the question "When another sector's service goes down, what functions in your own sector does that disrupt?" For example, water is necessary for certain electricity generation processes, and electricity is necessary to power water pump stations.

The system as a whole is extremely complex (see Figure 36 and explore online here). Failures can cascade from one sector to another in unpredictable ways that magnify the initial impact.[240] Following any single path through the map tells a story of possible cascading consequences, not consequences that will necessarily come to pass. However, an analysis of the whole structure highlights systemic issues and may help stakeholders design more resilient networks.


Metro | Steve Hymon

Infrastructure interdependencies

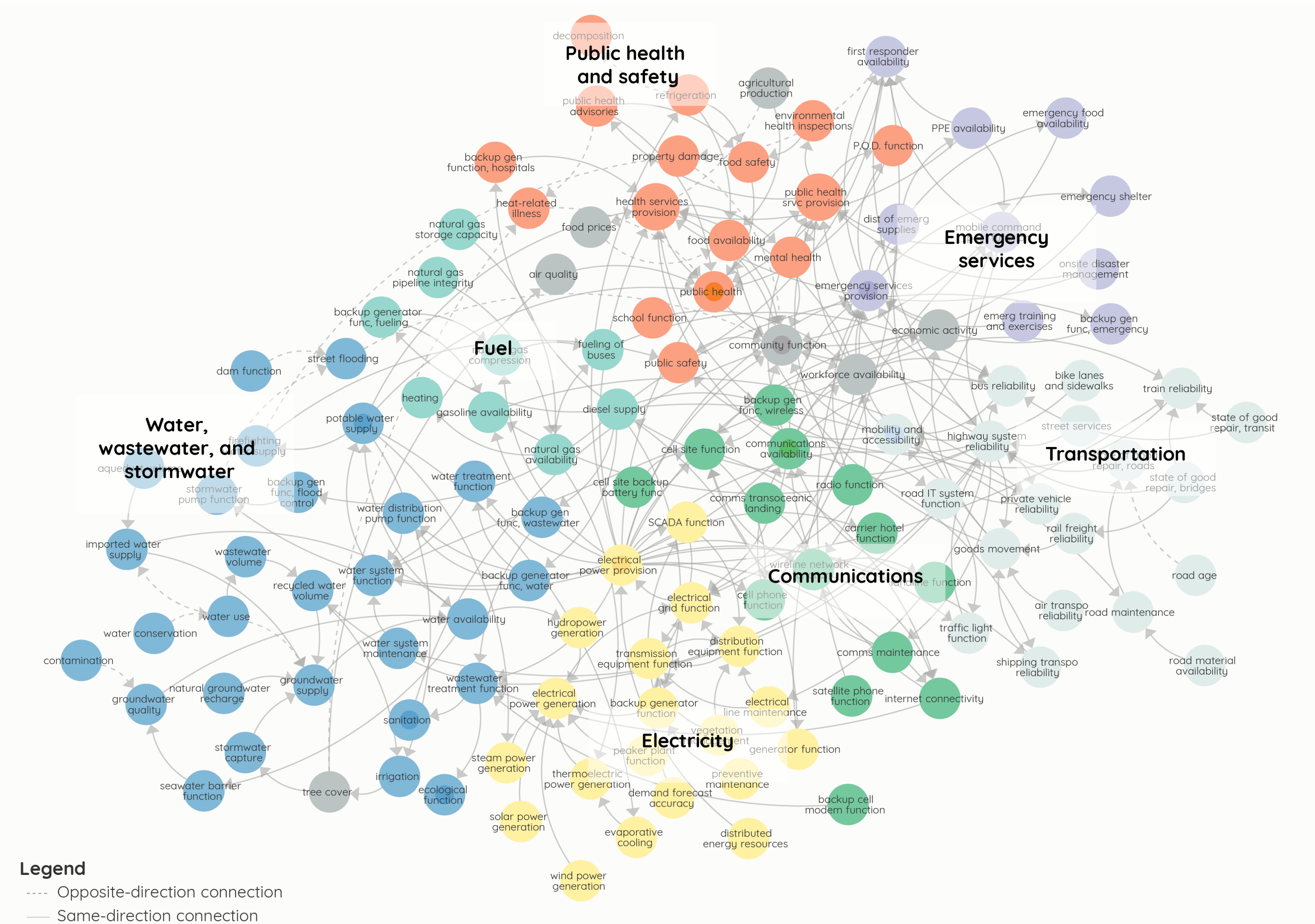


Figure 36: Infrastructure interdependencies in Los Angeles County

NOTE: The color of each node indicates its sector. Arrows mean that the second node depends on the first. For solid arrows, the nodes change in the same direction; for dotted arrows, the nodes change in opposite directions.

Some sectors are critical to all others

Electricity strongly influences every other infrastructure sector. It powers cell towers and wireline communications networks, hospitals and traffic signals, community facilities, water treatment plants, and pumping stations. It supplies pressurized water to fire hydrants.[241] The sector as a whole, represented by all yellow nodes in Figure 36, has the most connections to other sectors (Figure 37). The single node "electrical power provision" has by far the highest *outdegree centrality*, or number of outgoing connections.

Highway system reliability and communications availability are the nodes with the second- and third-highest number of outgoing connections, affecting every other mapped infrastructure sector. Ambulances need roads, as does the distribution of diesel fuel to power backup generators; roads provide access to repair powerlines impacted by fire or flood. Without internet access, wastewater treatment operations are compromised; without cell phones, many people cannot contact first responders.

Critical infrastructure sectors rely heavily on one another. Water is necessary for most electrical power generation, whether it is being used directly for hydropower generation or indirectly for cooling thermoelectric power plants (see Figure 36). A severe lack of water, therefore, can have all the same effects as a lack of electrical power, interrupting cell phone service and internet access, causing gridlock when traffic signals fail, and backing up sewers, for example. It could also have its own direct effects, like impaired hospital function and dry faucets.

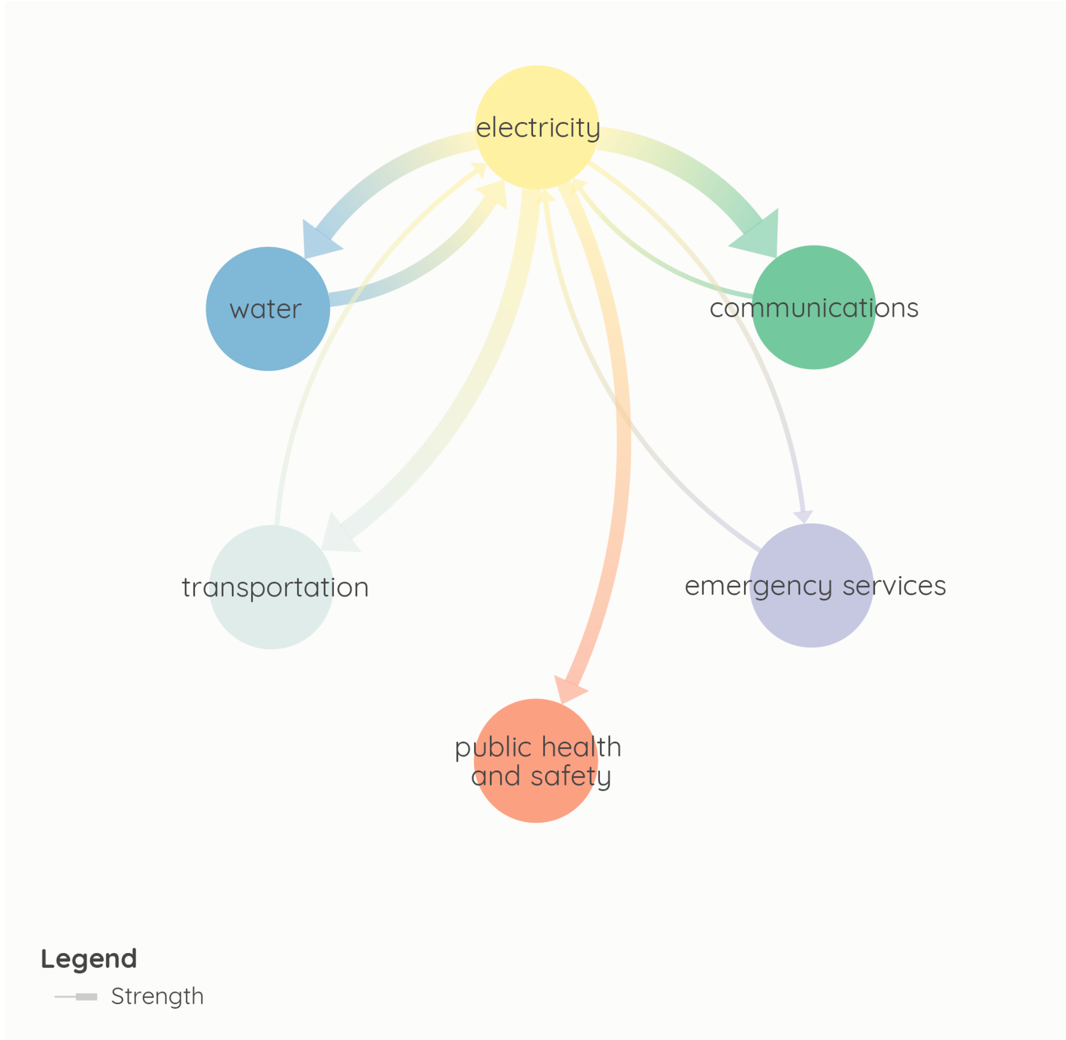


Figure 37: The degree to which electricity supports and depends on other infrastructure sectors

NOTE: The thickness of the arrow indicates the number of connections it represents.

Infrastructure depends on people

Direct connections, like those that come out of electrical power provision, are only part of the story. Indirect connections that follow a path through several nodes, like the earlier example of hospitals being affected by traffic jams caused by a power outage, can have just as much influence on the dynamics of the system. Quantifying these connections reveals a more complex landscape that depends solely on people.

There are different ways to analyze the network structure in Figure 36. The most straightforward is to simply count the number of connections into and/or out of a given node, as in electrical power provision. More-sophisticated algorithms can be used to look at flows not just through direct connections but across the whole network. These network analysis metrics measure things like which nodes have the most influence or connections overall and which could be bridges or bottlenecks.

Community function—or human health, well-being, and livelihoods—is by far the most connected node when indirect connections are considered. A metric called *eigenvector centrality*, related to how Google ranks webpages, measures how well connected a node is to other well-connected nodes. The eigenvector centrality for community function is almost double that of the next highest node, which is public health. This is in part a reflection of the fact that maintaining community function is the very purpose of the lifelines like energy, communications, transportation, and health services.

Community function specifically, and public health and safety more generally, are not only endpoints. They are also necessary inputs. Infrastructure keeps people healthy and safe, and it is people who keep infrastructure running.

The network analysis shows that workforce availability is the central element that connects all sectors to one another. More than any other node, workforce availability mediates interactions between different parts of the system. This is indicated by its high *betweenness centrality*—a measure of how many times the node lies on the shortest path between two other nodes. Workers are a key bridge between infrastructure and community function, making them also a potential single point of failure.

When a climate impact interferes with workforce availability, it can have exponential effects. For example, when flooding impacts bus reliability, mobility of the bus drivers may be affected. This can create a reinforcing feedback loop: fewer bus drivers working makes buses less reliable, which prevents more bus drivers from getting to work, and so on. Workforce availability occurs in thousands of such reinforcing feedback loops in the systems map, each of which has the potential to snowball.

Because a major impact to any single lifeline can affect workers across all of them, people are key to containing cascading failures. Essential workers are essential not just to the services they directly provide but to the functioning of the whole community system.

Human impacts of infrastructure disruption

The services that infrastructure provides support the fabric of our everyday lives. Losing access to these services is disruptive to everyone, but socially vulnerable populations can be disproportionately affected. The LA County Climate Vulnerability Assessment (CVA) listening sessions, previously referenced in the *Social Vulnerability Assessment* section of this report, helped us learn how infrastructure disruptions affect specific climate-vulnerable communities. The following sections summarize some of the examples we heard during those listening sessions, in which participants articulated how disruptions to the services provided by different critical infrastructure sectors cascade into the lives of LA County residents.

Human impacts of infrastructure disruption

Electricity

Power outages, whether they are caused by wildfire, Public Safety Power Shutoffs, or extreme heat, have widespread impacts. Utilities sometimes work with other critical infrastructure operators to minimize cascading impacts by providing advance warning or by selectively maintaining power, like to pump stations feeding hydrants that are fighting active fires. Some facilities, as well as some households that can afford it, have backup power options. However, those who do not are left in the dark and without refrigeration, elevator service, or air conditioning.

