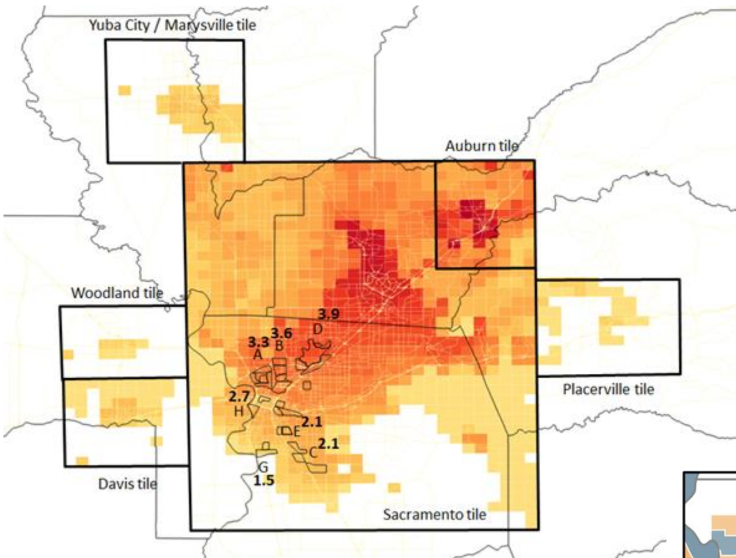
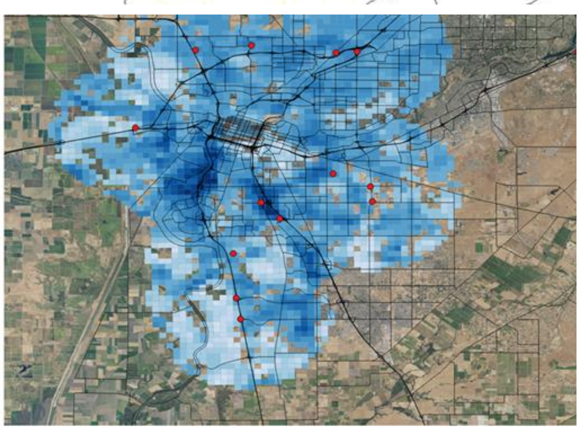
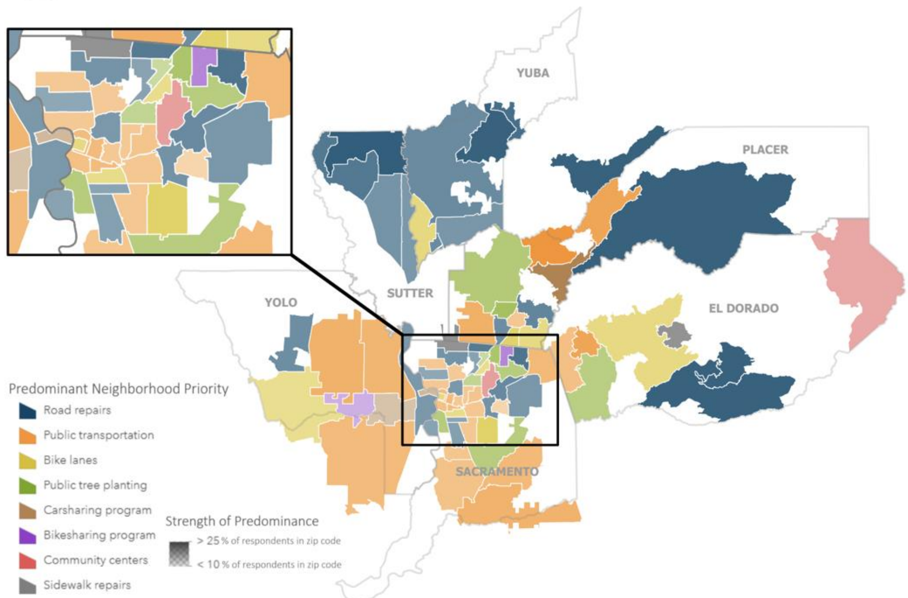
Summary Report

Capital Region Urban Heat Island Mitigation Project







SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Local Government Commission
Leaders for Livable Communities

CAPITAL REGION CLIMATE READINESS COLLABORATIVE

TABLE OF CONTENTS

INTRODUCTION

Like many places around the world, California's Capital Region faces increasing threats from urban heat to its economy, infrastructure, and the health and safety of its people. This challenge is projected to worsen dramatically over time as a result of the climate crisis. By the 2040 to 2070 period, the Sacramento Region will experience as many as 24 to 35 extreme heat days per year, up from 3-4 days historically.[1] This rising heat is further exacerbated by the urban heat island (UHI) effect, increasing summer temperatures in cities, suburbs, and towns. Strategies and measures widely available today can help cities and communities to reduce the UHI effect.

Recognizing this opportunity, the Sacramento Metropolitan Air Quality Management District (SMAQMD) and the Local Government Commission (LGC) led a project to address the UHI effect in the six-county Capital Region and identify the most effective urban heat reduction measures. The project was funded by a SB1 Adaptation Planning Grant, awarded by the California Department of Transportation (Caltrans) in December 2017; the project timeline ran from May 2018 to February 2020.

The urban heat island effect describes the higher day and night temperatures experienced in urban and suburban areas in comparison to their surrounding rural areas. This temperature gap results from solar heat trapped and absorbed by the built environment – roads, pavements, buildings, and roofs – as well as waste heat released as a byproduct of human activity such as combustion engines and air-conditioners. With its miles of roads, highways, and pavements, the transportation sector is a major contributor to the UHI effect. In turn, transportation infrastructure is also vulnerable to the effects of extreme heat, which contributes to pavement deterioration, higher maintenance costs, and buckled rails and bridge joints.

To address the UHI challenge, the project developed an advanced model of the UHI effect in the Capital Region, at local and regional scales, and for today's conditions as well as a 2050 land use and climate scenario. The model identifies the geographic areas with the most severe UHI effect but more importantly, it evaluates the effectiveness of different potential heat mitigation measures deployed at various scales. These findings were then distilled into transportation resilience recommendations and strategies for local governments. The project team also conducted community outreach and engagement throughout the Capital Region to understand community concerns around extreme heat, transportation needs, and priorities for neighborhood and transportation improvements.

The project's findings and recommendations can aid local governments in their overall planning for extreme heat and heat resilience for public health, land use design, urban forestry, and more. For the transportation sector, the project findings can help to improve the resilience of roadways and pavements, as well as support the health of active transportation users. These goals are in line with the State of California's broader goals for climate resilience planning and the California Transportation Plan 2040's goals for a vibrant multi-modal transportation system.

This report summarizes the overall project and provides a summary of main findings and takeaways. The full set of project documents and deliverables will be hosted online and will include:

- Project Summary Report (this document)
- Urban Heat Island Analysis Technical Report
- Transportation Plan Recommendations
- Community Priorities Report
- Community Engagement Toolkit
- Interactive maps and appendices

[1] https://cal-adapt.org/tools/extreme-heat/

PROJECT BACKGROUND

Participants and Stakeholders

The project was staffed by Altostratus, Inc., which modeled the urban heat island effect and mitigation measures for the region, and WSP, which analyzed transportation plans and projects and developed transportation-sector recommendations. The Sacramento Municipal Utility District (SMUD) and the Capital Region Climate Readiness Collaborative (CRCRC) – a cross-sectoral, multi-jurisdictional collaborative of agencies, organizations, and other stakeholders – provided in-kind support through staff time and donations. This project also benefited from the guidance, recommendations, and feedback from a technical advisory committee representing jurisdictions, agencies, and other organizations from across the region: California Air Resources Board, California Department of Public Health, El Dorado County, El Dorado County Transportation Commission, City of Davis, Feather River Air Quality Management District, Placer County Air Pollution Control District, Sacramento Area Council of Governments (SACOG), City of Sacramento, Sacramento County, Sacramento County Department of Public Health, SMUD, the Sacramento Tree Foundation, Yolo County, and Yolo-Solano Air Quality Management District.

Climate Impact Area

Extreme heat is a critical issue facing the Sacramento region and is projected to worsen as climate change intensifies. Extreme heat can deteriorate pavements and other transportation infrastructure, resulting in not only delays, disruptions, and inconveniences for travelers but also increasing maintenance costs for the government organizations that manage them. The UHI effect also exacerbates air pollution like ozone and increases GHG emissions as a result of greater reliance on air conditioning. Heat is a serious health risk, especially for those who are elderly or young, have preexisting health conditions, work outdoors or in unconditioned spaces, are experiencing homelessness, and are socially or linguistically isolated. For transportation users, those who are dependent on the public transportation system, rely on walking or biking, or face limited mobility choices are also more exposed to extreme heat.

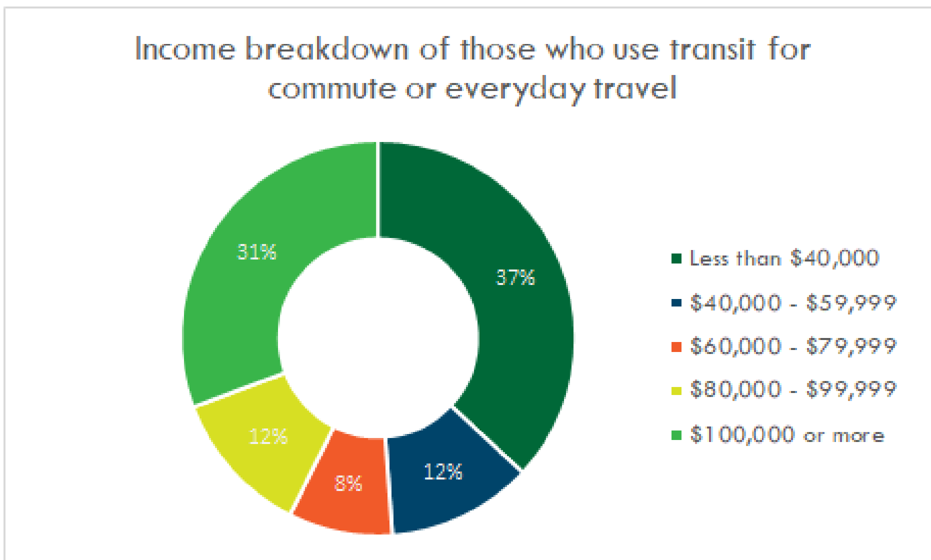


Figure 1. The results of the community survey carried out for this project show that low-income residents in the Capital Region are more likely to depend on public transit for their travel needs.

While this project analysis focuses on urban heat islands, the recommendations for heat reduction strategies can be applied in all neighborhoods, not just urban areas or heat islands. The UHI effect offers a useful metric for quantifying locally generated heat, and thus also a potential target for the cooling possible in urbanized or developed locations. Nonetheless, it should be emphasized that the urban heat strategies recommended and modeled in this analysis can help lower absolute temperatures in all neighborhoods – and with increasing temperatures due to climate change, these measures will become more and more relevant in all areas.

Urban Heat and Transportation Impacts

The UHI effect can exacerbate heat impacts on transportation infrastructure as well as on the users and riders of the transportation system. Many transportation infrastructure design processes rely on historical temperature ranges, but the combination of climate change and the UHI effect will lead to an increasing frequency of temperatures exceeding the Capital Region's historic averages. Here is a brief summary of how extreme heat can impact transportation infrastructure:

- **Pavements:** Temperatures that exceed the design range of pavement mix binders can result in thermal cracking and pavement distortion. This can lead to buckling and rutting on not only roads but also airport runways.
- **Rails:** When temperatures exceed the range within which rails are designed to operate, they can expand and warp, risking derailments. Trains generally must slow their speeds to reduce rail stress.
- **Electrical systems:** Higher temperatures can cause electrical systems to overheat. The Sacramento Regional Transit (SacRT) powers their light rail system with overhead catenary systems lines, which can stretch with heat and may lead to severing of the connection with the rail car. As mitigation, SacRT issues slow orders to reduce train speeds when temperatures are above 100°F (38°C).
- **Decreased ridership and active transportation:** A recent study of Fresno found that public transit use declined as temperatures increased. Similarly, walking and biking use are also likely to decrease during hot days.

RESULTS AND FINDINGS

Urban Heat Island Modeling

This project developed an urban heat model for the Capital Region at the 2-kilometer and 500-meter domain levels, using meteorological data for the months of May through September 2013-2016. Land use, land cover, tree cover, and urban data was derived from a comprehensive set of sources, from national to local. The 2-kilometer model allowed the project team to identify and analyze heat islands in the region, including how heat is shifted by wind from urban Sacramento east and north through the region, and evaluate the effectiveness of different heat mitigation measures deployed at varying levels at a regional scale. The 500-meter domain level, which is modeled separately, allows for an in-depth examination of cooling benefits at neighborhood scales.

Unlike many lidar and satellite-based remote-sensing studies, this project calculates UHIs using air temperatures at human height levels, not the surface temperatures of roads or buildings. This focus on air-temperature data provides a more accurate reflection of temperatures as experienced by people. This study refines and deepens the analysis in the California UHI Index developed by Altostratus Inc. for the California Environmental Protection Agency (First-of-Its-Kind Index Quantifies Urban Heat Islands).

The **urban heat island index (UHII)** offers one way to quantify urban heat islands and is used throughout the report. UHII expresses the cumulative temperature difference between an urban location and a non-urban reference point summed over a certain time interval – for example, hours or days. The units of UHII are degree-hours (ºC · hr. or ºF · hr.) or degree-days, and represent the total urban heat island effect added up over a time period. This allows for comparison between instantaneous heat island effects at a given time, all-hours heat island index (over 24 hours, combining the effect of day and night), and a UHII summed over a two week period, which smooth out variations in weather.

The UHII was computed for the May to September period for years 2013 through 2016 for the regions of interest in this study. The UHII was calculated for all hours (24-hour day), specific hours (6am, 1pm, and 3pm), as well as for ranges of hours (2-8pm, representing peak periods for the electricity system).

