Summer 2025 MaRTy Data and Sac Metro Air District's Recommendations for Increasing Thermal Comfort at SacRT's Heat-Resilient Bus Shelters

February 2026

SAC METRO AIR DISTRICT

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Purpose

The Sacramento Metropolitan Air Quality Management District (Sac Metro Air District) aims to provide recommendations to increase thermal comfort for transit riders as they wait at and near bus stops that are receiving new heat-resilient shelters under SacRT's "Enhancing Public Health with Heat-Resilient Shelters" project. SacRT has selected a contractor to produce the final designs. This report presents data using the mobile biometeorological platform instrument, MaRTy, and other resources to assist SacRT in selecting appropriate shade types and the final shelter design to reduce heat stress for transit riders.

Background

As extreme heat becomes more frequent in Sacramento, the Sac Metro Air District is taking action to help protect public transit riders from dangerous temperatures. In summer 2025, Sac Metro Air District staff deployed MaRTy, a state-of-the-art mobile weather device, to measure mean radiant temperatures (MRT) at eight different bus stops in the region in partnership with the Sacramento Regional Transit District (SacRT).

Funded by a grant from the Governor's Office of Land Use and Climate Innovation, SacRT will install up to 20 heat-resilient shelters in high-need locations as part of its Bus Stop Improvement Plan. MaRTy is being used at these stops to measure the real-world impact of these shelters on passenger comfort. Last summer, MaRTy went out to eight of the 20 stops due to time constraints. All eight stops are included in this report, and all are included in the grant project except one (Stop #2: Valley Hi Dr and Mack Rd).

The Sac Metro Air District is collecting data at the transit stops before and after the bus shelters are installed to understand how much of a cooling benefit they provide. The data will give insight into how the new, heat-resilient shelters can reduce heat exposure and support future funding requests for similar projects.

Developed by researchers at Arizona State University, MaRTy captures MRT, a measure of the heat burden and heat stress human bodies experience outdoors on hot summer days. MaRTy is equipped with three net radiometers and sensors that measure incoming heat from the sun and surrounding surfaces. MaRTy captures radiant heat from six different directions and has a built-in computer that runs calculations on how the human body regulates heat. Sac Metro Air District also conducted heat comfort surveys to understand transit riders' heat experience and thermal comfort during data collection days. Around 50% of thermal comfort is determined by parameters such as age, fitness, and adaptation, so the survey provides more insight into metabolic factors that affect heat stress. The survey is provided at the end of the report.

MaRTy measures shortwave (SW) radiation emitted by the sun and longwave (LW) radiation emitted by Earth's surface and atmosphere. Radiation is the transfer of heat energy by electromagnetic waves of different wavelengths. The sun emits electromagnetic waves, and these waves carry energy. SW radiation encompasses shorter wavelengths that transfer more energy than LW radiation. SW radiation is direct or reflected radiation from the sun, and LW radiation is heat that has been absorbed and remitted. Some SW radiation is reflected into the atmosphere as LW radiation due to albedo. Albedo quantifies the amount of solar radiation that is reflected by a surface. Sources of SW radiation can include direct sunlight, reflective surfaces like windows, or materials with high albedo (i.e., higher reflectivity). Sources of LW radiation are surfaces and building materials with low albedo (i.e., higher heat absorption). Lighter-colored surfaces will reflect SW radiation and remain cooler, while darker surfaces absorb more heat, leading to higher temperatures and more LW radiation. These radiative measurements are used to calculate the mean radiant temperature of the environment.
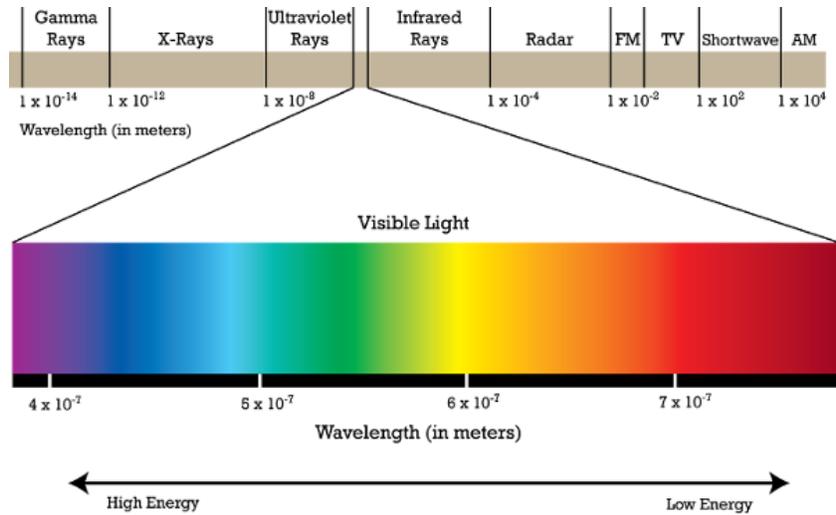
Electromagnetic Spectrum: Ultraviolet rays are a form of SW radiation on the left-side of the spectrum, and infrared rays are a form of LW radiation on the opposite side of the spectrum. SW radiation has more energy and shorter wavelengths than LW radiation.
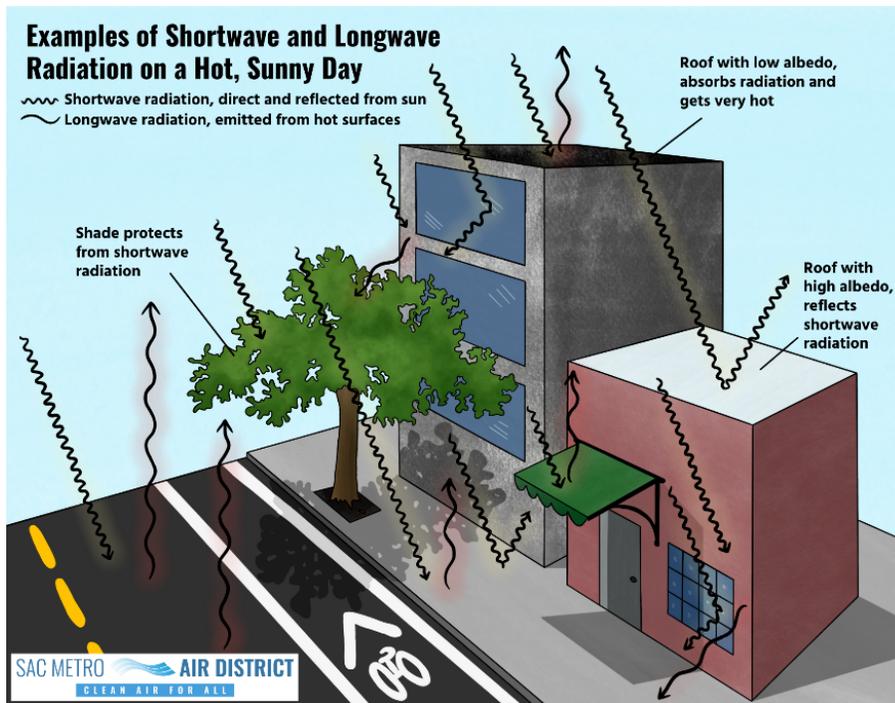

Examples of SW and LW radiation along a city street. Illustration by Fiona McLaughlin

Unlike traditional air temperature readings, MRT provides a clearer picture of how infrastructure affects human heat exposure. MRT and air temperature measure two different aspects of heat. While air temperature measures the temperature of the air molecules, MRT measures the surrounding radiant heat from the environment and how the body absorbs and emits heat. On the graphs in the report, the difference between air temperature and MRT will be dramatic, with MRT showing 25 – 50 degrees higher than air temperature. This is because MRT considers radiant heat from the sun and surrounding surfaces, while air temperature does not. Air temperature is typically measured under shady conditions to protect thermometers from direct sunlight and is a key metric for understanding temperature variation on a regional scale.

