A follow-on to the study on heat and mortality
Rx for Hot Cities: Climate Resilience Through Urban Greening and Cooling in Los Angeles

Rx FOR HOT CITIES 2

Reducing Heat and ER Visits With Trees and High-albedo Surfaces in Los Angeles

TreePeople

LOS ANGELES URBAN COOLING COLLABORATIVE

UCLA Institute of the Environment & Sustainability

The Los Angeles Urban Cooling Collaborative (LAUCC) is a multi-disciplinary, national partnership of academic researchers and nonprofit organizations working with communities and government agencies to research and implement data-driven, inclusive strategies for cooling urban areas and protecting vulnerable communities from heat-related health risks.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

01

As the planet warms, there is an increasingly urgent need for strategies to prevent the heat-health impacts of climate change. Cooling urban neighborhoods by adding trees and vegetation and increasing solar reflectance (or albedo) of roofs, pavements, and walls can mitigate urban heat — a problem that disproportionately affects low-income communities and people of color. In a previous study, the Los Angeles Urban Cooling Collaborative looked at how various tree cover and albedo scenarios would impact heat and heat-related mortality in Los Angeles, both under a present and future climate. We found that roughly one in four lives currently lost during heat waves could be saved. We also found that climate change-induced warming could be delayed approximately 40-70 years under business-as-usual and moderate mitigation scenarios, respectively.

In this follow-on study, we focused on heat-related *morbidity* as measured by emergency room visits. Using synoptic climatology, we used meteorological data for historical summer heat waves, classifying days into discrete air mass types. We analyzed those data against historical data on ER visits to determine excess and heat-related morbidity. We then used the Weather Research and Forecasting model to explore the effects that tree cover and albedo scenarios would have, correlating the resultant meteorological data with standardized morbidity data algorithms to quantify potential reductions in ER visits. We tested "prescriptions" of low, medium, and high tree cover and albedo changes and found that all-cause and heat-related ER visits would be reduced substantially — especially during moderate heat waves and during hot, dry Santa Ana heat events. ER reductions in the double-digit percentages were common, meaning that between 25% and 50% of ER visits could be avoided if L.A.'s urban environment had more trees and higher-albedo surfaces.

INTRO DUC TION

03

The Los Angeles region faces a range of challenges induced or exacerbated by climate change. Of all of the changes anticipated for the region, extreme heat has the potential to impact the largest number of people because many of the region's residents lack the resources necessary to cope (Li et al., 2020; Chakraborty et al., 2019). Continued warming is projected to increase average temperatures 4-5°F by mid-century, and by 5-8°F by the end of the century, with temperature extremes expressed both in the rising number of extremely hot days, and in the hottest days being up to 10°F hotter than we see today (Hall et al., 2018). Due to climate and topographic variability in Los Angeles County, some cities will have 5 to 6 times the number of extreme heat days compared to current levels (Hall et al., 2018). As the planet warms, urban areas are heating up at a faster rate than non-urban areas, placing in question the habitability of many cities and highlighting the importance of better understanding the impacts in order to provide a fitting response (Estrada et al., 2017).

Heat-related health problems are consequently expected to rise in California (Ostro et al., 2011). During the hottest summer days in Los Angeles there is already an 8% increase in all-cause mortality — deaths from all causes combined — as heat puts extra stress on people with a range of underlying conditions (Kalkstein et al., 2014). Consecutive days of intense heat can have a more harmful impact, with all-cause deaths occasionally increasing by 30% (Kalkstein et al., 2014). Escalating back-to-back extreme heat days are expected to occur more frequently in the future, setting the stage for potentially devastating heat waves (Sheridan, et al., 2012). Health suffers when higher heat exposure is coupled with limited ways of coping with heat, particularly in the absence of nighttime relief from the heat, which can increase health risk even more than high daytime temperatures (Dousset, et al., 2011).

Like many shifts brought on or exacerbated by climate change, heat raises equity concerns, as the burden of extreme heat disproportionately affects low-income urban populations and people of color (Jesdale et al., 2013). These communities often live in neighborhoods of denser development that have older, substandard housing, less UFC, and limited access to air conditioning or the ability to pay for it — living conditions which contribute to a pronounced urban heat island, and which create a feedback loop of heating effects. Black Americans are 52% more likely than average to live in areas where a high risk for heat-related health problems exists, while Latino/a communities are 21% more likely to live under such conditions (Jesdale et al., 2013). Residents of neighborhoods that were formerly subject to redlining — a Federal practice that determined home lending risk based on racial composition — experience higher surface temperatures (on average +4.7°F and up to +12.6°F) than their non-redlined counterparts more than 50 years after the end of redlining policy (Hoffman et al., 2020). In Los Angeles, inequity of heat impacts among Black and Latino/a communities means that these communities are likely to see some of the largest increases in mortality as the climate warms (Kalkstein et al., 2014). During extended heat waves in L.A., mortality already increases about five-fold from the first to the fifth consecutive day; after the fifth day, mortality risk increases 46% in Latino/a communities and 48% in elderly Black communities (Kalkstein et al., 2014).

Despite the growing threat of heat, effective approaches to alleviate urban heat exist and are within reach. These include risk mitigation strategies designed to facilitate institutional response during extreme heat events, as well as built environment strategies that focus on reducing urban temperatures through measures such as increasing vegetation, improving building standards, and increasing reflectance of the built environment (Keith et al., 2020).