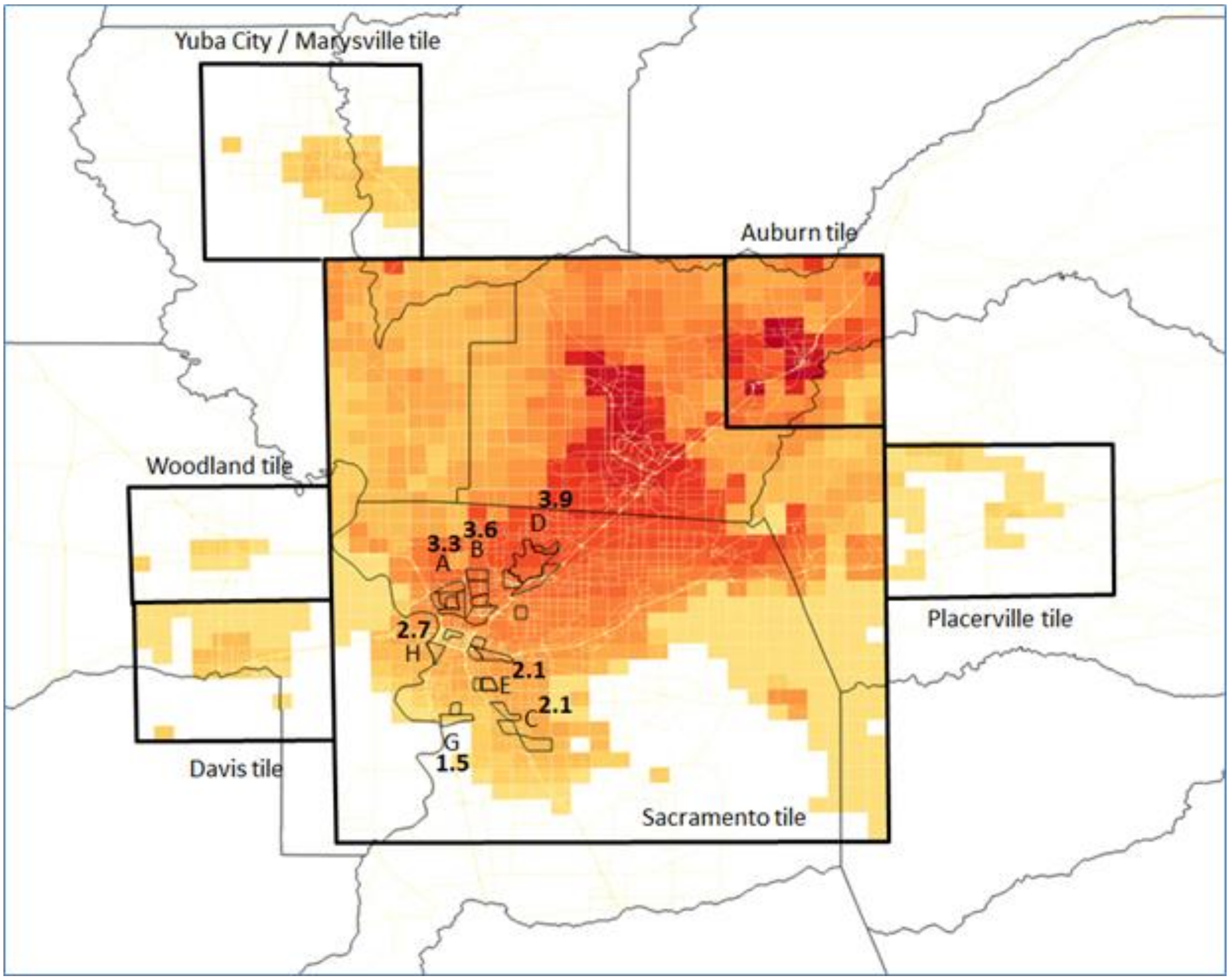


Figure 2. This shows the all-hours UHII for the region, not the absolute temperatures. The UHII in each of the six tiles is calculated independently; each tile has different wind directions and upwind (rural) reference points. Thus, areas such as Auburn and Lincoln may have a higher UHII than other areas, but not necessarily a higher absolute temperature, with the high UHII due to day/night variations in temperature of natural surroundings, higher elevations, or heat transport from upwind urban areas. The UHII range in this example, reflecting July 16-31, 2015, is 0 to 2176 °C·hr/15 days (3917 °F·hr/15 days). The lettered areas within the Sacramento tile denote AB-617 communities, and the numbers in bold are the all-hours temperature equivalents (in ºC) of the UHII.

Identifying and Prioritizing Urban Heat Islands

This study developed two sets of scores to help rank heat islands in the region and prioritize areas for deployment of UHI mitigation measures. The first set is based on the size of the UHI effect alone, regardless of air temperatures. This approach shows that the region's largest UHI is in an area from Roseville to Lincoln and a part of Auburn – this area is about 9-11°F (5-6°C) warmer than their surrounding areas. In the second highest UHII category are Northeast Sacramento, Roseville, Rocklin, Granite Bay, Lincoln, parts of Folsom, and areas west of Auburn, with a UHII of about 7-9°F (4-5°C). Central Sacramento, AB 617 communities[2] A, B, and D (South Natomas, Northgate, Del Paso, and North Highlands), Folsom, and El Dorado Hills have a UHII of about 5-7°F (3-4°C). Most of north and south Sacramento and AB 617 communities C, E, and G (South Sacramento, Florin, and Meadowview) have the second-to-lowest UHI effects. Finally, Yuba City / Marysville, Woodland, Davis, and Placerville have the smallest UHII scores.

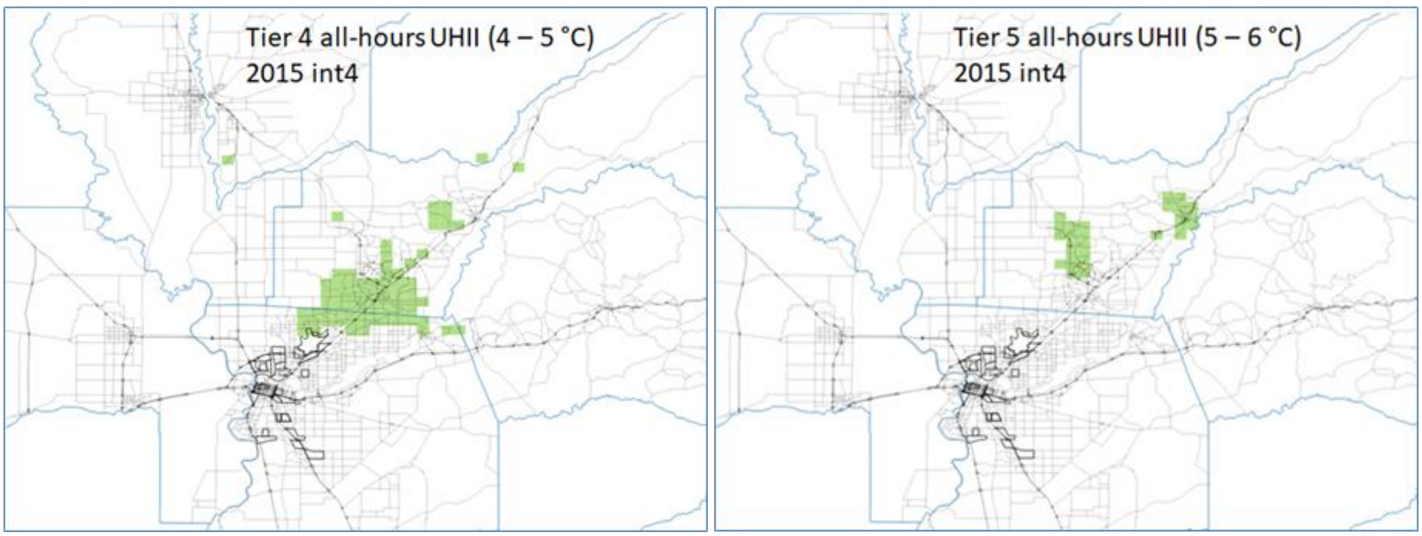


Figure 3. *Based on the all-hours UHII alone, the priority areas for UHI mitigation would be the area around Roseville, Lincoln, and Auburn (Tier 5) and Northeast Sacramento, Roseville, Folsom, Granite Bay, and Rocklin (Tier 4).*

However, a more intuitive ranking should also take into account the absolute air temperature in an area, not just the size of its UHII. This method of ranking gives higher scores to areas with both a large UHII and high air temperature than areas with the same UHII but lower temperatures. Combining the 24-hour UHII with the 24-hour temperature averages for the studied time periods results in a different prioritization ranking. Now, the highest priority areas for heat reduction would include parts of AB 617 community D, parts of northeastern Sacramento, Folsom, El Dorado Hills, Roseville, Rocklin, Lincoln, central parts of Yuba City and Marysville, and parts of Auburn. The second-highest priority areas would include AB 617 communities A, B, and D, north Sacramento and parts of downtown Sacramento, an area extending east to include south Folsom and El Dorado Hills, and parts of Lincoln and Auburn.

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[2] AB 617 (2017) established the Community Air Protection Program to improve air quality in communities disproportionately impacted by air pollution in California. As part of its AB 617 program, SMAQMD identified 10 communities within Sacramento County as priority communities for air quality improvement. These communities were highlighted throughout this project to understand their exposure to urban heat islands as well as their cooling potential, especially as heat exacerbates summertime ozone pollution.

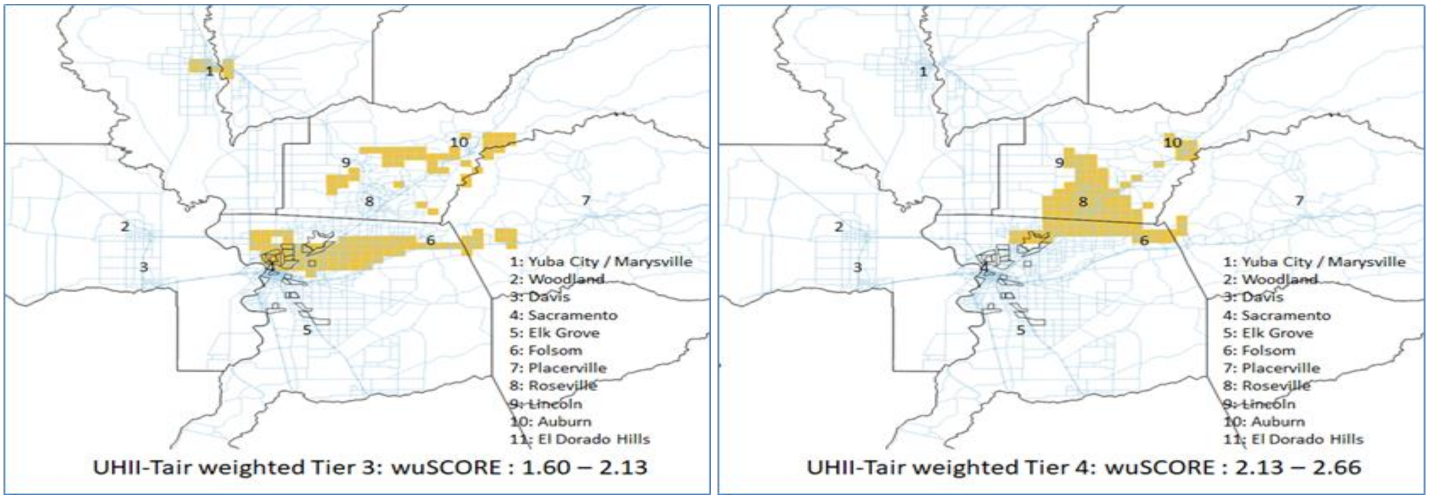

Figure 4. This UHI ranking score accounts for UHII as well as the absolute air temperature. Tier 4 (right) shows the highest priority areas for heat reduction under this scoring, and Tier 3 (left) shows the second highest priority areas.

These prioritization rankings can be combined with CalEnviroScore 3.0 or other tools to help prioritize support for communities that are most at risk from extreme heat.

Urban Heat Island Mitigation Measures

This study focused on analyzing urban heat mitigation strategies that are reasonable, realistic, and deployable today, rather than hypothetical or based on unrealistic implementation levels. The strategies were selected based on input from the counties, cities, and communities that participated in the technical advisory committee. The primary measures include cool roofs, cool pavements, vegetation canopy cover, vehicle electrification, solar photovoltaics (PV), and cool walls.

Albedo is a ratio that describes the percentage of incoming solar radiation (sunlight) that is absorbed or reflected away by a surface. A dark pavement has an albedo closer to 0, absorbs almost all heat, and thus increases the UHI effect, while a lighter surface has an albedo closer to 1, reflects instead of absorbs heat, and remains cooler. A cool roof or pavement will have a higher albedo than a dark roof or pavement.

At the 2km modeling scale, the project focused on evaluating the regional cooling impact of mitigation measures related to vegetation canopy cover and albedo. These were deployed in the following scenarios based on feasibility and reasonableness indicated by prior studies:

- **case10:** A small increase in albedo by 0.15 for roof and pavements.
- **case20:** A larger increase in albedo by 0.25 for roofs and pavements.
- **case01:** A first-level increase in canopy cover, about a 12 percentage point increase in tree canopy, i.e., going from 15% to 27% canopy cover. This increase could be achieved by adding 2.5-3 million trees throughout the six-county region.
- **case02:** A second-level (extreme) increase in canopy cover, about a 20 percentage point increase in tree canopy, i.e., going from 15% to 35% canopy cover. This increase could be achieved by adding 5 million trees throughout the region, but is not a realistic or practical scenario at this time. Thus, this measure is omitted in the combination scenario below or in certain analyses in this project. This scenario is included only as a test for potential upper-bound effects, per suggestions from local tree organizations.
- **case31:** A high-ambition but nonetheless realistic combination scenario of a 0.35 increase in albedo and a 12 percentage point increase in tree canopy (identical to case01).