Infrastructure and the built environment play a factor in how heat is exchanged and experienced. Specific surface types can emit or retain heat better based on material and color, with lighter surfaces absorbing less heat than darker surfaces. Impervious surfaces (surfaces that impede water) like concrete are hotter in the summer compared to grass or light-colored surfaces. Infrastructure for shade, whether natural or human-made, can provide varying levels of shade performance based on shape, orientation, material, and the time of day. This performance can affect how much radiation, whether in the form of LW or SW, is blocked or emitted during extreme heat days. The design of cities and the materials used to build them have an impact on the overall temperature of the city and thermal comfort for city residents.

Summer 2025 Dates & Locations			
Date	Location	Bus Direction	Bus Stop ID
May 28	*Walerga Rd and Elverta Rd*	*Southbound*	#1570
May 30	*Valley Hi Dr and Mack Rd*	*Southbound*	#3939
June 17	*Arcade Blvd and Marconi Ave LRS*	*Northbound*	#241
June 19	*Del Paso Rd and El Centro Rd*	*Westbound*	#1334
July 8	*Fair Oaks Blvd and Palm Dr*	*Northbound*	#1481
July 11	*Greenback Ln and Mariposa Ave*	*Westbound*	#1190
July 31	*Arden Way and Royal Oaks Dr*	*Eastbound*	#1096
August 21	*Freeport Blvd and 7th Ave*	*Southbound*	#2271
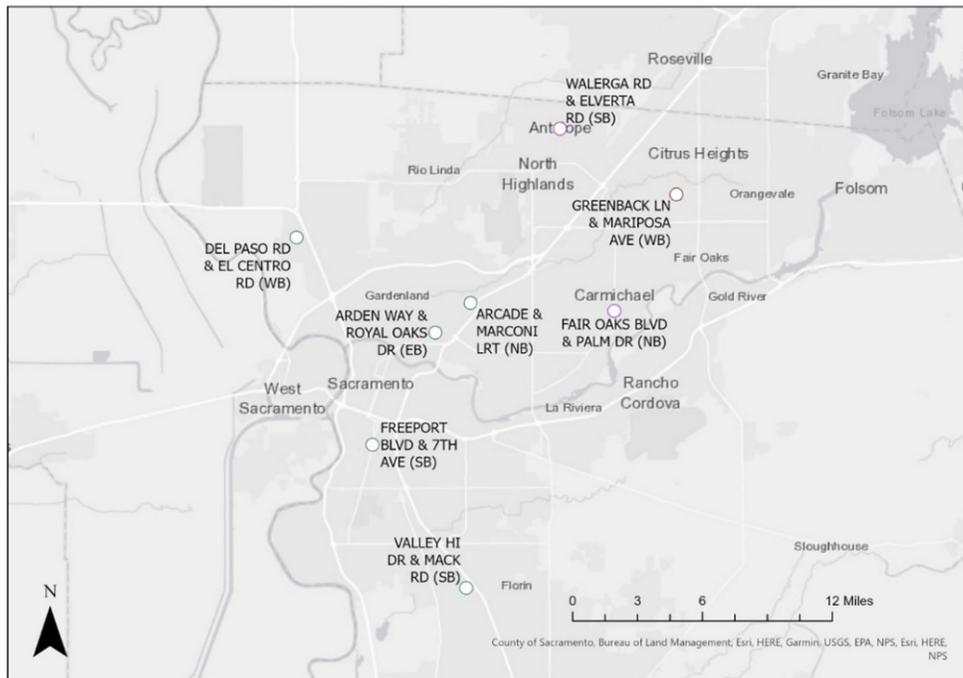
Summer 2025 MaRTy Data Collection Stops
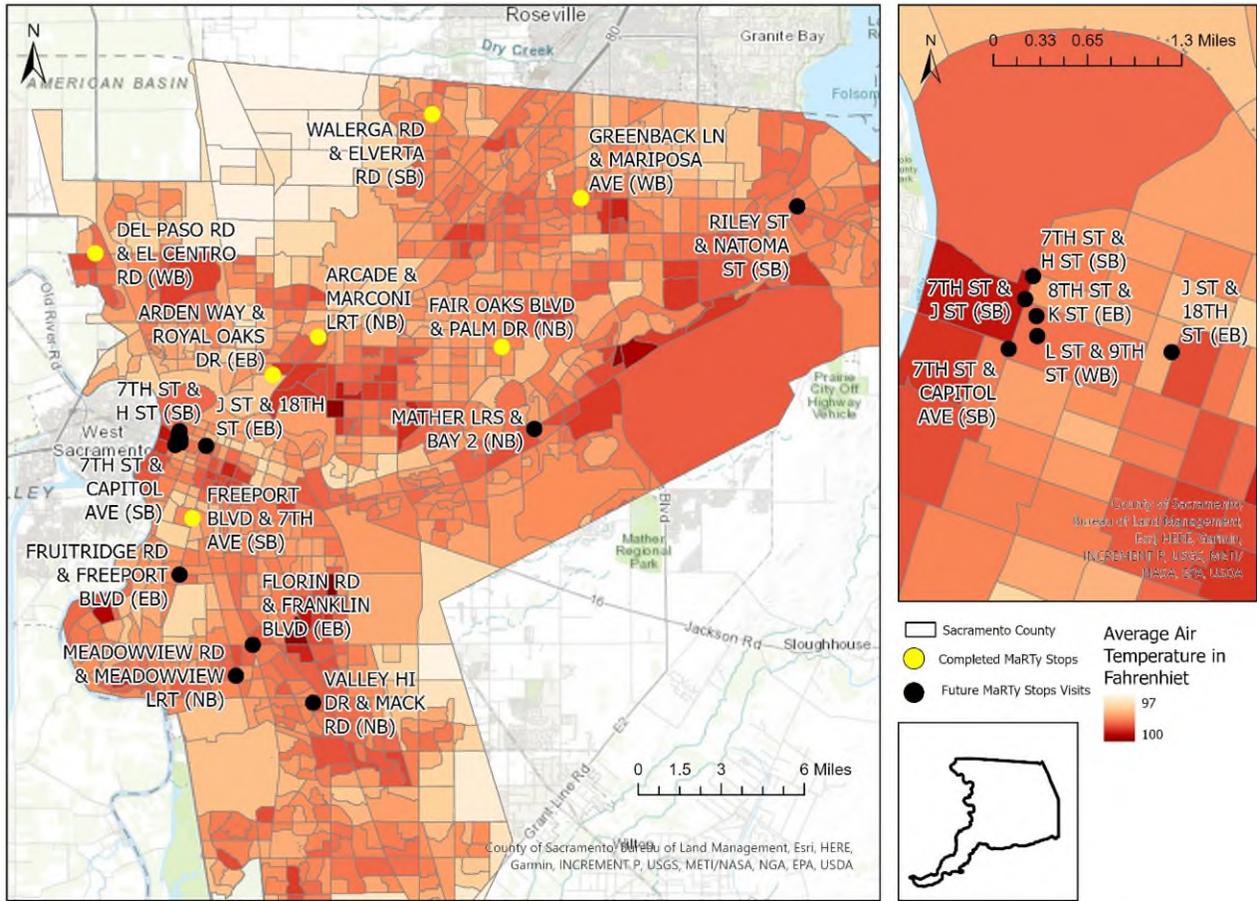
Average Summer Air Temperatures and Sacramento Regional Transit District's Heat-Resilient Bus Shelters