GOALS OF THE PROJECT

05

This project builds off of a study completed by the Los Angeles Urban Cooling Collaborative in 2020 which evaluated the effects of tree cover and cooling scenarios on heat-related mortality in Los Angeles County. In that study, we used historical meteorological and public health data to quantify how increases in tree cover and solar reflectance (or albedo) of roofs and pavements in Los Angeles could reduce summer temperatures, decrease the number of oppressive air mass days leading to higher heat-health risks, and prevent heat-related deaths. For L.A. County as a whole, results showed temperature reductions of up to 3.6°F, leading to mortality reductions between 10 to 30%, depending on the tree cover/albedo scenario (Kalkstein et al., 2022). A more granular, district-level analysis used the conservative assumption that tree canopy/albedo increases would only occur in each district while the rest of the county's land cover remained unchanged. That second analysis indicated that mortality reductions between 20 and 40% were a common outcome under various scenarios, and that the largest numbers of lives would be saved in low-income communities of color. Combined with other measures, increasing tree canopy and albedo in Los Angeles clearly holds promise for reducing heat-health risk and saving dozens or hundreds of lives during the hottest years. We also found that climate change-induced warming could be delayed approximately 40-70 years under business-as-usual and moderate mitigation scenarios, respectively.

The goal of this follow-on project was to quantify the effect that similar scenarios could have on reducing temperatures and decreasing heat-induced *morbidity* (rather than *mortality*) as measured by emergency room visits, which typically spike during heat waves. We then tested the impacts of different scenarios for L.A. County and at a smaller geographic scale for a heat-vulnerable area in the northeast San Fernando Valley. This smaller area corresponds to District 9 — one of the 11 districts that we modeled in the morbidity study completed in 2020 (de Guzman et al., 2020).

STUDY TERMS AND DEFINITIONS

Urban Tree Cover
The layer of tree leaves, branches, and stems that provide tree coverage of the ground when viewed from above.

Solar Reflectance (or Albedo)
The fraction of solar radiation that a surface reflects, measured from 0 (not reflective) to 1 (fully reflective). In general, lighter surfaces reflect more than darker surfaces.

Temperature Conversions
1 Celsius degree is equivalent to 1.8 Fahrenheit degree. That means that a 2°C reduction is the same as reducing temperature by 3.6°F.

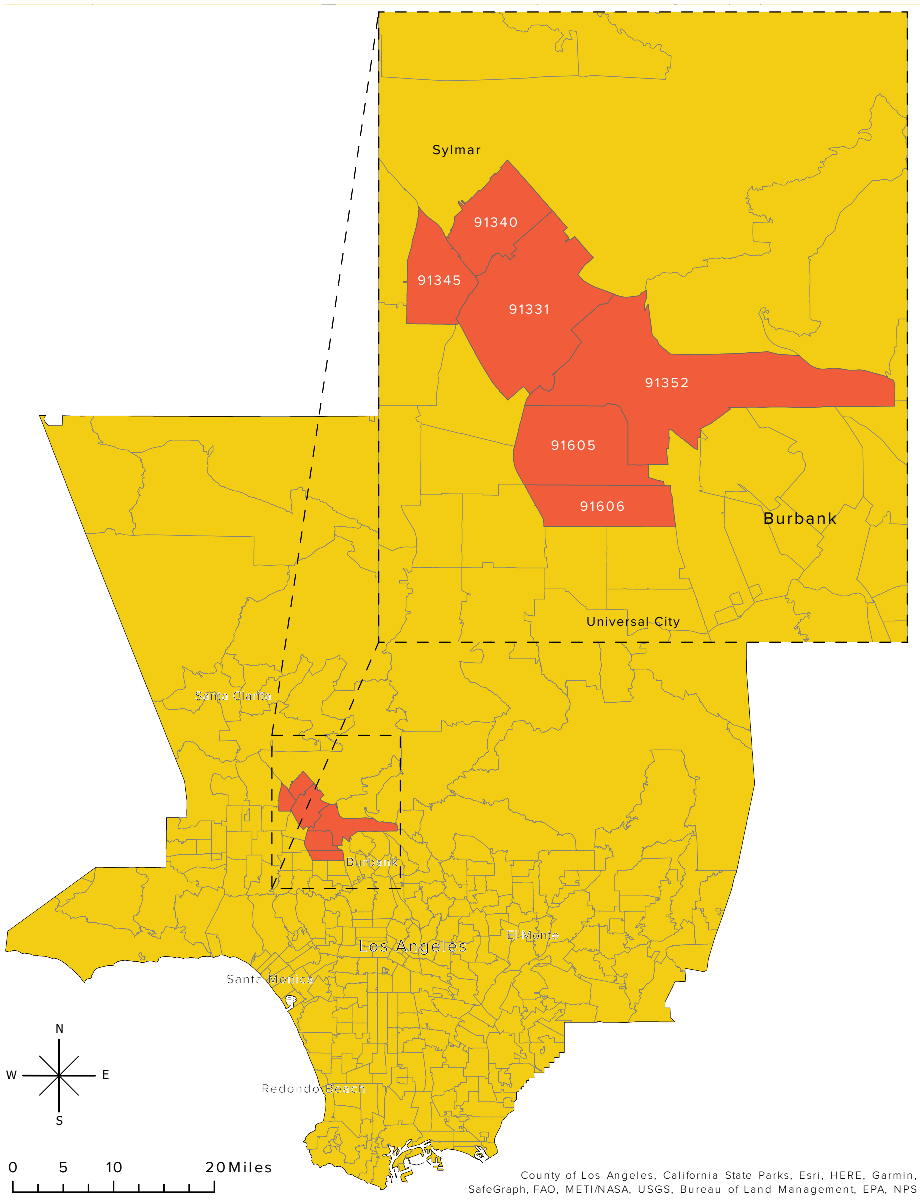
Extreme Heat
Occurs when the weather is much hotter and/or humid than usual, which can lead to heat-related illnesses and deaths. In this study, we use the Excessive Heat Factor, which compares mean apparent temperature over the most recent three days to the prior 30 days (see Methods section).