Urban Heat Island Mitigation and Public Health

Through their significant cooling potentials, UHI mitigation measures can help to reduce extreme heat from levels considered dangerous to public health to less hazardous levels. This can be demonstrated by their modeled impact on various public-health heat indicators – for example, decreasing exceedances in the National Weather Service's Heat Index (NWS HI), which combines air temperature and relative humidity into an index of perceived temperatures categorized by their level of threat to human health.

This study shows that at 5pm, the combination mitigation scenario (case 31) can shift air temperatures below thresholds considered dangerous by the NWS Heat Index. In other words, heat island mitigation strategies can shift temperatures from one warning threshold to a lower one, such as from Danger to Extreme Caution. As shown in the graph below, the implementation of the combination scenario can eliminate temperatures above the Danger threshold (106°F) by between 50% and 100% in all testing locations, shifting them into the lower Extreme Caution threshold. The scenario can also shift 18% to 36% of temperatures exceeding the Extreme Caution (91°F) threshold to the Caution (80°F) threshold.

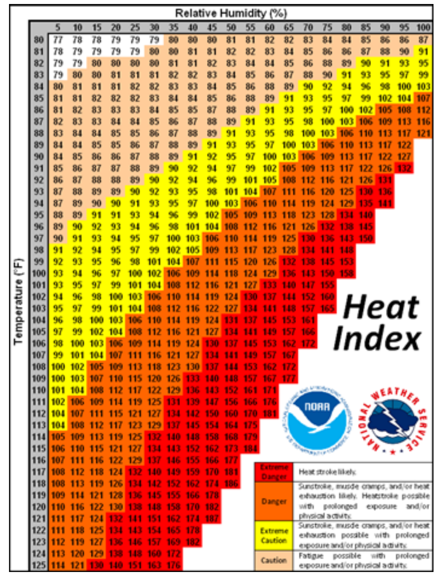

Figure 5. National Weather Service Heat Index for high-heat, low-humidity areas.

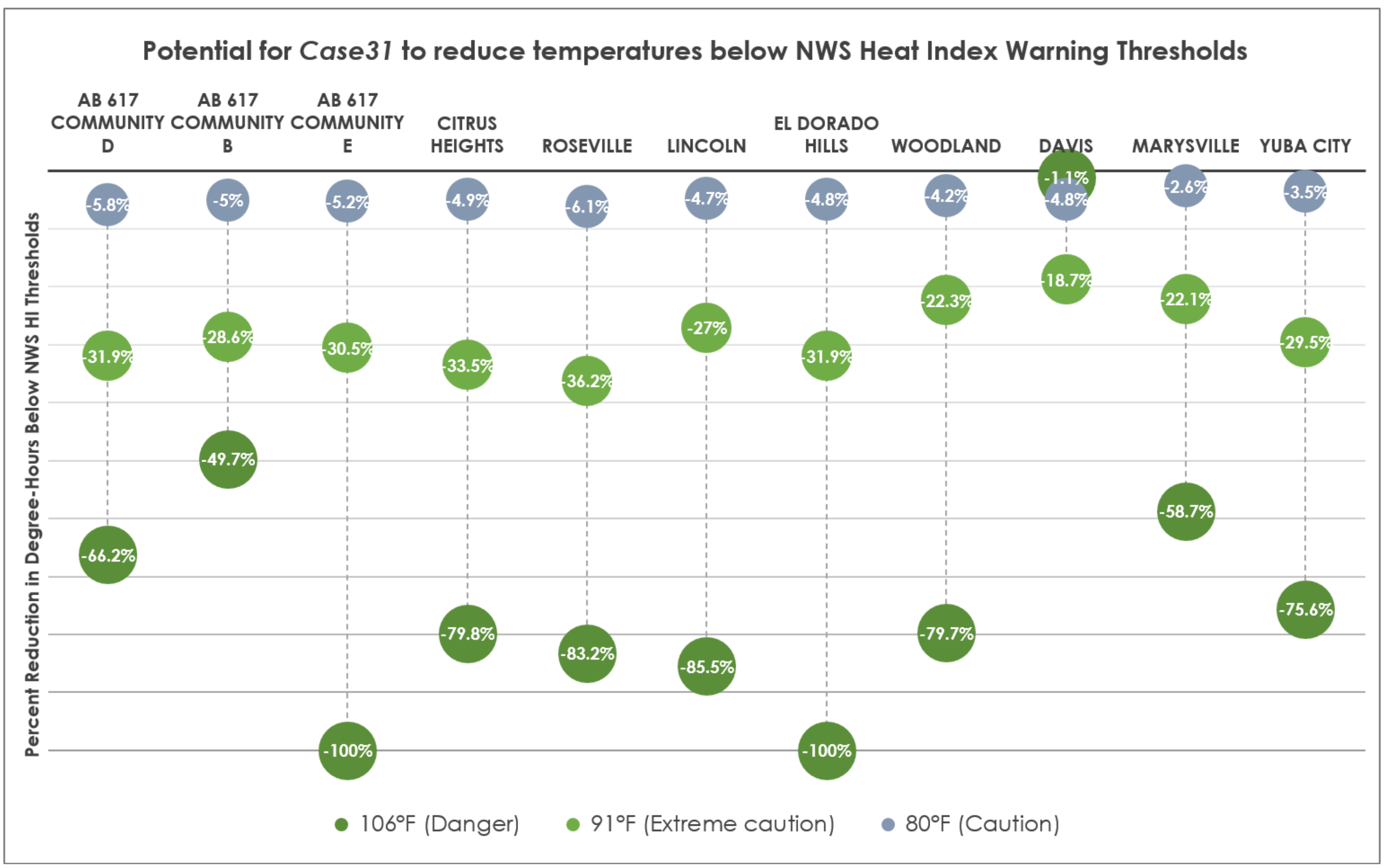

Figure 6. Percentage reductions in temperature (degree-hours) exceedances of NWS Heat Index warning levels at 5pm for selected locations, as a result of case31 (+0.35 albedo, +12 percentage point increase in tree canopy).

Heat mitigation strategies can also help to reduce the number of extreme heat days and heat wave events. For extreme heat days (NWS HI of 105°F to 110°F) and three heat waves that occurred during the modeled period, the combined mitigation scenario (case 31) was modeled to reduce the number of heat-event days from 3-5 to 1 or 0 in most locations.

For example, for a June to early July 2013 heat wave, this scenario is able to reduce the number of extreme heat days from 5 to just a single day in AB 617 community D and Citrus Heights. Such reductions could be highly important for protecting public health, especially for vulnerable and under-resourced communities.

Ranking Heat Mitigation Measures for Current Land Use Conditions

Figure 7 shows a high-level summary of the regional-scale UHI-mitigation potentials of the five mitigation scenarios in the current climate and land use / land cover conditions. This ranking identifies the most effective mitigation measures for different times of day and locations. This does not provide the size of the cooling effects for each measure, but simply shows their relative ranking, even if differences between one measure and another are very small or almost tied.

The modeling shows that albedo scenarios (e.g., cool roofs and cool pavements) are the top choice for reducing daytime urban air temperature. Because vegetation canopy cover can cool the air both during the day and at night, its impacts are dominant in the 24-hour average metrics and early-morning averages. The combination scenario generally produces the largest cooling effect regardless of time of day, whereas other measures vary in their ranking from one time of day to another.

For example, excluding the combination scenario, the 12% increase in tree canopy (case01) produces the largest cooling at night, and the 0.25 increase in albedo is the most effective in the daytime. Lastly, some of the urban areas such as Sacramento consistently experience larger cooling effects, especially in the combination scenario (case31). This is mainly because urban areas tend to have larger areas available for implementing UHI-mitigation measures.

Period	Measure	Auburn	Davis	El Dorado Hills	Placerville	Sacramento	Woodland	Yuba City
6am	Albedo + 0.15	5	5	5	5	5	5	5
	Albedo + 0.25	4	4	4	4	4	4	4
	Canopy cover + 12%	3	3	3	3	3	3	3
	Canopy cover + 20%	1	1	1	1	1	1	1
	Combination Case	2	2	2	2	2	2	2
1pm	Albedo + 0.15	5	4	5	4	4	4	5
	Albedo + 0.25	3	3	3	4	3	2	3
	Canopy cover + 12%	4	5	4	3	5	5	4
	Canopy cover + 20%	2	2	2	2	3	3	2
	Combination Case	1	1	1	1	1	1	1
2-8pm	Albedo + 0.15	5	5	5	5	4	3	5
	Albedo + 0.25	3	3	3	4	3	2	3
	Canopy cover + 12%	4	4	4	3	5	4	4
	Canopy cover + 20%	2	2	2	2	2	2	2
	Combination Case	1	1	1	1	1	1	1
3pm	Albedo + 0.15	4	4	4	5	4	4	4
	Albedo + 0.25	3	3	3	3	2	2	3
	Canopy cover + 12%	4	4	4	3	5	5	4
	Canopy cover + 20%	2	2	2	2	3	3	2
	Combination Case	1	1	1	1	1	1	1
24-hours	Albedo + 0.15	5	5	5	5	5	5	5
	Albedo + 0.25	4	4	4	4	4	4	4
	Canopy cover + 12%	3	3	3	3	3	3	3
	Canopy cover + 20%	1	1	1	1	2	2	1
	Combination Case	2	2	2	2	1	1	2

Figure 7. Summary of urban-heat mitigation potential: ranking of measures case01 through case31 by cooling effectiveness in the current climate (1 to 5, with darker green colors representing more cooling and the lighter yellow/green colors representing less cooling). Note that case02 should be excluded in some analysis. Also note that these are impacts on temperature, not UHII.

A focus on specific heat risks and goals may help determine which heat mitigation measures to implement. For example, the 6am and all-hours (24 hour) metric may be of interest from a heat-wave perspective, the 2-8pm and 3pm period may be of interest to utilities for peak cooling demand analysis, and the 1pm period may be of relevance to assessments of the most effective measures at solar noon.

Generally, the ranking of the most effective heat reduction measures remains largely unchanged in a 2050 climate scenario, though the magnitudes of the cooling effects may differ. This suggests that heat mitigation measures are largely a no-regrets strategy: the most effective strategies today will continue to provide cooling benefits in the future, even as the climate warms.

Urban Heat Island Mitigation Measures at the Local Scale

In addition to regional (2-km averaged) assessments, this study also evaluated the localized, site-specific effects of UHI-mitigation measures in areas of interest and at specific Metropolitan Transportation Plan (MTP) project locations. Generally, at the 500-meter level, the cooling effects are significantly larger than at the 2km modeling level, where cooling is averaged across the region; as an example, a tree-lined street may deliver significant cooling benefit to pedestrians on that street, but its cooling benefits become more diffuse at the regional scale.

Based on the 2km scenarios and input from the technical advisory committee, the following reasonable and realistic scenarios were modeled at the community scale (500-m resolution) for current climate and land use and land cover conditions:

Albedo scenarios:

- For MTP projects, the roadway albedo is increased from a mean of 0.12 (average for current conditions) to 0.35. This is a cap to minimize glare issues.
- For AB 617 communities and other urban areas of interest, such as downtown or specific projects, the roof albedo is increased from a current mean of 0.17 to 0.5 and the roadway albedo from a mean of 0.12 to 0.30. These are caps to minimize potential glare or radiative concerns at pedestrian level.

Heat-emission scenarios: A vehicle-electrification (or zero-emissions vehicle) scenario is applied in designated areas and in transportation corridors of interest. Time- and location-dependent heat emissions from mobile sources are reduced by up to 25% (per California Energy Commission and SMAQMD studies that propose an electric-vehicle ownership level of 25%). This scenario also quantifies the benefits of electrification per SMAQMD's ZEV Readiness Plan.

Vegetation-canopy scenarios: Increases in canopy cover are applied in areas of interest defined by the SMAQMD, LGC, and project TAC, including AB 617 communities, downtown areas, and other underserved communities. As an estimate, about 300 large trees are added to a neighborhood of ~ 0.25 km^2 (0.1 mi^2).

Cool-wall scenarios: The albedo of walls is increased from an existing average of 0.15 to a maximum of 0.40.

Solar PV scenarios: Solar PV panels are added to roof- or ground-based surfaces such as parking lots, with different coverages, conversion efficiencies, background albedo, and other parametric considerations.

Combination scenarios: These scenarios combine cool surfaces, vegetation cover, and tailpipe heat emission reductions.

Focus areas for modeling these measures at a local, 500-m level were selected based on suggestions of priority areas and projects from the technical advisory committee as well as MTP roadway projects.

One way to evaluate and compare the effectiveness of various project – or area-specific measures is to quantify their potential to offset the local UHII, or how completely it can reduce the UHII at the specific location where the measures are implemented. Thus, the effect of each mitigation measure at the community level (500-m scale) were compared to the local all-hours (24-hours) UHII for two situations: 1) a scenario where only the community implements the measure and no other nearby communities take any action; and 2) a scenario where both the community and its upwind neighbors implement the measures. In this second situation, the community will benefit from cooler air transported from upwind areas, in addition to the local cooling resulting from implementation of its own UHI-mitigation strategies.