Data Overview:

Summary data of the eight stops shows the daytime conditions and site notes, graphs with MRT and air temperature, pictures, and results from the heat comfort survey. Each stop includes the day's weather based on information from a weather app including temperature, feels like temperature (which considers humidity and wind speed), wind speed and gusts, and humidity. Some stops have different graphs due to coding or data issues; this is noted in the stop's description. Stops with complete sun and shade data have MRT graphs and a table with percentage and degree difference for temperature. Notes describing the location and observations from the day are included. Photos showing MaRTy at each stop taking measurements are included and some stops have a fisheye image of the available shade. The stop summaries also include heat survey results from four of the stops. Following the heat survey results are additional radiation graphs and more information about MaRTy's radiometers. The end of the report provides a summary of the data and recommendations for future data collection days. Additional resources, including tree species suggestions for shade, the heat comfort survey, and humidity charts, are located at the end of the report.
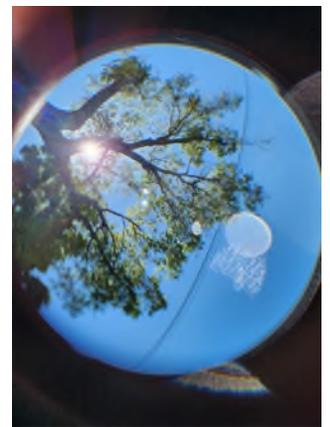
Stop #1

May 28th – Walerga Rd and Elverta Rd, SB #1570

| MaRTy Readings	Temperature °F	Feels Like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%)
1:00 pm	82	84.9	6	10	38

Site Notes:

Location: Adjacent to busy road near entrance to parking lot and shopping center. There was a shelter pad surrounded by bushes and dry grass. No shade and most users waited under trees further away while they waited for the bus. Many walkers, bike riders, and scooter riders passed by before and after data collection.

This was the first data collection day with MaRTy. Some of the radiation measurements were not captured due to an error with MaRTy's code. This stop helped us understand how to use MaRTy better. One reading from 12:59 – 1:02 pm was captured. This was the first day of taking measurements. The data is inconclusive because of the small data pool.

Fisheye Photo of Shade

MRT vs Air Temperature at Walerga and Elverta

MRT: 150.39
Air Temperature: 81.34
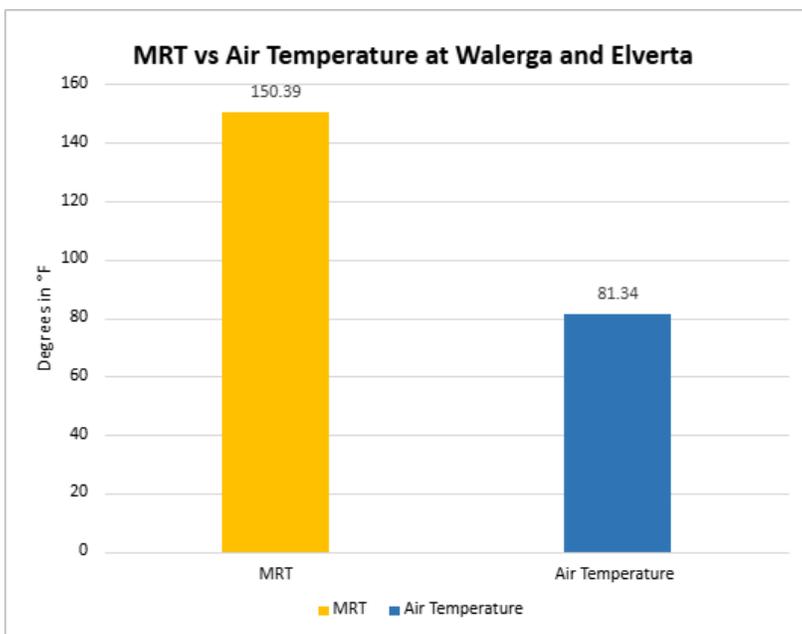
Survey Responses (5 total)

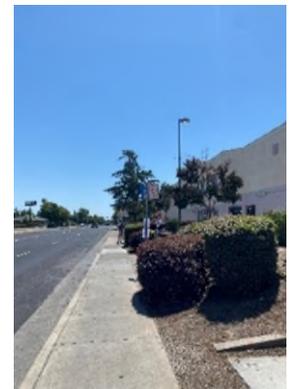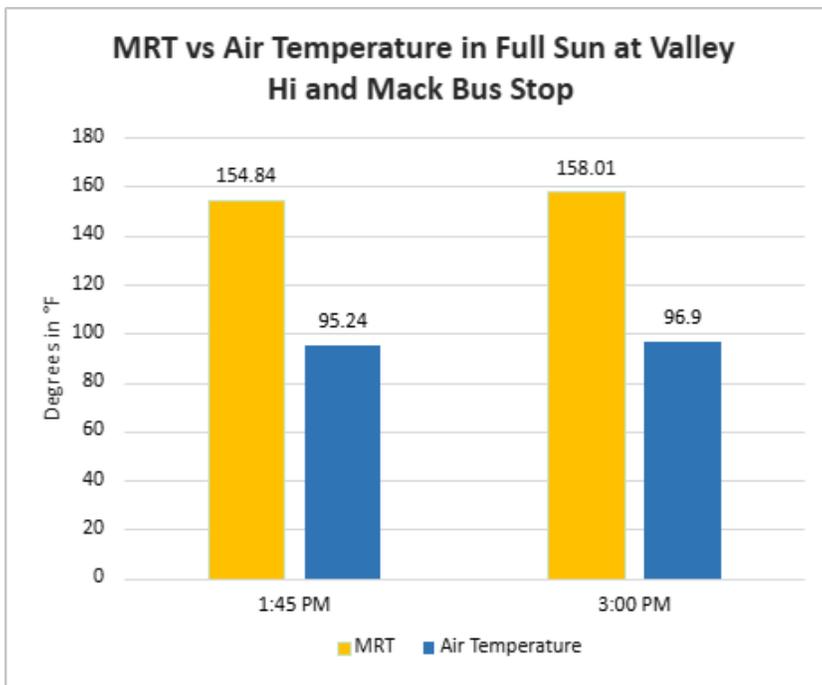| Respondents	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Very familiar	Comfortable	Full sun	Biking
2	Familiar	Comfortable	-	-
3	Very familiar	Slightly uncomfortable	Full sun	Outdoor work
4	Very familiar	Slightly uncomfortable	Full sun	-
5	Very familiar	Slightly uncomfortable	Full sun	Walking

Stop #2

May 30th – Valley Hi Dr and Mack Rd, SB #3939

MaRTy Readings	Temperature °F	Feels Like Temp °F	Wind Speed (mph)	Humidity (%)	Notes
1:45 pm	94	97	5	35	Heat Advisory
3:00 pm	97	97	5	29	

Site Notes:

Location: Next to several businesses with lots of activity and a construction crew was present. A security guard said that this is an active site with many unhoused individuals and crime is frequent.

The shade readings for this site were not recorded. Below are the measurements for MRT and air temperature for the full sun readings. This station has only full sun measurements.