STUDY METHODS AND FINDINGS

07

SYNOPTIC CLIMATOLOGY

For this study, we developed a model for Los Angeles County to see what various combinations — or "prescriptions" — of increases in urban tree cover and albedo would do to temperature, humidity, air mass type, and heat-related morbidity. We studied four historical summer heat waves between the years 2006 to 2010, each with different characteristics, which enabled us to capture the range of heat events that commonly impact Los Angeles. We considered heat waves with characteristics such as early vs. late season, dry vs. humid, and intense vs. moderate heat. We then tested the impacts of four different prescriptions for L.A. County as a whole and at a smaller geographic scale for a heat-vulnerable area centered around the northeast San Fernando Valley, located near the northern part of the City of Los Angeles.



County of Los Angeles, California State Parks, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, Bureau of Land Management, EPA, NPS

91331 - *Pacoima*
91340 - *San Fernando*
91345 - *Mission Hills*
91352 - *Sun Valley*
91605-91606 - *North Hollywood*

We used a "synoptic" climatological approach, which classifies days into one of a number of discrete "air mass" types that traverse a given area and provide unique weather characteristics to that area. Rather than analyzing temperature, humidity, and other meteorological variables separately, the holistic approach of synoptic evaluation allows us to pinpoint "offensive" conditions that lead to unusually high health impacts, such as heat-related mortality (Hondula et al., 2014). This is important because humans respond to an entire suite of weather variables that impact the individual simultaneously. Our modeling team has used this approach to examine heat-health relationships in major cities around the world.

By considering observations of temperature, dewpoint, pressure, wind, and cloud cover four times daily for a particular location, we develop a "spatial synoptic classification" that classifies days into air mass types (Sheridan, 2002). Two particular air masses have been found in many studies to be associated with statistically significant higher mortality rates, particularly during the summer months: dry tropical (DT) and moist tropical plus (MT+) (Lee & Sheridan, 2018). These are the air mass types we focused on.

Table 1. *Summary of air mass type abbreviations and descriptions. Bold items indicate air mass types with statistically significant higher mortality rates.*

SSC Air Mass Type Abbreviation	Air Mass Type Description
DP	Dry Polar: cool, dry air mass
DM	Dry Moderate: comfortable and seasonally warm
DT	**Dry Tropical: hot, dry, and very oppressive**
MP	Moist Polar: cool and moist, overcast
MM	Moist Moderate: warmer than MP but still wet and overcast
MT	Moist Tropical: typical summer air mass, warm and humid
MT+, MT++	**Moist Tropical Plus: excessively hot and humid; oppressive**
TR	Transition between different air masses; frontal boundary

DATA AND METHODS

Morbidity data

For this analysis, we focused on how heat impacts human morbidity in Los Angeles — that is, to what degree the number of emergency room visits changes during heat events. For the period 2005-2018, daily totals of emergency room visits were acquired from the California Department of Health Care Access and Information. Four different subsets of emergency room visits were acquired:

1. **ER visits due to *all causes* for Los Angeles County as a whole.** While this clearly includes many visits unrelated to the weather, it has been widely recognized that hospitalizations and mortality increase during hot weather for more than just what are categorized as 'direct heat-related' health impacts (Hajat et al., 2006).
2. **ER visits that are directly *heat-related* across Los Angeles County as a whole.** While these totals are much smaller than the all-cause totals, exploring direct heat-related morbidity outcomes provides additional insight into the most directly observable impacts of heat.
3. **ER visits due to *all causes* in District 9.**
4. **ER visits that are directly *heat-related* in District 9.**

We took historical data and then calculated **relative risk**, or the likelihood of going to the ER on a given heat wave day compared to if the heat wave had not occurred. Hence, a factor of 2 or a 200% increase represents double the likelihood of ER visits.

We also calculated the data as **visits per 100,000 people**. This enables comparison of heat vulnerability between regions. Overall, we see that while L.A. County is considered a heat-vulnerable region, the District 9 subregion is even more vulnerable than the county as a whole.

Calculation of Extreme Events

Heat exposure in this work is defined using a modified version of the Excess Heat Factor (EHF) developed by Nairn and Fawcett (2014), modified in Sheridan et al. 2019 by changing temperature to apparent temperature. The EHF compares mean apparent temperature over the most recent three days compared to the 30 before those. Thus, hot conditions following relatively cool weather yield the highest EHF, and in a number of studies, EHF has been shown to be an effective predictor of temperature-related human mortality (Langlois et al., 2013; Oliveira, 2022). Statistically, EHF is calculated as a product of the magnitude of the heat event, and an acclimatization term[1]. To define an extreme heat event (EHE), using the Nairn and Fawcett (2014) definition, the EHF exceeds the 85th percentile of all positive EHF values for a location over the climatological period. For the period of study, the greatest EHF observed is 84.8 (on September 3, 2010), and the threshold for an EHF is 25.5.

