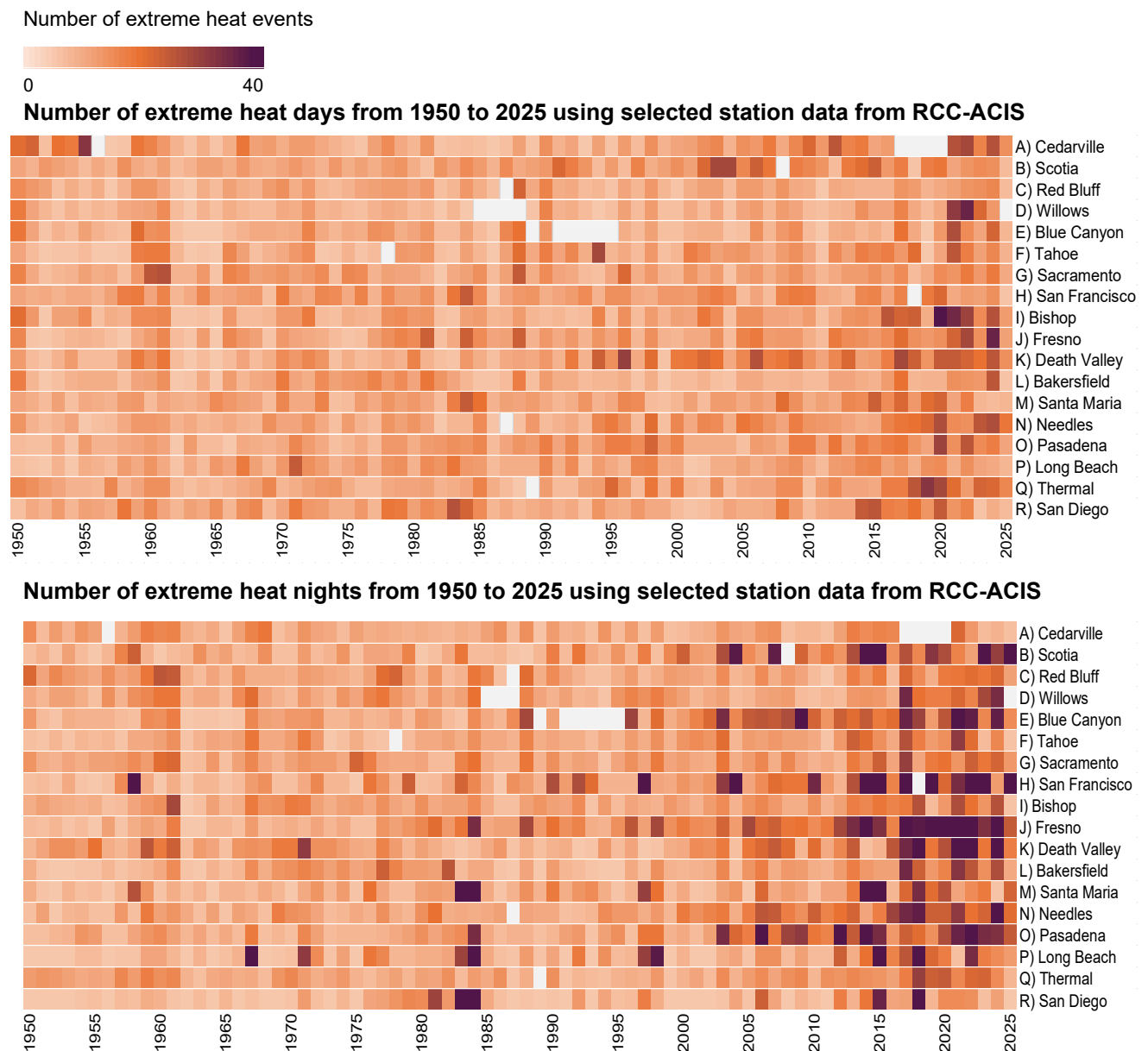


## 2.4 Extreme Heat Events

Extreme heat events are days or nights when temperatures exceed a defined threshold. Since 1950, extreme heat days and nights have become more frequent at multiple locations in California, with the most widespread increases occurring at night. This has driven an increase in the number of heatwave days and nights, defined here as two or more consecutive extreme heat days or nights.

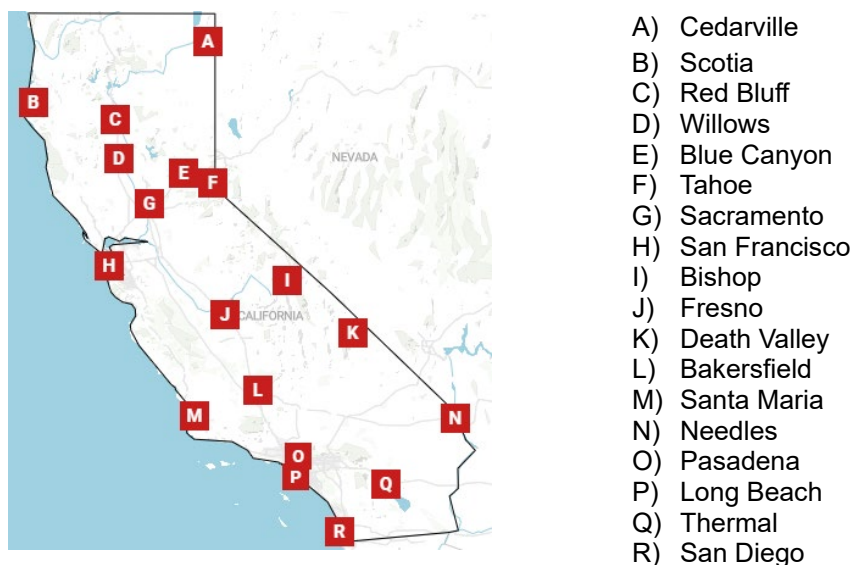
Figure 2.4.1. Frequency of Extreme Heat Events.



The charts show the annual sum of extreme heat days or nights from 1950 to 2025 for 18 weather stations in California, listed from north to south. Years for which not enough data was available are greyed out. For data to be included for the months of July and August, in a given year, there had to be fewer than seven days of data missing.

Source: NOAA Regional Climate Center's Applied Climate Information System (RCC-ACIS). Data retrieved April 2026.

**Figure 2.4.2. Locations of Selected Weather Stations.**



The map shows the locations of the 18 weather stations used to calculate extreme heat days and nights.

Source: Map created with Datawrapper and OpenstreetMap contributors.

## What does the indicator show?

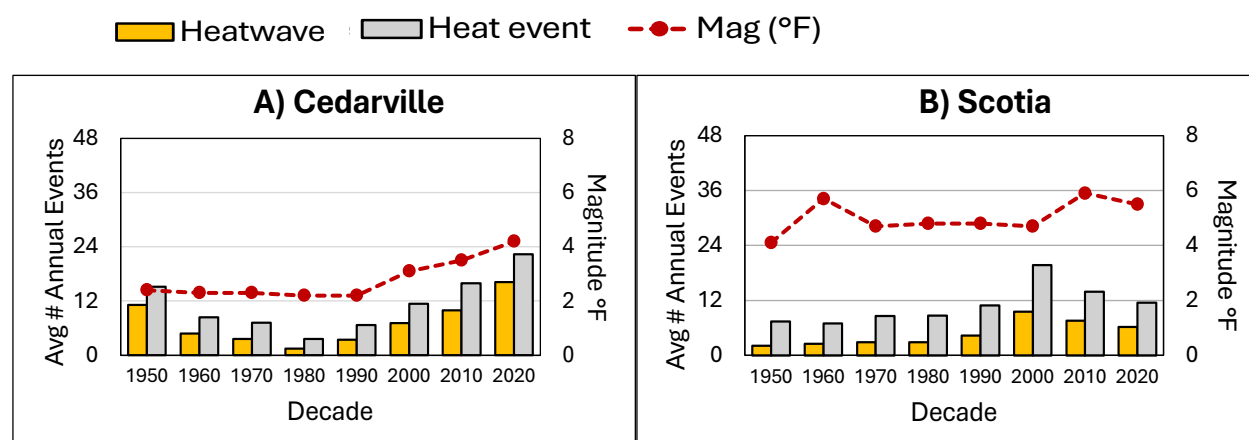
Extreme heat events broadly refer to individual days or nights or multiple days or nights when temperatures exceed a defined threshold for a designated length of time. While there is no standard definition for an extreme heat event, researchers often apply a percentile-based threshold from a set historical period to identify heat events. Here, extreme heat events are defined as days or nights from April to October where the air temperature is above the location-specific 95<sup>th</sup> percentile of either the daily maximum temperatures (for daytime events) or the daily minimum temperatures (for nighttime events) for the 1960–1990 reference period. Since 1950, the total number of extreme