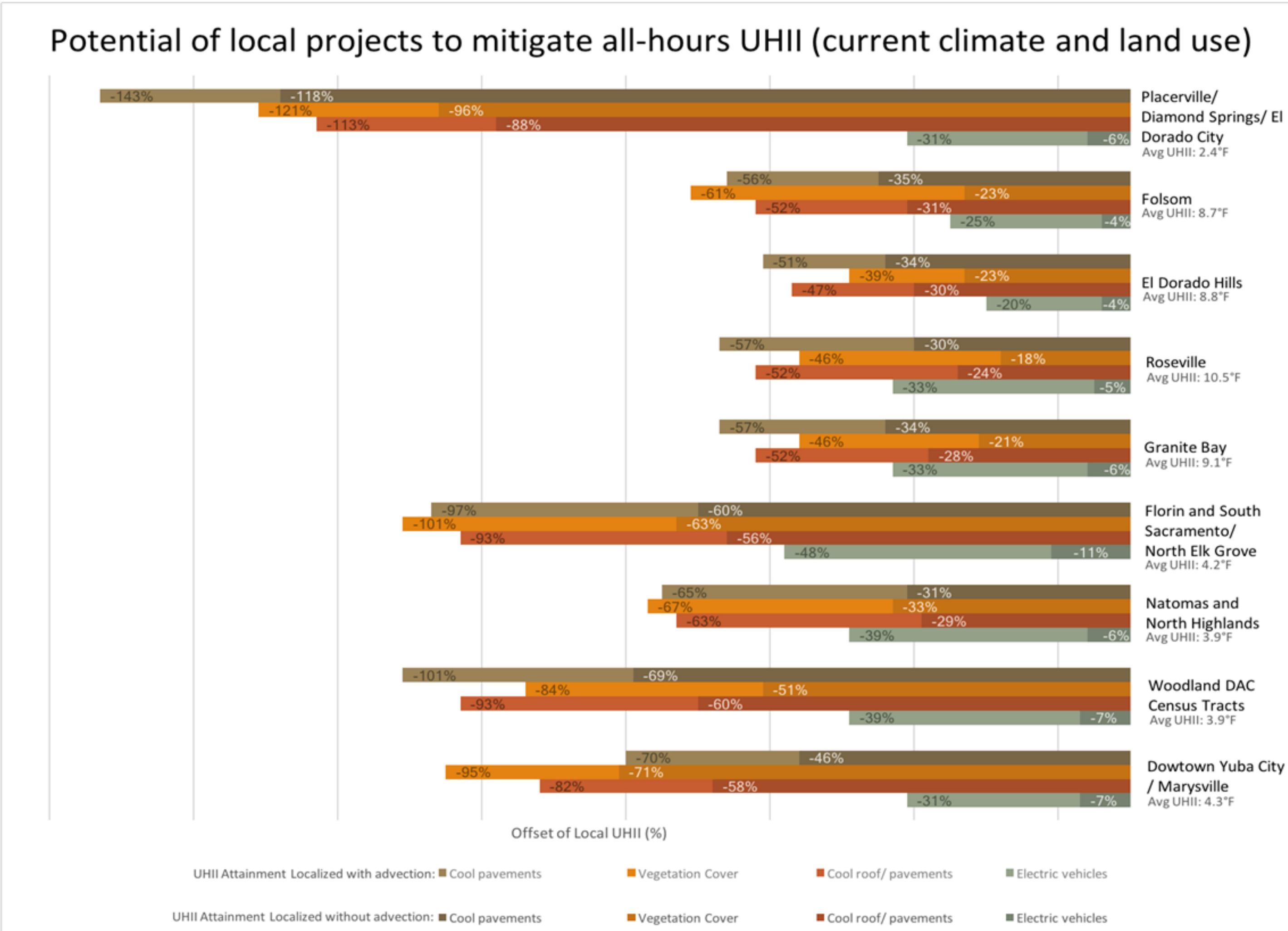

Figure 8. This graph shows the potential of local projects in mitigating the all-hours UHII in current climate and land use for different locations. The lower bar shows the percent reduction in UHII if the community implemented that measure alone (without advection), and the complete bar shows the percent reduction in UHII if the community and its upwind neighboring communities all implemented the same measure (with advection).

The evaluations are summarized in Figure 8 for each measure on its own, implemented only in that community alone (without advection, the bottom half of the bar for each measure), or in conjunction with its upwind communities (with advection, the total bar for each measure). The figure shows that some measures, even implemented alone, can completely offset the local UHII. Furthermore, when neighboring communities also join in implementation, the local benefits increase significantly, nearly doubling in some locations for certain measures. This highlights the importance of regional coordination for heat island mitigation measures. It should be emphasized that these are localized effects, i.e., temperature changes at or near the surface of the modified roadways or air temperature within the urban canyons of the selected communities. Thus, the effects of cool pavements alone at the 500m scale can sometimes be larger than the effects of combined cool pavements and cool roofs at the 2km level.

For combinations of measures, the cumulative effect is non-linear – their total cooling is smaller than the sum effect of individual components. Still, the table can provide rough magnitudes of the cooling effects that can be anticipated if measures were combined.

Electric Vehicles

Electric vehicles (EVs) generate only 20% of the waste heat as conventional internal combustion engine vehicles, which release heat via tailpipe exhaust. Thus, the conversion of vehicle fleets to electric and zero-emissions models will reduce waste heat from tailpipe emissions and result in localized cooling. For the vehicle electrification scenario, this study superimposes locations of proposed charging facilities according to SMAQMD's ZEV Readiness Plan on the UHII map of the Capital Region. This visualization can help prioritize charging station implementation if UHI reduction is taken as a criterion. The cooling benefit is modeled by assuming that EVs are up to 25% of the vehicle population at the location hosting the charging station, and gradually declines to zero at a 10km (6.2 miles) radius from the station.

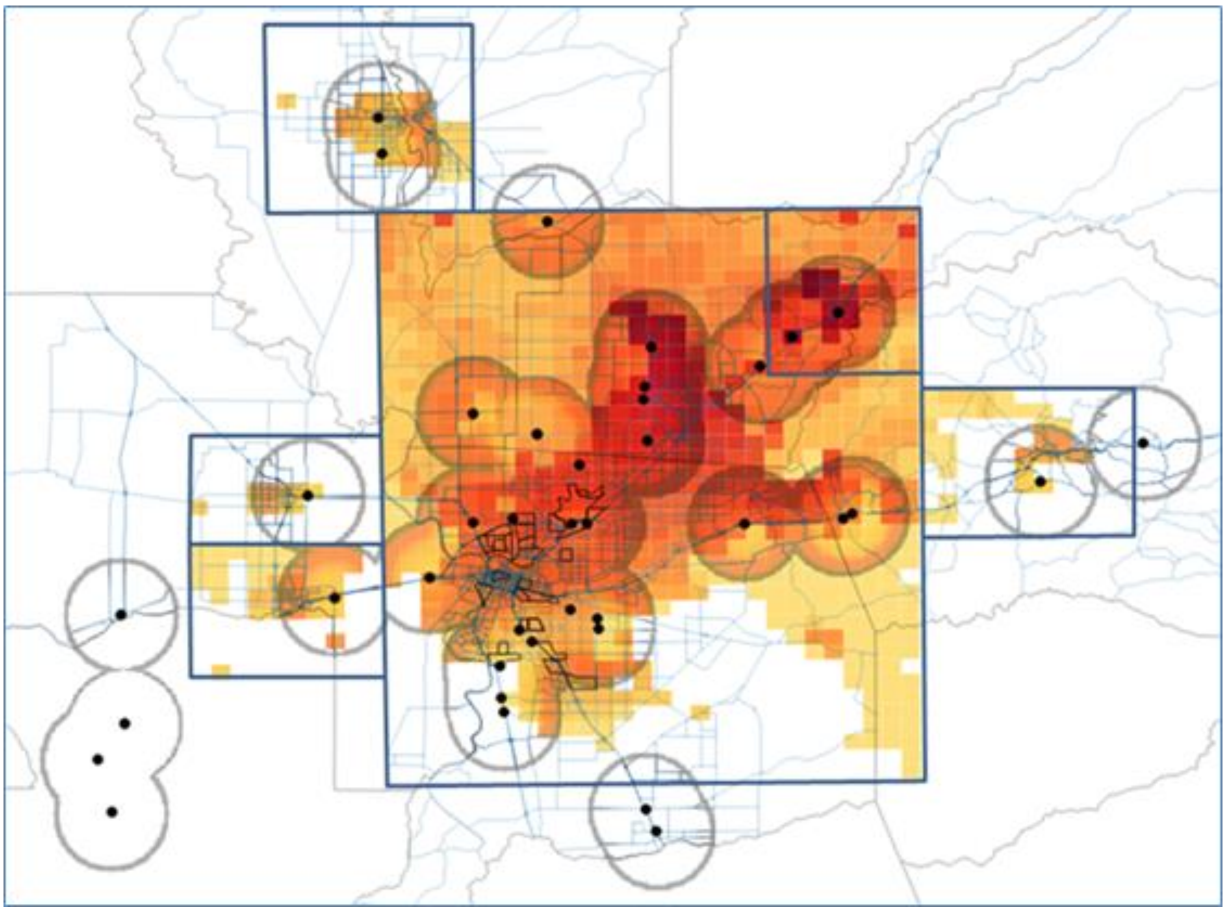

Figure 9: Recommended locations for EV charging and hydrogen fueling stations in SMAQMD's ZEV Readiness Plan are overlaid upon the UHI map for the Sacramento Region. This map shows station locations that can be prioritized if heat island reduction were to be identified as an important co-benefit; conversely, it also shows stations that may be more at risk to heat exposure and thus candidates for mitigation measures such as solar PV shading.

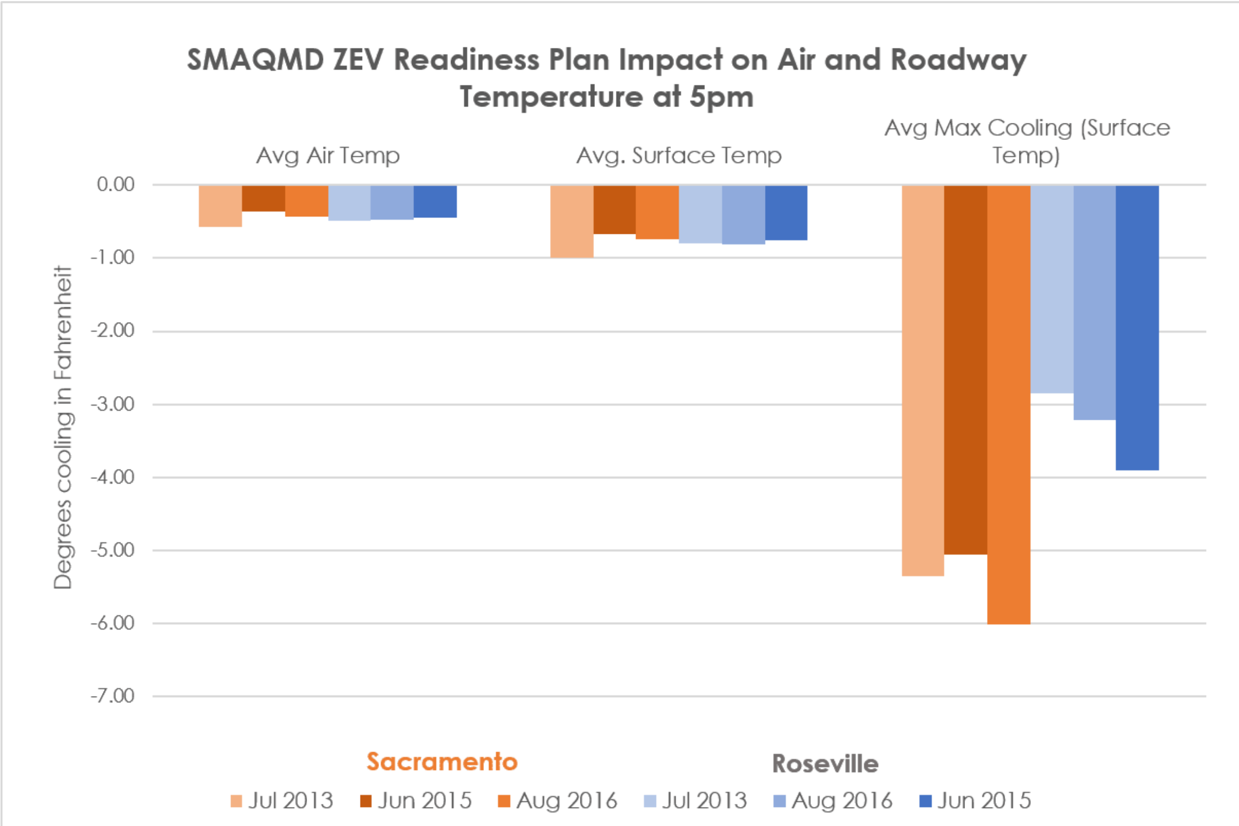

Figure 10. This shows the impact of SMAQMD's ZEV Readiness Plan on air and surface temperatures at 5pm for modeled intervals in Sacramento and Roseville.

Sample modeled results show that vehicle electrification can reduce roadway surface temperature by a maximum of 5 to 6 degrees Fahrenheit at 5pm. The change in air temperature is smaller, less than one degree, but as noted in the full technical report, surface temperatures may be a better representation of the impact of reducing tailpipe waste heat. Figure 11 provides a depiction of the modeled cooling effect across the Sacramento domain. The temperature reduction pattern is affected by not only the level of vehicle electrification but also land use and land cover properties, density, locations of major transportation corridors, and other factors.

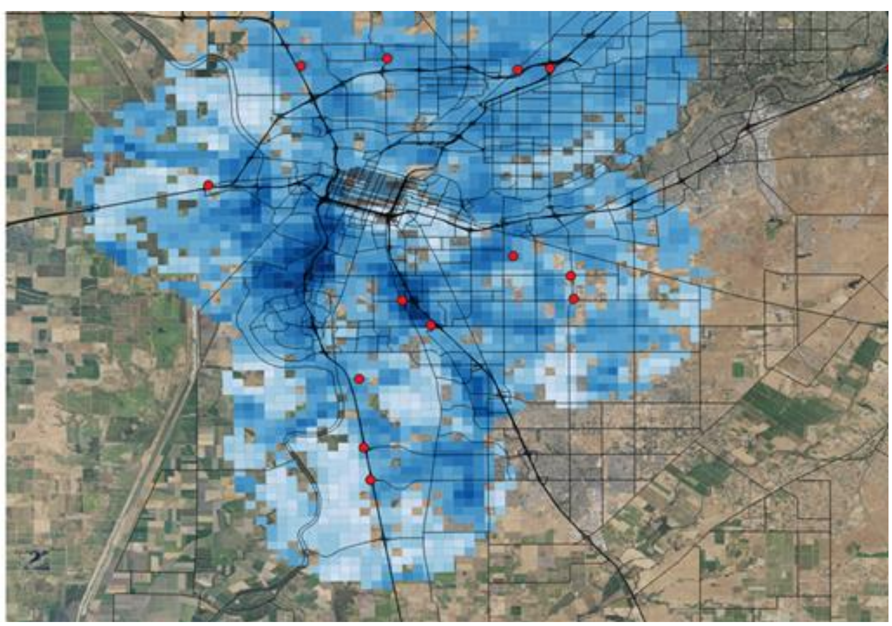

Figure 11. Average changes in surface temperature in central Sacramento at 5pm, assuming 25% vehicle electrification radiating out from proposed charging stations (red dots) in SMAQMD's ZEV Readiness Plan. The modeled interval in this map is June 2015 and the maximum cooling is 5˚F.