Calculating Relative Risks of Morbidity

Relative risks (RR) of morbidity were calculated for each of the four data sets: countywide ER visits, countywide heat-related ER visits, local ER visits, and local heat-related ER visits. For each of these, we calculated relative risks using a distributed-lag non-linear model (DLNM) that assesses the cumulative impact of weather on morbidity, using the dlnm package in R. The model is:

Log (Morbidity) = intercept + EHF + ns (time)

Where:

- morbidity is the daily total of ER visits from the relevant data set;
- ns (time) is a natural spline fit to the full 14-year period with 9 degrees of freedom per year to account for long-term changes in baseline morbidity as well as seasonal variations; and
- EHF is the excess heat factor defined above.

Each model examines the cumulative impact of heat over a 3-day period, as this allows a full assessment of potential lags in ER visits due to heat.

To explore the effects of increasing tree cover or albedo at the district scale, we used a leading regional scale atmospheric model called the Weather Research and Forecasting (WRF) model, version 3.8.1 (Chen et al., 2011). This model is routinely used to simulate urban climates, considering the effects of individual buildings and the various processes occurring within an urban area. For this study, we simulated Los Angeles County using three nested domains.

[1] *The magnitude of the heat event, excess heat (EH) is calculated as* $EH = \max\left(0, \left(\sum_{i=-2}^{0} AT_i\right)/3 - AT_{95}\right)$, *(1) where ATi is the apparent temperature on day i, averaged over a three-day period, and AT95 is the overall 95th percentile of apparent temperature for a particular location (based on the 1981-2010 normal period). The acclimatization term is defined as:* $EH_{accl} = \left(\sum_{i=-2}^{0} AT_i\right)/3 - \left(\sum_{i=-32}^{-3} AT_i\right)/30$, *(2) the difference between the three-day mean apparent temperature and the 30 days prior. EHF then is the product of these two terms, EHF = max (0, EH) x max (1, EHaccl), (3)in units of K2.*

Scenarios

The next step in the project was to estimate how the various prescriptions in urban tree cover and albedo would impact local meteorology — the results of which are then used to determine impacts on health. We selected three distinct prescriptions plus a present-day baseline case (Table 2). The four scenarios vary considerably in tree cover and reflectance of pavements, walls, and roofs, with Rx 4 being the most aggressive scenario.

We used the Los Angeles County Tree Canopy Advanced Viewer, a parcel-level LiDAR-based land cover assessment of Los Angeles County.[2]

To determine baseline roof and pavement albedo and propose scenarios for their increase, we reviewed relevant literature and efforts, such as Lawrence Berkeley National Laboratory's Hot Roofs, Cool Roofs mapping tool.[3] Tree canopy and albedo scenarios were developed for both the countywide analysis and the district analysis. A baseline number was determined to represent existing tree cover, roof albedo (two numbers — one for flat and another for steep roofs, as flat roofs tend to have higher albedo), pavement albedo, and wall albedo.

Table 2. *Tree cover and solar reflectance "prescriptions" tested.*

	Tree Cover	**Albedo**
Rx 1	Baseline	Baseline
Rx 2	Low	Low
Rx 3	Medium	Medium
Rx 4	High	High

Tree Cover Scenarios Defined
Baseline = 18% for LA County, 20% for District 9
Low = 25% relative increase (baseline x 1.25)
Medium = 50% relative increase (baseline x 1.5)
High = 40% tree cover (regardless of baseline)

Albedo Scenarios Defined
Baseline = 0.3 flat roofs, 0.1 steep roofs, 0.1 pavement, 0.35 walls
Low = 0.45 flat roofs, 0.2 steep roofs, 0.2 pavement, 0.45 walls
Medium = 0.63 flat roofs, 0.3 steep roofs, 0.3 pavement, 0.5 walls
High = 0.75 flat roofs, 0.35 steep roofs, 0.35 pavement, 0.6 walls

We then selected four historic, distinct heat waves to evaluate for the Los Angeles County area, each different from the others. These are the same heat waves used for the study on mortality impacts completed in 2020. Note that the heat waves occur at different times during the summer season. While these are historic heat waves, they represent the types of heat waves that the L.A. region is likely to continue to experience — even in a warming climate.

- **July 22-26, 2006:** hot and humid, dominated by MT+ air mass days.
- **June 19-22, 2008:** a drier event with a mixture of MT and DT days.
- **August 26-30, 2009:** the least excessive heat wave of the four; we wanted to evaluate a more common situation that was not extreme.
- **September 26-29, 2010:** a very hot Santa Ana event, with an abundance of DT days.

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[2] *Accessed at treepeople.org/los-angeles-county-tree-canopy-map-viewer/*
[3] *Accessed at albedomap.lbl.gov*

RESULTS

How heat impacts ER visits

As shown in Figures 1 and 2, there is a clear increase in ER visits as excess heat factor increases, across all four data sets analyzed — indicating that historical public health data records corroborate that heat waves send more Angelenos to the ER. In Figure 1, the relative risk of an ER visit is linearly related to excess heat, when considering **all-cause ER visits**. Using Nairn-Fawcett Criteria (Nairn & Fawcett 2014) a heat event day would be considered to be one with an EHF of 40 or higher, and an extreme heat event day as one with an EHF of 81 or higher. For Los Angeles County as a whole, these thresholds are associated with a relative risk of 1.034 and 1.069 respectively, translating to 3.4% and 6.9% expected increases in ER visit totals across all causes. For District 9, the relative risks are slightly higher, at 1.042 and 1.086, respectively, suggesting that residents of the district are slightly more susceptible to the impacts of heat than residents in the rest of the County as a whole. In District 9, we thus expect to see approximately 4.2 to 8.6% more visits to the ER during heat waves.