Lack of air conditioning is dangerous in extreme heat, especially for older adults, children, and for people with disabilities that make it harder to regulate body temperature.[242] Stakeholders noted that disruptions in elevator service trap people with disabilities and mobility challenges in multistory buildings. Lack of refrigeration can cause medications and food to spoil, which people with low income or limited food access are not necessarily able to replace.

Electricity also supports in-home medical devices for thousands of people in Los Angeles County who rely on them for treatment, well-being, or survival. Electricity-dependent populations include people using ventilators, oxygen concentrators, in-home dialysis, and electric wheelchairs. In times of crisis, hospitals often

Climate story: City of Long Beach and power outages

In July 2015, high temperatures may have been a factor in equipment failures that caused two power outages in downtown Long Beach that left thousands of residents and businesses without power for days. The power outage stranded people without medical devices, refrigeration, air conditioning or elevator service during a period of high temperatures. This was particularly challenging for seniors living in high-rise apartments. Adaptive capacity to this event was relatively strong between the community and City departments. Long Beach Search and Rescue and Community Emergency Response Team (CERT) members were able to go around and check in with vulnerable residents. They were assisted by neighbors that helped with distributing flashlights, food, and water to residents of Park Pacific Towers, where residents on floors ten and above did not have flushable water. The City, with help from nonprofits, local businesses, and Volunteer Organizations Active in Disaster (VOAD), assisted with operation of a shelter for those affected, and the City provided a generator. Key takeaways from this experience were the importance of having trained members, knowledge and readiness of resources available to be called on to help with response, like where CERT residents were located, the availability of back-up generators and access to impacted buildings, and using various avenues to reach and communicate with residents including face-to-face, social media, and Alert Long Beach, the City's emergency response system. Emergency response to this event was a significant learning experience that can be applied as a part of planning for climate events and secondary impacts (like a power outage).

City of Long Beach

act as backup power, but the increased demand can overwhelm the capacity of inpatient facilities.[243]

Communications

Communications disruptions can exacerbate safety issues during a climate crisis. During a disaster or a Public Safety Power Shutoff, people are often unable to receive mandatory evacuation notices, get information from the internet on wildfire spread, or connect with emergency services or caregivers. Rural communities and people with disabilities and mobility challenges are particularly vulnerable to loss of telecommunications services.

Local outreach workers noted that, for people experiencing homelessness, cell phones are critical assets in their daily lives. In addition to their role in social connection, cell phones give many people access to services, from mental health care to housing vouchers to case management services to prescription drop-off.

Transportation

Transit interruptions can lead to lost wages. Disruptions in transit service can especially impact low-income commuters and commuters of color, who make up most of Metro ridership.[244] Delays mean increased exposure to heat or poor air quality, which is particularly harmful for older adults, people with disabilities, and people with cardiac or respiratory illness. Residents reported that, when sidewalks flood and become littered with debris, people with visual and/or mobility impairments have difficulty navigating them.

During disasters, transportation is crucial for evacuation. People who rely on transit may be stranded when transit operators themselves evacuate. People with disabilities and mobility challenges normally reserve 24 hours in advance for Access Services, the agency that provides transportation for people unable to use regular public bus and train service. Even if they find a more timely ride, it is often difficult to transport medical equipment. People who use in-home supportive services may find their caregivers barred from the mandatory evacuation zone.

Water

Hydration is the human body's defense against extreme heat. Drinking water is crucial for those most vulnerable to heat-related illness, like older adults and people with disabilities. If water infrastructure were to fail, there would be health consequences for anyone who relies on tap water. Even when systems are functioning, accessing drinking water can be difficult for people experiencing homelessness or for climate-exposed workers.

The water system also supplies inputs to the wastewater treatment system and to agriculture. Toilets flush, and food grows with tap water. A lack of water can increase food prices, which disproportionately affects people who are food insecure or have low income.

Inequitable access to services

For some populations, existing inequities in critical service delivery are compounded during a climate crisis. Undocumented workers have less access to emergency shelters, affordable health care, worker protections, and federal disaster relief funds. Even in situations where these services are available to all, a person's concern over their immigration status may prevent them from using these resources. Official emergency warnings can exclude non-English speakers, leaving local migrant rights groups and environmental justice groups to translate mandatory evacuation notices over social media, low-power community radio, or WhatsApp.[245]

People with disabilities or access and functional needs also encounter challenges in emergency response. Emergency notifications may not be translated into American Sign Language for people who have hearing impairments. Emergency shelters have been known to illegally turn away service animals. Shelters might also lack accessible cots and bathrooms or a refrigerator for medications.

Climate change compounds the need to properly address the inequities present in these services.

Conclusion

The importance of physical infrastructure can be measured by its effects on the services that it supports and the people who rely on those services.[246] Because infrastructure in Los Angeles County is interdependent, a disruption or failure in one sector can create cascading impacts for related sectors. Some of these relationships are less obvious than others, underscoring the importance of strong communication and collaboration across the stakeholders that make up this system.

Understanding the interconnectedness of critical infrastructure systems and the communities they support is essential to creating climate resilience. Infrastructure keeps people healthy and safe, and people keep infrastructure running. Disruptions to the lives of workers, who are a key bridge between lifeline sectors, can magnify climate impacts throughout the system. When evaluating adaptation priorities, assets must be judged by the consequences of their failure—not only by the direct and economic consequences, but also by the systemic and social consequences too.

City of Long Beach

Conclusion

The LA County Climate Vulnerability Assessment (CVA) outlines LA County's physical and social vulnerabilities to this century's most pressing climate hazards. The vulnerabilities identified in the report intersect with other social, economic, and cultural issues: historic injustices, housing insecurity, income inequality, and more. Although climate change is an undeniable and inevitable force, this moment is also one of great opportunity and hope. Collectively, we must decide how to respond to the multitude of challenges posed by climate hazards. The County is committed to championing a resilient and equitable future for all County residents.

What the County can do

Implement adaptation and mitgation measures.

CVA insights will inform future budget allocations, legislation, and infrastructure investments. With equity as a guiding principle for the County's future climate action, projects must also support climate resilience and prioritize historically disadvantaged people. To maximize resources, investments should be multi-beneficial, addressing multiple hazards when possible. Continuing to take bold action to mitigate greenhouse gas emissions and slow down climate change is also critical to reducing the impacts on our communities. An integrated approach to adaptation and mitigation ensures we simultaneously curb and prepare for climate change.

Engage in collaboration across County agencies, local jurisdictions, and community organizations.

Climate vulnerability, as emphasized in the cascading impacts discussion, connects to all facets of County operations. Sharing the CVA's findings with all County departments, related agencies, and local jurisdictions will be crucial to coordinating comprehensive climate resilience strategy. County administrators should reference CVA findings when developing and implementing their department's work plans and identify opportunities for incorporating climate adaptation measures. Local jurisdictions have their own specific climate vulnerability needs that they must explore through their own area-specific climate vulnerability plans. The County will act as a resource and partner for these individual jurisdictions in this work. Additionally, maintaining strong relationships with community groups can continue to illuminate population-specific climate concerns.

Advocate for equitable climate action.

The County recognizes the ways in which past policies have perpetuated injustice and how those injustices contribute to climate vulnerability experienced today. Thus, the County is committed to partnering with climate justice organizations to advocate at the state level for legislation and funding that supports regional adaptation initiatives. This advocacy will advance policies that protect vulnerable people and communities and grant opportunities for local jurisdictions and community organizations, as well as climate resilient infrastructure projects.

Lead public education on climate resilience.

Every County resident deserves to be well-informed on how climate hazards may affect their community. The County will make the CVA findings and related key data publicly accessible for informed communications with key stakeholders of highly vulnerable communities. The new online data and mapping tool allows individuals and organizations to engage with the CVA's data and craft narratives relevant to their needs.

Explore opportunities for future climate research.

California's network of academic and research partners produced key insights to inform the CVA. However, there are gaps in what we know, such as about flooding and precipitation risk and the adaptive capacity of communities. By advancing research on emerging questions and trends related to climate change, we will ensure our actions stay relevant.

Conclusion

What local government can do

Develop local adaptation plans.

A primary objective of the LA County CVA is to provide a foundational assessment that can be used and enhanced through local planning efforts. This CVA provides a countywide look at vulnerability but can go further with local expertise and knowledge about specific communities and infrastructure. As cities and local governments approach their own planning efforts, particularly to meet SB 379 requirements, they are encouraged to use the LA County CVA as a first step.

Advocate for and plan with vulnerable populations.

General plan updates offer a great opportunity for municipalities to prioritize equitable climate action. When local governments engage local communities early in the process, it enables more inclusive, effective, and successful planning. Advocates can reference the CVA's data around social vulnerability to center equity.

What community organization and stakeholders can do

Root local action in climate resilience.

The CVA can be used as a guiding document for community organizations and local stakeholders looking to build adaptive capacity. The County encourages readers to review the CVA with a critical eye and to help illuminate any gaps, especially as they relate to the lived experiences of vulnerable populations. By using the online mapping and data tool, organizations can mobilize their communities to act on the issues most pressing to them, including developing emergency preparedness plans of their own.

Build awareness of climate issues.

Community organizations can help residents contextualize the CVA's findings to underscore the most effective messaging. From community meetings to translated resources to working groups, there are several methods to spread awareness. Awareness-building can start internally: the more confident local advocates feel discussing climate issues, the more confidently they can share this knowledge with others.

Get to know your neighbors and build community social networks to provide resilience.

Tight-knit and connected communities inherently build strong social resilience. In the face of climate hazards and their impacts, a resilient community can recognize and understand challenges, help neighbors, share resources, and quickly respond and recover. Strong community social networks signal community-level adaptive capacity that can enable more successful preparation for and recovery from climate change.

CEO Countywide Communications

Appendix

Contents:

Appendix A: Acknowledgements

Appendix B: Acronyms and Abbreviations

Appendix C: Glossary

Appendix D: Additional Resources
Additional CVA resources are provided as separate documents for review and reference. These include:

LA County CVA Desktop Review

LA County Climate Hazard Assessment

LA County CVA Social Sensitivity Indicators

LA County CVA Physical Vulnerability, By Infrastructure Type

LA County CVA Stakeholder Engagement Process and Findings

LA County CVA Technical Methodologies and Resources

Appendix A: Acknowledgements

County Project Team

Chief Sustainability Office / Department of Regional Planning / Department of Public Health

Advisory Committee

Active San Gabriel Valley / Association of Rural Town Councils / BizFed Institute / Communities Actively Living Independent & Free / Greenlining Institute / Instituto de Educación Popular del Sur de California / Los Angeles County Department of Public Health / Los Angeles County Department of Regional Planning / Los Angeles Regional Water Quality Control Board / Mayor's Office of Resilience, City of Los Angeles / Prevention Institute / Sacred Places Institute for Indigenous Peoples / Southern California Edison / UCLA Sustainability / USC Sea Grant

Consultant Team and Project Advisors

Buro Happold / Climate Resolve / Jessica Ruvinsky / Mikhail Chester / Natalie Donlin-Zappella / ICF

Listening Session Co-Hosts

Association of Rural Town Councils / Communities Actively Living Independent & Free / Instituto de Educación Popular del Sur de California / Los Angeles Homeless Services Authority / Move the World / Sacred Places Institute for Indigenous Peoples / Tamika L Butler Consulting

Interviews

County Departments: Chief Executive Office / Department of Parks and Recreation / Department of Public Health / Department of Public Works / Department of Regional Planning / Office of Emergency Management / Internal Services Department

External Organizations: BizFed Institute / California Cable and Telecommunications Association / Governor's Office of Planning and Research / California Public Utilities Commission / California State Water Resources Control Board / City of Los Angeles Mayor's Office / Greenlining Institute / Hospital Association of Southern CA / LA Metro / Los Angeles Regional Water Quality Control Board / Loyola Marymount University Center for Urban Resilience / National Centers for Coastal Ocean Science, NOAA National Ocean Service / Prevention Institute / Tree People / Southern California Association of Governments / UCLA Labor Occupational Health & Safety

Appendix B: Acronyms and Abbreviations

CAL FIRE	California Department of Forestry and Fire Protection
CBO	Community-based organization
CDC	Center for Disease Control and Prevention
CERT	Community Emergency Response Team
CHA	Climate Hazard Assessment
CSD	California Department of Community Services and Development
CSO	Chief Sustainability Office (LA County)
CVA	Climate Vulnerability Assessment
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GHG	Greenhouse gases
HVAC	Heating, ventilation, and air conditioning
IDEPSCA	Instituto de Educación Popular del Sur de California
MDT	El Monte Multidisciplinary Team
NOx	Nitrogen oxides
OSHA	Occupational Safety and Health Administration
PCH	Pacific Coast Highway

ppb	Parts per billion
PSPS	Public Safety Power Shutoff
PTSD	Post-traumatic stress disorder
PVA	Physical Vulnerability Assessment
RCP	Representative Concentration Pathway
SCORE	Southern California Optimized Rail Expansion
SVA	Social Vulnerability Assessment
VOC	Volatile organic compound
WUI	Wildland urban interface

Appendix C: Glossary

A

Adaptation	The effort to adjust practices and development in response to climate change in order to lessen future impacts.
Adaptive Capacity	The ability of a system or sub-population to adjust to climate change, to moderate potential damages, or to cope with the consequences.
Albedo	The solar reflectivity of a surface. Those surfaces with a higher albedo can reflect sunlight and not absorb on the surface. Lower albedo absorbs sunlight making surfaces significantly hotter.