Solar Photovoltaics

The project compared the potential impacts of solar PV arrays on near-surface temperature to the effects of tree canopies on parking lots. As expected, the analysis indicates solar PV installed over parking lots had a greater cooling impact for above-ground air temperatures than those installed at rooftop level. As pavements are generally darker than roofs, shading parking lots can deliver greater cooling benefits, while roofs and solar PV already have similar albedo. However, at higher air levels, both roof-based and ground-based solar PV have significant and similar effects on air temperature.

The study finds that higher PV efficiency can help improve cooling benefits. For ground-level PVs with a higher conversion efficiency of 0.30, near-surface temperatures can average 2°F (1.18°C) cooler over 24 hours, and be as much as 4.4°F (2.44°C) cooler during peak periods. Increasing the albedo of roofs and pavements can also increase cooling effects. While rooftop solar PV have small effects on near-surface temperatures, nor do they have negative effects – they do not increase air temperature at street level. This is an important finding as residential rooftop solar PV is now part of California's building code and is likely to increase across neighborhoods, especially new ones that are more likely to lack a mature tree canopy.

Compact Growth

This project also evaluated a scenario of compact urban growth, whereby 15% less urbanization occurs by 2050 relative to a business-as-usual (BAU) scenario. While there are several ways the impacts of smart growth could be quantified, here the impacts were evaluated mainly at those locations where urbanization was prevented. The model indicates that the average avoided warming at 6am is about 3.6°F (2°C) in areas where urbanization was prevented or minimized. On the other hand, if averaged over the region – instead of just the locations where urbanization was avoided – the cooling effects are smaller, between 0.09-0.27°F (0.05-0.15°C) region-wide. At 1pm, the avoided warming ranges from an average of 0.09°F (0.05°C) in Davis to up to an average of 0.72°F (0.4°C) in Auburn. If averaged over each modeling area, compact growth avoids warming of between 0.09 and 0.18°F (0.05 and 0.1 °C) region-wide. Averaged over 24 hours, cooling benefits of compact growth are more uniform across the regions, with the exception of Auburn and El Dorado Hills, and show an avoided warming benefit of between 2 and 3°F (1.2 and 1.6°C).

One observation from this analysis is that the cooling impacts resulting from compact growth measures are larger during the night than during the day. This is a direct result of urbanization affecting nighttime temperatures more than daytime temperatures, as buildings and pavements slowly radiate off the heat they absorbed during the day at night.

Combinations of Measures

Most measures were evaluated separately at the 500m community scale, and only one combination scenario was modeled, due to the large number of possible permutations. The modeling was conducted in the Elk Grove area and shows the cooling impacts of vegetation canopy cover increases, cool roofs and pavements, and these two measures in combination with vehicle electrification. The results show that the combination of measures provides larger cooling benefits than each measure alone, but the combined impact is smaller than the sum of its component parts.

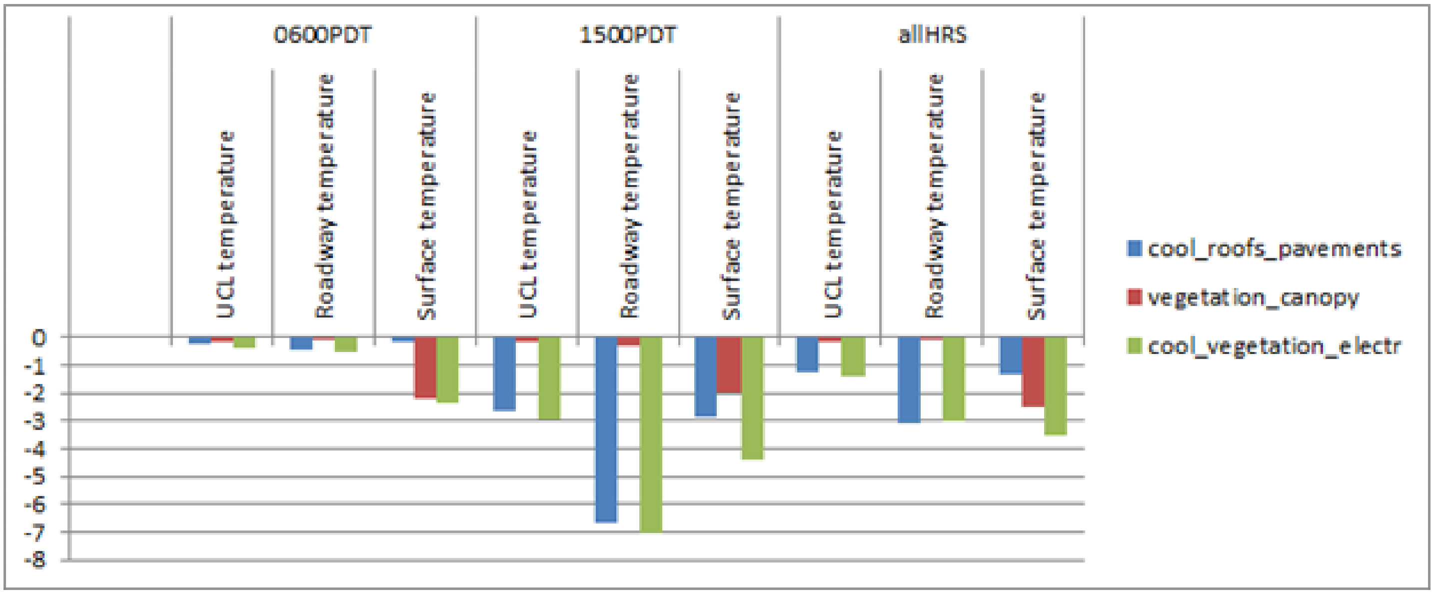

Figure 12. This compares the cooling effects of 1) cool roofs and pavements (blue); 2) vegetation canopy increases (red); and 3) the combination of canopy increases, cool roofs and pavements, and vehicle electrification. The y-axis on the left shows temperatures in Celsius; -7°C is 12.6°F and -3°C is about 5.4°F. The x-axis shows the cooling at 6am, 3pm, and the 24-hour average for the above-ground air temperature (urban canopy layer/ UCL), roadway temperature, and surface-level temperatures.

Cool Walls

The potential impacts of cool walls were quantified for a scenario where wall albedo was increased from a current average of 0.15 to a maximum value of 0.40. As expected, the wall albedo effects are largest during the daytime, reaching up to a maximum average localized cooling of 2.5°F (1.4 ºC). Note that this does not account for additional cooling that may be experienced inside the buildings, which could potentially lead to decreased air-conditioning operations and thus lower waste heat.

Urban Heat Islands in 2050

How will future climate change affect urban heat islands? This question was evaluated by dynamically downscaling global climate models for the 2050 Representative Concentration Pathway (RCP) 4.5, a best case scenario for climate mitigation, and RCP 8.5, a worse scenario representing the world's current emissions trajectories.[3] These climate models, in combination with future urbanization and land-use change projections from USGS LUCAS, were evaluated in the Altostratus-modified urban Weather Research and Forecasting model.

Two effects determine future UHII: (1) local climate change is the predominant impact on temperature and UHII in already urbanized areas, whereas (2) in areas that will be urbanizing between now and 2050, the impacts on air temperature will result from both changes in land use (urbanization) and changes in climate. In general, the UHII in 2050 RCP 8.5 is larger than in RCP 4.5, as expected, but there are exceptions in the areas of Yuba City / Marysville and Woodland. This area has a smaller future UHII

[3] Representative Concentration Pathways refer to the concentration of greenhouse gas emissions in the atmosphere and reflect various potential trajectories for reducing greenhouse gas emissions depending on the level of global action. See Box 2.2 here.

because climate change will warm the rural areas surrounding Yuba City / Marysville and Woodland at a faster rate than the urban areas, resulting in a smaller differential between urban and non-urban areas.

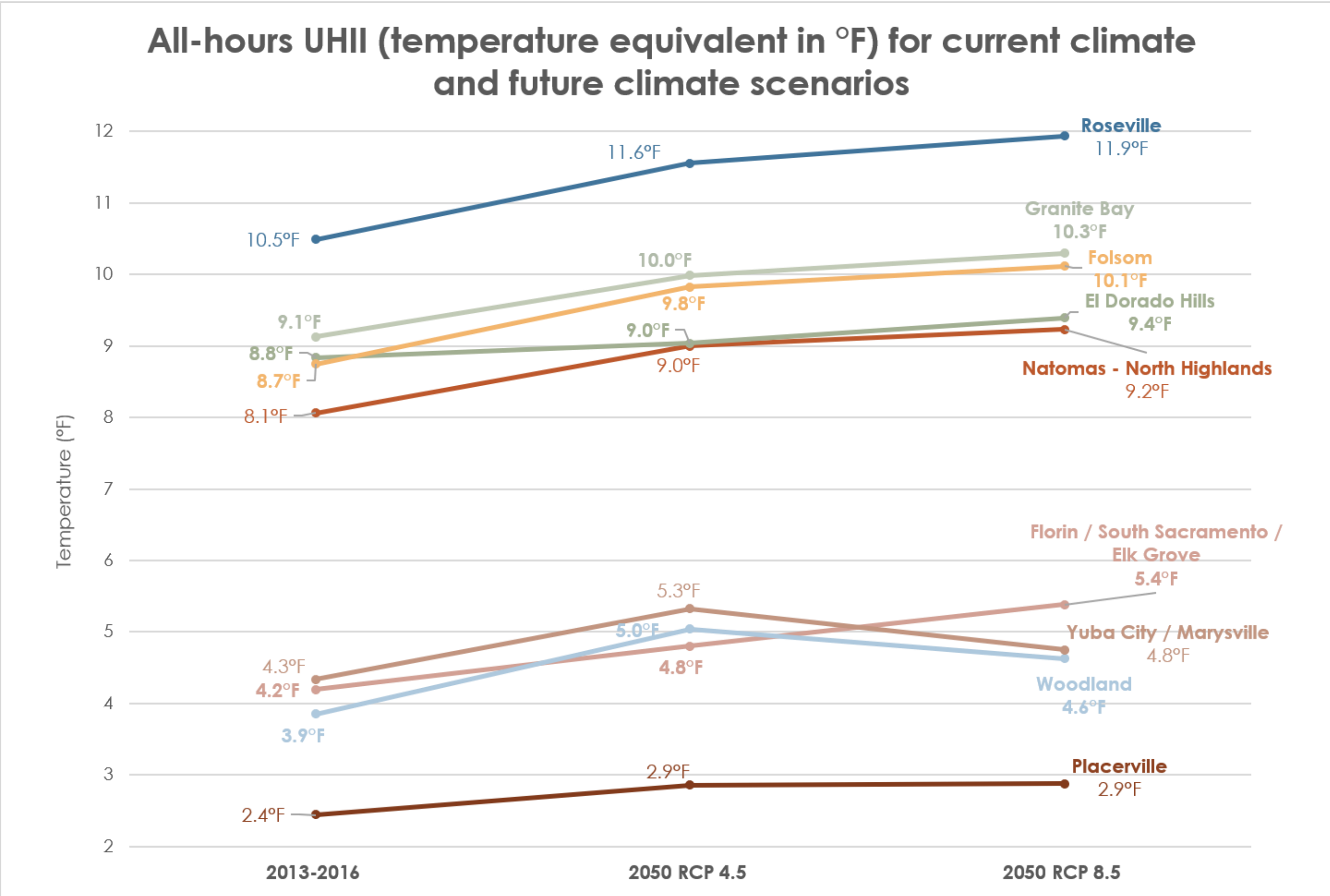

Figure 13. All-hours Urban Heat Island Index for the present-day climate scenario and 2050 RC 4.5 and 8.5.

The effects of local, community-scale heat-mitigation measures (i.e., at the 500-m level) were re-evaluated for future climate and land use conditions to assess their effectiveness in addressing UHII with future climate change. In Figure 14 and 15, the future-climate all-hours UHII in 2050 is presented for each of the areas identified earlier and for RCP 4.5 and RCP 8.5, respectively. Figure 14 and 15 also shows the effects of heat island mitigation measures when implemented by only that community (without advection) and when implemented jointly with upwind communities (with advection). The results show that the mitigation measures have similar effectiveness in 2050 as they do in the current climate. This is because the increased extent of urbanization, while contributing to additional local warming, also increases the technical potential (i.e., area available) for the deployment of mitigation measures, thus keeping the UHII offset levels similar or slightly larger in some cases.

As was the case for current conditions, some mitigation measures can completely offset the local future-climate UHII. And, as before, when neighboring communities also implement UHI mitigation measures, the cumulative local benefits increase significantly as a result of the cooler air movement from its upwind neighbors.