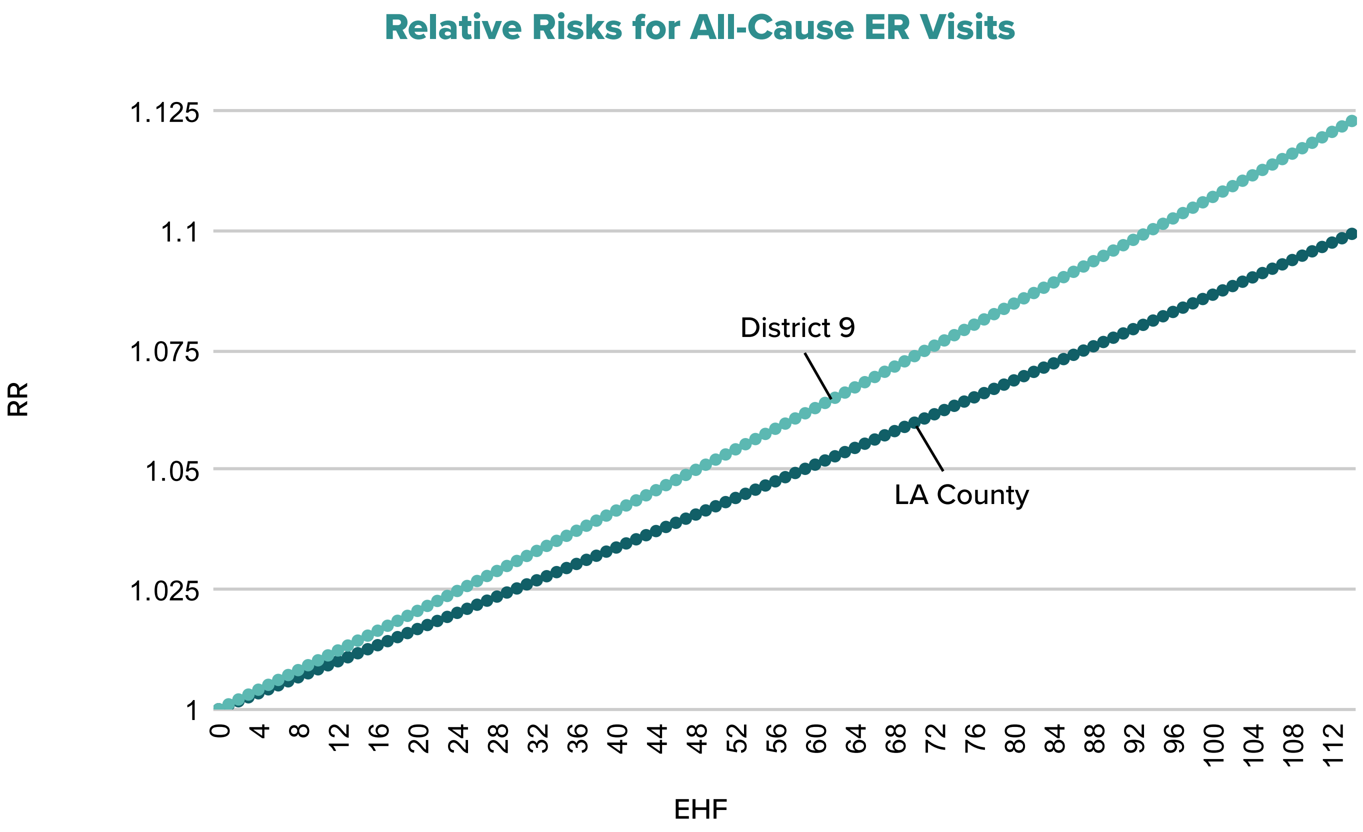

Figure 1. *The relationship between excess heat factor (EHF) and relative risk (RR) of emergency room visits due to all causes for Los Angeles County as a whole (dark blue) and District 9 (light blue).*

In Figure 2, the corresponding relationships between EHF and relative risk of **heat-related ER visits** are shown. As heat-related ER visits are uncommon outside of hot weather, the relative risk values are much greater, with a curvilinear relationship that suggests extreme impacts on the hottest days. For Los Angeles County as a whole, a heat event is associated with a relative risk of 3.44 (which is 2.44 above a factor of 1, indicating a 244% increase in expected ER visits). As an EHF rises — indicating a more extreme heat wave — so too does relative risk. An extreme heat event is thus associated with a relative risk of 11.51 (1051% increase). As with overall ER visits, District 9 is slightly more vulnerable, with relative risks of 3.49 and 12.58.