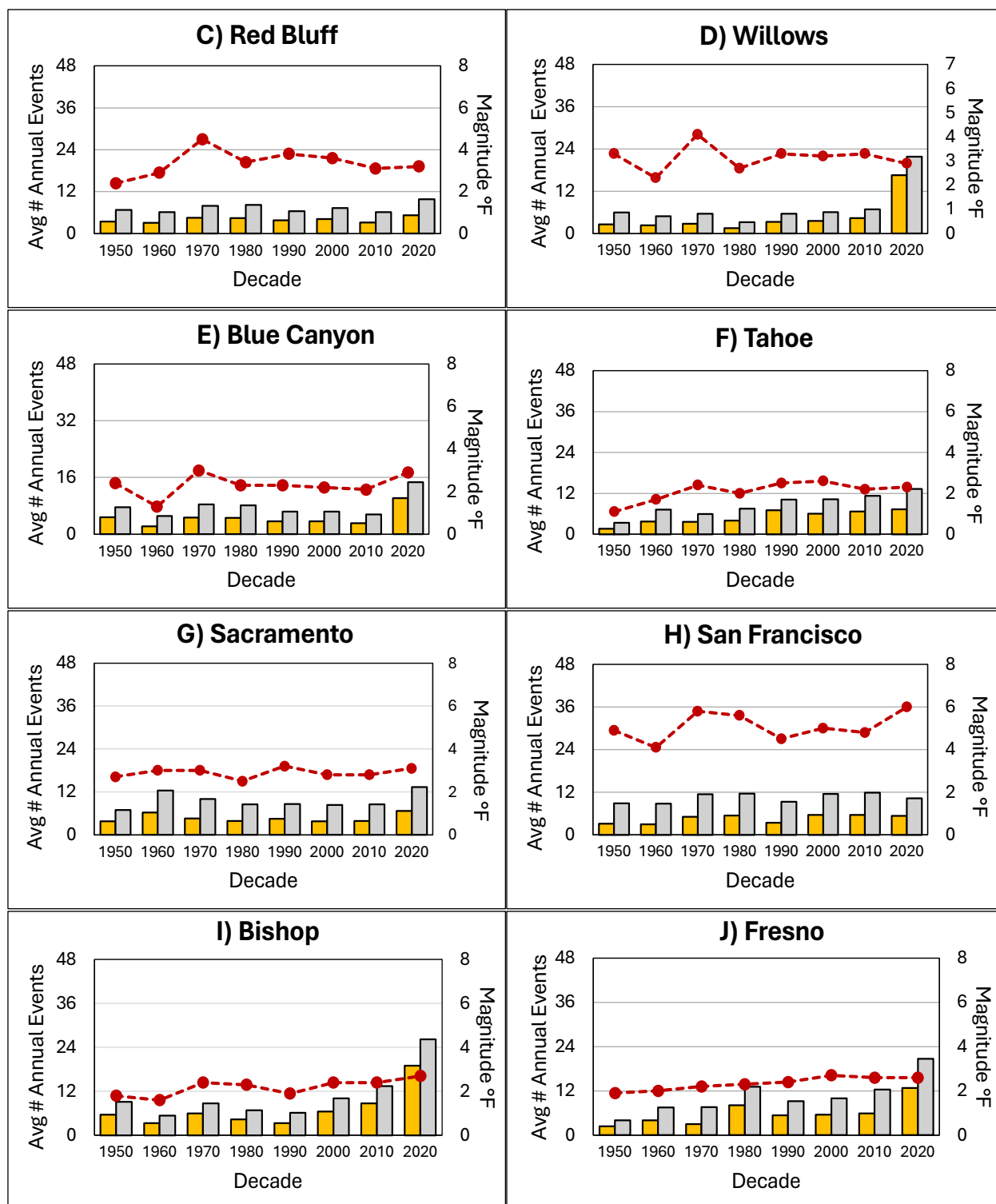


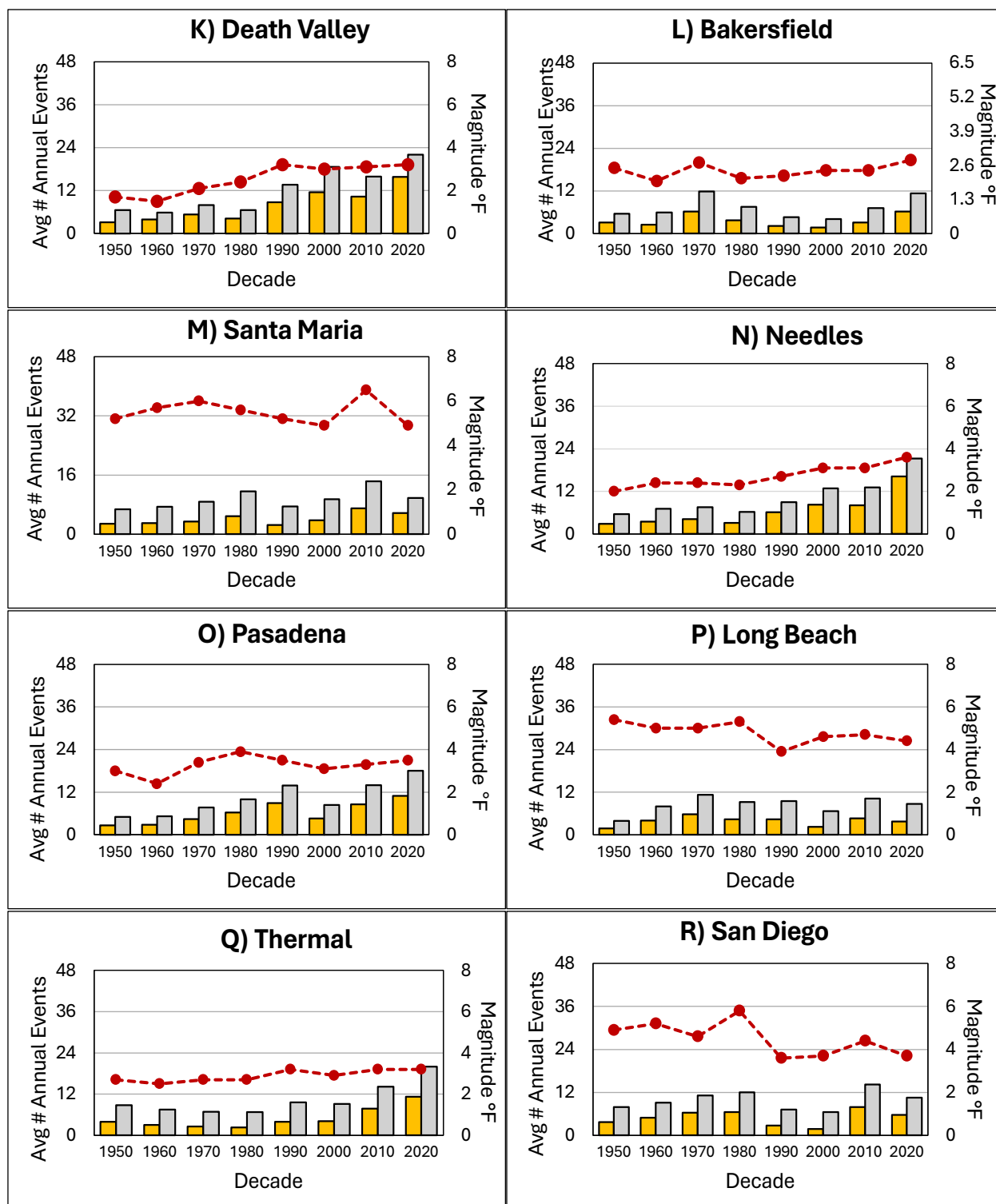
heat events at multiple locations in California has increased, especially at night (**Figure 2.4.1**; map of locations in **Figure 2.4.2**).