B

Biodiversity	The variety and variability of flora, fauna and ecosystems. Biodiversity can be observed on macro levels, micro levels and in between. Biodiversity is complex, fragile and increasingly threatened by urbanization and climate change. Rich biodiversity supports many aspects of human life from food and medicine to environmental quality.
Biogenic	Coming from or brought about by living organisms.

C

Catenary Lines	Overhead power lines that provide electricity to light rail trains and streetcars.
Climate Change	Long-term change in average weather patterns that can alter local, regional, and global climates.
Climate Hazards	A category of meteorological, oceanic, or climatic events/phenomena that can harm human health, livelihood, and natural resources. Examples include flooding, extreme temperatures, and wildfires.
Climate Vulnerability Assessment	An analysis of the extent to which a species, habitat, ecosystem or civilization is susceptible to harm from climate change impacts. Vulnerability assessments are an integral component of climate adaptation planning.
Community-Based Organizations (CBO)	Entrusted public or private non-profit resource hubs that are able to provide services to communities.

Community Emergency Response Team (CERT)	The CERT program educates volunteers about disaster preparedness for the hazards that may impact their area and trains them in basic disaster response skills. These skills may include fire safety, light search and rescue, and disaster medical operations. Training in LA County is offered by the County Fire Department.
Cooling Centers	Community facilities that offer relief from extreme heat and keep people safe from severe temperatures. They also provide other important resources such as water, restrooms, medical attention, or social services. Public facilities such as libraries and schools can serve as cooling centers.

E

Environmental Justice	Defined by California state law as "the fair treatment of people of all races, cultures and incomes with respect to the development, adoption, implementation and enforcement of environmental laws, regulations and policies."
Exposure	The nature or degree to which a system or sub-population is exposed to significant climate variations.

F

Fire Hazard Severity Zone	CAL FIRE areas that have high probability of fire hazards. These zones are determined based on factors such as fuel, slope, terrain conditions and weather patterns. Degrees of fire hazard can range from moderate to high to very high. While these designations do not specifically identify areas where wildfires will occur, they represent areas where wildfire hazards could be more severe and are of greater concern.
Floodplain	An area of low-lying land near a stream or river which is subject to flooding during periods of high flow, such as heavy rains.
Frontline Communities	Communities that continuously experience injustice and inequities through systemic racism leading to experience unsafe, unhealthy neighborhoods, limited access to education, public services and economic opportunities. They often consist of Black, Indigenous and people of color, immigrants, low-income individuals, and rural areas.

G

Gentrification	The process that occurs when the increasing property values brought about through gentrification drive out existing residents and business operators and attract a new and different demographic population to an area. Lower income residents may also become unable to access housing in certain areas due to increasing housing prices

Green Infrastructure	A method for naturally managing rain and flood waters. Green infrastructure reduces and treats stormwater runoff while also improving the local environment by mimicking natural processes. Green infrastructure includes strategies such as green roofs, bioswales, and permeable pavements.
Greenhouse Gases (GHG)	Gases that trap heat in the atmosphere by absorbing and emitting solar radiation within the atmosphere, causing a greenhouse effect that warms the atmosphere and leads to global climate change. The main human-made GHGs are carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons.
Groundwater Recharge	The process that occurs when water infiltrates into the ground to fill underground aquifers. In the state of California, it is done intentionally to ensure that groundwater levels can be maintained to withstand droughts.
Ground-level Ozone	Created by nitrogen oxide and volatile organic compounds that happens when cars, power plants or refineries pollute and react with the sunlight. It can cause for unhealthy pollution especially during hot days in urban environments.

H

Heat Island Effect	A measurable increase in ambient air temperatures resulting primarily from the replacement of vegetation with buildings, roads, and other heat-absorbing infrastructure. The heat island effect can result in significant temperature differences between rural and urban areas.
Heat Refuge	Public places such as official cooling centers, libraries, museums, or indoor shopping malls that act as safe places for people to escape the heat.
Heat Waves	Extended periods of high and extreme temperatures.

I

Impermeable Surfaces	Solid surfaces, such as paved roads and parking lots, which do not allow water to penetrate into the ground below due to their water-resistant characteristics such as asphalt and concrete.

L

Landslides	The mass movement of rock, debris, and soil down a slope.

M

Mega-droughts	Severe droughts that last for at least two decades.
Mudslides	The event where fast-moving liquified debris and mud slide down a hill, mountain, or slope.

N

National Flood Insurance Program (NFIP)	According to FEMA, it "provides flood insurance to property owners, renters and businesses, and having this coverage helps them recover faster when floodwaters recede. The NFIP works with communities required to adopt and enforce floodplain management regulations that help mitigate flooding effects."
Nitrogen Oxides (NOx)	A highly reactive gas that is found from the burning of fuel such as from cars, buses, and power plants. It can aggravate the human respiratory system.

O

Ozone	A gas that is found in the upper and lower atmosphere. The ozone layer found 6 to 30 miles above the surface of the earth has the ability to reduce harmful UV radiation.

P

Particulate Matter (PM)	A combination of solid and liquid droplets found in the air. Particulate matter can include dust, dirt, soot, or smoke. Some PM is large enough to be seen but other types are microscopic (fine particulate matter). Fine particulate matter can travel deeply into the human respiratory tract and can cause health effects such as throat irritation, coughing, or asthma.

R

Redlining	A government-sponsored practice that exacerbated inequality by prioritizing home loans in desirable areas for White homeowners, driving away low-income people and people of color, and leaving them with fewer pathways to home ownership, reduced economic security, and a decreased ability to adapt to shocks and stresses such as impacts from climate change.
Regenerative Agricultural Practices	A set of holistic land management and agriculture practices that reverses the effects of climate change through rebuilding soil organic matter and restoring degraded soil biodiversity. Practices that make up regenerative agriculture include well-managed grazing, the use of compost, or minimal tillage.
Resilience	The capacity to survive, adapt and thrive in the face of chronic stresses and acute shocks and to even transform as conditions require.
Retrofits	Major changes to the structure or systems of an existing building for the purpose of achieving significant reductions in energy consumption, operational costs, or resilience with the use of more efficient technologies, products, and designs. Retrofits may also reduce water consumption and improve occupant amenities.

S

Sea-level Rise	An occurrence where the level of the ocean's water increases. Examples include burning fossil fuels and greenhouse gasses leading to global warming. It can increase flooding and intense storm surges causing damage to coastal areas.
Sedimentation	It is a process of where the bottom of a reservoir will fill with large and small sediments travel through the reservoir by the water. It can accumulate and form layers of sediment causing compaction.
Sensitivity	The degree to which a system or sub-population is affected by climate-related stimuli.
Shoaling	This occurs when rising seawater pushes inland. In the case of low-lying coasts, it can force groundwater to the surface causing for more intense waves resulting in an increase of flooding events.
Smoke Waves	Periods of two or more consecutive days of unhealthy levels of PM2.5 present in the ambient air, due to wildfires.
Snow-water Equivalent (SWE)	A measurement that hydrologists use to calculate the amount of liquid water that will be released from the snow as it melts.

Social Vulnerability	The susceptibility of a group or population's ability to prepare, respond, and recover from exposures, harms, or hazards.
Spreading Grounds	Used as a water conservation facility, they are adjacent to rivers and channels to allow for water to percolate into the groundwater basis. The groundwater is recharged to be pumped at a later time and can do so due to its soil permeability and connection to the aquifer,
Susceptibility	A population or person's potential for vulnerability due to its socioeconomic, demographic and geolocation characteristics.

T

Thermal Building Performance	Efficiency of a building or house to prevent the passage of heat. Older buildings may heat up faster due to cool air leakage and potentially face higher utility costs.
Thermal Envelope	Also known as the heat flow control layer, they are the parts of a house/building that separate hot and cool areas from the outside. Examples include windows, wall, and insulation.
Thermoregulate	Process that allows the human body to main its stable internal temperature to survive and function.
Tree Canopy Cover	Form of green infrastructure that reduces the urban heat island effect (See Urban Heat Island). It can serve as natural habitat for local wildlife and provide cooling refuge for residents using sidewalks and/or public transportation
Tribal Land Stewardship	Tribes can have control and access to ancestral lands and resources to ensure sustainable, economic, spiritual, and cultural well-being of Tribal communities. It ensures preservation of sacred sites, protection of traditional gathering areas, and natural habitat.

U

Unincorporated Areas	More than 65% of LA County (or 2,654 square miles) is unincorporated, meaning not within a city boundary. For the population of nearly 1 million people living in these areas, the County Board of Supervisors acts as their city council and the supervisor representing a specific area acts as the city mayor. County departments provide the municipal services for these areas. There are nearly 150 unincorporated areas in LA County.

V

Vector-borne Diseases	Diseases that result from an infection transmitted to humans or other animals by blood-feeding arthropods (i.e., mosquitos, ticks, fleas).
Volatile Organic Compound (VOC)	Emitted as gases, these chemicals may have short and long-term health effects. They are often found in household products such as solvents, cleaning, and disinfecting products.
Vulnerability	This describes the function of how exposure and sensitivity to a particular climate risk align with the corresponding adaptive capacity.

W

Watershed	An area of land that drains all the streams and rainfall to a common outlet such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel.
Wildland Urban Interface (WUI)	A zone of transition between unoccupied wildland, and urban or suburban development.

Endnotes

1 University of Southern California, Dana and David Dornsife College of Letters, Arts and Sciences, Center for Economic and Social Research. *LABarometer: Top 5 Takeaways from The Sustainability and Resilience Report*. University of Southern California, 25 Sept. 2020, cesr.usc.edu/sites/default/files/Top5_sustainability.pdf. Accessed 10 Sept. 2021.

2 Cooley, Heather et al. *Social Vulnerability to Climate Change in California*. CEC-500-2012-013, Pacific Institute, Jul. 2012, pacinst.org/wp-content/uploads/2012/07/social-vulnerability-climate-change-ca.pdf. Accessed 10 Sept. 2021.

3 *Top 20 Largest California Wildfires*. Cal Fire, 10 Sept. 2021, www.fire.ca.gov/media/4jandlhh/top20_acres.pdf. Accessed 10 Sept. 2021.

4 "Wildfires in Los Angeles County." *Los Angeles Almanac*, www.laalmanac.com/fire/fi07.php#largest. Accessed 10 Sept. 2021.

5 Wigglesworth, Alex, and Jaclyn Cosgrove. "At 121 Degrees, Woodland Hills Hits All-Time High Temperature for L.A. County." *Los Angeles Times*, 6 Sept. 2020, www.latimes.com/california/story/2020-09-06/southern-california-weather-forecast-sunday-los-angeles-record-breaking-heat. Accessed 10 Sept. 2021.

6 Zscheischler, Jakob, et al. "Future Climate Risk from Compound Events." *Nature Climate Change*, vol. 8, 2018, pp. 469–77, www.nature.com/articles/s41558-018-0156-3. Accessed 10 Sept. 2021.

7 Oppenheimer, Michael, et al. "Emergent Risks and Key Vulnerabilities." *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Christopher Field, et al., Cambridge University Press, 2014, pp. 1039–99, www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap19_FINAL.pdf. Accessed 10 Sept. 2021.