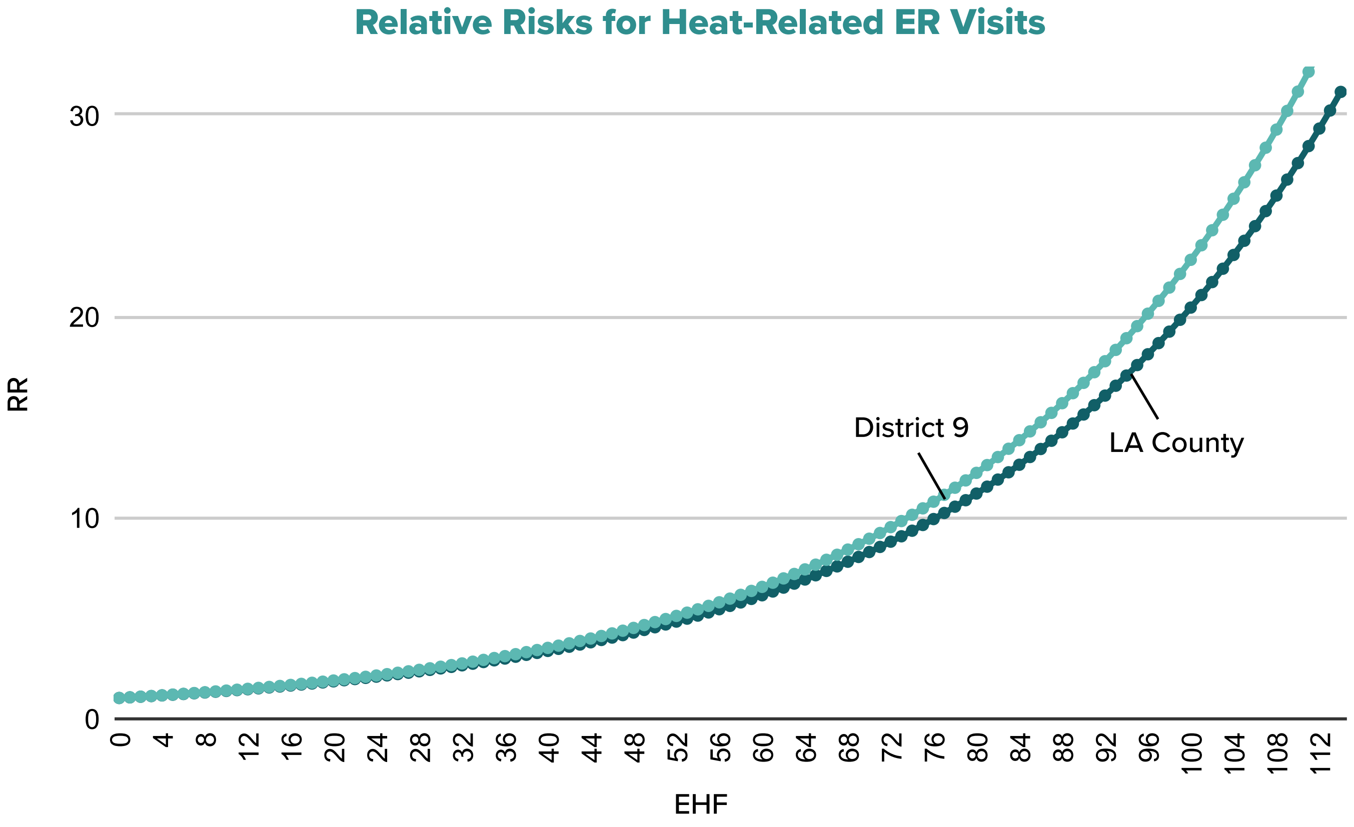

Figure 2. *The relationship between excess heat factor (EHF) and relative risk (RR) of heat-related emergency room visits for Los Angeles County as a whole (dark blue) and District 9 (light blue).*

Impacts of cooling scenarios on meteorological conditions

Though the four heat events are all simulated for the same length of time (focused on the five hottest days of a given period), it is clear from Tables 3 and 4 that there are differences in magnitude of the heat events, with the very hot and humid 2006 event (MT+) by far the most extreme, followed by the Santa Ana event of 2010 (a DT event).

The potential changes in meteorological conditions, as expected, are more pronounced with the more aggressive prescription scenario than more moderate scenarios, with the magnitude of change varying across events. The 2009 and 2010 heat events, the two drier heat waves, show a greater temperature decrease with interventions than the more humid events in 2006 and 2008.

Table 3. *Mean apparent temperature (°F) for each of the four heat waves in the study under baseline conditions and with the study's tree cover and albedo scenarios applied*

EVENT	BASELINE	LOW		MEDIUM		HIGH	
	Mean	Mean	Change	Mean	Change	Mean	Change
2006	**87.4**	**87.2**	-0.3	**86.8**	-0.6	**86.5**	-1.0
2008	**83.9**	**83.7**	-0.2	**83.3**	-0.6	**83.1**	-0.8
2009	**82.9**	**82.4**	-0.5	**81.9**	-1.0	**81.5**	-1.5
2010	**84.4**	**83.7**	-0.7	**83.0**	-1.4	**82.4**	-2.0

Table 4. *Modeled Excess Heat Factor for each of the four heat waves in the study under baseline conditions and with the study's tree cover and albedo scenarios applied*

EVENT	BASELINE	LOW		MEDIUM		HIGH	
	EHF	EHF	Change	EHF	Change	EHF	Change
2006	**290**	**273**	-17	**264**	-26	**256**	-34
2008	**146**	**139**	-7	**126**	-20	**117**	-29
2009	**68**	**55**	-13	**51**	-17	**47**	-21
2010	**139**	**108**	-31	**93**	-46	**83**	-56

Impacts of cooling scenarios on ER visits due to all causes

The differences in the magnitude of the heat events translates directly into differences in health impacts. The 2006 event as modeled shows an additional 245 all-cause ER visits in Los Angeles County (Table 5), and 10.4 additional visits in District 9 (Table 6). The rate of increase in ER visits is higher across District 9 (3.41 / 100,000) than Los Angeles County (2.49 / 100,000) as a whole, as the district itself has a higher level of vulnerability as shown in Figure 1. The other three events show a similar relationship but with smaller impacts.