Heatwaves, which are multi-day heat events, are also important to consider as the short-term accumulation of heat can have greater impacts. Since there is no set definition for how many consecutive extreme heat days or nights make up a heatwave, this report defines a daytime or nighttime heatwave as two or more consecutive daytime or nighttime heat events, respectively. **Figures 2.4.3** and **2.4.4** present the decadal averages of the magnitudes (intensities of temperatures compared to historical averages) of daytime and nighttime extreme heat events, as well as the annual number of days and nights in a heatwave; values presented for the last decade (“2020”) are for 2020 through 2025 only. For comparison, the frequency of extreme heat events is also presented. For most of the stations, the magnitude and frequency of extreme heat events and frequency of days and nights in heatwaves are higher in the second half of the time series (1988 to 2025) for both nighttime and daytime events.

**Figure 2.4.3. Daytime Heatwaves and Heat Events by Decade.**







The average annual values by decade for the number of days in heatwaves and individual extreme heat events (yellow and grey bars) and the magnitude (the average of daily exceedances above the historical threshold, in degrees Fahrenheit (°F)) (dotted line) of individual extreme heat events are presented for each station. Yellow bars represent the average annual number of days in a heatwave, the grey bars represent the annual average

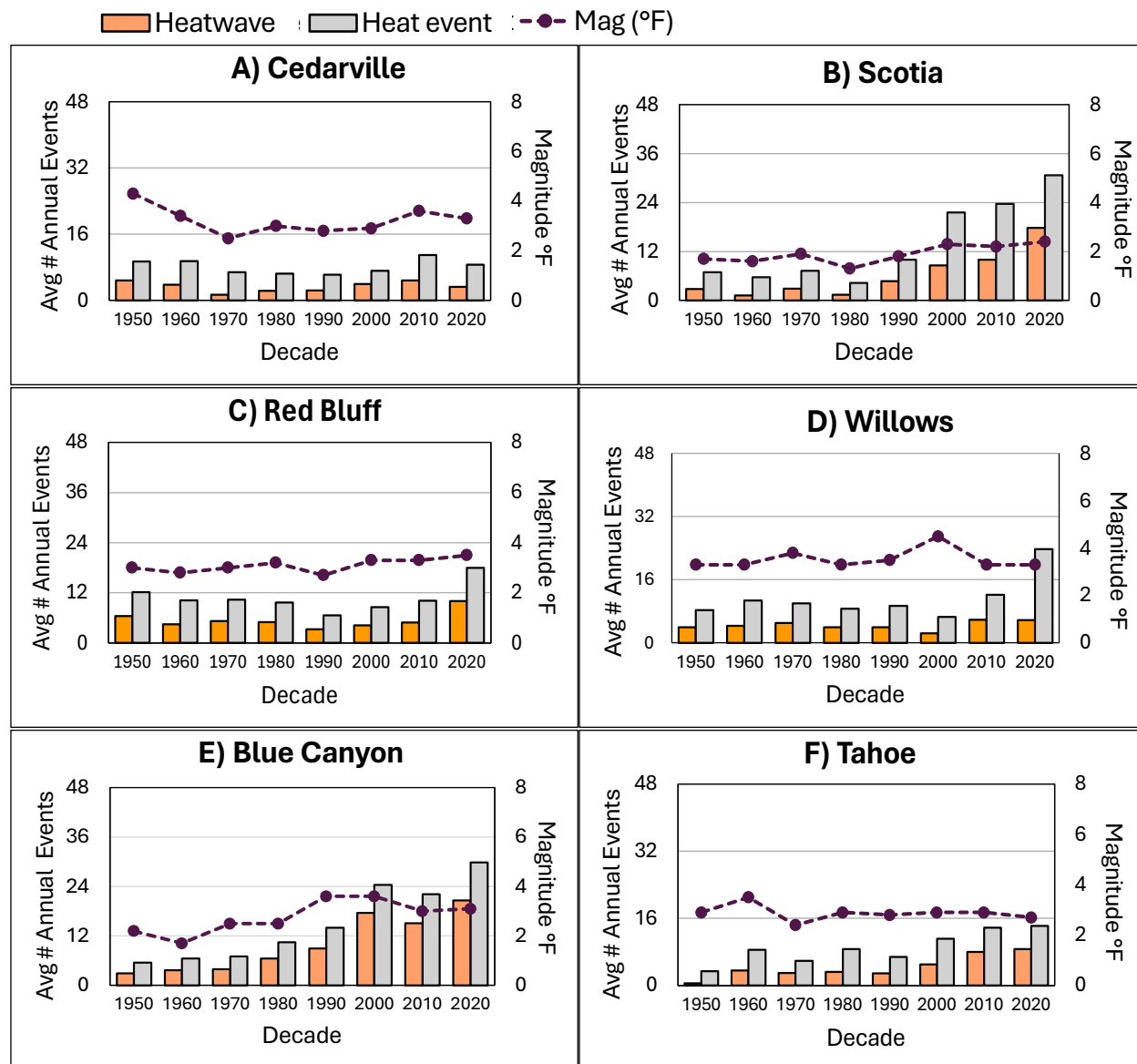


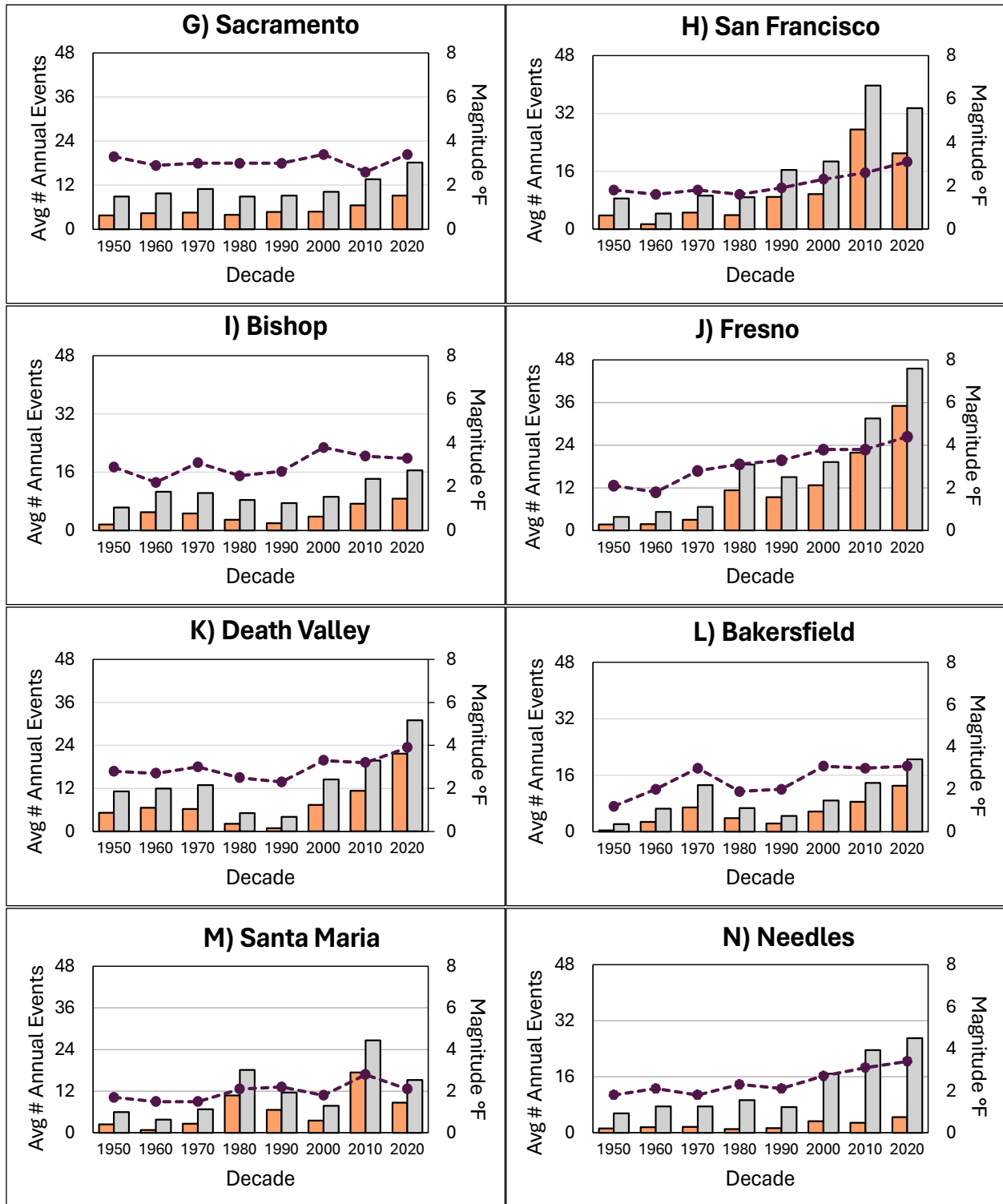
number of extreme heat days overall (irrespective of whether they were in a heatwave), and the red dotted line represents the average decadal magnitude of an extreme heat day for that year.