8 Dunne, Daisy. "US Sees 'Alarming' Increase in Combined Heatwaves and Droughts." *Carbon Brief*, 23 Sept. 2020, www.carbonbrief.org/us-sees-alarming-increase-in-combined-heatwaves-and-droughts. Accessed 10 Sept. 2021.

9 Established by the Intergovernmental Panel on Climate Change, RCPs are "scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover." https://www.ipcc-data.org/guidelines/pages/glossary/glossary_r.html

10 The Paris Agreement and many climate goals aim to limit global temperature increase to 1.5°C. See *Paris Agreement*. United Nations, 2015, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. Accessed 10 Sept. 2021.

11 Pachauri, Rajendra K. amd Andu Reisinger. *IPCC Fourth Assessment Report*. IPCC, Geneva 2007.

12 Tamrazian, Arbi, et al. "Heat Waves in Southern California: Are They Becoming More Frequent and Longer Lasting?" *Yearbook of the Association of Pacific Coast Geographers*, vol. 70, no. 1, 2008, pp. 59–69, muse.jhu.edu/article/240163. Accessed 10 Sept. 2021.

13 “Record Temperatures for Select Los Angeles County Locations.” *Los Angeles Almanac*, www.laalmanac.com/weather/we03.php. Accessed 10 Sept. 2021.

14 Cal-Adapt. “Data: LOCA Downscaled CMIP5 Projections (Scripps Institution of Oceanography), Gridded Observed Meteorological Data.” University of Colorado, Boulder, cal-adapt.org/data/loca. Accessed 10 Sept. 2021.

15 Jin, Yufang, et al. “Identification of Two Distinct Fire Regimes in Southern California: Implications for Economic Impact and Future Change.” *Environmental Research Letters*, vol. 10, no. 9, 2015, iopscience.iop.org/article/10.1088/1748-9326/10/9/094005. Accessed 10 Sept. 2021.

16 Swain, D. L., et al. “Increased Flood Exposure Due to Climate Change and Population Growth in the United States.” *Earth’s Future*, vol. 8, no. 11, 2020, agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EF001778. Accessed 10 Sept. 2021.

17 Swain, D. L., et al. “Increasing Precipitation Volatility in Twenty-First-Century California.” *Nature Climate Change*, vol. 8, no. 5, 2018, pp. 427–33, www.nature.com/articles/s41558-018-0140-y. Accessed 10 Sept. 2021.

18 Hall, Alex, et al. *Los Angeles Region Report*. California’s Fourth Climate Change Assessment, Governor’s Office of Planning and Research, State of California Energy Commission, and California Natural Resources Agency, 2018, www.energy.ca.gov/sites/default/files/2019-11/Reg%20Report-%20SUM-CCCA4-2018-007%20LosAngeles_ADA.pdf. Accessed 10 Sept. 2021.

19 Befus, K. M., et al. “Increasing Threat of Coastal Groundwater Hazards from Sea-level Rise in California.” *Nature Climate Change*, vol. 10, no. 10, 2020, pp. 946–52, www.nature.com/articles/s41558-020-0874-1. Accessed 10 Sept. 2021.

20 Hall, et al. 2018.

21 Cook, Benjamin I., et al. “Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains.” *Science Advances*, vol. 1, no. 1, 12 Feb. 2015, www.science.org/doi/10.1126/sciadv.1400082. Accessed 10 Sept. 2021.

22 Meixner, Thomas, et al. “Implications of Projected Climate Change for Groundwater Recharge in the Western United States.” *Journal of Hydrology*, vol. 534, Mar. 2016, pp. 124–38, www.sciencedirect.com/science/article/pii/S0022169415009750?via%3Dihub. Accessed 10 Sept. 2021.

23 Swain, Daniel L., et al. “Increasing Precipitation Volatility in Twenty-First-Century California.” *Nature Climate Change*, vol. 8, no. 5, 2018, pp. 427–33, www.nature.com/articles/s41558-018-0140-y. Accessed 10 Sept. 2021.

24 Robbins, Jim. “Climate whiplash: Wild Swings in Extreme Weather Are on the Rise.” *Yale Environment 360*, 14 Nov. 2019, e360.yale.edu/features/climate-whiplash-wild-swings-in-extreme-weather-are-on-the-rise. Accessed 10 Sept. 2021.

25 White, P. A. *Can Soil Save Us? Making the Case for Cover Crops as Extreme Weather Risk Management*. National Wildlife Federation, Jun. 2015, www.nwf.org/~/media/PDFs/Water/2015/Drought-and-Flood-Report-Final.pdf. Accessed 10 Sept. 2021.

26 *Drought Conditions for Los Angeles County*. National Integrated Drought Information System, 2021. https://www.drought.gov/states/california/county/los%20angeles. Accessed 6 Oct. 2021.

27 Golembo, Max. "Californians Prepare for Possible Mudslides as Rain Hits Wildfire-Affected Regions." ABC News, 29 Nov. 2018, abcnews.go.com/US/californians-prepare-mudslides-rain-hits-wildfire-affected-regions/story?id=59489722. Accessed 10 Sept. 2021.

28 Cascio, Wayne E. "Wildland Fire Smoke and Human Health." *Science of the Total Environment*, vol. 624, 15 May 2018, pp. 586–95. Accessed 10 Sept. 2021.

29 Naeher Luke P., et al. "Woodsmoke Health Effects: A Review." *Inhalation Toxicology*, vol. 19, no. 1, Jan. 2007, pp. 67–106, pubmed.ncbi.nlm.nih.gov/17127644. Accessed 10 Sept. 2021.

30 Liu, Jia C., et al. "A Systematic Review of the Physical Health Impacts from Non-Occupational Exposure to Wildfire Smoke." *Environmental Resources*, vol. 136, Jan. 2015, pp. 120–32, www.ncbi.nlm.nih.gov/pmc/articles/PMC4262561. Accessed 10 Sept. 2021.

31 Hall, et al., 2018.

32 National Ambient Air Quality Standards. *Overview EPA's Updates to the Air Quality Standards for Ground-Level Ozone*. U.S. Environmental Protection Agency, Oct. 2015, www.epa.gov/sites/production/files/2015-10/documents/overview_of_2015_rule.pdf. Accessed 10 Sept. 2021.

33 Melillo, Jerry M., et al. *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 2014, nca2014.globalchange.gov/downloads/high/NCA3_Climate_Change_Impacts_in_the_United%20States_HighRes.pdf. Accessed 10 Sept. 2021.

34 Duran-Encalada, J. A., et al. "The Impact of Global Climate Change on Water Quantity and Quality: A System Dynamics Approach to the US–Mexican Transborder Region." *European Journal of Operational Research*, vol. 256, no. 2, 16 Jan. 2017, pp. 567–81, www.sciencedirect.com/science/article/pii/S0377221716304362?via%3Dihub. Accessed 10 Sept. 2021.

35 Major, D. C., et al. "Climate Change, Water, and Wastewater in Cities." *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*, edited by Cynthia Rosenzweig, et al., Apr. 2011, pp. 113–44, www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/climate-change-and-cities-first-assessment-report-urban-climate-change-research-network?format=PB&isbn=9781107004207. Accessed 10 Sept. 2021.

36 Smith, Deborah J., and Céline Gallon. *Los Angeles Region Framework for Climate Change Adaptation and Mitigation: Current State of Knowledge & Water Quality Regulatory Program Considerations*. Los Angeles Regional Water Quality Control Board, Jul. 2015, www.waterboards.ca.gov/losangeles/water_issues/programs/climate_change/docs/2015/Climatechange-frameworkforclimatechangeadaptation-final7-20-2015.pdf. Accessed 10 Sept. 2021.

37 Stokstad, Erik. "Deep Deficit: Droughts." *Science*, 15 Apr. 2020, www.sciencemag.org/news/2020/04/droughts-exposed-california-s-thirst-groundwater-now-state-hopes-refill-its-aquifers. Accessed 10 Sept. 2021.

38 Pierce, David W., et al. *Climate, Drought, and Sea Level Rise Scenarios for the Fourth California Climate Assessment. California's Fourth Climate Change Assessment*, California Energy Commission, Aug. 2018, www.energy.ca.gov/sites/default/files/2019-11/Projections_CCCA4-CEC-2018-006_ADA.pdf. Accessed 10 Sept. 2021.

39 *Landscape & Ecosystems*. County of Los Angeles County Open Data, data.lacounty.gov/stories/s/kryq-rey9. Accessed 10 Sept. 2021.

40 Parker, Sophie, et al. *Biodiversity Analysis in Los Angeles (BAILA)*. The Nature Conservancy and the Natural History Museum of Los Angeles County, Jul. 2019, www.scienceforconservation.org/assets/downloads/BAILAreport_FINAL.pdf. Accessed 10 Sept. 2021.

41 Hall, et al., 2018.

42 Gruber, Nicolas, et al. "Rapid Progression of Ocean Acidification in the California Current System." *Science*, vol. 337, no. 6091, pp. 220–23, www.science.org/doi/abs/10.1126/science.1216773. Accessed 10 Sept. 2021.

43 Sandel, Brody and Emily M. Dangremond. *Climate change and the invasion of California by grasses*. Global Change Biology, 21 Jun. 2011. https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2011.02480.x. Accessed 6 Oct. 2021.

44 Trumble, John T. and Casey D. Butler. *Climate change will exacerbate California's insect pest problems*. California Agriculture 63(2):73-78, 1 Apr. 2009. https://calag.ucanr.edu/Archive/?article=ca.v063n02p73. Accessed 6 Oct. 2021.

45 *What Climate Change Means for California*. EPA 430-F-16-007, U.S. Environmental Protection Agency, Aug. 2016, www.epa.gov/sites/production/files/2016-09/documents/climate-change-ca.pdf. Accessed 10 Sept. 2021.

46 Hall, et al., 2018.

47 *Vector-Borne Diseases*. World Health Organization, 2 Mar. 2020, www.who.int/news-room/fact-sheets/detail/vector-borne-diseases. Accessed 10 Sept. 2021.

48 Hall, et al., 2018.

49 West Nile Virus." *Acute Communicable Disease Control: 2016 Annual Morbidity Report*. County of Los Angeles, Department of Public Health, 2016, publichealth.lacounty.gov/acd/Diseases/WNV.pdf. Accessed 10 Sept. 2021.

50 *Zika: What Californians Need to Know*. California Department of Public Health, www.cdph.ca.gov/Programs/CID/DCDC/Pages/Zika.aspx. Accessed 10 Sept. 2021.

51 Campbell, Lindsay P., et al. "Climate Change Influences on Global Distributions of Dengue and Chikungunya Virus Vectors." *Philosophical Transactions B*, vol. 370, no. 1665, www.ncbi.nlm.nih.gov/pmc/articles/PMC4342968. Accessed 10 Sept. 2021.

52 *Rainfall and Landslides in Southern California*. U.S. Geological Survey, www.usgs.gov/natural-hazards/landslide-hazards/science/rainfall-and-landslides-southern-california?qt-science_center_objects=0#qt-science_center_objects. Accessed 10 Sept. 2021.

53 Kirschbaum, Dalia, and Thomas Stanley. "Satellite-Based Assessment of Rainfall-Triggered Landslide Hazard for Situational Awareness." *Earth's Future*, vol. 6, no. 3, Mar. 2018, pp. 505–23, agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017EF000715. Accessed 10 Sept. 2021.

54 Ong, Paul, et al. *Los Angeles County 2020 Census Response Rate Falling Behind 11 Percentage Points and a Third of a Million Lower than 2010*. UCLA Luskin School of Public Affairs and UCLA Center for Neighborhood Knowledge, 7 May 2020, escholarship.org/uc/item/3v38054w. Accessed 10 Sept. 2021.

55 "NALEO Educational Fund Statement on Release of 2020 Census Redistricting Data." *NALEO Educational Fund*, 12 Aug 2021, naleo.org/wp-content/uploads/2021/08/8_12_2021_-_NEF_Release_-_Census_Legacy_Data_Part_1_-_Final.pdf. Press release.

56 *11 Terms You Should Know to Better Understand Structural Racism*. Aspen Institute, 11 Jul. 2016, www.aspeninstitute.org/blog-posts/structural-racism-definition. Accessed 10 Sept. 2021.

57 Haughwout, Andrew, et al. *Inequality in U.S. Homeownership Rates by Race and Ethnicity*. Federal Reserve Bank of New York, Liberty Street Economics, 8 Jul. 2020, libertystreeteconomics.newyorkfed.org/2020/07/inequality-in-us-homeownership-rates-by-race-and-ethnicity. Accessed 10 Sept. 2021.