Fisheye Photo of Shade

Survey Responses (2 total)

Respondents	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Very Familiar	Extremely Uncomfortable	Full Sun	Walking
2	Very Familiar	Extremely Uncomfortable	Sun, partial shade under tree and shelter	Walking, public transit, inside with AC

Stop #3

June 17th – Arcade Blvd and Marconi Ave LRS, NB #241

| MaRTy Readings	Temperature °F	Feels Like Temp °F	Wind Speed (mph)	Humidity (%)
1:15 pm	90	87	2-4	27
1:50 pm	91	88	4-5	26
3:00 pm	94	90	5-8	22
3:23 pm	95	92	4-5	22

Site Notes:

Location: Busy and large transit hub. Bus routes and the light rail line have their own stops. Bus routes 25 and 86 were popular.

Stop 25: Bench is in full sun and close to trees. It was busy with people huddling under the tree. This is where the shade readings were taken.

Stop 86: Bench is in full sun, and the tree is closer. People waited near a trash can and a wall located under the tree. This site has bus stops and a light rail station. There was more foot traffic here, and people huddled in the shade.

Shade vs Sun MRT		
Time	Temperature Difference in °F	Percent Difference (%)
1:00 pm	26.57	20
3:00 pm	45.27	30
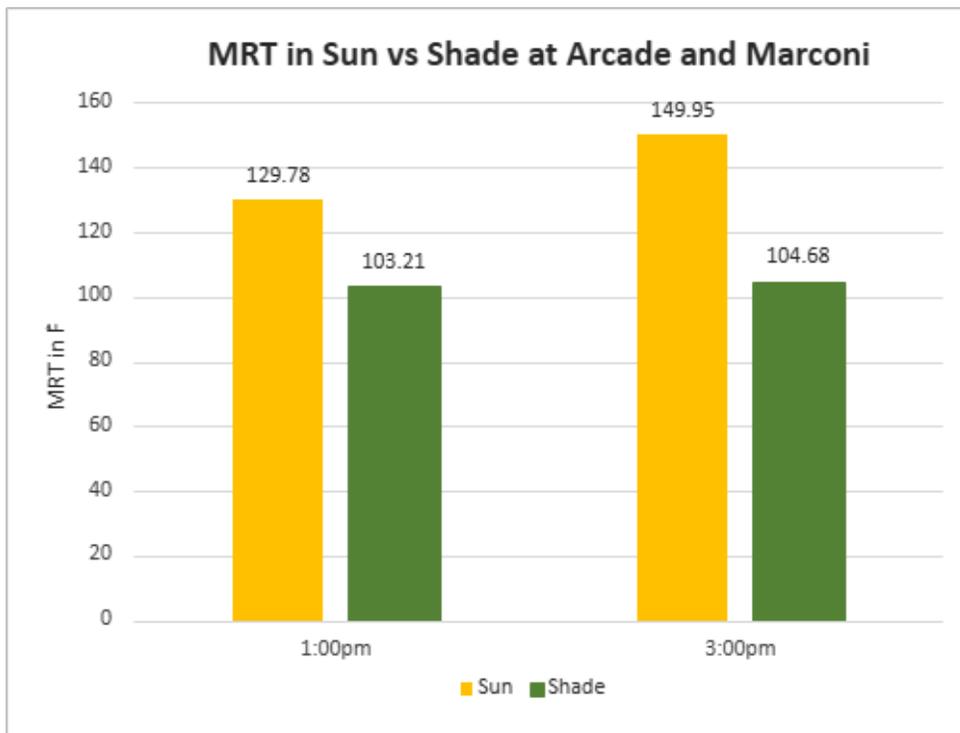
Fisheye Photos of Shade
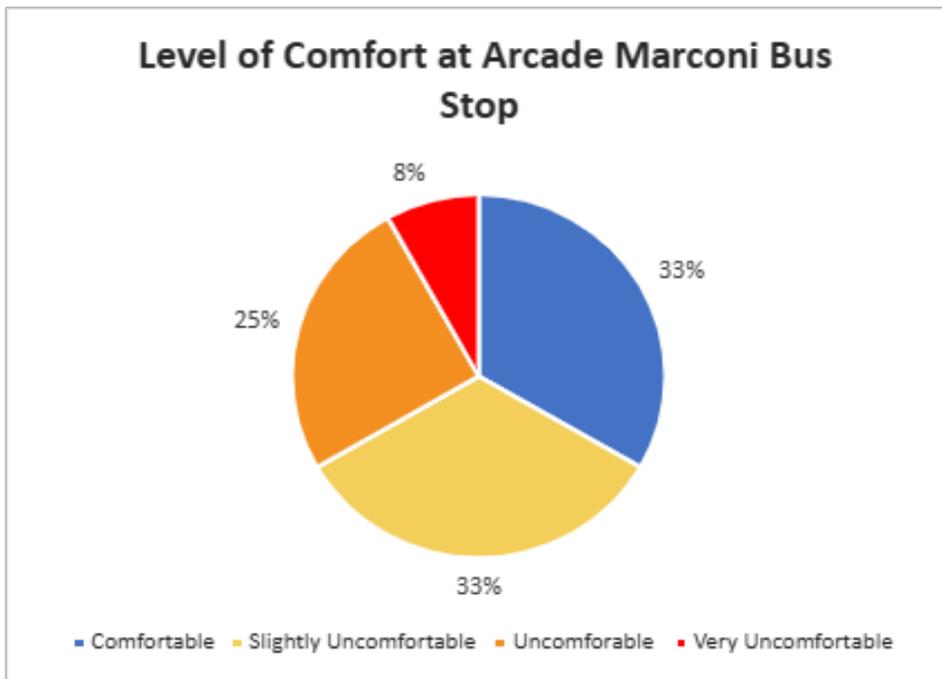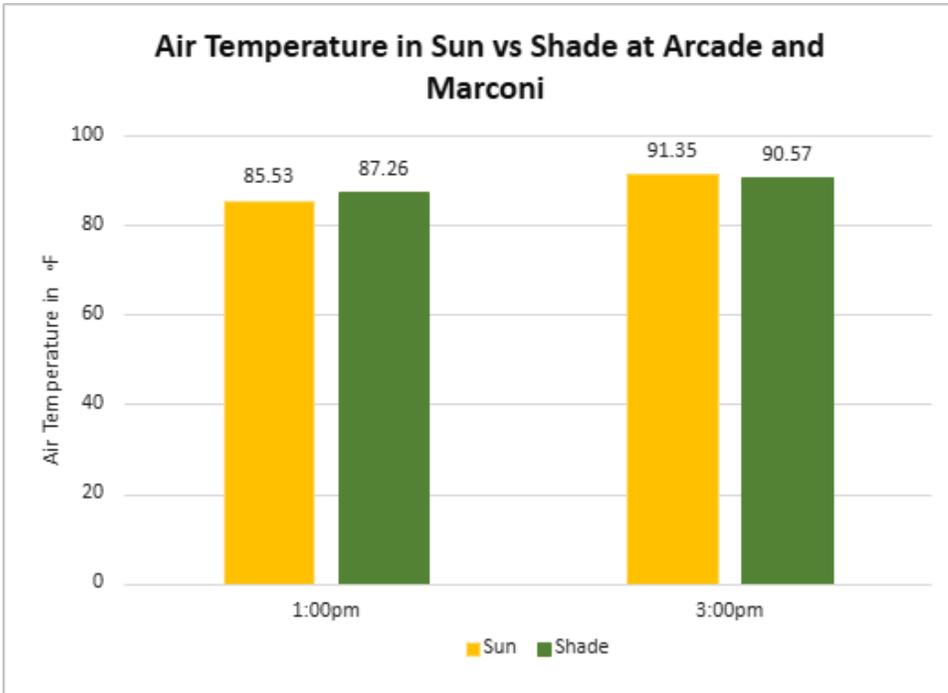
12 Survey Responses – 66% were comfortable or slightly comfortable, 33% were uncomfortable and very uncomfortable. These participants were either in the shade or sun.