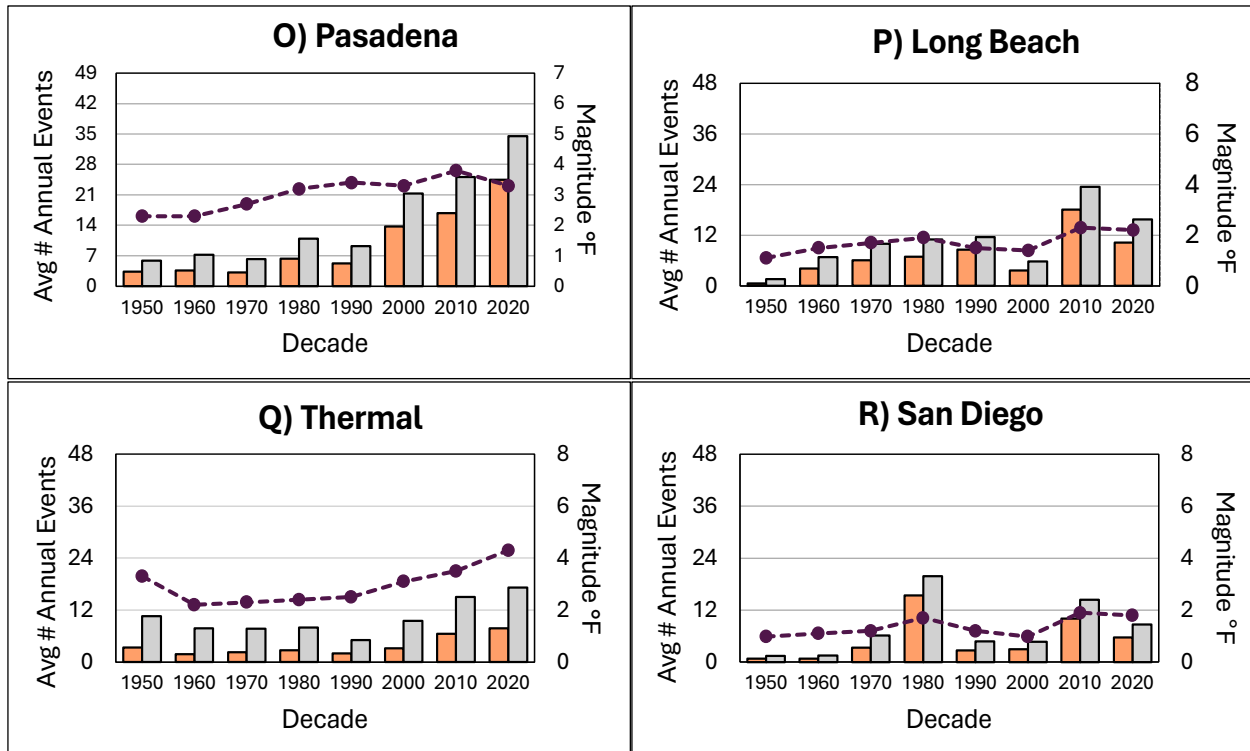
Note: The decadal average for 2020s represents the average values for the years 2020 to 2025 only.

Source: RCC-ACIS (2026)

**Figure 2.4.4. Nighttime Heatwaves and Heat Events by Decade.**







The average annual values by decade for the number of nights in heatwaves and individual extreme heat events (orange and grey bars) and the magnitude (the average of daily exceedances above the historical threshold, in degrees Fahrenheit (°F)) (dotted line) of individual extreme heat events are presented for each station. Orange bars represent the average annual number of nights in a heatwave, the grey bars represent the annual average number of extreme heat nights overall (irrespective of whether they were in a heatwave), and the purple dotted line represents the average magnitude of an extreme heat night for that year. The decadal average for 2020s represents the average values for the years 2020 to 2025 only. Source: RCC-ACIS (2026)

#### Tribal Connection 2.4.1

Tribal nations in Northern and Southern California alike have been experiencing more extreme heat events. The Big Valley Band of Pomo Indians, living around Clear Lake in Lake County, had a record-breaking heat event in July 2024, when they experienced 15 days of temperatures above 100°F (37.8°C) (Big Valley Band of Pomo Indians, 2026). The Pala Band of Mission Indians in San Diego County is also seeing higher temperatures during heat events. They write, “Over the past 3 decades, there have been an average of 35.75 days per decade with temperatures over 100°F (37.8°C) at Pala. The number of days of the most

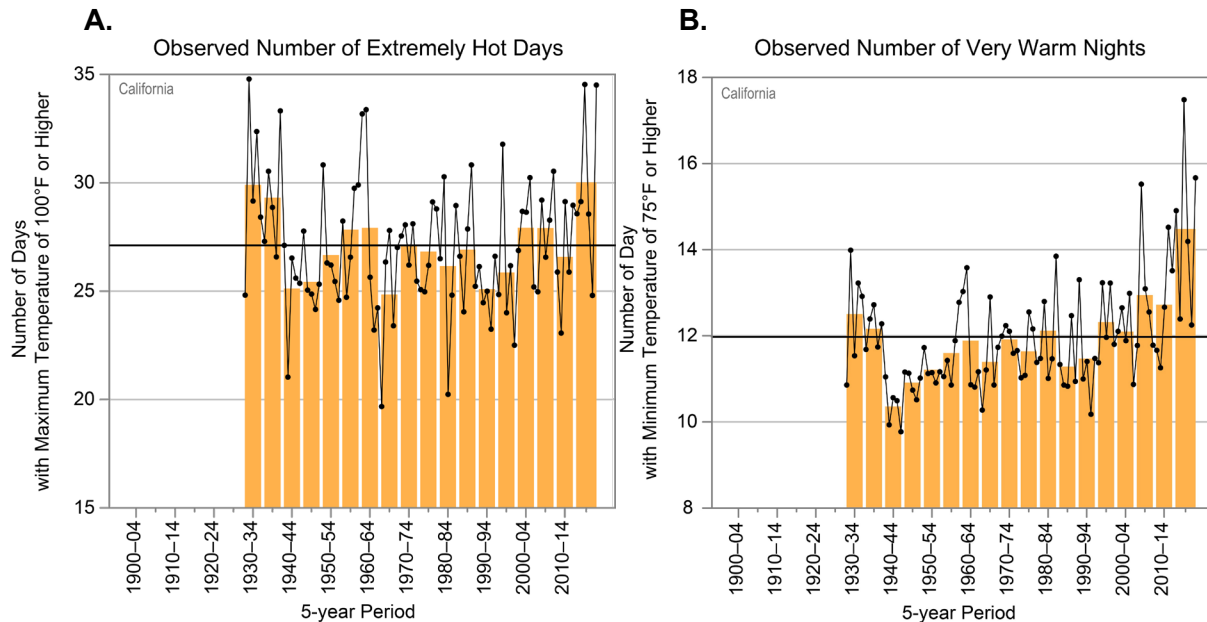


*extreme heat, above 105°F (41°C) and 110°F (43.3°C), are increasing over time”*  
(Pala Band of Mission Indians, 2026).