58 Howell, Junia, and James R. Elliott. "As Disaster Costs Rise, So Does Inequality." *Socius: Sociological Research for a Dynamic World*, vol. 4, nos. 1–3, 2018, journals.sagepub.com/doi/pdf/10.1177/2378023118816795. Accessed 10 Sept. 2021.

59 *Los Angeles City/County Native American Indian Commission*, lanaic.lacounty.gov. Accessed 10 Sept. 2021.

60 *Extreme Heat*. Ready, www.ready.gov/heat. Accessed 10 Sept. 2021.

61 Joe, Lauren, et al. "Mortality During a Large-Scale Heat Wave by Place, Demographic Group, Internal and External Causes of Death, and Building Climate Zone." *International Journal of Environmental Research and Public Health*, vol. 13, no. 3, Mar. 2016, p. 299, www.ncbi.nlm.nih.gov/pmc/articles/PMC4808962. Accessed 10 Sept. 2021.

62 *Climate Change and the Health of People with Existing Medical Conditions*. 430-F-16-059, U.S. Environmental Protection Agency. May 2016, www.cmu.edu/steinbrenner/EPA%20Factsheets/existing-conditions-health-climate-change.pdf. Accessed 10 Sept. 2021.

63 Poumadère, Marc, et al. "The 2003 Heat Wave in France: Dangerous Climate Change Here and Now." *Risk Analysis*, vol. 25, no. 6, Dec. 2005, pp. 1483–94, onlinelibrary.wiley.com/doi/abs/10.1111/j.1539-6924.2005.00694.x. Accessed 10 Sept. 2021.

64 Knowlton, Kim, et al. "The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits." *Environmental Health Perspectives*, vol. 117, no. 1, 2009, pp. 61–7, ehp.niehs.nih.gov/doi/10.1289/ehp.11594. Accessed 10 Sept. 2021.

65 Bekkar, Bruce, et al. “Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review.” *JAMA Network Open*, vol. 3, no. 6, 2020, jamanetwork.com/journals/jamanetworkopen/fullarticle/2767260. Accessed 10 Sept. 2021.

66 Basu, Rupa, et al. “Temperature and Term Low Birth Weight in California.” *American Journal of Epidemiology*, vol. 187, no. 11, Nov. 2018, pp. 2306–14, https://pubmed.ncbi.nlm.nih.gov/29901701/. Accessed 10 Sept. 2021.

67 Burke, Marshall, et al. “Higher Temperatures Increase Suicide Rates in the United States and Mexico.” *Nature Climate Change*, vol. 8, 2018, pp. 723–29, www.nature.com/articles/s41558-018-0222-x. Accessed 10 Sept. 2021.

68 Basu, Rupa, et al. “Examining the Association Between Apparent Temperature and Mental Health-Related Emergency Room Visits in California.” *American Journal of Epidemiology*, vol. 187, no. 4, Apr. 2018, pp. 726–35, academic.oup.com/aje/article/187/4/726/4081578. Accessed 10 Sept. 2021.

69 Cedeño Laurent, Jose Guillermo, et al. “Reduced Cognitive Function During a Heat Wave Among Residents of Non–Air-Conditioned Buildings: An Observational Study of Young Adults in the Summer of 2016.” *PLoS Medicine*, vol. 15, no. 7, 10 Jul. 2018, journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1002605. Accessed 10 Sept. 2021.

70 Riley, Kevin, et al. “Mortality and Morbidity During Extreme Heat Events and Prevalence of Outdoor Work: An Analysis of Community-Level Data from Los Angeles County, California.” *International Journal of Environmental Research and Public Health*, vol. 15, no. 4, 2018, p. 580, www.mdpi.com/1660-4601/15/4/580. Accessed 10 Sept. 2021.

71 Sarofim, Marcus C., et al. “2: Temperature-Related Death and Illness.” *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, edited by A. Crimmins et al., U.S. Global Change Research Program, 2016, pp .43–68, https://www.researchgate.net/publication/299864019_Ch_2_Temperature-Related_Death_and_Illness. Accessed 10 Sept. 2021.

72 Cal-Adapt

73 Hoffman, Jeremy S., et al. “The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas.” *Climate*, vol. 8, no. 1, 2020, p. 12, www.mdpi.com/2225-1154/8/1/12/htm. Accessed 10 Sept. 2021.

74 Browning, Christopher R., et al. “Neighborhood Social Processes, Physical Conditions, and Disaster-Related Mortality: The Case of the 1995 Chicago Heat Wave.” *American Sociological Review*, vol. 71, no. 4, 1 Aug. 2006, pp. 661–78, journals.sagepub.com/doi/10.1177/000312240607100407. Accessed 10 Sept. 2021.

75 Basu, Rupa. “High Ambient Temperature and Mortality: A Review of Epidemiologic Studies from 2001 to 2008.” *Environmental Health*, vol. 8, no. 40, 2009, ehjournal.biomedcentral.com/articles/10.1186/1476-069X-8-40. Accessed 10 Sept. 2021.

76 Melillo, Jerry M., et al., editors. *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, Subcommittee on Global Change Research, 2014, data.globalchange.gov/report/nca3. Accessed 10 Sept. 2021.

77 Park, R. Jisung, et al. "Heat and Learning." *American Economic Journal: Economic Policy*, vol. 12, no. 2, May 2020, pp. 306–39, www.aeaweb.org/articles?id=10.1257%2Fpol.20180612. Accessed 10 Sept. 2021.

78 Kovats, R. Sari, and Shakoor Hajat. "Heat Stress and Public Health: A Critical Review." *Annual Review of Public Health*, vol. 29, 2008, pp. 41–55, pubmed.ncbi.nlm.nih.gov/18031221. Accessed 10 Sept. 2021.

79 Page, Lucy, and Stephen Sheppard. "Heat Stress: The Impact of Ambient Temperature on Occupational Injuries in the US." *Department of Economics Working Papers 2016-16*, published by Department of Economics, Williams College, 2016, ideas.repec.org/p/wil/wileco/2016-16.html. Accessed 10 Sept. 2021.

80 Zivin, Joshua Graff, and Matthew Neidell. "The Impact of Pollution on Worker Productivity." *American Economic Review*, vol. 102, no. 7, Dec. 2012, pp. 3652–73, www.aeaweb.org/articles?id=10.1257/aer.102.7.3652. Accessed 10 Sept. 2021.

81 He, Jiaxiu, et al. "Severe Air Pollution and Labor Productivity: Evidence from Industrial Towns in China." *American Economic Journal: Applied Economics*, vol. 11, no. 11, Jan. 2019, pp. 173–201, www.aeaweb.org/articles?id=10.1257/app.20170286. Accessed 10 Sept. 2021.

82 USC Dornsife LA Barometer. *Sustainability and Resilience Survey, Wave 2*. USC Dornsife Center for Economic and Social Research, 2021. https://uasdata.usc.edu/index.php. Accessed 6 Oct. 2021.

83 *Browse by O*NET Data: Work Context*. O*NET OnLine, www.onetonline.org/find/descriptor/browse/Work_Context. Accessed 10 Sept. 2021.

84 Fraser, Andrew M., et al. "Household Accessibility to Heat Refuges: Residential Air Conditioning, Public Cooled Space, and Walkability." *Environment and Planning B: Urban Analytics and City Science*, vol. 44, no. 6, 1 Nov. 2017, pp. 1036–55, journals.sagepub.com/doi/abs/10.1177/0265813516657342. Accessed 10 Sept. 2021.

85 *Los Angeles Countywide Comprehensive Parks & Recreation Needs Assessment*. Los Angeles County Department of Parks & Recreation, 9 May 2016, lacountyparkneeds.org/wp-content/uploads/2016/06/FinalReport.pdf. Accessed 10 Sept. 2021.

86 Bell, Simon, et al. *Greenspace and Quality of Life: A Critical Literature Review*. Greenspace Scotland, 2008, www.openspace.eca.ed.ac.uk/wp-content/uploads/2015/10/Greenspace-and-quality-of-life-a-critical-literature-review.pdf. Accessed 10 Sept. 2021.

87 *Los Angeles County Tree Canopy Assessment*. SavATree Consulting Group, University of Vermont Spatial Analysis Laboratory, TreePeople, and Loyola Marymount University Center for Urban Resilience, 2016.

88 Nahlik, Matthew J., et al. "Building Thermal Performance, Extreme Heat, and Climate Change." *Journal of Infrastructure Systems*, vol. 23, no. 3, Sept. 2017, https://ascelibrary.org/doi/10.1061/%28ASCE%29IS.1943-555X.0000349 . Accessed 10 Sept. 2021.

89 Buyung, Nurul Rezuana, and Abdul Naser Ghani. "Permeable Pavements and Its Contribution to Cooling Effect of Surrounding Temperature." *AIP Conference Preceedings*, vol. 1892, no. 1, 16 Oct. 2017, aip.scitation.org/doi/abs/10.1063/1.5005783. Accessed 10 Sept. 2021.

90 Westerling, A. L., et al. “Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity.” *Science*, vol. 313, no. 5789, 18 Aug. 2006, pp. 940–43, www.science.org/doi/full/10.1126/science.1128834. Accessed 10 Sept. 2021.

91 Ullrich, P. A., et al. “California's Drought of the Future: A Midcentury Recreation of the Exceptional Conditions of 2012–2017.” *Earth's Future*, vol. 6, no. 11, Nov. 2018, pp. 1568–87, agupubs.onlinelibrary.wiley.com/doi/10.1029/2018EF001007. Accessed 10 Sept. 2021.

92 Swain, Daniel L., et al. “Increasing Precipitation Volatility in Twenty-First-Century California.” *Nature Climate Change*, vol. 8, 2018, pp. 427–33, www.nature.com/articles/s41558-018-0140-y. Accessed 10 Sept. 2021.

93 Liu, Jia Coco, et al. “Particulate Air Pollution from Wildfires in the Western US Under Climate Change.” *Climatic Change*, vol. 138, no. 3, Oct. 2016, pp. 655–56, pubmed.ncbi.nlm.nih.gov/28642628. Accessed 10 Sept. 2021.

94 Cain, Josh, “Woolsey Fire Left Some Homeowners Fearful They Can't Stay in LA County,” *Los Angeles Daily News*, 7 Nov. 2019, www.dailynews.com/2019/11/07/the-woolsey-fire-hit-los-angeles-county-a-year-ago-and-left-some-homeowners-fearful-they-cant-stay. Accessed 10 Sept. 2021.

95 Agyapong, Vincent I. O., et al. “Long-Term Mental Health Effects of a Devastating Wildfire Are Amplified by Socio-Demographic and Clinical Antecedents in Elementary and High School Staff.” *Frontiers in Psychiatry*, vol. 11, May 2020, www.frontiersin.org/articles/10.3389/fpsyt.2020.00448/full. Accessed 10 Sept. 2021.

96 Gaughen, Shasta, et al. *Summary Report from Tribal and Indigenous Communities within California*. Governor's Office of Planning and Research, State of California Energy Commission, and California Natural Resources Agency, 2018, www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-010_TribalCommunitySummary_ADA.pdf. Accessed 10 Sept. 2021.

97 Eisenman, David P., et al. *Review of the Mental Health Effects of Wildfire Smoke, Solastalgia, and Non-Traditional Firefighters*. UCLA Center for Healthy Climate Solutions, UCLA David Geffen School of Medicine, and Climate Resolve. Mar. 2021, https://healthyclimatesolutions.org/wp-content/uploads/2021/07/REVIEW-OF-THE-MENTAL-HEALTH-EFFECTS-OF-WILDFIRE-SMOKE-SOLASTALGIA-AND-NON-TRADITIONAL-FIREFIGHTERS.pdf. Accessed 10 Sept. 2021.

98 Silveira, Sarita, et al. “Chronic Mental Health Sequelae of Climate Change Extremes: A Case Study of the Deadliest Californian Wildfire.” *International Journal of Environmental Research and Public Health*, vol. 18, no. 4, 2021, p. 1487, www.mdpi.com/1660-4601/18/4/1487/htm. Accessed 10 Sept. 2021.

99 Eisenman, et al., 2021.

98 *Bobcat*. InciWeb—Incident Information System, 17 Oct 2020, inciweb.nwcg.gov/incident/7152. Accessed 13 Mar. 2021.