## Stop #4

June 19th – Del Paso Rd and El Centro Rd, WB #1334

MaRTy Readings	Temperature °F	Feels Like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%)
1:00 pm	91	80	7	9	37
3:00 pm	86	84	4	6	32

Site Notes:

Location: Outside of a strip mall with lots of traffic. MaRTy was next to some shrubs and there was little pedestrian traffic. It was windier than at other stops.

During the first reading the **front-back radiometer was facing up-down**. The first reading is not displayed because of the radiometer misplacement. The 2nd reading was at 3pm.

This site only had full sun measurements. Shade measurements were not recorded.
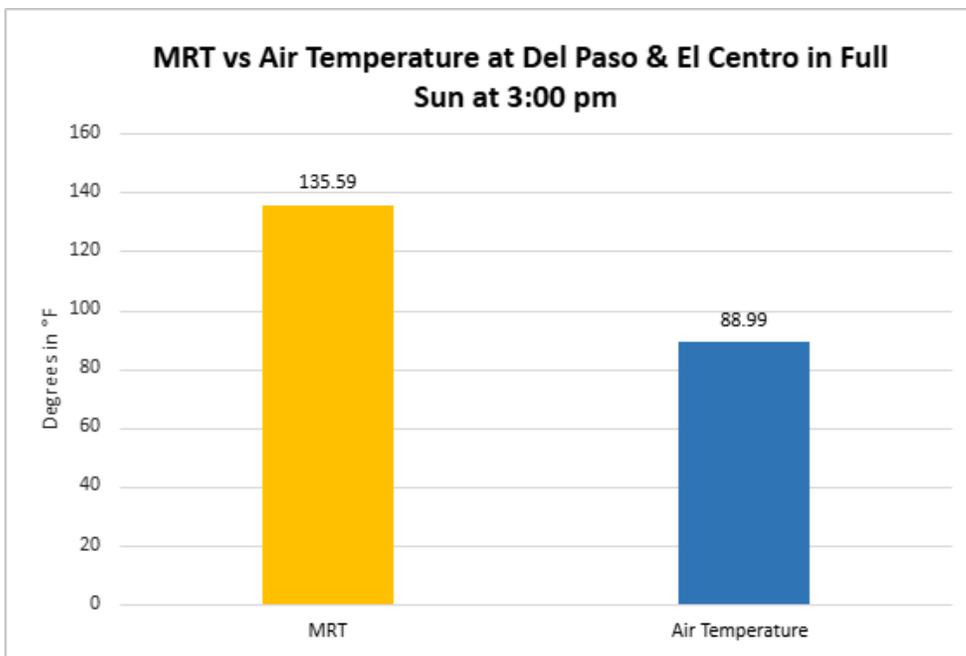
Fisheye Photo of Shade

Survey Responses (3 total)

Respondents	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Familiar	Uncomfortable	Full Sun	Walking
2	Very Familiar	Uncomfortable	Full Sun	Walking, public transit
3	Very Familiar	Slightly Uncomfortable	Full Sun	Inside with AC

Stop #5

July 8th – Fair Oaks Blvd and Palm Dr, NB #1481

MaRTy Readings	Temperature °F	Feels like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%)
1:00 pm	82	82	2	5	45
3:00 pm	88	87	2	5	39

Site Notes:

Location: Shady bus stop with bench in full sun and nearby tree shade. Next to a busy road. These readings had the least amount of people walking near or around MaRTy. This area was also open and had less buildings or structures to affect the readings.

Shade vs Sun MRT		
Time	Temperature Difference in °F	Percent Difference (%)
1:00 pm	35	27
3:00 pm	36	26

Fisheye Photos of Shade
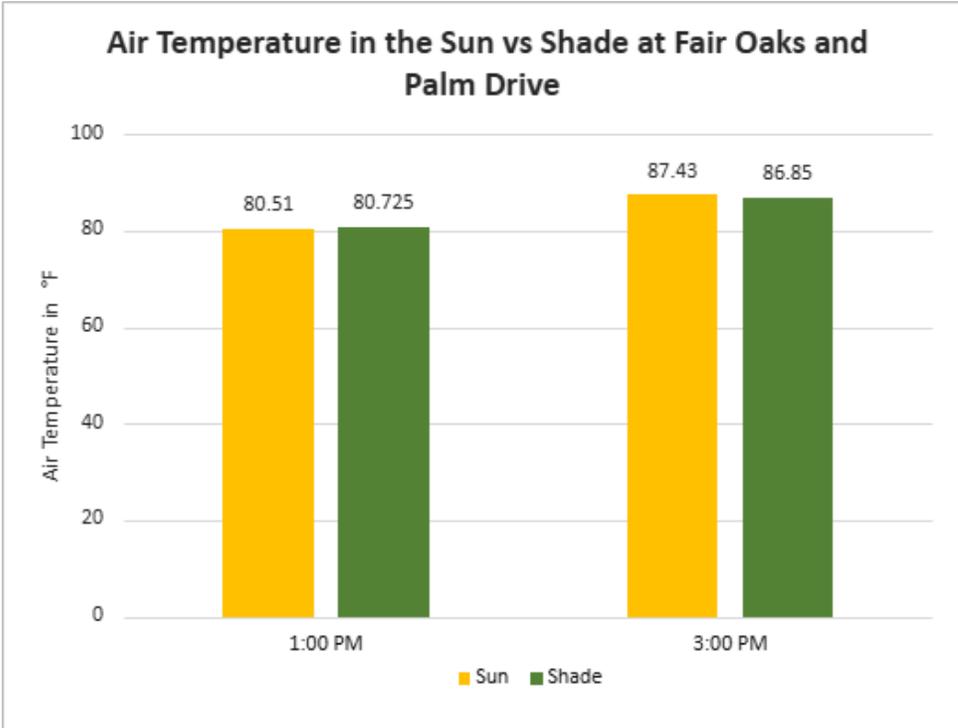
Survey Responses (3 total)