Similar to station-specific data, statewide averages show a variable but overall increasing trend in annual extreme heat days and nights. **Figure 2.4.5** is based on statewide analyses conducted by the National Oceanic and Atmospheric Administration’s National Centers for Environmental Information. For this analysis, a state-average time series was created. First, California was divided into 1-degree grid boxes. Then, grid box time series were produced by averaging all stations within that grid box. Finally, a state-average time series was created by averaging the grid box time series (Frankson et al., 2022). Statewide, the number of extremely hot days (**Figure 2.4.5A**) (days on which the maximum temperature was at or above 100°F (37.8°C)) has been variable since 1930, both in terms of annual and five-year averages. The greatest number of hot days were observed during the 2015–2020 period, followed by 1930–1934 and 1935–1939 (the temperature spike during the “Dust Bowl” of the 1930s reflects large natural variability that can occur regionally; see Donat et al. (2016) for more information about anomalously high temperatures and severe drought conditions driven by abnormal sea surface temperatures during this time period). A more pronounced increase is evident in the number of very warm nights (**Figure 2.4.5B**), when minimum temperatures were at or above 75°F (23.9°C). As with extremely hot days, the 2015–2020 period had the greatest number of very warm nights; numbers have exceeded the long-term average on all five-year periods since 1995–1999.



**Figure 2.4.5. Statewide Number of Extremely Hot Days and Very Warm Nights.**



Left: Observed annual number of extremely hot days (maximum temperature of 100°F (37.8°C) or higher) 1930 to 2020. Right: Observed annual number of very warm nights (minimum temperature of 75°F (23.9°C) or higher). Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black lines show the long-term (entire period) averages: 27 days and 12 nights, respectively. Source: Frankson et al. (2022)

### Why is this indicator important?

Periods of extremely high temperatures have significant public health, ecological and economic impacts. Heat causes the most weather-related deaths in the United States (NOAA, 2026). Heat waves accompanied by high humidity are especially dangerous to human health. Humidity prevents surfaces (both environmental and the human body) from cooling down at night, leading to higher nighttime temperatures (Brown, 2025; Joshi et al., 2024; Gershunov et al., 2009). People, wildlife, domesticated animals, and plants adapted to California's traditionally dry daytime heat and nighttime cooling are unable to recover from extreme heat, especially when humidity is high at night.

Heat can also accelerate the formation of ground-level ozone, trap ozone, particulate matter and other harmful air pollutants (Peel et al., 2013; Rahman et al., 2022).



Temperature is also a leading meteorological driver of ozone formation (Nolte et al., 2018). Air pollution may also work in synergy with extremely high temperatures to increase adverse cardiovascular, respiratory and other health effects (Anenberg et al., 2020; Rahman et al., 2022; see the *Heat-Related Deaths and Illnesses* chapter).

Although warmer temperatures are likely to impact a range of individuals and populations, certain subgroups are at greatest risk of health impacts from extreme heat due to intrinsic factors (such as age and health status), greater likelihood of exposures, or less capacity for adaptive measures (such as access to air conditioning). These include the elderly, children, pregnant individuals, people of color, those with lower socioeconomic status, those who have unequal access to green spaces, those who are socially, linguistically, or geographically isolated, or those who work in agriculture, construction, landscaping or other outdoor occupations (Berberian et al., 2022; Cheney et al., 2022; Jiao et al., 2023; Ma et al., 2026; Santodomingo et al., 2024; Syed et al., 2022; Ye et al., 2024; Yin et al., 2023) (see the *Heat-Related Deaths and Illnesses* and *Occupational Heat-Related Illnesses* chapters).

#### Tribal Connection 2.4.1

Elders of California Native American tribes are one at-risk group in extreme heat who may lack the cooling resources. The Wiyot Tribe writes, “*The temperature regime of Wiyot territory is relatively stable compared to other areas of California experiencing rapid warming, higher extreme heat, and higher variability. However, because Wiyot Tribal members are accustomed to low and consistent temperatures and most of them do not have air conditioning, even relative heat, such as extended temperatures in the high 70s or 80s °F, can be dangerous for vulnerable Tribal members such as elders.*” (Wiyot Tribe, 2026).

Extreme heat impacts infrastructure and economies (LCI, 2021). Urban infrastructure is especially threatened by cascading effects of extreme heat stress on interdependent water, power, and transportation systems. High heat can deteriorate pavement, buckle railway tracks, and restrict aircraft operations (Janatabadi et al., 2025; Sias et al., 2025; Yu and Shi, 2025). During hot weather, increased use of air conditioning and refrigeration increase electricity usage, thus straining the electrical grid (see the *Cooling*



*and Heating Degree Days* chapter). The strain on the electrical grid has caused blackouts during extreme heat events, eliminating many of the methods for coping with extreme heat such as air conditioning and manual ventilation leading to increased heat morbidity and mortality (Stone et al., 2023). Further, the increase in electricity generation to meet the demand for air conditioning during extreme heat events leads to increased emissions of highly reactive nitrogen oxides (NO<sub>x</sub>) (Abel et al., 2017; Peel et al., 2013). NO<sub>x</sub> and the ozone it can form through a sunlight-driven process in the troposphere (i.e., the atmospheric layer near the ground) can significantly impact human health, affecting respiratory and cardiovascular systems. NO<sub>x</sub> also interacts with other air pollutants, amplifying their overall health impacts (Donzelli and Suarez-Varela, 2024; Taha et al., 2025).

#### Tribal Connection 2.4.2

Extreme heat can exacerbate pre-existing health disparities within California Native American tribes, and strain limited resources. For the Big Valley Band of Pomo Indians, *“Rising temperatures also strain energy demand and infrastructure, increasing the number and length of the Public Safety Power Shutoffs (PSPS) the Tribe has seen. To protect Elders during these PSPS events the Tribe has purchased generators. Increasing air temperatures promote ozone formation leading to adverse health effects such as lung irritation, inflammation, worsening of asthma, and increasing mortality (US EPA, 2021)”* (Big Valley Band of Pomo Indians, 2026).

Water resources are strained during heat events due to increased domestic, industrial and agricultural demand. Extreme heat conditions can also influence tourism, such as in California’s Coachella Valley, where it is projected that hotter temperatures will deter visitors and pose a major financial impact to the local economy (Yañez et al., 2020).

Agricultural systems in California and across the globe are experiencing the impacts of heat stress and decreased water supplies. Extreme heat exposure stresses plants and stunts development of agricultural crops, resulting in reduced quality and lower yields. Scientists fear that current heat adaptation practices such as enhanced irrigation and crop breeding may not be sustainable under future climate conditions. Heat stress also



affects livestock by reducing weight gain or milk and egg production; in extreme cases, heat stress can lead to animal mortality (Parker et al., 2020; Walsh et al., 2020).

Extreme heat exposure may also cause mismatches between the timing and duration of crucial life stages for flowering crops and their pollinators (Walters et al., 2022).

Droughts, heat waves, wildfires, and floods often result from interactions between various physical processes that in isolation might not be considered extreme but when combined result in significant impacts. A warming climate promotes co-occurrence of weather extremes, a higher risk of environmental disasters and greater reliance on emergency management and relief resources (AghaKouchak et al., 2020; Zscheischler et al., 2018). The western United States has experienced a larger frequency of simultaneously occurring dry and hot years in recent decades (see the *Drought* chapter). Multiple extreme events, also known as compound events, can amplify ecological and societal damage, as shown by the exceptionally dangerous wildfire seasons in recent years (AghaKouchak et al., 2020). For example, the Thomas fire in December 2017 and the Woolsey fire in November 2018, which caused tremendous devastation in four southern California counties, were both preceded by record-breaking heatwaves and extraordinarily dry autumn conditions (Hulley et al., 2020). Extreme rainfall over the burned area in January 2018 led to the deadliest debris flow event in California's history, killing 23 people, damaging more than 400 homes, and depositing large volumes of sediment, ash, and debris into the waterways, altering stream channels and degrading aquatic habitat (AghaKouchak et al., 2020). Severe wildfires also can disrupt aquatic ecosystems by altering streamflow, increasing sediment, and introducing pollutants like ash, fire retardants, and heavy metals—threatening species such as Chinook salmon (Alizadeh et al., 2021; Neary et al., 2008; see the *Wildfires* and *Chinook Salmon Population Abundance* chapters). Runoff from burned areas can carry such contaminants to the ocean, harming marine ecosystems for years (OPC, 2026).