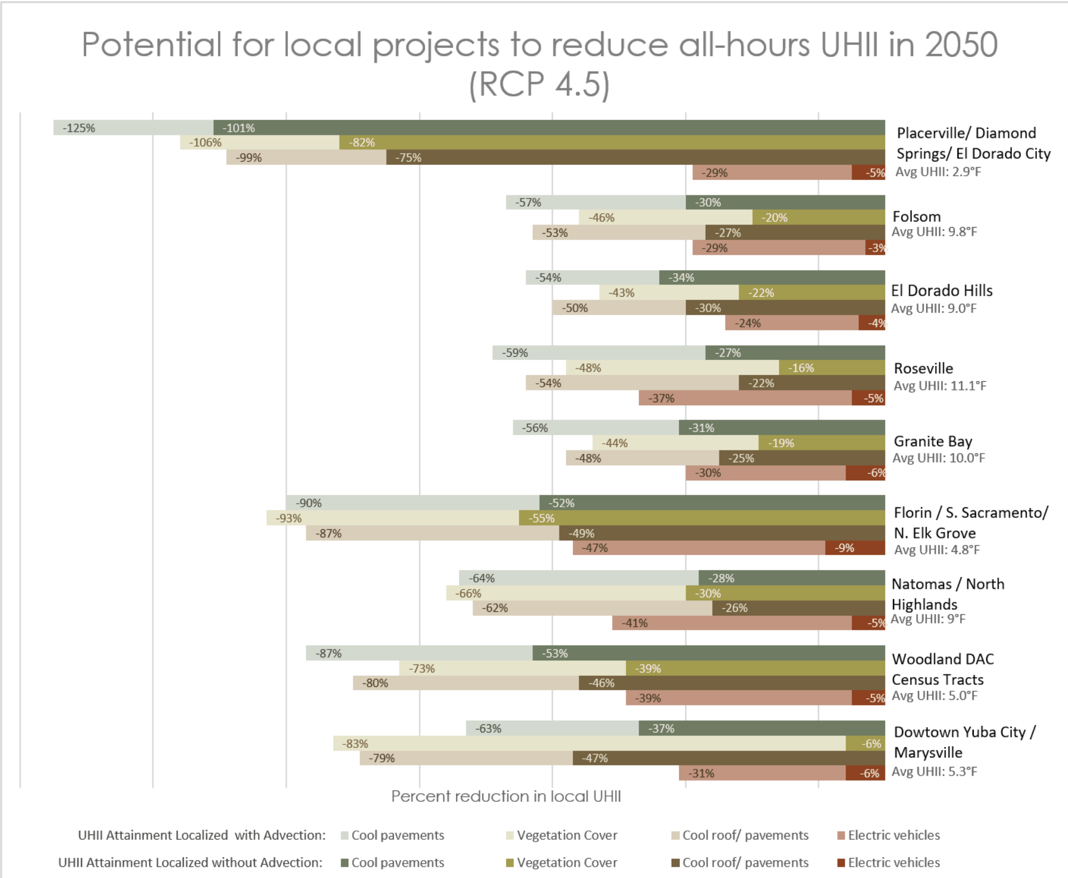

Figure 14. Potential of local projects in mitigating the all-hours UHII in future climate (2050 RCP 4.5) and with future land use conditions.

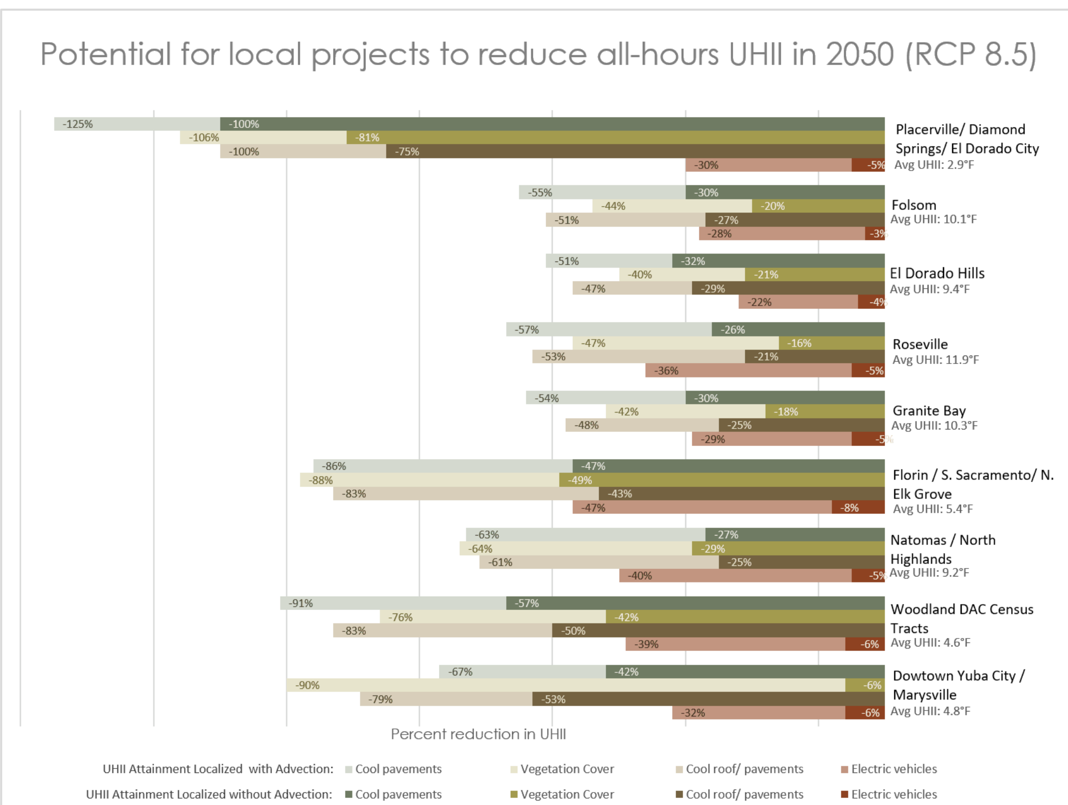

Figure 15. Potential of local projects in mitigating the all-hours UHII in future climate (2050 RCP 8.5) and with future land use conditions.

Qualitative Takeaways

This summary broadly touches on key general points of the UHI analysis and findings contained in Altostratus's technical report. The full report describes the complete methodology, including datasets, model configuration, and modeling process, as well as results, analysis, and comparisons between different heat island mitigation measures for various times of day and locations.

- Significant urban-heat pollution exists throughout the Capital Region. The UHI and the UHII are larger in urban areas that are (1) more densely built up, (2) cover a larger geographical area, (3) located at the downwind end of an urban zone (trajectory-wise), (4) located at higher elevations, and (5) surrounded by non-urban areas that cool down significantly faster at night.
- From today to 2050, the UHII increases in almost all locations, reaching as high as 9 to 12°F in North Sacramento / North Highlands, Roseville, Granite Bay, Folsom, and El Dorado Hills.
- It is possible and highly feasible to mitigate the current UHI and offset the UHII (in some cases completely) using materials and technologies available on the market today. The proposed UHI mitigation measures are reasonable and do not require hypothetical or extreme implementation levels.
- Mitigation measures, even when implemented alone, can help reduce or offset the local UHII, in some cases completely. Various combinations of measures can further offset the UHII, although the total effects of combinations of measures are not linear and are generally smaller than the sums of the individual cooling effects.
- If a community and its neighboring communities all implement UHI mitigation measures, the local cooling effects could double (although there is a range of effects depending on location, time, specific measures, etc.). This demonstrates the importance of coordination, as air flow and wind can amplify cooling across boundaries and jurisdictions.
- The measures can have significant beneficial effects in terms of public health as indicated by their ability to lower the warning levels in the NWS Heat Index. This was assessed for both current and future climates.
- The cooling measures can significantly reduce or completely erase the number of heat-wave days during several excessive-heat event periods identified in the study.
- The mitigation measures are as effective under conditions of future climate and land use as they are under current conditions.
- Different mitigation measures affect urban heat and temperature differently during different times of the day. Hence it is possible to target certain specific time intervals, e.g., peaks, night, day, or 24 hours, based on a community or city's needs, by choosing a specific mitigation measure or combinations of measures.
- Some measures that are not conventionally associated with urban cooling (or urban heat island mitigation), such as vehicle electrification, solar PV installations, and smart urban growth all appear to have significant urban-cooling effects.
- The cooling effects, which can help improve thermal comfort, reduce emissions of air pollutants, and improve air quality, are beneficial across various urban areas in the Capital Region, including vulnerable or underserved communities.
- These results can be used by cities and agencies in the Capital Region to prioritize projects and implementation of various measures or in the allocation of resources both today and for the future.

Transportation Planning and Analysis

One project goal was to translate the technical findings of the urban heat island analysis and modeling into recommendations and strategies that can be adopted and implemented by local jurisdictions, transportation planners, transportation agencies, public health departments, and other public agencies. These transportation-based recommendations are found in the transportation planning report, which contains:

- Policy context for climate planning and adaptation
- Transportation plans and policies in the region into which urban heat mitigation strategies can be incorporated
- Best practices, co-benefits, and implementation examples for mitigation measures in the UHI model.
- Potential cooling benefits for modeled mitigation measures in the identified priority areas
- Comparison chart of cool pavement types, applications, solar reflectance, estimated service life, approximate costs, and target uses.
- Overview of implementation mechanisms available to local agencies to deploy UHI mitigation strategies
- Tailored implementation solutions and sample policy language that can be adopted by local agencies in the Capital Region
- Select case studies of transportation projects in the Capital Region with the potential to implement UHI mitigation strategies

Cool Roofs

While cool roofs and green roofs are common UHI mitigation applications for development projects, their applicability within transportation projects can be somewhat limited. Nonetheless, implementing these strategies at transit facilities can create demonstration projects that show commitment to mitigating UHI in the community. Overall, regardless of the building type, widespread adoption and implementation of cool or green roofs can provide cooling benefits in areas where heat is especially detrimental, such as along active transportation corridors.

Generally, cool roofs have much lower costs for both installation and maintenance than green roofs and, as such, have broader potential applicability for roofs of varying slopes, designs, and styles. There are a wide range of cool roof products, from coatings, to membranes, to roof tiles, or lighter-colored shingles. Within the transportation sector, available opportunities for cool roof adoption may include transit shelters, transit stations, and maintenance facilities, as well as less indirect project elements such as restroom or rest area facilities along greenways. The Capital Region's dry, hot summers can make establishing and maintaining green roofs more challenging; however, the use of heat- and drought-tolerant plants may be successful in certain applications.

Example best practice: **Cool and green roofs at transit stations.** Cool and green roofs are recommended for uncooled areas, such as bus stops. These techniques can reduce heat-related health and productivity impacts while mitigating the broader UHI effect. They can improve aesthetics, increase public awareness of cool/green roofs and urban heat islands, and (in the case of green roofs) offer a refuge for wildlife. The addition of low-cost educational signage could easily enhance the awareness-building capacity of green roofs at transit stations.

Implementation Strategies

Incentives

- Planning-Based:
    - Adopt expedited permitting processes for projects that incorporate certain UHI mitigation strategies, such as a transit shelter or transit station utilizing cool roofs. This incentive can also be applied to other project types and mitigation strategies.
- Financial-Based:
    - Highlight, create, or expand financial incentive to increase participation, such as:
        - Grant programs aimed at government-led projects to help fund transportation infrastructure projects that include UHI reduction measures;
        - Grant programs and local agency incentive programs aimed at contractors and builders to help offset costs and encourage use of UHI reduction measures.
    - Include heat Island reduction as part of the scoring criteria for existing grants and funding, such as SACOG's various funding programs.
    - Adopt a tax credit or other incentive program to encourage the adoption of cool and green roofs.
    - Revitalize previous programs and strengthen existing programs, including SMUD's Cool Roof Program and SMAQMD's Targeted Green Infrastructure Fund program.

Programs

- Agency-Focused:
    - Adopt a green procurement policy that provides a mechanism for green or cool roofs (or other UHI reduction measures); includes performance characteristics and performance measures to track results; provides general specifications for various applications; and further supports implementation of the CalGreen building code requirements related to cool or green roofs.
    - Implement demonstration projects at highly visible/trafficked buildings/areas, such as libraries, transit passenger facilities, rest areas along active transportation corridors, or shade structures at public parks.
- Community-Focused:
    - Establish community education campaigns that raise awareness about urban heat within the transportation network and benefits of cool roofs and green roofs, addressing how transportation more broadly impacts communities (including public health, safety, and heat pollution) and how both agencies and residents can act to reduce the negative impacts.
    - Provide fact sheets, specification information, and other tools or resources that provide clear direction and information on cool and green roofs to project applicants and the building industry.

Mandates

Mandates have the additional benefit of helping to grow the local market, spurring contractors and builders to increase their awareness of and product supplies of cool roof materials, thus potentially leading to more widespread community-level change.

- Code-Based:
    - Update code elements or guidelines to require UHI reduction measures as part of a project. The code should be clear in the building types that are applicable and set performance or quality standards to be used during project or proposal review.
- Policy-Based:
    - Develop green building programs and associated policies that require certain institutional or commercial buildings to have cool roofs. These strategies can be phased in based on square footage and allow for flexible compliance between cool roofs, green roofs, and rooftop solar PV to help alleviate cost concerns.

Cool Pavements

Cool pavements have the most direct applicability within transportation projects, and can be applied to roadway projects, active transportation projects, transit infrastructure, and parking facilities. Cool pavements can generally be categorized as either permeable/porous or high albedo/light-colored and offer a wide variety of options with different costs, applications, and maintenance considerations. There are a number of factors that impact the choice of solution, including vehicle weights, traffic volumes, project area size, cost sensitivities, maintenance requirements, regulatory agency policies/requirements (i.e., Caltrans requirements for highway projects), and stormwater considerations.