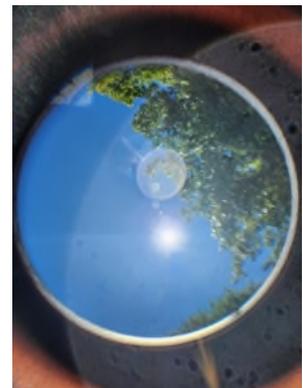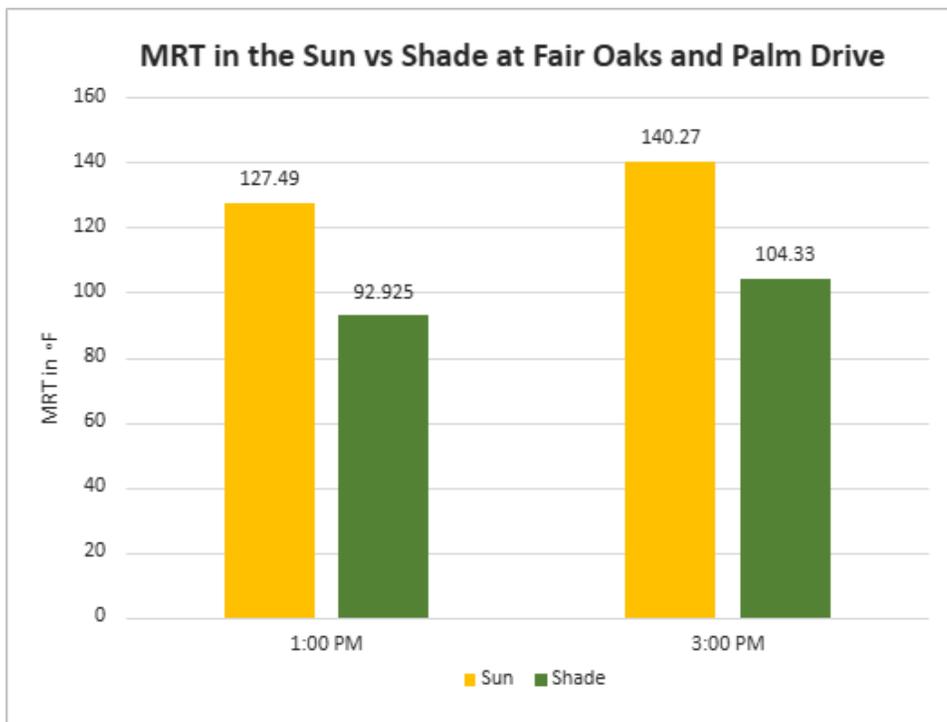| Respondents	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Very familiar	Comfortable	-	Inside with AC
2	Not familiar	Uncomfortable	Full sun	Public transit
3	Very familiar	Comfortable	Partial shade under tree	Public transit

Stop #6

July 11th – Greenback Ln and Mariposa Ave, WB #1190

MaRTy Readings	Temperature °F	Feels like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%)	Notes
1:00 pm	98	101	3	6	36	Heat
3:00 pm	100	109	7	-	29	Advisory

Site Notes:

Location: San Juan High School. Shaded areas included trees near a hot brick wall. The brick wall near the shaded spot may have affected the left/right radiometer readings. There was little foot traffic.

Shade vs Sun MRT		
Time	Temperature Difference in °F	Percent Difference %
1:00 pm	36	24
3:00 pm	45	28

Fisheye Photo of Shade
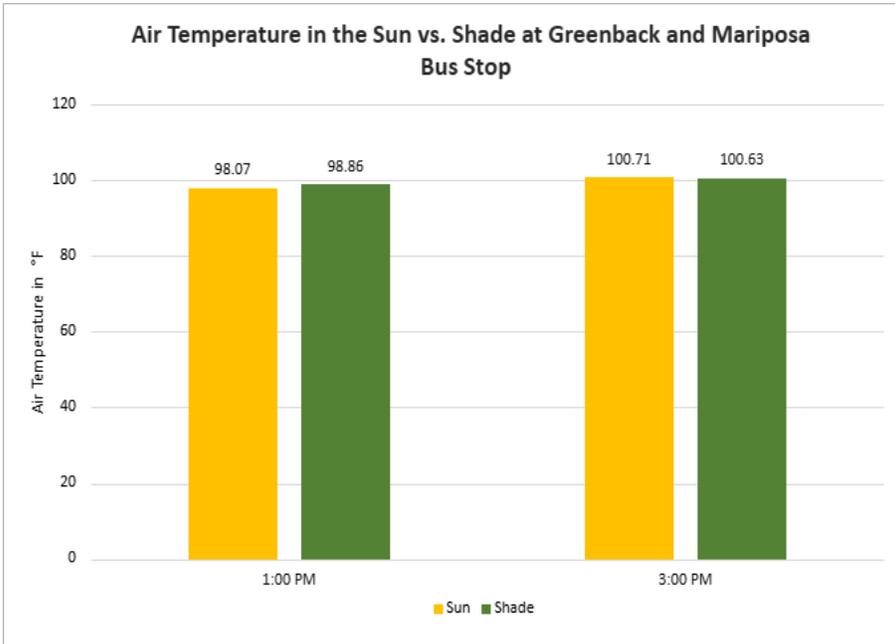
Survey Responses (2 total)

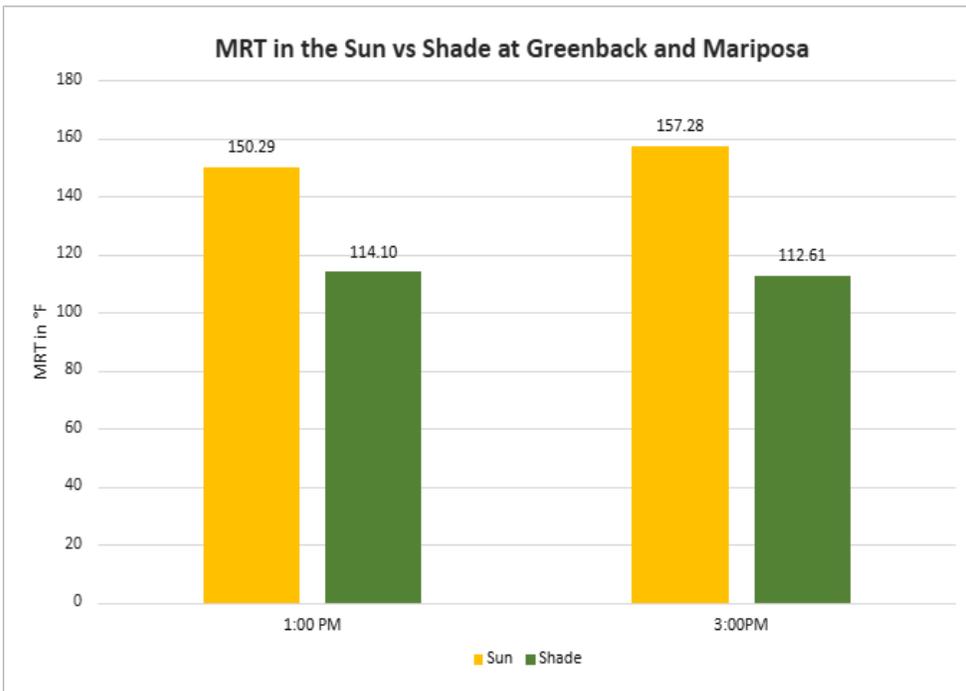| Respondent	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Not familiar	Uncomfortable	Full Sun	At work
2	Very familiar	Uncomfortable	Partial Shade under tree	Walking, public transit, inside with AC

Stop #7

July 31st – Arden Way and Royal Oaks Dr, EB #1096

MaRTy Readings	Temperature °F	Feels like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%) / MaRTy Humidity (%)
1:00 pm	83	84	1	2	51/39
1:30 pm	87	88	3	3	47/37
3:00 pm	90	93	2	2	40/28

Site Notes:

Location: This area is a transit hub with light rail and buses and there was heavy foot traffic and busy roads nearby.

Humidity on this day was higher than on other days. It is possible that the location of the weather station that we used for weather data was influenced by the nearby American river.

Higher humidity was recorded, however, MaRTy had lower humidity readings. Humidity does not affect thermal comfort unless it is over 40%.