Heat events are projected to become more intense, more frequent, and longer lasting, globally and in California (Cal-Adapt, 2026; IPCC, 2021). Taking action to mitigate and adapt to the impacts of extreme heat in California is critical, particularly given the largely preventable adverse effects on public health (LCI, 2021). Due to the need for a comprehensive statewide response, California developed an Extreme Heat Action Plan



that coordinates action across state agencies to improve public awareness and preparedness, strengthen community services and emergency response, increase the resilience of the environment, and expand solutions to reduce heat risk (CNRA, 2022).

### What factors influence this indicator?

The increased frequency and intensity of temperature extremes since pre-industrial times is attributable to human-induced greenhouse gas emissions (IPCC, 2021). Some recent heatwaves would have been extremely unlikely without human influence on the climate system. For example, the duration, spatial extent, and amplitude of an unprecedented “Heat Dome” that formed in late June 2021 over western North America, and which contributed to large wildfires across the United States and Canada, was exacerbated by climate change: the event is estimated to have been 59% longer, 34% larger and 6% higher in maximum amplitude than the same event would have been without a warming climate (Jain et al., 2024). Similarly, record-breaking extreme heat events observed during an early spring heatwave that developed across the southwestern United States in March 2026 (with temperatures more typical of summer than late-March) were also driven by a “Heat Dome” and determined to have been virtually impossible without climate change (Clarke et al., 2026).

Regional heat extreme patterns are influenced by aerosol emissions, land use and land cover changes, feedback processes involving land-atmosphere interactions (for example, dry soils increasing temperatures due to reduced evaporation), and large-scale modes of natural climate variability (Hulley et al., 2020; Kornhuber et al., 2024). Local temperatures are influenced by topography, elevation, proximity to the ocean, and global and regional atmospheric and oceanic circulations. Clouds have a cooling effect during the day and a warming effect at night (Cox et al., 2020; Luo et al., 2024). Very small airborne particles from human and natural sources can have various effects on climate. Sulfate aerosols, which result from burning coal, biomass, and volcanic eruptions, tend to cool Earth. Other kinds of particles, such as black carbon, have a warming effect. The net effect on air temperatures of aerosols, dust, smoke, and soot is cooling (NASA, 2023). In addition, as air temperatures rise, the atmosphere can hold more water vapor, which traps heat and reduces nighttime cooling, providing less relief



from heat. Moreover, humid heat waves, as can occur in coastal areas, tend to last longer due to the stronger coupling of maximum and minimum temperatures during humid heat waves (Gershunov et al., 2009).

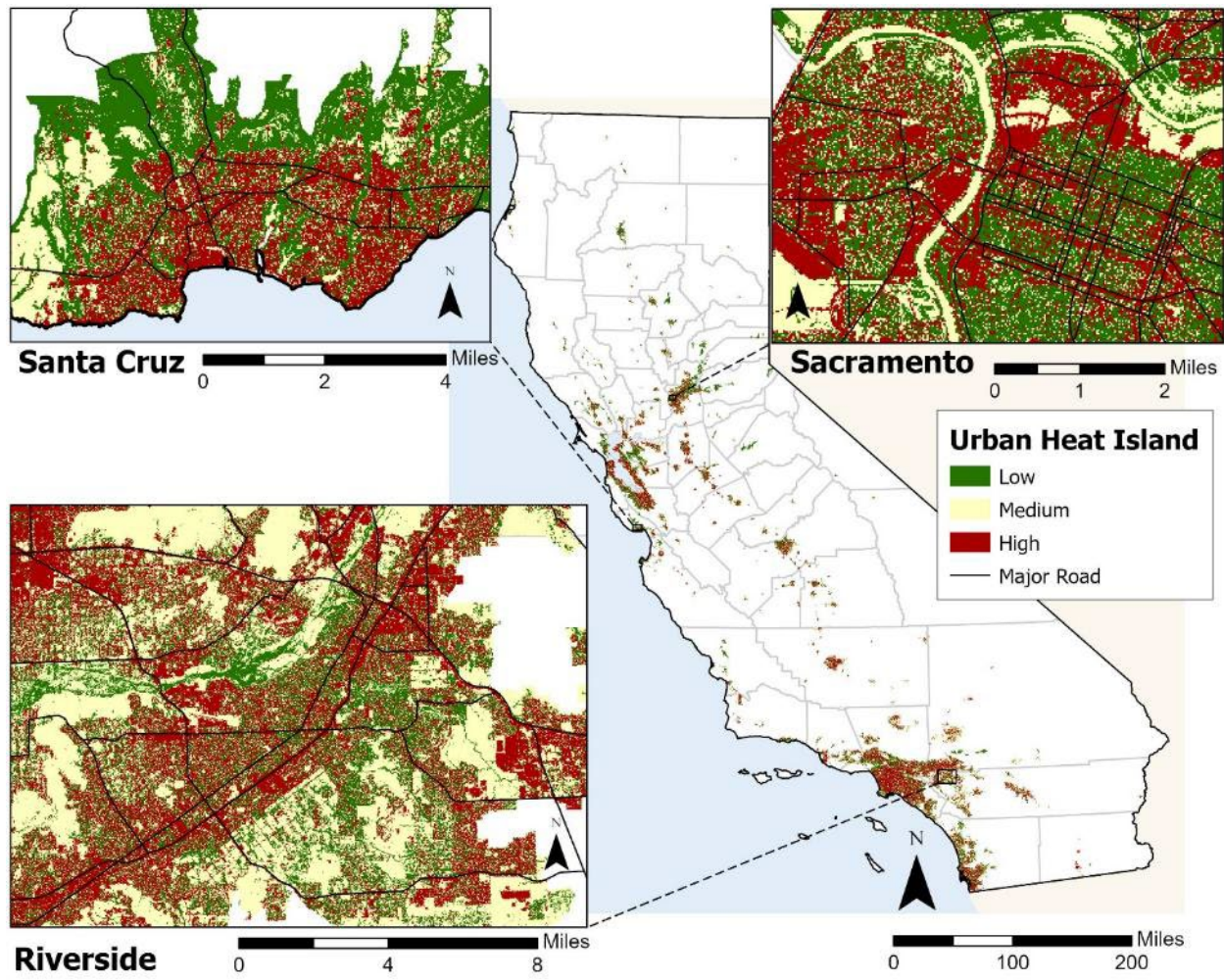
Urbanization is generally known to have a warming effect, due in large part to the heat-absorbing concrete and asphalt in building materials and roadways and can amplify the effects of extreme heat in cities (the urban heat island effect) (Lasky et al., 2024), while expansion of irrigation has a cooling effect on summertime temperatures (Bonfils and Lobell, 2007). Climate change and urbanization are the most significant drivers of warming in cities. A major factor in the urban heat island effect in California (**Figure 2.4.6**) is the scarcity of city trees (**Figure 2.4.7**), which provide shade and cooling, and can reduce energy needed to heat and cool buildings (McPherson et al., 2018).

California's urban tree canopy currently covers just 14.5% of the state's urban areas (USFS and CAL FIRE, 2026).

Research on urban tree cover shows that its distribution in the United States is unequal: In most U.S. cities, neighborhoods that are predominantly low-income or disproportionately people-of-color have less tree cover than high-income or non-Hispanic white neighborhoods and often experience higher summer surface temperatures (McDonald et al., 2024).