Example best practices:

- **Maintenance surface applications for low-traffic volume areas:** Surface treatments such as reflective surfaces, microsurfacing, and chip-sealing with high albedo materials or whitetopping would increase albedo and help maintain low-volume traffic areas such as parking lanes, parking lots, alleys, sidewalks, bike lanes, plazas, playgrounds, and some intersections. As the technologies improve and costs decrease, these surface applications may become more applicable to high-volume traffic areas as well.
- **Non-vegetated permeable pavement for new construction of low-volume traffic areas:** Porous asphalt or pervious concrete can be used when constructing parking lanes, parking lots, and alleys as well as in pedestrian areas such as playgrounds, sidewalks, and plazas. These permeable pavements, especially those with high albedo materials, reduce the quantity and temperature of stormwater runoff and improve water quality by filtering dust, dirt, and pollutants, thereby lessening damage to the Capital Region's watersheds.
- **High albedo or permeable pavements for transit stations, centers, and corridors:** Transit infrastructure, such as parking lots and exterior waiting areas, provides ample opportunities to apply cool pavements. High albedo or permeable pavements are becoming more viable options for both circulation elements and the transit structure. For example, transit center vertical infrastructure (such as buildings) may provide opportunities for high albedo building materials and cool walls and roofs, while permeable pavements can be used for parking lots and pedestrian areas.

- **High albedo or permeable pavements for pedestrian corridors and bicycle paths:** High albedo and permeable pavement bicycle paths can help support active transportation, protect public health, and encourage exercise, with significant benefits for low-income and underserved populations. High albedo and permeable pavements are also highly suitable for pedestrian corridors such as sidewalks, trails, or areas around transit centers. Factors such as foot traffic volume, material costs, and co-benefits for specific locations should be considered during planning and deployment. Cool pavement coatings applied to existing pavements can reduce long-term maintenance costs by extending the pavement's lifespan.

Implementation Strategies

Incentives

- Establish state-level tax credits or similar programs applicable to government projects and require development of specific criteria for evaluation and qualification (i.e., tied to statewide or local goals and policies).
- Create regional agency-led grant programs to encourage and offset costs of cool pavement construction. Agencies like SACOG, for example, could develop a grant program that encourages the use of cool or permeable pavements in publicly funded or government-led infrastructure projects at a smaller scale, such as new local road and street construction, repaving and maintenance, transit centers and stations, complete street or corridor projects, or bicycle and pedestrian facilities.
- Create state agency-led grant programs (i.e., Caltrans) aimed at implementing cool pavements for large highway infrastructure projects.

Programs

- Agency-Focused
    - Develop and implement agency procurement programs/policies for government facilities as a means to incorporate mechanisms for cool and permeable pavement project components.
    - Establish criteria and performance characteristics for procurement or bid specifications to ensure implementation for transportation facilities (or other agency-led projects) and infrastructure projects. Costs may be higher at the bid stage, but long-term savings are generally received.
- Community-Focused
    - Create and establish community education campaigns that raise awareness about urban heat within the transportation network and benefits of cool pavements. As with all education and outreach, costs are not static and depend on level of effort and material production requirements.
    - Provide demonstration projects for cool pavements at transportation facilities and within infrastructure projects. For example, reflective pavements could be implemented alongside other heat mitigation measures within a complete streets project to illustrate positive impacts including how reduced temperatures can encourage use of alternative modes.

    - Expand outreach outside of the transportation community, with resources available to school districts, developers, the building industry, and homeowners, as cool pavements can be incorporated into a wide range of projects such as playgrounds, parking lots, or residential landscaping/driveways. For larger development projects, cool pavement applications like permeable pavers can serve as a way to meet stormwater requirements.

Mandates

- Code-Based
    - Update various code elements or guidelines related to cool pavements within infrastructure or development projects. This may include:
        - Requiring certain measures within a project, such as through project Conditions of Approval;
        - Encouraging code requirements for both new roadways and maintenance activities to ensure that roadways are designed and built at the outset to support heat-resilient paving materials – especially critical in new developments where tree canopy has yet to mature.
    - Create strategies for specific project types that set performance or quality standards that must be used during proposal review. CalGreen mandates low impact development, which is inclusive of the use of cool pavements or permeable pavements; local agencies can seek to exceed these with more stringent requirements within local zoning or building codes.
- Policy-Based
    - Develop green building programs requiring certain transportation infrastructure projects to implement cool pavement components, focusing on complete corridor projects or specific facility projects.
    - Develop robust stormwater management plans that include urban heat island reduction requirements through decreasing impermeable surfaces and increasing green or cool surfaces.

Vegetation Cover

The Capital Region is known for its extensive tree canopy. The region benefits from strong support for maintaining and growing tree canopy through nonprofits like the Woodland Tree Foundation, Sacramento Tree Foundation, and Tree Davis. These nonprofits provide many resources about the tree species most suitable for the Capital Region's climate and for shading. Landscape guidelines in the Capital Region can leverage these resources to develop requirements regarding the types of trees that should be planted alongside roadways, transit stops, parking lots, and active transportation corridors.

The report contains a list of trees that are screened to have both "moderate to fast" or "fast" growth rate and "good" or "excellent" air quality ratings in terms of emissions of biogenic volatile organic compounds (VOCs) that can contribute to ozone pollution. The fast-growing shade trees were identified for potential prioritization in order to address urgent impacts from rising temperatures and heat pollution.

Implementation Strategies

Incentives

- Tax-deductible programs to fund tree planting programs that can be applied to publicly led transportation projects or to increase street trees along existing roadways. Donations could be focused on non-profits or corporate sponsors, for example.
- Creation of a designated tree district or tree fund that is funded by fees charged as part of development projects.
- Regional or state-led grant programs that provide funding assistance to infrastructure projects that incorporate urban forestry.

Programs

- Agency-Focused:
  - Develop targeted programs (as part of ordinance, code or other policy efforts) that help guide urban forestry within communities. These programs may focus on increasing canopy in underserved communities or require tree planting or other landscape-based measures as part of major roadway or utility projects.
  - Establish an agency-focused resource database to help staff select tree species based on maintenance costs, structural integrity (i.e., can withstand high winds or storms with lower likelihood of falling branches), and the most appropriate planting locations (i.e., will not disrupt sidewalks or cause safety concerns).
- Community-Focused:
  - Establish education programs such as:
    - Programs to educate local contractors on how to preserve trees during infrastructure project construction.
    - Awareness campaigns for private developers to underscore the importance of urban canopy and its role within reducing urban heat.
    - Resource tool kit designed for developers, contractors, and homeowners that provides guidance on the best types of trees for development plans and projects. The toolkit should provide useful information about the most desirable attributes in street trees for reducing urban heat – canopy size, growth rate, and water requirements, for example, can all impact a tree's cooling effects.
  - Develop partnerships between local or regional agencies and community groups to work on street tree planting; in addition to planting trees, these programs educate residents about urban heat and proper tree maintenance.

Mandates

- Code-Based
  - Codify language related to urban forestry to ensure implementation of trees or other landscaping measures in projects. This may include landscaping ordinances or language specific to tree planting within certain code sections. Code or ordinance language should include tree protection requirements as well as replacement specifications if tree removal is unavoidable during project development.
  - Example: The City of Sacramento has both the Parking Lot Tree Shading Design and Maintenance Guidelines and a tree ordinance that could serve as models for other agencies in the region.

- Policy-Based
    - Develop targeted urban forestry plans that provide policy level goals and strategies to increase tree canopy coverage. Agencies should give consideration to and guidance on successful tree types and implications for network safety, transportation operations, and maintenance costs in relation to tree growth and maintenance requirements. Agencies should also calculate baseline tree canopy levels and establish goals at the community level, as well as for targeted areas like communities of concern, to ensure equitable investment and attention to urban heat impacts.

Electric Vehicles

Because zero-emissions transportation is a key priority for SMAQMD and many partners, such as the Sacramento Municipal Utility District, the City of Sacramento, the Sacramento Area Council of Governments, and many more, this project team was interested in exploring how increasing percentages of zero-emissions vehicles (ZEVs) in the region's fleet could contribute toward heat island reduction. At the same time, designing and building EV charging stations with shading or solar PV shade structures to reduce charging temperatures can help mitigate the capacity for extreme heat to reduce the health and lifespan of vehicle batteries, as well as contribute to UHI reduction.

Traditional internal combustion engine vehicles lose 58 to 62 percent of their gasoline's energy as waste heat, which is released into the surrounding environment and contributes to the UHI effect.[4] In contrast, ZEVs, including both EVs and hydrogen vehicles, are far more efficient, losing only 19.8 percent of the total heat that conventional vehicles emit per mile. Current and projected increases in average temperatures will impact EV range and long-term battery health—extreme heat causes long-term degradation that will reduce overall battery lifespan. As the Capital Region and California strive for higher vehicle electrification levels, it is important to consider electric vehicle heat vulnerabilities and resiliency improvement strategies. Designing public charging stations with passive cooling elements can help protect batteries as they charge and help reduce overall UHI effects.

Electric vehicle charging station solutions could include shade canopies, solar photovoltaic (PV) canopies, higher albedo pavements, permeable pavements, trees, and other vegetation. Conventional pavements can be 50 (27.7 °C) to 90ºF (50 °C) warmer than surrounding air temperatures by absorbing 80 to 95 percent of incoming solar energy, and the heat would then be radiated back to the electric vehicles (Lawrence Berkeley National Laboratory n.d.). By contrast, permeable and cool pavements would absorb and reflect less heat. Shaded parking can reduce the internal temperature of a parked car during hot days, saving battery power for cooling the interior. An appropriately-sized solar PV canopy can provide some (or all) of the electricity needed for EV charging. If designed well, greenery and urban vegetation can provide electric vehicle travelers both cooling and a desirable place to rest and rejuvenate while waiting for their vehicles to recharge.

Best Practice: **Solar PV shading / Cool roofs: Solar PV Shading for parking lots.** When installed on shelters above a parking lot, solar PV can provide shade for parked vehicles while generating renewable energy. The shading can achieve multiple benefits: it reduces the UHI effect from parking lot pavements, protects EV batteries from higher temperatures (and reduces evaporation of VOCs from the fuel tanks of conventional cars), and cools the car interior, saving vehicle energy through lower air-conditioning needs.

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[4] Department of Energy: https://www.fueleconomy.gov/feg/atv.shtml

Implementation Strategies

Incentives

- Financial-Based
  - Leverage and support existing tax credit, grant, and rebate programs at the regional agency level that increase the share of EVs in the market while reducing the financial burden for residents and organizations.
  - Develop regional agency-led grant funding and rebate programs that can be utilized by developers and local agencies to encourage inclusion of EV equipment like charging facilities in projects.
  - Participate in existing grant funding and tax rebate programs to meet California mandates for zero emission vehicles, including transit buses and agency fleet vehicles.
  - Establish local agency-led grant programs for developers and homeowners. Example: El Dorado County Air Quality Management District offers additional grants to help with EV purchases and charging infrastructure installations; similar programs can be found at SMUD and Roseville Electric.
- Planning-Based
  - Revise code language, create new incentive programs, and introduce new ordinances to encourage more ZEV use.
  - For projects that incorporate EV charging stations, incentives could include reductions in the amount of traditional parking spaces required, density bonuses, and streamlining permitting processes and requirements.

Programs

- Agency-Focused
  - Develop local government procurement programs that include ZEV-related requirements to assist agencies in meeting California's zero emission mandate. This could include requiring some or all of new fleet vehicles purchases be zero-emissions, and establishing specific charging infrastructure standards (i.e., Level 2, DC) for projects.
  - Develop EV car-sharing programs, such as Gig Car Share and Our Community CarShare in the Capital Region or BlueLA (the latter two are both focused on communities of concern), to promote EV use, raise public awareness of their benefits, and expand economic opportunity and mobility for residents.
  - Establish a process and program to ensure a cohesive network of charging stations, and adopt policies to support equitable access to equipment.
- Community-Focused
  - Develop public awareness and education campaigns that are targeted towards residents as well as the business community. Programs should provide an understanding of how ZEVs can help reduce the UHI effect as well as improve air quality; educate business owners on the benefits of having charging infrastructure adjacent to a business; educate developers on the costs, benefits, and requirements associated with EV charging.

- Hold events, such as Ride and Drive events, led by agencies or utility companies to engage and educate the community on technology and available resources for ZEVs.

Mandates

- Code-Based
  - Amend or adopt new codes or ordinances to support: Permitted charging locations by land use type, wiring specifications and requirements, and curbside charging options and management.
  - Specify land uses supportive of EV charging infrastructure to aid in expanding and encouraging EV infrastructure networks. Clear language related to land use type, such as multifamily or commercial, should be included.
  - Develop EV-ready wiring codes and ordinances to ensure EV charging installations are cost-efficient; by including the proper wiring and infrastructure at the onset, developers (or agencies) can save money, as the cost to retrofit a site is higher than that of a new installation within a new project.
  - Update local agency codes to require EV-ready or EV-installed spaces at parking lots, commercial buildings, garages, multifamily units, and other requirements
  - Design programs that can support compliance with new building code requirements for residential solar through developing solar-shaded parking lots with EV charging.
  - Develop innovative methods for curbside charging, as well as methods to manage or protect EV parking spaces.
- Policy-Based
  - Expand, where needed, policies within adopted Climate Action Plans (or similar documents) through amendments to include additional language that supports ZEVs. Some expansions may include specific goals and policies related to increasing access to programs within communities of concern or setting more specific targets for the percent of vehicles that should be ZEV by a certain date. These policies guide implementation, which is achieved through the zoning code, building code, or other ordinances at the local agency.
  - Other public agencies like transit operators/districts can develop their own policy documents that detail goals for moving towards zero-emission fleets and meeting GHG reduction mandates.

Community Engagement

Many populations are vulnerable to extreme heat for physiological reasons, including the elderly, young children, and people with pre-existing health conditions. Others are vulnerable due to socioeconomic factors; this includes outdoor workers, workers in unconditioned spaces (e.g., delivery warehouses), and those without vehicle access, experiencing homelessness, living in substandard housing, experiencing social or linguistic isolation, or otherwise facing financial challenges. Finally, there are systemic barriers that prevent individuals from comfortably or safely accessing health care, cooling centers, or other government services tasked with addressing extreme heat.