101 Sahagún, Louis. "Bobcat Fire Aftermath Threatens Endangered Species in San Gabriel Mountains." *Los Angeles Times*, 14 Oct. 2020, www.latimes.com/environment/story/2020-10-14/fire-stripped-slopes-and-winter-storms-point-to-a-bleak-scenario-for-wildlife-in-the-san-gabriel-mountains. Accessed 4 Nov. 2020.

102 *Bobcat Fire Scorches Southern California*. NASA Earth Observatory, 21 Sept. 2020, earthobservatory.nasa.gov/images/147324/bobcat-fire-scorches-southern-california. Accessed November 4, 2020.

103 Taylor, Alan. "California's Fast-Moving Lake Fire." *The Atlantic*, 12 Aug. 2020, www.theatlantic.com/photo/2020/08/photos-californias-fast-moving-lake-fire/615232. Accessed 3 Sept. 2020.

104 *Lake Fire Morning Update*, August 28. InciWeb—Incident Information System, 28 Aug. 2020, inciweb.nwcg.gov/incident/article/6953/54241. Accessed 3 Sept. 2020.

105 *Lake Fire Incident Morning Update for August 15, 2020*. InciWeb—Incident Information System, 15 Aug. 2020. Accessed 2 Sept. 2020.

106 Lunetta, Caleb. "Tick Fire Update: Number of Structures Destroyed Jumps to 18, 3 Firefighters Injured." *The Signal: Santa Clarita Valley*, 26 Oct. 2019, signalscv.com/2019/10/tick-fire-update-number-of-structures-destroyed-jumps-to-18-3-firefighters-injured. Accessed 20 Nov. 2019.

107 Austin, Paige. "Tick Fire Containment Grows, Wind Shifts Pose Challenge." *Patch*, 25 Oct. 2019, patch.com/california/northhollywood/canyon-country-fire-hops-freeway-forcing-thousands-flee. Accessed 20 Nov. 2019.

108 "SoCal Edison Cut Power to Agua Dulce Before Fast-Moving Tick Fire Erupted in Area." KTLA 5, 24 Oct. 2019, ktla.com/news/local-news/socal-edison-cut-power-to-agua-dulce-before-fast-moving-tick-fire-erupted-in-area. Accessed 20 Nov. 2019.

109 "TICK FIRE EVACUATION MAP: Residents Return Home, Others Remain Under Mandatory Evacuations as Blaze Rages." ABC 7 staff, 27 Oct. 2019, abc7.com/santa-clarita-fire-in-agua-dulce-canyon-county-map/5646199. Accessed 20 Nov. 2019.

110 *Saddle Ridge Brush Fire*. Los Angeles Fire Department, 10 Oct. 2019, www.lafd.org/news/saddle-ridge-brush-fire. Accessed 3 Nov. 2019.

111 Fausto, Alma, and Ariella Plachta. "Saddleridge Fire in Sylmar Races Through 7,500 Acres, with Homes Burned, 1 Dead and Only 13% Containment." *Los Angeles Daily News*, 11 Oct. 2019, www.dailynews.com/2019/10/11/saddleridge-blaze-in-sylmar-spreads-to-4000-acres-burning-homes-forcing-evacuations. Accessed 11 Oct. 2019.

112 Los Angeles County. *After Action Review of the Woolsey Fire Incident*. Citygate Associates, LLC, 17 Nov. 2019, www.citygateassociates.com/wp-content/uploads/2019/11/Citygate-After-Action-Review-of-the-Woolsey-Fire-Incident-11-17-19.pdf. Accessed 7 Nov. 2020.

113 Pamer, Melissa, and Doug Kolk. "Western Town at Paramount Ranch, Filming Location Since 1927, Burns in Woolsey Fire: NPS." KTLA 5, 9 Nov. 2018, ktla.com/news/local-news/western-town-at-paramount-ranch-filming-location-since-1927-burned-in-woolsey-fire-nps. Accessed 10 Nov. 2018.

114 Holland, Emily. "$6 Billion in Real Estate Destroyed in Woolsey Fire: Report." *Patch,* 28 Nov. 2018, patch.com/california/malibu/6-billion-real-estate-destroyed-woolsey-fire-report. Accessed 1 Sept. 2020.

115 *Creek Fire: Incident Overview*. InciWeb—Incident Information System, 14 Dec. 2020, inciweb.nwcg.gov/incident/7147. Accessed 10 Sept. 2021.

116 Los Angeles County, 2019.

117 "More than 400 Schools in LA Closed Because of Wildfires." KPCC, 8 Dec. 2017, archive.kpcc.org/news/2017/12/08/78596/la-schools-closed-wildfire. Accessed 8 Dec. 2017.

118 *Rye Fire*. CAL FIRE, 18 Jan. 2018, www.fire.ca.gov/incidents/2017/12/5/rye-fire/#incident-contacts. Accessed 10 Dec. 2017.

119 Etehad, Melissa, and Laura J. Nelson. "Rye Fire Spreads to 5,000 Acres, Triggers Evacuations and Gridlock in Santa Clarita." *Los Angeles Times*, 5 Dec. 2017, www.latimes.com/local/lanow/la-me-fire-santa-clarita-20171205-story.html. Accessed 8 Dec. 2017.

120 Valenzuela, Beatriz E. "The Rye Fire is 50 Percent Contained in Santa Clarita Area, Acreage Downgraded." *Press Enterprise*, 8 Dec. 2017, www.pe.com/2017/12/08/power-restored-to-all-santa-clarita-customers-affected-by-rye-fire. Accessed 8 Dec. 2017.

121 University of Southern California, Dana and David Dornsife College of Letters, Arts and Sciences, Center for Economic and Social Research, 2020.

122 Kenward, Alyson, et al. Wildfires and Air Pollution: *The Hidden Health Hazards of Climate Change*. Climate Central, 2013, assets.climatecentral.org/pdfs/WildfiresAndAirPollution.pdf. Accessed 10 Sept. 2021.

123 Liu, et al., 2016.

124 Jones, Gavin M., et al. "Megafires: An Emerging Threat to Old-Forest Species." *Frontiers in Ecology and the Environment*, vol. 14, no. 6, Aug. 2016, pp. 300–06, esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.1298. Accessed 10 Sept. 2021.

125 Cascio, 2018.

126 Naeher, et al., 2007.

127 Liu, et al., 2015.

128 Jiang, Xu-Qin, et al. "Air Pollution and Chronic Airway Diseases: What Should People Know and Do?" *Journal of Thoracic Disease*, vol. 8, no. 1, Jan. 2016, pp. E31–40, www.ncbi.nlm.nih.gov/pmc/articles/PMC4740163. Accessed 10 Sept. 2021.

129 Kollanus, Virpi, et al. "Mortality Due to Vegetation Fire-Originated PM2.5 Exposure in Europe-Assessment for the Years 2005 and 2008." *Environmental Health Perspectives*, vol. 125, no. 1, Jan. 2017, pp. 30–37, www.ncbi.nlm.nih.gov/pmc/articles/PMC5226696. Accessed 10 Sept. 2021.

130 Reid, Colleen E., et al. "Differential Respiratory Health Effects from the 2008 Northern California Wildfires: A Spatiotemporal Approach." *Environmental Research*, vol. 150, Oct. 2016, pp. 227–35, pubmed.ncbi.nlm.nih.gov/27318255. Accessed 10 Sept. 2021.

131 Haikerwal, Anjali, et al. "Impact of Fine Particulate Matter (PM2.5) Exposure During Wildfires on Cardiovascular Health Outcomes." *Journal of the American Heart Association*, vol. 4, no. 7, 15 Jul. 2015, pubmed.ncbi.nlm.nih.gov/26178402. Accessed 10 Sept. 2021.

132 Holstius, David M., et al. "Birth Weight Following Pregnancy During the 2003 Southern California Wildfires." *Environmental Health Perspectives*, vol. 120, no. 9, Sept. 2012, pp. 1340–45, www.ncbi.nlm.nih.gov/pmc/articles/PMC3440113. Accessed 10 Sept. 2021.

133 Bekkar, et al. 2020.

134 Currie, Janet, et al. "What Do We Know About Short- and Long-Term Effects of Early-Life Exposure to Pollution?" *Annual Review of Resource Economics*, vol. 6, Nov. 2014, pp. 217–47, www.annualreviews.org/doi/abs/10.1146/annurev-resource-100913-012610. Accessed 10 Sept. 2021.

135 Künzli, Nino, et al. "Health Effects of the 2003 Southern California Wildfires on Children." *American Journal of Respiratory and Critical Care Medicine*, vol. 174, no. 11, 1 Dec. 2006, pp. 1221–28, pubmed.ncbi.nlm.nih.gov/16946126. Accessed 10 Sept. 2021.

136 Lee, Byeong-Jae, et al. "Air Pollution Exposure and Cardiovascular Disease." *Toxicological Research*, vol. 30, no. 2, 2014, pp. 71–75, www.ncbi.nlm.nih.gov/pmc/articles/PMC4112067. Accessed 10 Sept. 2021.

137 Gaughen, et al., 2018.

138 *The Burden of Disease in Los Angeles County: A Study of the Patterns of Morbidity and Mortality in the County Population*. Los Angeles County Department of Health Services, the UCLA Center for Health Policy Research, Jan. 2000, www.publichealth.lacounty.gov/epi/docs/Disease_Burden_web.pdf. Accessed 10 Sept. 2021.

139 Logan, Erin B. "More Than 78,000 Southern California Edison Customers Lose Power as High Winds Increase Wildfire Risk." *Los Angeles Times*, 19 Jan. 2021, www.latimes.com/california/story/2021-01-19/southern-california-edison-power-shutoff-wildfire. Accessed 10 Sept. 2021.

140 Tong, Van T., et al. "Impact of the Red River Catastrophic Flood on Women Giving Birth in North Dakota, 1994–2000." *Maternal and Child Health Journal*, vol. 15, no. 3, Apr. 2011, pp. 281–88, pubmed.ncbi.nlm.nih.gov/20204482. Accessed April 8, 2021.

141 French, Clare E., et al. "Impact of Repeat Flooding on Mental Health and Health-Related Quality of Life: A Cross-Sectional Analysis of the English National Study of Flooding and Health." *BMJ Open*, vol. 9, no. 11, 2019, bmjopen.bmj.com/content/bmjopen/9/11/e031562.full.pdf. Accessed 10 Sept. 2021.

142 Stanke, Carla, et al. "The Effects of Flooding on Mental Health: Outcomes and Recommendations from a Review of the Literature." *PLoS Current Disasters*, 30 May 2012, currents.plos.org/disasters/index.html%3Fp=1947.html. Accessed 10 Sept. 2021.

143 *LA River Master Plan at a Glance*, d3n8a8pro7vhmx.cloudfront.net/larmp/pages/351/attachments/original/1609861576/LARMP_At-A-Glance_PUBLIC_DRAFT.pdf?1609861576. Accessed 10 Sept. 2021.

144 Luciano Paul, et al. *Report on the Viability and Disaster Resilience of Mobile Home Ownership and Parks*. Vermont Department of Housing and Community Development, Dec. 2013, accd.vermont.gov/sites/accdnew/files/documents/H-MHP-Report-mobile-home-viability-report.pdf. Accessed 10 Sept. 2021.

145 Rumbach, Andrew, et al. “Mobile Home Parks and Disasters: Understanding Risk to the Third Housing Type in the United States.” *Natural Hazards Review*, vol. 21, no. 2, May 2020, ascelibrary.org/doi/abs/10.1061/%28ASCE%29NH.1527-6996.0000357. Accessed 10 Sept. 2021.

146 Reid-Wainscoat, Elizabeth, et al. *2021 Sustainable LA Grand Challenge Sustainability Report Card for Los Angeles County Ecosystem Health*. UCLA: Sustainable LA Grand Challenge, 2021, escholarship.org/uc/item/117326k1. Accessed 10 Sept. 2021.

147 Vitousek, Sean, et al., “A Model Integrating Longshore and Cross-Shore Processes for Predicting Long-Term Shoreline Response to Climate Change.” *Journal of Geophysical Research: Earth Surface*, vol. 122, 2017, pp. 782–806, agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016JF004065. Accessed 10 Sept. 2021.

148 *State of California Sea-Level Rise Guidance. California Ocean Protection Council*, 2018, opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf. Accessed 10 Sept. 2021.

149 Link, Bruce G., and Jo Phelan. “Social Conditions as Fundamental Causes of Disease.” *Journal of Health and Social Behavior*, 1995, pp. 80–94, pubmed.ncbi.nlm.nih.gov/7560851. Accessed 10 Sept. 2021.