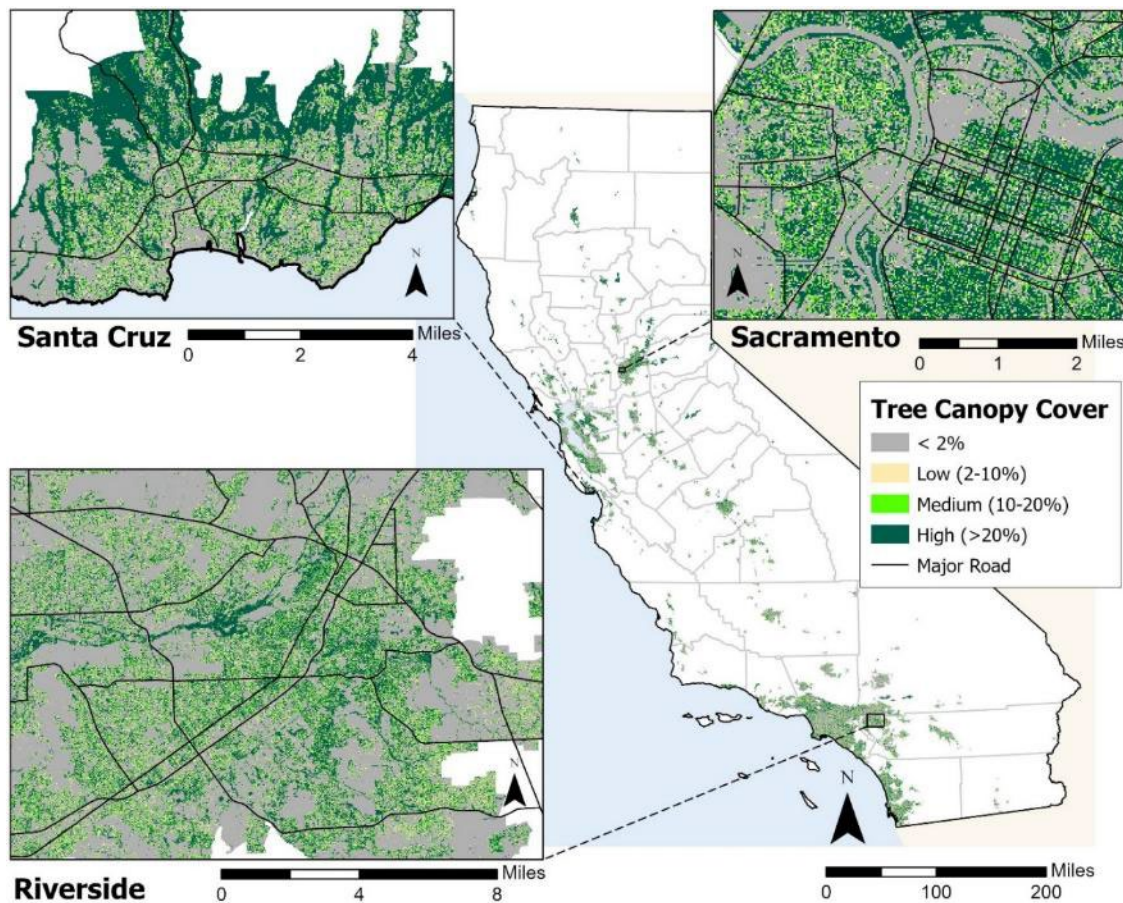
Figure 2.4.6. Statewide Urban Heat Islands.



Source: Bjorkman et al. (2015)



Figure 2.4.7. Percent of Urban Tree Canopy Cover.



Source: Bjorkman et al. (2015)

## Technical considerations

### Data characteristics

This indicator uses station data from the National Oceanic and Atmospheric Administration's (NOAA) Regional Climate Centers (RCCs) cooperative observation network acquired from the [Applied Climate Information System](#) (ACIS). The RCC Program partners with public and private partners, as well as other state, regional, and national climate services providers, to provide access to regional climate information and support the advancement of applied climate research (Umphlett et al., 2024).



### Strengths and limitations of the data

The RCC-ACIS dataset is hosted online by the Southwest Climate and Environmental Information Collaborative and comprised of station data containing minimum and maximum daily temperature. RCC-ACIS station data pulls weather information from various networks such as the Cooperative Observer Program (COOP) and the Weather-Bureau-Army-Navy (WBAN). The network includes the National Weather Service (NWS) principal climatological stations. Observing equipment used at all the stations is calibrated and maintained by NWS field representatives, Cooperative Program Managers, and Hydro-Meteorological Technicians.

The station data have received a high measure of quality control through computer and manual edits, and are subjected to internal consistency checks, compared against climatological limits, checked serially, and evaluated against surrounding stations. Values calculated from RCC-ACIS may differ from those in other high-quality station datasets due to methodological differences. In addition, station coverage is not uniformly distributed geographically, and a limited number of stations were analyzed. Recorded temperatures in urban areas can also be affected by the urban heat island effect due to land surface modification and other human activities. Since most of California's population resides in urban areas, heat impacts from urban-induced warming on health are significant. Quantification of the specific magnitudes of station-based urban heat contributions are beyond the scope of the present study but are the subject of ongoing research.

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Felicia Chiang, Ph.D.  
Office of Environmental Health Hazard Assessment  
California Environmental Protection Agency  
[Felicia.Chiang@oehha.ca.gov](mailto:Felicia.Chiang@oehha.ca.gov)



James Thorne  
Department of Environmental Science and Policy  
University of California Davis  
[jhthorne@ucdavis.edu](mailto:jhthorne@ucdavis.edu)



## References

- Abel D, Holloway T, Kladar RM, Meier P, Ahl D, et al. (2017). Response of Power Plant Emissions to Ambient Temperature in the Eastern United States. *Environmental Science & Technology* **51**(10): 5838–5846.
- AghaKouchak A, Chiang F, Huning LS, Love CA, Mallakpour I, et al. (2020). Climate extremes and compound hazards in a warming world. *Annual Review of Earth and Planetary Sciences* **48**(1): 519–548.
- Alizadeh MR, Abatzoglou JT, Lucec CH, Adamowskia JF and Faridd A (2021). Warming enabled upslope advance in western US forest fires. *Proceedings of the National Academy of Sciences* **118**(22): e2009717118.
- Anenberg SC, Haines S, Wang E, Nassikas N and Kinney PL (2020). Synergistic health effects of air pollution, temperature, and pollen exposure: a systematic review of epidemiological evidence. *Environmental Health: a global access science source* **19**(1): 130.
- Berberian AG, Gonzalez DJ and Cushing LJ (2022). Racial disparities in climate change-related health effects in the United States. *Current Environmental Health Reports* **9**(3): 451–464.
- Big Valley Band of Pomo Indians (2026). Impacts of Climate Change on the Big Valley Band of Pomo Indians. In: OEHHA 2026 Indicators of Climate Change in California.
- Bjorkman J, Thorne JH, Hollander A, Roth NE, Boynton RM, et al. (2015). *Biomass, Carbon Sequestration, and Avoided Emissions: Assessing the Role of Urban Trees in California*. Information Center for the Environment, University of California, Davis. Davis, CA.
- Brown H (2025). *Nighttime-Accentuated Heatwaves in California: An Application of Spatial Epidemiology to Inform Policy*. UC San Diego: Climate Science and Policy.
- Cal-Adapt (2026). [Extreme Heat Days & Warm Nights](#). Retrieved March 12, 2026.
- Cheney AM, Barrera T, Rodriguez K and Jaramillo López AM (2022). The intersection of workplace and environmental exposure on health in Latinx farm working communities in rural inland Southern California. *International Journal of Environmental Research and Public Health* **19**(19): 12940.
- Clarke B, Keeping T, Zachariah M, Barnes C, Vahlberg M and Otto F (2026). Record-shattering March temperatures in Western North America virtually impossible without climate change. *World Weather Attribution*.
- CNRA (2022). *Protecting Californians from Extreme Heat: A State Action Plan to Build Community Resilience*. California Natural Resources Agency. Sacramento, CA.
- Cox DT, Maclean IM, Gardner AS and Gaston KJ (2020). Global variation in diurnal asymmetry in temperature, cloud cover, specific humidity and precipitation and its association with leaf area index. *Global Change Biology* **26**(12): 7099–7111.
- Donat MG, King AD, Overpeck JT, Alexander LV, Durre I and Karoly DJ (2016). Extraordinary heat during the 1930s US Dust Bowl and associated large-scale conditions. *Climate Dynamics* **46**(1): 413–426.
- Donzelli G and Suarez-Varela MM (2024). Tropospheric ozone: a critical review of the literature on emissions, exposure, and health effects. *Atmosphere* **15**(7): 779.



Frankson R, Stevens LE, Kunkel KE, Champion SM, Easterling DR, et al. (2022). *California State Climate Summary 2022*. NOAA Technical Report NESDIS 150-CA. National Oceanic and Atmospheric Administration National Centers for Environmental Information. Silver Spring, MD.