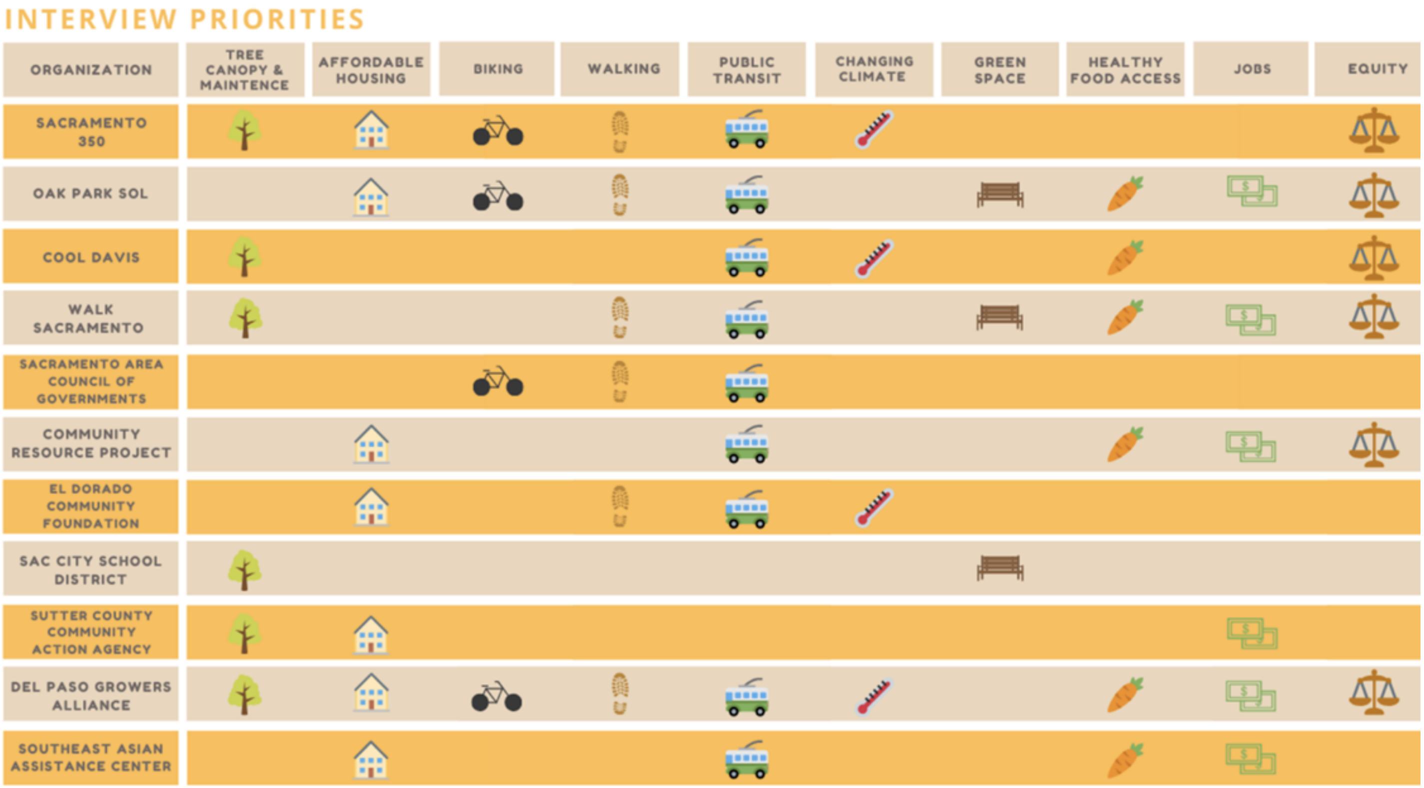

Figure 16. This chart summarizes the responses from community and non-profit organizations interviewed for listening sessions for this project. The icons indicate issues that an organization mentioned as priorities for their community or members.

The project team gathered input from vulnerable communities on their transportation needs, concerns, and priorities, using a survey with questions informed by listening sessions with community and environmental groups in the region. Instead of hosting standalone events dedicated to heat or UHI, the project team attended community events planned by independent cultural and community organizations to decrease barriers to attendance, especially for working families that may find a traditional after-work government workshop inconvenient. This approach ensured participation from a wide range of individuals, even those lacking pre-existing interest in urban heat. At the events, the project team distributed surveys and information about extreme heat, in addition to an interactive game. The survey was translated into 10 languages, which encouraged inclusion for non-English speakers. Over 1,600 responses were received from the survey, including nearly a third from in-person events. Using the survey results, the project team created a Communities Priorities Report that summarized community interests and concerns, their heat exposure, transportation needs, and preferred transportation sector improvements.

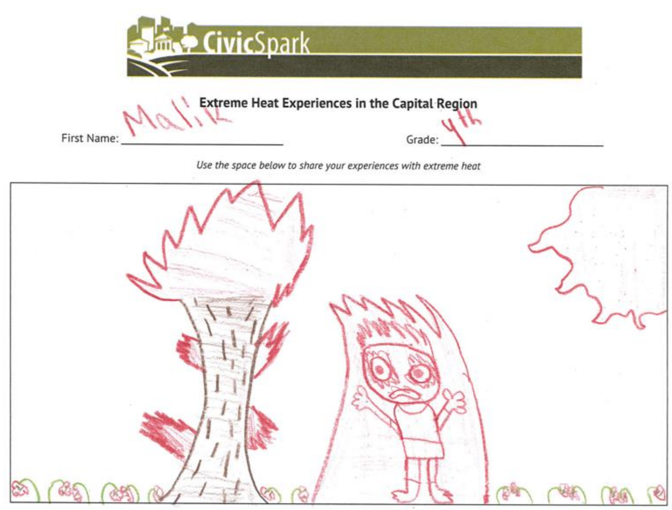

Figure 17. A sample drawing from a student engagement activity around urban heat with a 4th grade class.

The project team also engaged with local students of varying ages at three schools on urban heat, climate change, and zero-emissions transportation.

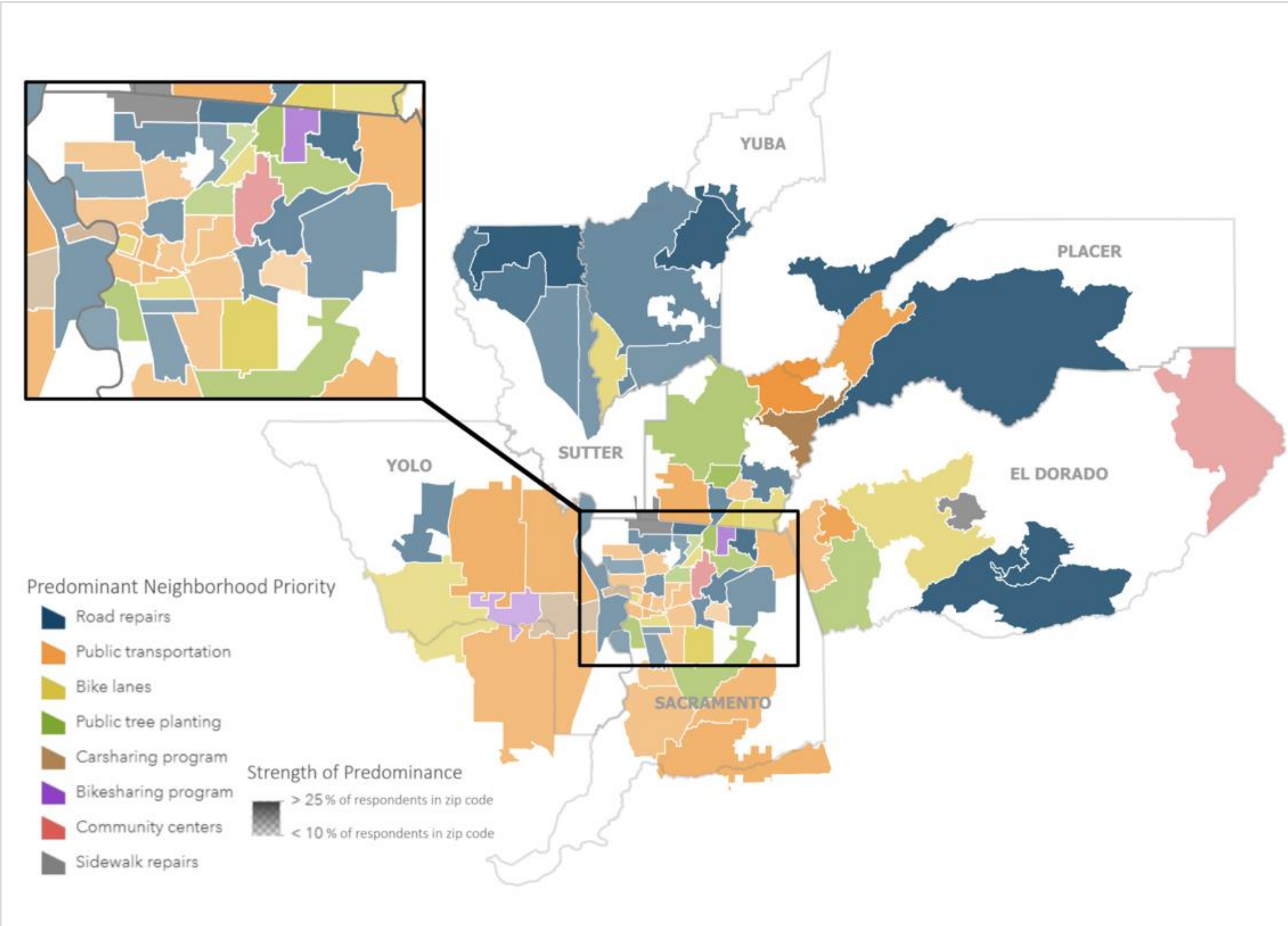

Figure 18. This map shows the top neighborhood priority by zip code in the Sacramento Region, as reflected in responses to the community priorities survey. The color's light/dark gradience indicates how strongly that priority came out as the top choice in that zip code. More in-depth findings can be found in the Community Priorities Report.

Once the project was nearly complete, the project team visited community meetings to give a summary of the heat island modeling, effective mitigation strategies, and resources and strategies for keeping cool during extreme heat events. In addition, the team developed an engagement toolkit with materials for individuals interested in engaging with their communities about urban heat and ways to combat it locally. The posters, handouts, and slideshows included in the toolkit inform about UHI in the region and dangers of urban heat. Lastly, all of the models, reports, and resources have been compiled and uploaded on a website for easy access by the public. The modeling and research is communicated through maps designed to be accessible to average American adults (9th grade reading level).

CONCLUSION AND NEXT STEPS

The results of this project suggest that jurisdictions and agencies in the Capital Region will achieve significant localized and regional cooling impacts by adopting measures that will encourage and support:

- A 0.25 to 0.35 increase in average albedo of roofs, pavements, and walls through the deployment of cool roofs, pavements, and walls
- An increase in average tree canopy in the region by at least 12 percentage points
- Zero-emissions vehicles deployment, ground-based solar PV development, and compact/smart growth policies – which can all provide local cooling benefits, despite not being traditional urban heat mitigation measures.

These mitigation measures should be prioritized in areas identified as having the great UHI/heat burdens (see Identifying and Prioritizing Urban Heat Islands, p4-6) and low-income and underserved communities, as well as new developments, new roads and road maintenance projects, and active transportation corridors.

This project is only the first step; the findings and recommendations are designed to establish a foundation for continued work in the Capital Region to reduce urban heat through improvements to the built environment and the transportation sector.

Because the urban heat island effect is a regional problem, it can be most effectively addressed with regional solutions. Urban heat moves around the region, transported by winds much like air pollution. Acting on its own, a community can reduce a large part of the urban heat island. But when neighborhoods act together to all implement heat mitigation strategies, the cooling effect is much greater. Thus, an effective response to the urban heat island challenge calls for collaborative networks and partnerships like the Capital Region Climate Readiness Collaborative (CRCRC), Valley Vision, and the Sacramento Area Council of Governments in helping the region to come together to develop complementary policies and programs.

Working together, SMAQMD, LGC, SMUD, and the CRCRC will continue to elevate and prioritize urban heat as a growing concern for community health, economic resilience, and the region's livability. The team plans to meet with local jurisdictions to share their findings and recommendations. The long-term goal is to support the region-wide adoption of programs and policies to implement cool pavements, cool roofs, urban tree canopy, and other heat-reduction strategies in transportation plans, projects, climate action plans, and other planning documents.

Community outreach will also continue to be an important element of project follow up, as public awareness and support is necessary for successful local implementation, and low-income and underserved residents will be on the front lines of heat exposure. The project team will promote the community engagement toolkit to neighborhood associations, community groups, and other interested stakeholders. Through the CRCRC, the project team will continue to develop health-oriented solutions to improve heat resilience.

As 2020 looks likely to become the hottest year on record, building our cities and transportation systems to reduce – and not worsen – local heat impacts becomes all the more urgent. The buildings, streets, highways, and railways built today will all be here in 2050, when parts of our region – Sutter and Yuba County – could see as many as 40 days over 100°F each year. By transitioning to cool roofs and pavements, as well as substantially increasing our tree canopy and EV adoption, we can make sure our streets and urban design can help cool communities, protect public health, and safeguard the economy and infrastructure.

This project has provided a comprehensive analysis of the Capital Region's urban heat challenge, and established a baseline and impetus for action. It has also modeled the cooling benefits of a range of realistic, effective heat mitigation strategies, as well as the policy and implementation mechanisms to move them forward. More importantly, it has also demonstrated the essential interconnected nature of our heat pollution: just as the warm air generated in urbanized areas can spread across the region, so too can the cooling air from well-designed heat-reduction projects. In that sense, our shared heat problem is not an island, and nor should we address the issue in isolation. We hope that this project can help bring together partners from across the region to craft thoughtful, collaborative approaches to solve our growing heat challenge, with the goal of creating healthy, resilient neighborhoods and transportation systems for all communities.