Shade vs Sun MRT		
Time	Temperature Difference in °F	Percent Difference (%)
1:00 pm	39	28
3:00 pm	51	34

MRT in Sun vs Shade at Arden Way and Royal Oaks
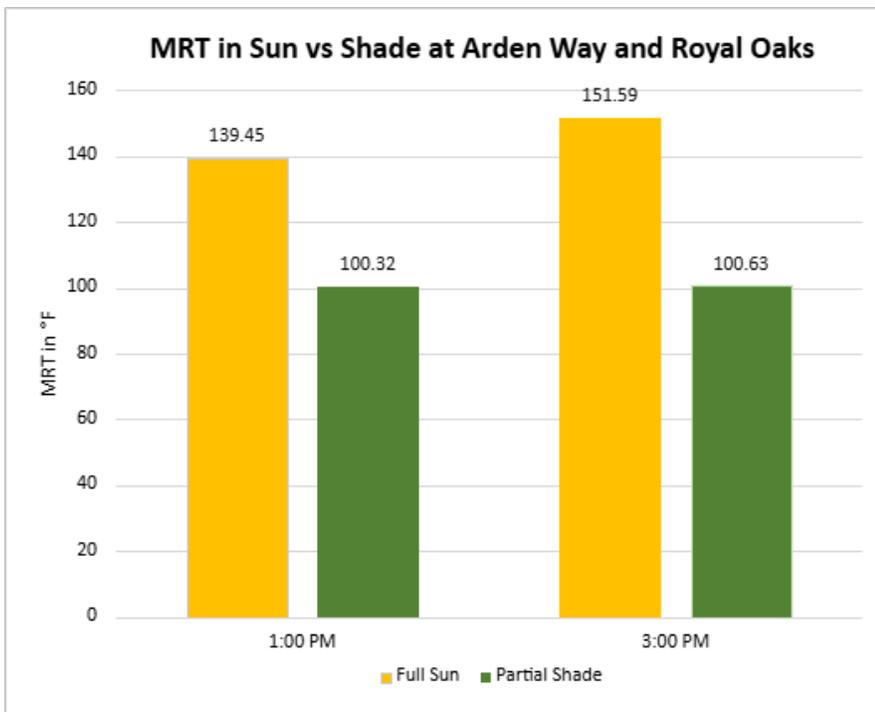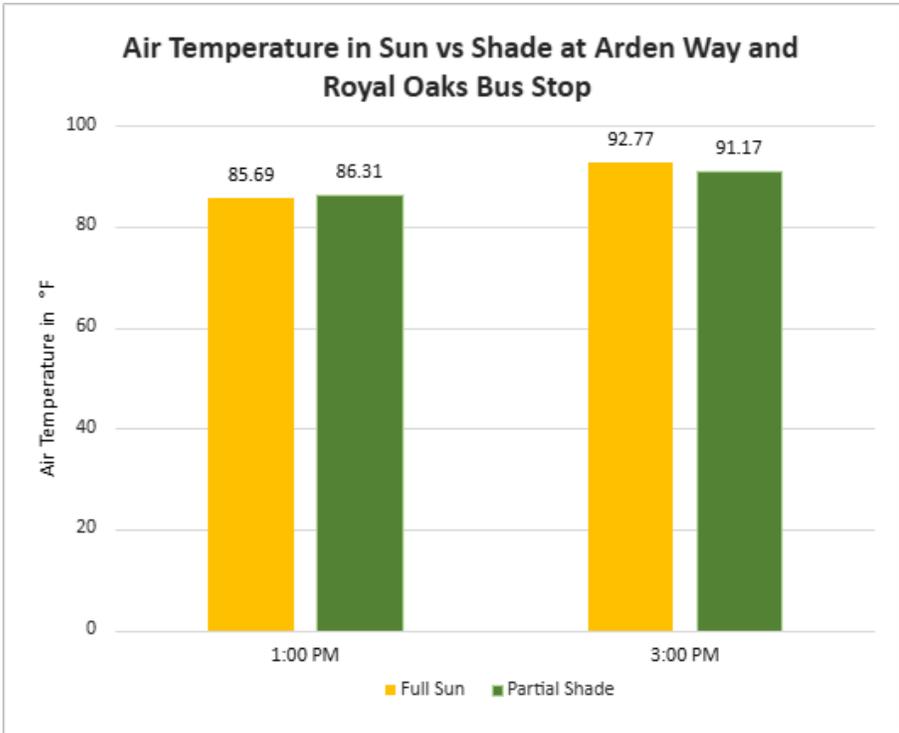
Fisheye Photo of Shade

Fisheye Photo of Shade

About 62.5% were very uncomfortable or uncomfortable. About 37.5% of passengers were either slightly uncomfortable or comfortable. There were 8 respondents.

Stop #8

August 21ˢᵗ – Freeport Blvd and 7th Ave, SB #2271

MaRTy Readings	Temperature °F	Feels like Temp °F	Wind Speed (mph)	Gusts (mph)	Humidity (%)
1:00 pm	98	99	1	2	28

Site Notes:

Location: This bus stop is located near a school. People waited near the trees and in the shade on woodchips for the bus. This day, the readings were taken around the same time and accounted for different surface types. There were some partial shade and full sun readings.

Surface temperature: This can vary based on the presence of shade. The surface material can have higher temperatures depending on its albedo and the time spent in full sun/shade. At this stop, surfaces in the shade had a lower surface temperature. Shade has a direct influence on surface temperature since it blocks the radiation from reaching the surface. The grass at this stop had a lower MRT and surface temperature than the concrete due to evapotranspiration (the process by which water moves from through the soil and plants due to evaporation and transpiration). This process cools the surrounding environment. For the woodchips, the MRT was low due to the presence of shade which likely cooled the nearby building and the woodchips.

Shade vs Sun MRT		
Condition	**Temperature Difference in °F**	**Percent Difference (%)**
Sun on concrete vs shade on woodchips	49	32
Sun on grass vs shade on woodchips	39	28
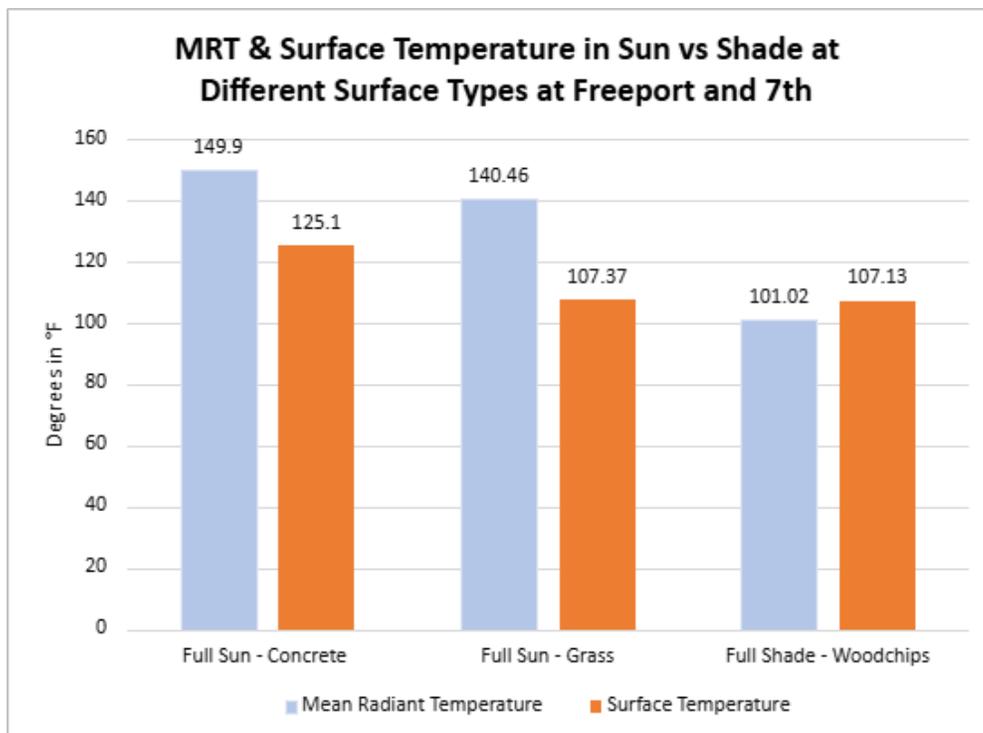
MRT & Surface Temperature in Sun vs Shade at Different Surface Types at Freeport and 7th