150 Brooks-Gunn, Jeanne, and Greg J. Duncan. “The Effects of Poverty on Children.” *Future of Children*, vol. 7, no. 2, summer–autumn 1997, pp. 55–71, www.jstor.org/stable/1602387?seq=1#metadata_info_tab_contents. Accessed 10 Sept. 2021.

151 *Social Determinants of Health*. Healthy People 2030, health.gov/healthypeople/objectives-and-data/social-determinants-health. Accessed March 22, 2021.

152 DeShazo, J. R., et al. *Los Angeles County Community Water Systems: Atlas and Policy Guide*. UCLA Luskin Center for Innovation, Nov. 2015, https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/LA_County_Community_Water_Systems.pdf. Accessed 10 Sept. 2021.

153 Gleick, Peter H. *Impacts of California’s Ongoing Drought: Hydroelectricity Generation*. Pacific Institute, 2015, pacinst.org/wp-content/uploads/2015/03/California-Drought-and-Energy-Final1-1.pdf. Accessed 10 Sept. 2021.

154 Gleick, 2015.

155 *Valley Fever (Coccidioidomycosis)*. Centers for Disease Control and Prevention, 29 Dec. 2021. https://www.cdc.gov/fungal/diseases/coccidioidomycosis/index.html. Accessed 4 Oct. 2021.

156 *Valley Fever (Coccidioidomycosis) Statistics*. Centers for Disease Control and Prevention, 30 Jun. 2021, www.cdc.gov/fungal/diseases/coccidioidomycosis/statistics.html. Accessed 10 Sept. 2021.

157 *Coccidioidomycosis in California - Provisional Monthly report,* January – August 2021. California Department of Public Health, 31 Aug. 2021. https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/CocciinCAProvisionalMonthlyReport.pdf. Accessed 4 Oct. 2021.

158 *Acute Communicable Disease Control: Coccidioidomycosis*. County of Los Angeles Public Health, publichealth.lacounty.gov/acd/Diseases/Cocci.htm. Accessed 10 Sept. 2021.

159 *Valley Fever (Coccidioidomycosis) Frequently Asked Questions (FAQ)*. Los Angeles County Department of Public Health, 3 Aug. 2015. http://publichealth.lacounty.gov/hea/library/topics/valleyfever/CDCP-ACDC-0037-01.pdf. Accessed 4 Oct. 2021.

160 Howitt, Richard, et al. *Economic Analysis of the 2014 Drought for California Agriculture*. Center for Watershed Sciences, University of California, Davis, 23 Jul. 2014, watershed.ucdavis.edu/files/biblio/DroughtReport_23July2014_0.pdf. Accessed 10 Sept. 2021.

161 *American Community Survey 2015–2019 5-Year Data Release*. United States Census Bureau, 10 Dec. 2020, www.census.gov/newsroom/press-kits/2020/acs-5-year.html. Accessed 10 Sept. 2021.

162 *American Community Survey 2015–2019 5-Year Data Release*, 2020.

163 Feinstein, Laura, et al. *Drought and Equity in California*. Pacific Institute, the Environmental Justice Coalition for Water, Jan. 2017, pacinst.org/wp-content/uploads/2017/01/PI_DroughtAndEquityInCA_Jan_2017.pdf. Accessed 10 Sept. 2021.

164 *Final: Root Cause Analysis: Mid-August 2020 Extreme Heat Wave*. California Independent System Operator, California Public Utilities Commission, California Energy Commission, 13 Jan. 2021, www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf. Accessed January 13, 2021.

165 Fazio, Marie. “Heat Wave Roasts Southern California with Record of 121 Degrees.” *New York Times*, 7 Sept. 2020, www.nytimes.com/article/california-weather.html. Accessed September 7, 2020.

166 Thorne, James H., et al. *A Climate Change Vulnerability Assessment of California’s Terrestrial Vegetation*. California Department of Fish and Wildlife, and the University of California, Davis, Jan. 2016, lccnetwork.org/sites/default/files/Resources/California%20Climate%20Vulnerability%20Assessment%20of%20Macrogroup%20Vegetation_01.31.2016_FINAL.pdf. Accessed 10 Sept. 2021.

167 Burillo, Daniel et al. Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat. California Energy Commission, Aug. 2018. https://www.energy.ca.gov/sites/default/files/2019-11/Energy_CCCA4-CEC-2018-013_ADA.pdf. Accessed 6 Oct. 2021.

168 Anshul. “The Effect of Temperature on Solar Panel Efficiency.” *Alternative Energy Sources*, alternativeenergysourcesv.com/effect-of-temperature-on-solar-panel-efficiency. Accessed 10 Sept. 2021.

169 *Final: Root Cause Analysis: Mid-August 2020* Extreme Heat Wave, 2021.

170 *Adapting the Energy Sector to Climate Change*. International Atomic Energy Agency, 2019, www-pub.iaea.org/MTCD/Publications/PDF/P1847_web.pdf. Accessed 10 Sept. 2021.

171 McKenzie, Donald, et al. “Chapter 15: Global Warming and Stress Complexes in Forests of Western North America.” *Developments in Environmental Sciences*, vol. 8, Wildland Fires and Air Pollution, edited by Andrzej Bytnerowicz, et al., pp. 319–37, www.sciencedirect.com/science/article/abs/pii/S1474817708000156?via%3Dihub. Accessed 10 Sept. 2021.

172 Shepherd, Marshall. “The Science of Why It’s Too Hot For Some Planes to Fly In The Southwest U.S.” *Forbes*, 20 Jun. 2017, www.forbes.com/sites/marshallshepherd/2017/06/20/the-science-of-why-its-too-hot-for-some-planes-to-fly-in-the-southwest-u-s/?sh=4de8cf2754ce. Accessed 10 Sept. 2021.

173 Colicchio, Lisa, and Metrolink Green Team. *Metrolink Climate Action Plan: A Link to a Zero Emissions Future*. Metrolink, 26 Mar. 2021, metrolinktrains.com/globalassets/about/agency/sustainability/climate-action-plan.pdf. Accessed 10 Sept. 2021.

174 Peterson, Thomas C., et al. ”Changes in Weather and Climate Extremes: State of Knowledge Relevant to Air and Water Quality in the United States.” *Journal of the Air & Waste Management Association*, vol. 64, no. 2, 2014, pp. 184–97, www.tandfonline.com/doi/full/10.1080/10962247.2013.851044#.UnpxinDkseg. Accessed 10 Sept. 2021.

175 Burt, Kory, et al. *Evaporation: An Analysis of the California State Water Project’s Efficiency*. UC Davis Water Management, spring 2015, watermanagement.ucdavis.edu/files/4114/3891/2385/A01_Burt_Good_Shachar_Pascual_ESM121_FinalReport.pdf. Accessed 10 Sept. 2021.

176 Smith, Kandler, et al. *Life Prediction Model for Grid Connected Li-ion Battery Energy Storage System*. National Renewable Energy Laboratory, Aug. 2017, www.nrel.gov/docs/fy17osti/67102.pdf. Accessed 10 Sept. 2021.

177 Bartos, Matthew D., and Mikhail V. Chester. “Impacts of Climate Change on Electric Power Supply in the Western United States.” *Nature Climate Change*, vol. 5, no. 8, 2015, pp. 748–52, www.nature.com/articles/nclimate2648. Accessed 10 Sept. 2021.

178 Hirsch, Adam, et al. “Microgrids: A Review of Technologies, Key Drivers, and Outstanding Issues.” *Renewable and Sustainable Energy Reviews*, vol. 90, Jul. 2018, www.sciencedirect.com/science/article/pii/S136403211830128X?via%3Dihub. Accessed 10 Sept. 2021.

179 Nahlik, Matthew J., et al. “Building Thermal Performance, Extreme Heat, and Climate Change.” *Journal of Infrastructure Systems*, vol. 23, no. 3, 2017, pp. 402–11, www.sciencedirect.com/science/article/pii/S136403211830128X?via%3Dihub. Accessed 10 Sept. 2021.

180 *Assessor Parcels Data - 2019*. County of Los Angeles County Open Data, data.lacounty.gov/Parcel-/Assessor-Parcels-Data-2019/csig-gtr7. Accessed 10 Sept. 2021.

181 Chen, Mo, et al. "Utilizing Smart-Meter Data to Project Impacts of Urban Warming on Residential Electricity Use for Vulnerable Populations in Southern California.” *Environmental Research Letters*, vol. 15, no. 6, 19 May 2020, iopscience.iop.org/article/10.1088/1748-9326/ab6fbe. Accessed 10 Sept. 2021.

182 Borunda, Alejandra. “In California, Extreme Heat and Ozone Pollution Hit Poor Communities the Hardest.” *National Geographic*, 25 May 2021, www.nationalgeographic.com/environment/article/-in-california-extreme-heat-and-ozone-pollution-hit-poor-communities-hardest. Accessed 10 Sept. 2021.

183 Los Angeles County, 2019.

184 *Woolsey Fire*. Cal Fire, 25 Oct. 2019, www.fire.ca.gov/incidents/2018/11/8/woolsey-fire. Accessed 10 Sept. 2021.

185 ”Crucial Communication Proves Difficult as Wildries Knock Out Cell Towers.” CBS News, 11 Oct. 2017, www.cbsnews.com/news/northern-california-wildfires-cell-towers. Accessed 10 Sept. 2021.

186 *Decision Adopting Wireless Provider Resiliency Strategies*. Rulemaking 18-03-011, Before the Public Utilities Commission of the State of California, 16 Jul. 2020, docs.cpuc.ca.gov/PublishedDocs/Published/G000/M344/K021/344021480.PDF. Accessed 10 Sept. 2021.

187 Anderson, Scott, et al. “Five Alarms: Assessing the Vulnerability of US Cellular Communication Infrastructure to Wildfires.” *IMC '20: Proceedings of the Association for Computing Machinery Internet Measurement Conference*, Oct. 2020, pages.cs.wisc.edu/~pb/wildfires_final.pdf. Accessed 10 Sept. 2021.

188 *Decision Adopting Wireless Provider Resiliency Strategies*, 2020.

189 Beland, Deanna. *Sustainability Roadmap 2020–2021 California Department of Corrections and Rehabilitation: Progress Report and Plan for Meeting the Governor's Sustainability Goals for California State Agencies*. California Department of Corrections and Rehabiliation, 2020, www.cdcr.ca.gov/green/wp-content/uploads/sites/176/2020/04/R_2020-21-CDCR-Sustainability-Roadmap-FINAL-Electronic-Signature.pdf. Accessed 10 Sept. 2021.

190 Sathaye, Jayant, et al. *Estimating Risk to California Energy Infrastructure from Projected Climate Change*. Lawrence Berkeley National Laboratory, 2011, www.osti.gov/servlets/purl/1026811. Accessed 11 Sept. 2021.

191 *Statement of Los Angeles Mayor Eric Garcetti Before the Senate Committee on Environment and Public Works Hearing on “Building Back Better: Addressing Climate Change in the Electricity Sector and Fostering Economic Growth.”* 10 Mar. 2021, www.epw.senate.gov/public/_cache/files/2/6/26ee3417-f991-4f6c-a5c4-a90730ae249e/C4CC21D0AF57629C3C5EF7DA566BC6B4.garcetti-testimony-03-10-2021.pdf. Accessed 11 Sept. 2021.

192 *Statement of Los Angeles Mayor Eric Garcetti Before the Senate Committee on Environment and Public Works Hearing on “Building Back Better: Addressing Climate Change in the Electricity Sector and Fostering Economic Growth*,” 2021.

193 Meixner, Tom, and Pete Wohlgemuth. “Wildfire Impacts on Water Quality.” *Southwest Hydrology*, Sept./Oct. 2004, swhydro.arizona.edu/archive/V3_N5/feature7.pdf. Accessed 11 Sept. 2021.

194 Smith, Deborah J., and Céline Gallon. *Los Angeles Region Framework for Climate Change Adaptation and Mitigation: Current State of Knowledge & Water Quality Regulatory Program Considerations*. Los Angeles Regional Water Quality Control Board, Jul. 2015. www.waterboards.ca.gov/losangeles/water_issues/programs/climate_change/docs/2015/Climatechange-frameworkforclimatechangeadaptation-final7-20-2015.pdf. Accessed 11 Sept. 2021.

195 *Bobcat Fire Emergency Reservoir Restoration Projects*. Los Angeles County Department of Public Works, 26 Apr. 2021, pw.lacounty.gov/wrd/Projects/Bobcatfire. Accessed 11 Sept. 2021.