Gershunov A, Cayan DR and Iacobellis SF (2009). The Great 2006 Heat Wave over California and Nevada: Signal of an Increasing Trend. *Journal of Climate* **22**(23): 6181–6203.

Hulley GC, Dousset B and Kahn BH (2020). Rising trends in heatwave metrics across Southern California. *Earth's Future* **8**(7): e2020EF001480.

IPCC (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte VP, Zhai A, Pirani SL, Connors C, Péan S, et al. (Eds.)]. Intergovernmental Panel on Climate Change. Cambridge University Press.

Jain P, Sharma AR, Acuna DC, Abatzoglou JT and Flannigan M (2024). Record-breaking fire weather in North America in 2021 was initiated by the Pacific northwest heat dome. *Communications Earth & Environment* **5**(1): 202.

Janatabadi F, Ortiz L and Ermagun A (2025). Extreme heat threatens railroads with connectivity and ridership loss in the United States. *NPJ Urban Sustainability* **5**(1): 37.

Jiao A, Sun Y, Avila C, Chiu V, Slezak J, et al. (2023). Analysis of heat exposure during pregnancy and severe maternal morbidity. *JAMA Network Open* **6**(9).

Joshi K, Khan A, Anand P and Sen J (2024). Understanding the synergy between heat waves and the built environment: A three-decade systematic review informing policies for mitigating urban heat island in cities. *Sustainable Earth Reviews* **7**(1): 25.

Kornhuber K, Bartusek S, Seager R, Schellnhuber HJ and Ting M (2024). Global emergence of regional heatwave hotspots outpaces climate model simulations. *Proceedings of the National Academy of Sciences* **121**(49): e2411258121.

Lasky E, Costello S, Ndovu A, Aguilera R, Weiser SD and Benmarhnia T (2024). The health benefits of reducing micro-heat islands: A 22-year analysis of the impact of urban temperature reduction on heat-related illnesses in California's major cities. *Science of the Total Environment* **949**: 175284.

LCI (2021). *Adapting to Extreme Heat in California: Assessing Gaps in State-Level Policies and Funding Opportunities*. UCLA Luskin Center for Innovation. Los Angeles, CA.

Luo H, Quaas J, and Han Y (2024). Diurnally asymmetric cloud cover trends amplify greenhouse warming. *Science Advances* **10**(25): eado5179.

Ma Y, Guirguis K, Jones-Ngo CG, Teyton A, Brown HE, Charlson F, et al. (2026). Daytime and nighttime heatwave intensity and acute care utilization for mental and neurological disorders in California. *Environmental Research: Health* **4**(1): 011001.

McDonald RI, Biswas T, Chakraborty TC, Kroeger T, Cook-Patton SC and Fargione JE (2024). Current inequality and future potential of US urban tree cover for reducing heat-related health impacts. *NPJ Urban Sustainability* **4**(1): 18.

McPherson EG, Berry AM and van Doorn NS (2018). Performance testing to identify climate-ready trees. *Urban Forestry & Urban Greening* **29**: 28–39.



NASA (2023). National Aeronautics and Space Administration. [The Study of Earth as an Integrated System](#). Retrieved March 19, 2025.

Neary DG, Ryan KC and DeBano LF (2008). *Wildland fire in ecosystems: effects of fire on soils and water*. General Technical Reports RMRS-GTR-42-vol.4. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Ogden, UT.

NOAA (2026). National Oceanic and Atmospheric Administration, National Weather Service. [Weather Related Fatality and Injury Statistics](#). Retrieved August 2026.

Nolte CG, Dolwick PD, Fann N, Horowitz LW, Naik V, et al. (2018). *Air Quality. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*. Volume II. [Reidmiller DR, Avery CW, Easterling DR, Kunkel KE, Lewis KLM, et al. (Eds.)]. U.S. Global Change Research Program. Washington, DC, USA.

OPC (2026). Ocean Protection Council. [From Ashes to Action: Wildfire Impacts on California's Coast and Ocean Health](#). Retrieved July 2026.

Pala Band of Mission Indians (2026). Impacts of Climate Change on the Pala Band of Mission Indians. In: OEHHA 2026 Indicators of Climate Change in California.

Parker LE, McElrone AJ, Ostojaa SM and Forrestd EJ (2020). Extreme heat effects on perennial crops and strategies for sustaining future production. *Plant Science* **295**: 110397.

Peel JL, Haeuber R., Garcia V, Russell AG and Neas L (2013). Impact of nitrogen and climate change interactions on ambient air pollution and human health. *Biogeochemistry* **114**(1–3): 121–134.

Rahman MM, McConnell R, Schlaerth H, Ko J, Silva S, et al. (2022). The effects of coexposure to extremes of heat and particulate air pollution on mortality in California: Implications for climate change. *American Journal of Respiratory and Critical Care Medicine* **206**(9): 1117–1127.

RCC-ACIS (2026). [Regional Climate Centers - Applied Climate Information System](#). "Applied Climate Information System." NOAA Regional Climate Centers, Retrieved May 2026.

Santodomingo M, Castillo EM, Schwarz L, Brennan JJ, Benmarhnia T and Chan TC (2024). Extreme heat events and emergency department visits among older adults in California from 2012–2019. *Medicina* **60**(10): 1593.

Sias JE, Dave EV, Underwood BS, Bowers BF, Harvey JT, et al. (2025). Climate change impacts on roadways. *Nature Reviews Earth & Environment* **6**(9): 555–573.

Stone B, Gronlund CJ, Mallen E, Hondula D, O'Neill MS, et al. (2023). How blackouts during heat waves amplify mortality and morbidity risk. *Environmental Science and Technology* **57**(22): 8245–8255.

Syed S, O'Sullivan TL and Phillips KP (2022). Extreme heat and pregnancy outcomes: A scoping review of the epidemiological evidence. *International Journal of Environmental Research and Public Health* **19**(4): 2412.

Taha SS, Idoudi S, Alhamdan N, Ibrahim RH, Surkatti R, et al. (2025). Comprehensive review of health impacts of the exposure to nitrogen oxides (NO<sub>x</sub>), carbon dioxide (CO<sub>2</sub>), and particulate matter (PM). *Journal of Hazardous Materials Advances* **19**: 100771.

Umphlett NA, Brown TJ, Konrad CE, Wall TU, Hall BL, et al. (2024). The Regional Climate Center Program—Past, Present, and Future: Reflections from 40 Years of Regional Climate Services. *Bulletin of the American Meteorological Society* **105**(10): E1849–1860.



USFS and CAL FIRE (2026). US Forest Service and California Department of Forestry and Fire Protection. [California's Urban Tree Canopy](#). Retrieved June 2026.

Walsh MK, Backlund P, Buja L, DeGaetano A and Melnick R (2020). *Climate Indicators for Agriculture*. USDA Technical Bulletin 1953. U.S. Department of Agriculture. Washington, DC.

Walters J, Zavalnitskaya J, Isaacs R and Szendrei Z (2022). Heat of the moment: extreme heat poses a risk to bee–plant interactions and crop yields. *Current Opinion in Insect Science* **52**: 100927.

Wiyot Tribe (2026). Impacts of Climate Change on the Wiyot Tribe. In: OEHHA 2026 Indicators of Climate Change in California.

Yañez CC, Hopkins FM and Porter WC (2020). Projected impacts of climate change on tourism in the Coachella Valley, California. *Climatic Change* **162**: 707–721.

Ye M, Ndovu A, Nguyen AV, Long D, Benmarhnia T and Thakur N (2024). Extreme Heat and Asthma Hospitalizations in Children in California (2017–2020). *American Journal of Respiratory and Critical Care Medicine* **209**(1): A2728.

Yin Y, He L, Wennberg PO and Frankenberg C (2023). Unequal exposure to heatwaves in Los Angeles: Impact of uneven green spaces. *Science Advances* **9**(17).

Yu Z and Shi Y (2025). Heat and productivity: Evidence from flight on-time performance. *Journal of the Association of Environmental and Resource Economists* **12**(5): 1243–1275.

Zscheischler J, Westra S, Van Den Hurk BJ, Seneviratne SI, Ward PJ, et al. (2018). Future climate risk from compound events. *Nature Climate Change* **8**(6): 469–477.