The three scenarios are all associated with a reduced impact on human health as measured by ER visits. Decreases for the humid 2010 event range from 28% to 47%, with the high scenario suggesting a decrease in 85 ER visits across Los Angeles County under these urban modifications. In the hottest event of 2006, though the improvement is lower due to modification leading to a less intense reduction in air temperature, there is still a 12% decrease in ER visits projected under the High Scenario, a decrease of 29 across the county — from 245 ER visits to 216.

Table 5. *Modeled excess ER visits due to all causes, Los Angeles County*

EVENT	BASELINE		LOW			MEDIUM			HIGH		
	Excess Visits	Rate per 100,000	Excess Visits	Rate per 100,000	Change	Excess Visits	Rate per 100,000	Change	Excess Visits	Rate per 100,000	Change
2006	**245**	*2.49*	**230**	*2.34*	-6%	**222**	*2.26*	-9%	**216**	*2.19*	-12%
2008	**158**	*1.61*	**150**	*1.53*	-5%	**135**	*1.38*	-14%	**125**	*1.27*	-21%
2009	**59**	*0.60*	**47**	*0.49*	-19%	**44**	*0.44*	-26%	**40**	*0.41*	-32%
2010	**180**	*1.83*	**131**	*1.33*	-27%	**107**	*1.10*	-40%	**95**	*0.97*	-47%

Table 6. *Modeled excess ER visits due to all causes, District 9*

EVENT	BASELINE		LOW			MEDIUM			HIGH		
	Excess Visits	Rate per 100,000	Excess Visits	Rate per 100,000	Change	Excess Visits	Rate per 100,000	Change	Excess Visits	Rate per 100,000	Change
2006	**10.4**	*3.41*	**9.8**	*3.21*	-6%	**9.4**	*3.09*	-9%	**9.2**	*3.00*	-12%
2008	**7.0**	*2.29*	**6.7**	*2.18*	-5%	**6.0**	*1.96*	-15%	**5.5**	*1.81*	-21%
2009	**2.6**	*0.86*	**2.1**	*0.69*	-19%	**1.9**	*0.63*	-25%	**1.8**	*0.59*	-31%
2010	**8.6**	*2.84*	**6.3**	*2.06*	-28%	**5.2**	*1.69*	-40%	**4.6**	*1.49*	-47%

Overall totals of *heat-related* ER visits are projected lower than overall visits, ranging across the four heat events from 15 to 145 visits in Los Angeles County (Table 7), and 1 to 6 visits in District 9 (Table 8). Though the totals are lower, once again standardized rates of heat vulnerability per 100,000 people are higher across District 9 than the county as a whole.

The percentage decreases in heat-related ER visits under the scenarios are greater than the decreases in overall ER visits, given the direct connection between heat and the reason for the visit. Under the low scenario, heat-related ER visits are projected to drop 7% to 45% based on the event, and to drop between 24% and 66% under a more aggressive land cover prescription.

Table 7. *Modeled heat-related ER visits, Los Angeles County*

EVENT	**BASELINE**		**LOW**			**MEDIUM**			**HIGH**		
	Total Visits	Rate per 100,000	Total Visits	Rate per 100,000	Change	Total Visits	Rate per 100,000	Change	Total Visits	Rate per 100,000	Change
2006	**145**	*1.47*	**126**	*1.29*	-13%	**117**	*1.20*	-19%	**111**	*1.13*	-24%
2008	**56**	*0.57*	**52**	*0.53*	-7%	**45**	*0.46*	-20%	**40**	*0.41*	-28%
2009	**15**	*0.16*	**10**	*0.09*	-38%	**8**	*0.08*	-48%	**7**	*0.08*	-54%
2010	**44**	*0.45*	**25**	*0.26*	-42%	**19**	*0.20*	-56%	**16**	*0.17*	-63%

Table 8. *Modeled heat-related ER visits, District 9*

EVENT	**BASELINE**		**LOW**			**MEDIUM**			**HIGH**		
	Total Visits	Rate per 100,000	Total Visits	Rate per 100,000	Change	Total Visits	Rate per 100,000	Change	Total Visits	Rate per 100,000	Change
2006	**6.0**	*1.96*	**5.2**	*1.71*	-13%	**4.8**	*1.58*	-19%	**4.5**	*1.49*	-24%
2008	**2.4**	*0.80*	**2.3**	*0.74*	-7%	**1.9**	*0.64*	-20%	**1.7**	*0.57*	-28%
2009	**0.9**	*0.28*	**0.6**	*0.18*	-36%	**0.5**	*0.15*	-46%	**0.4**	*0.14*	-51%
2010	**2.3**	*0.75*	**1.3**	*0.41*	-45%	**0.9**	*0.31*	-58%	**0.8**	*0.26*	-66%

CONCLUSION

Together with the mortality study completed in 2020, the morbidity analyses conducted in this follow-on study demonstrate that by relying on a suite of interventions available today, Los Angeles has the capability to cool its neighborhoods sufficiently to change local meteorology during extreme heat events. Though the meteorological outcomes of added tree cover and albedo vary based on heat wave characteristics — including seasonal timing, duration, intensity, and humidity — the cooling produced can lead to significant decreases in both morbidity and mortality during heat events.

Our mortality study provided estimates on how many lives could be spared, demonstrating that upwards of 25% lives could be saved during extreme heat events if aggressive action were taken to increase urban reflectivity and add tree canopy.