196 Scott, Joe H., et al. “Wildfire Risk to Communities: Spatial Datasets of Landscape-Wide Wildfire Risk Components for the United States.” Forest Service Research Data Archive, updated 25 Nov. 2020, www.fs.usda.gov/rds/archive/Catalog/RDS-2020-0016. Accessed 10 Sept. 2021.

197 *FACT SHEET: Wildland-Urban Interface Building Codes*. California Department of Forestry and Fire Protection, Office of the State Fire Marshal, May 2007, www.sccgov.org/sites/dpd/DocsForms/Documents/WUI_Construction_FactSheet.pdf. Accessed 10 Sept. 2021.

198 Berlin, Jeremy. “Meet the Wildfire Superspreaders.” *National Geographic*, 13 Oct. 2020, www.nationalgeographic.com/science/article/meet-the-wildfire-superspreaders-embers. Accessed 10 Sept. 2021.

199 Kasler, Dale, and Phillip Reese.“‘The Weakest Link’: Why Your House May Burn While Your Neighbor’s Survives the Next Wildfire.” *The Sacramento Bee*, 11 Apr. 2019, www.sacbee.com/news/california/fires/article227665284.html. Accessed 10 Sept. 2021.

200 Assembly Bill 3074. *Fire Prevention: Wildfire Risk: Defensible Space: Ember-Resistant Zones*. California Legislative Infomation, 30 Sept. 2020, leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB3074. Accessed 10 Sept. 2021.

201 Senate Bill 109. *Department of Forestry and Fire Protection: Office of Wildfire Technology Research and Development*. California Legislative Information, 8 Sept. 2021, leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB109. Accessed 10 Sept. 2021.

202 Assembly Bill 38. *Fire Safety: Low-Cost Retrofits: Regional Capacity Review, Wildfire Mitigation*. California Legislative Information, 2 Oct. 2019, https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB38. Accessed 10 Sept. 2021.

203 Peters, Jessica. *The 2020–21 Budget: Governor’s Wildfire-Related Proposals*. Legislative Analyst’s Office, 21 Feb. 2020, lao.ca.gov/Publications/Report/4172. Accessed 10 Sept. 2021.

204 *FloodFactor: Los Angeles County, California*. First Street Foundation, floodfactor.com/county/los-angeles-county-california/6037_fsid. Accessed 11 Sept. 2021.

205 Boggess, J. M., et al. "Storm & Flood Hardening of Electrical Substations" IEEE 2014 T&D Conference Paper 14TD0564, 2014. https://www.ieee-pes.org/presentations/td2014/td2014p-000564.pdf. Accessed 23 August. 2021.

206 Guenther, Robin, and John Balbus. *Primary Protection: Enhancing Health Care Resilience for a Changing Climate: A Best Practives Document under the HHS Sustainable and Climate Resilient Health Care Facilities Initiative*. U.S. Department of Health and Human Services, Dec. 2014. toolkit.climate.gov/sites/default/files/SCRHCFI%20Best%20Practices%20Report%20final2%202014%20Web.pdf. Accessed 11 Sept. 2021.

207 Blumenthal, David, and Shanoor Seervai. “To Be High Performing, the U.S. Health System Will Need to Adapt to Climate Change.” The Commonwealth Fund, 18 Apr. 2018, www.commonwealthfund.org/blog/2018/be-high-performing-us-health-system-will-need-adapt-climate-change. Accessed 11 Sept. 2021.

208 Dalton, Andrew, and Tami Abdollah. ”Flood Destroys Bridge, Severs Interstate 10 in Southern California.” KQED, 20 Jul. 2015, www.kqed.org/news/10608238/flood-destroys-bridge-severs-interstate-10-in-southern-california. Accessed 11 Sept. 2021.

209 Environmental Compliance and Sustainability Department. *Metro Climate Action and Adaptation Plan 2019*. Los Angeles County Metropolitan Transportation Authority (Metro), 2019, media.metro.net/projects_studies/sustainability/images/Climate_Action_Plan.pdf. Accessed 11 Sept. 2021.

210 Colicchio, Lisa, and Metrolink Green Team, 2021.

211 "Storm Slams Southern California: Expect More Flooding and Thunderstorms." *Los Angeles Times*, 23 Jan. 2017, www.latimes.com/local/california/la-me-live-winter-weather-california-20170106-htmlstory.html. Accessed 11 Sept. 2021.

212 Los Angeles County Flood Control District. *Section 2: Existing Facilities*. Los Angeles County Department of Public Works, 2013, dpw.lacounty.gov/lacfcd/sediment/dcon/421.pdf. Accessed 11 Sept. 2021.

213 Simes, Jack, et al. *Summary Report: Los Angeles Basin Study*. U.S. Department of the Interior and County of Los Angeles Department of Public Works, Nov. 2016, www.usbr.gov/watersmart/bsp/docs/fy2017/LABasinStudySummaryReport.pdf. Accessed 11 Sept. 2021.

214 "Emergency Assessment of Post-Fire Debris-Flow Hazards." U.S. Geological Survey, landslides.usgs.gov/hazards/postfire_debrisflow/detail.php?objectid=254. Accessed 11 Sept. 2021.

215 Shamberg, Caitlin. "After the Fire, Getty Works to Protect Hillsides and Neighbors." *The Iris*, J. Paul Getty Trust, 18 Dec. 2019, blogs.getty.edu/iris/after-the-fire-getty-works-to-protect-hillsides-and-neighbors. Accessed 11 Sept. 2021.

216 Chester, Mikhail V., and Rui Li. *Vulnerability of California Roadways to Post-Wildfire Debris Flow*. UC-ITS-2020-38, UCLA Institute of Transportation Studies, Jul. 2020, escholarship.org/uc/item/60d0k700, Accessed 11 Sept. 2021.

217 Hall, et al., 2018.

218 Hall, et al., 2018.

219 Hall, et al., 2018.

220 Wong, Garrett. *City of Santa Monica Climate Action & Adaptation Plan: A 2030 Community Plan to Reduce Carbon Emission & Become Climate Resilient*. City of Santa Monica, May 2019, www.smgov.net/uploadedFiles/Departments/OSE/Climate/CAAP_SantaMonica.PDF. Accessed 11 Sept. 2021.

221 *Transportation System: Goods Movement, Technical Report*. Southern California Association of Governments, 3 Sept. 2020, scag.ca.gov/sites/main/files/file-attachments/0903fconnectsocal_goods-movement.pdf. Accessed 11 Sept. 2021.

222 Grifman, Phyllis, et al. *Sea Level Rise Vulnerability Study for the City of Los Angeles*. USCSG-TR-05-2013,University of Southern California Sea Grant Program, 2013, dornsife.usc.edu/assets/sites/291/docs/pdfs/SeaLevelRiseDocs/City_of_LA_SLR_Vulnerability_Study_FINAL_Online_w_appen_sm.pdf. Accessed 11 Sept. 2021.

223 Lund, Jay, et al. "Lessons from California's 2012–2016 Drought." *Journal of Water Resources Planning and Management*, vol. 144, no. 10, Oct. 2018,ascelibrary.org/doi/10.1061/%28ASCE%29WR.1943-5452.0000984. Accessed 11 Sept. 2021.

224 Bedsworth, Louise, et al. *Statewide Summary Report*. California's Fourth Climate Change Assessment, Governor's Office of Planning and Research, State of California Energy Commission, and California Natural Resources Agency,Aug. 2018, www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf. Accessed 11 Sept. 2021.

225 Cook, Benjamin I., et al. "Unprecedented 21st Century Drought Risk in the American Southwest and Central Plains." *Science Advances*, vol. 1, no. 1, 12 Feb. 2015, www.science.org/doi/10.1126/sciadv.1400082. Accessed 11 Sept. 2021.

226 Governor Newsom Takes Action to Respond to Drought Conditions. Office of Governor Gavin Newsom. 21 Apr. 2021. https://www.gov.ca.gov/2021/04/21/governor-newsom-takes-action-to-respond-to-drought-conditions/. Accessed 6 Oct. 2021.

227 Fountain, Henry. "In a First, U.S. Declares Shortage on Colorado River, Forcing Water Cuts." New York Times. 16 Aug. 2021. https://www.nytimes.com/2021/08/16/climate/colorado-river-water-cuts.html. Accessed 6 Oct. 2021.

228 Simes, et al., 2016.

229 Staff discussion. County of Los Angeles Department of Parks and Recreation meeting, 5 Nov. 2020.

230 Hall, et al., 2018.

231 Staff discussion, 2020.

232 DeShazo, et al., 2015.

233 *Countywide Drought and Water Shortage Contingency Plans*. California Department of Water Resources, water.ca.gov/Programs/Water-Use-And-Efficiency/2018-Water-Conservation-Legislation/County-Drought-Planning. Accessed 11 Sept. 2021.

234 *National Integrated Drought Information System*. www.drought.gov. Accessed 11 Sept. 2021.

235 Smith and Gallon, 2015.

236 *Small Water Systems and Rural Communities Drought and Water Shortage Contingency Planning and Risk Assessment*. California Department of Water Resources, Water Use Efficiency Branch, Mar. 2021, water.ca.gov/Programs/Water-Use-And-Efficiency/2018-Water-Conservation-Legislation/County-Drought-Planning. Accessed 11 Sept. 2021.

237 Nichols, Leah, et al. “Sector Interactions, Multiple Stressors, and Complex Systems.” *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, edited by D. R. Reidmiller, et al., vol. II, U.S. Global Change Research Program, 2018, nca2018.globalchange.gov/downloads/NCA4_Ch17_Complex-Systems_Full.pdf. Accessed 11 Sept. 2021.

238 Alexander, David, and Gianluca Pescaroli. “What Are Cascading Disasters?” *UCL Open Environment*, vol. 1, no. 1, 8 Aug. 2019, ucl.scienceopen.com/document/read?vid=fa7edca1-ed1e-4c79-9c3d-dc6c19abd54e. Accessed 11 Sept. 2021.

239 Moser, Susanne, and Juliette Finzi Hart. *The Adaptation Blindspot: Teleconnected and Cascading Impacts of Climate Change in the Electrical Grid and Lifelines of Los Angeles*. CCCA4-CEC-2018-008, California Energy Commission, Aug. 2018, www.energy.ca.gov/sites/default/files/2019-11/Energy_CCCA4-CEC-2018-008_ADA.pdf. Accessed 11 Sept. 2021.

240 Vespignani, Alessandro. “The Fragility of Interdependency.” *Nature*, vol. 464, 2010, pp. 984–85, www.nature.com/articles/464984a. Accessed 11 Sept. 2021.

241 Parvini, Sarah, and Dakota Smith. “Some Fire Hydrants Didn’t Work Because of Power Outages, Firefighters Say.” *Los Angeles Times*, 5 Dec. 2017, www.latimes.com/local/lanow/la-me-fire-hydrants-not-working-venturs-20171205-story.html. Accessed 11 Sept. 2021.

242 Stone, Jr., Brian, et al. “Compound Climate and Infrastructure Events: How Electrical Grid Failure Alters Heat Wave Risk.” *Environmental Science and Technology*, vol. 55, no. 10, 30 Apr. 2021, pp. 6957–64, pubs.acs.org/doi/10.1021/acs.est.1c00024. Accessed 11 Sept. 2021.

243 Bean, Richard, et al. “Keeping the Power on to Home Medical Devices.” *PLOS ONE*, vol. 15, no. 7, 8 Jul. 2020, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0235068 . Accessed 11 Sept. 2021.

244 *On-Board Survey Results + Trend Report Fall ’19*. Los Angeles County Metropolitan Transportation Authority (Metro), 2019, media.metro.net/projects_studies/research/images/infographics/fall_2019__onboard_survey_results_and_trend_report.pdf. Accessed 11 Sept. 2021.

245 Méndez, Méndez, et al. “The (In)visible Victims of Disaster: Understanding the Vulnerability of Undocumented Latino/a and Indigenous Immigrants.” Geoforum, vol. 116, Nov. 2020, pp. 50–62, www.sciencedirect.com/science/article/abs/pii/S0016718520301925?via%3Dihub. Accessed 11 Sept. 2021.

246 Clark, Susan Spierre, et al. “A Capabilities Approach to the Prioritization of Critical Infrastructure.” *Environment Systems and Decisions*, vol. 38, no. 3, 2018, pp. 339–52, link.springer.com/article/10.1007%2Fs10669-018-9691-8. Accessed 10 Sept. 2021.

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