Temperatures during the emblematic heat events we modeled decreased by 3.6-5.4°F during the hottest times of day as well as overnight — which is of particular importance for public health. Heat events would still occur, but the magnitude of the heat would be reduced to below-lethal thresholds for many vulnerable individuals.

In the present study, we evaluated the impacts that increased urban tree cover and albedo of roofs, pavements, and walls would have on morbidity as measured by emergency room visits. Using the same four historical heat events we evaluated in the first study, we applied the Excessive Heat Factor — a predictor of a heat event's impact on public health outcomes.

We found that, depending on the heat event, all-cause ER visits in L.A. County and in District 9 would be reduced:

- **Between 5% and 27% under a LOW tree cover/albedo prescription**
- **Between 9% and 40% under a MEDIUM tree cover/albedo prescription**
- **Between 12% and 47% for a HIGH tree cover/albedo prescription**

We saw substantially higher reductions when focusing only on heat-related ER visits. For L.A. County as a whole we saw reductions of:

- **Between 7% and 42% under a LOW tree cover/albedo prescription**
- **Between 19% and 56% under a MEDIUM tree cover/albedo prescription**
- **Between 24% and 63% for a HIGH tree cover/albedo prescription**

For District 9 we saw slightly bigger reductions in heat-related ER visits:

- **Between 7% and 45% under a LOW tree cover/albedo prescription**
- **Between 19% and 58% under a MEDIUM tree cover/albedo prescription**
- **Between 24% and 66% for a HIGH tree cover/albedo prescription**

The findings of both studies indicate that we presently have the ability to address heat-related health impacts and reduce both heat-related illnesses and fatalities.

As the planet gets hotter — and as cities warm at an even more accelerated pace — practical and actionable land cover solutions to a problem that disproportionately affects low-income communities and people of color are available and should be prioritized.

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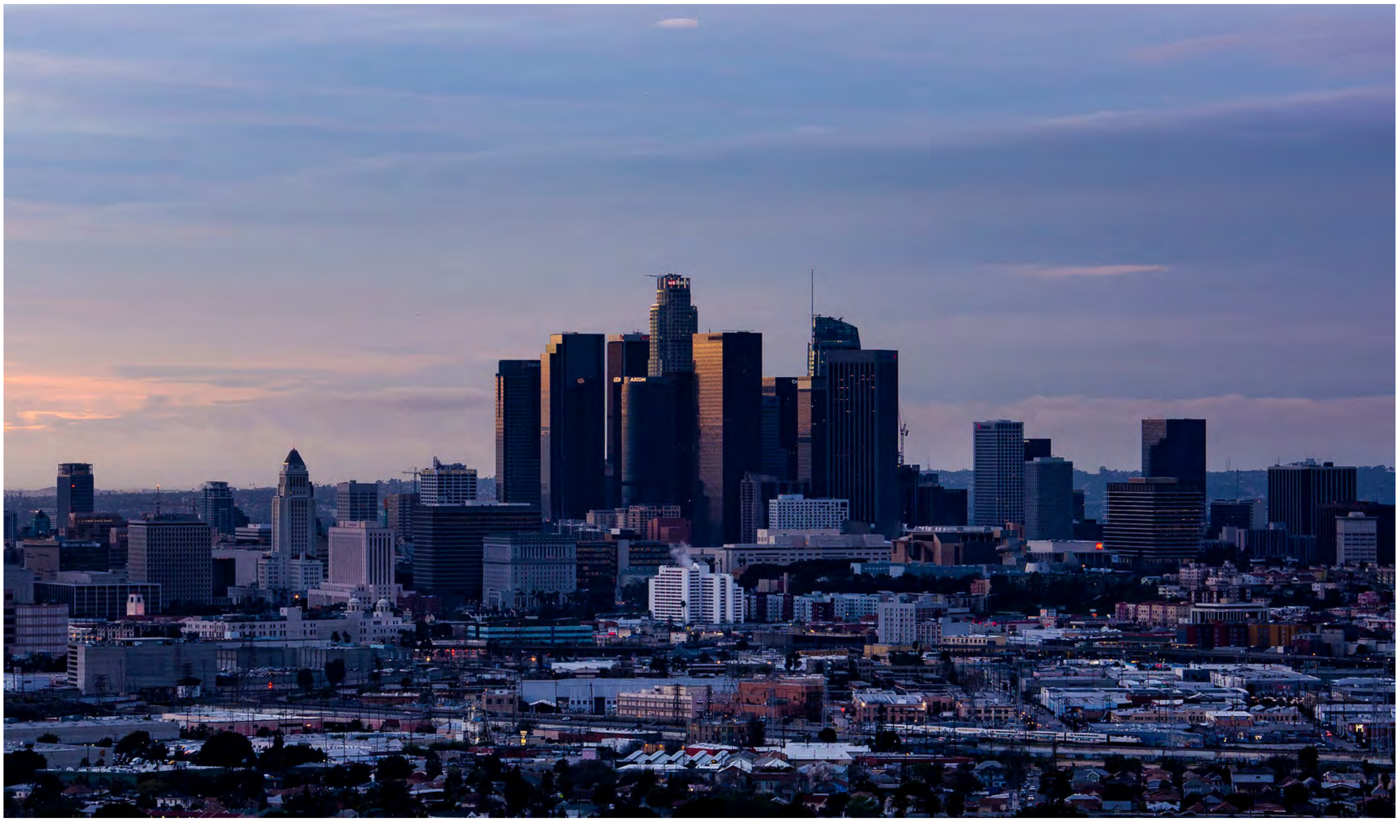
21



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