Survey Responses (3 total)

Respondent	Familiarity w/ Sac. Climate	Thermal Comfort	Shade vs Sun	Activity Before Waiting for Bus
1	Very familiar	Comfortable	Partial Shade under tree	Inside with AC
2	Familiar	Uncomfortable	Full Sun	In school
3	Very familiar	Slightly Uncomfortable	Partial Shade under tree	Public transit

Data Discussion

Graphs displaying data from across sites (four out of eight are presented)

MRT and Air Temperature at Various Bus Sites and Times in Full Sun

	1:00PM	3:00PM	1:00PM	3:00PM	1:00PM	3:00PM	1:00PM	3:00PM
	Arcade and Marconi		Arden and Royal Oaks		Fair Oaks and Palm Dr		Greenback and Mariposa	
MRT	129.78	149.95	139.45	151.59	127.49	140.27	150.29	157.28
Air Temperature	85.53	91.35	85.69	92.77	80.51	87.43	98.07	100.71

■ MRT   ■ Air Temperature

MRT and Air Temperature at Various Bus Sites and Times in Shade

	1:00pm	3:00pm	1:00pm	3:00pm	1:00pm	3:00pm	1:00pm	3:00pm
	Arcade and Marconi		Arden and Royal Oaks		Fair Oaks and Palm Dr		Greenback and Mariposa	
MRT	129.79	104.68	100.32	100.63	92.93	104.33	114.1	112.61
Air Temperature	85.53	90.57	86.31	91.17	80.73	86.85	98.86	100.63

■ MRT ■ Air Temperature

Degrees in °F

Heat Comfort Survey Results

Air Temperature Highs on Survey Collection Days
Shown as percent of total responses.

13%
5%
26%
56%

■ 86-90 °F   ■ 91-95 °F   ■ 96-100 °F   ■ 101-105 °F

Participant Familiarity with Sacramento Summer Climate
Shown as percent of total responses.

10%
8%
18%
62%

■ Very familiar ■ Familiar ■ Somewhat familiar ■ Not familiar
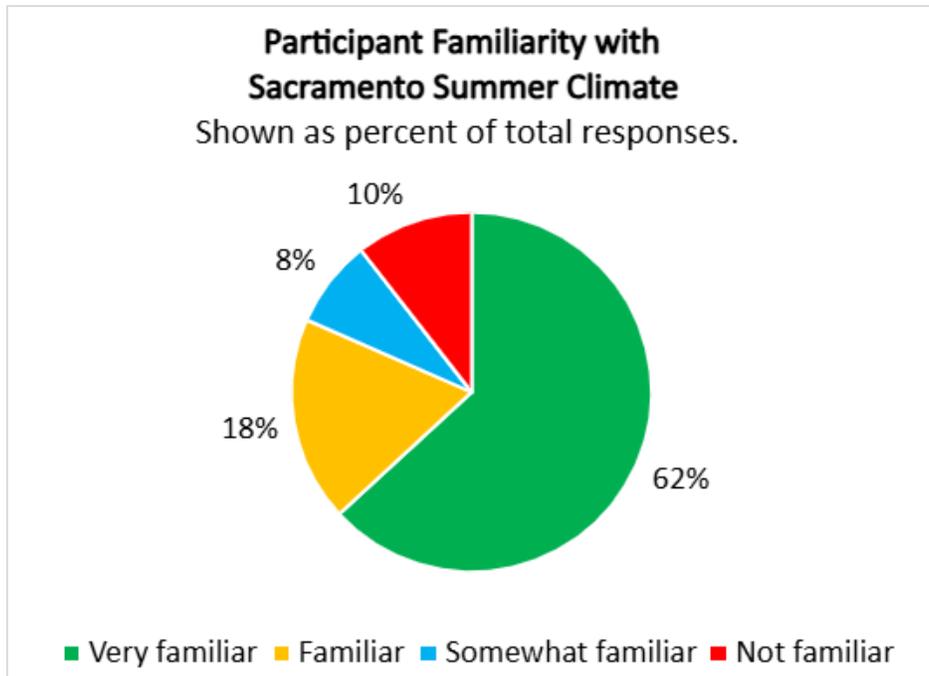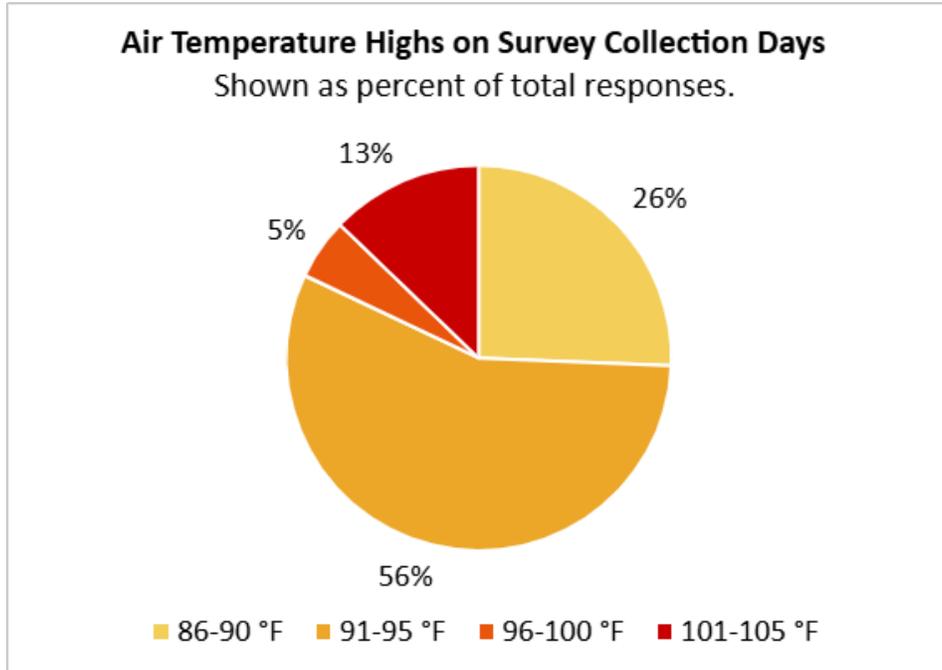
These graphics show results from all of the heat comfort surveys. Most surveys were taken on days with temperatures around 91-95 degrees Fahrenheit. Most survey takers were familiar or very familiar with Sacramento's climate (80%). Familarity to the climate does affect physiological equivalent temperature and other thermal comfort variables so it is important to collect this information for further analysis.

Radiation Graphs

Net Shortwave Radiation at 3pm in Sun and Shade

Net Longwave Radiation at 3pm in Sun and Shade
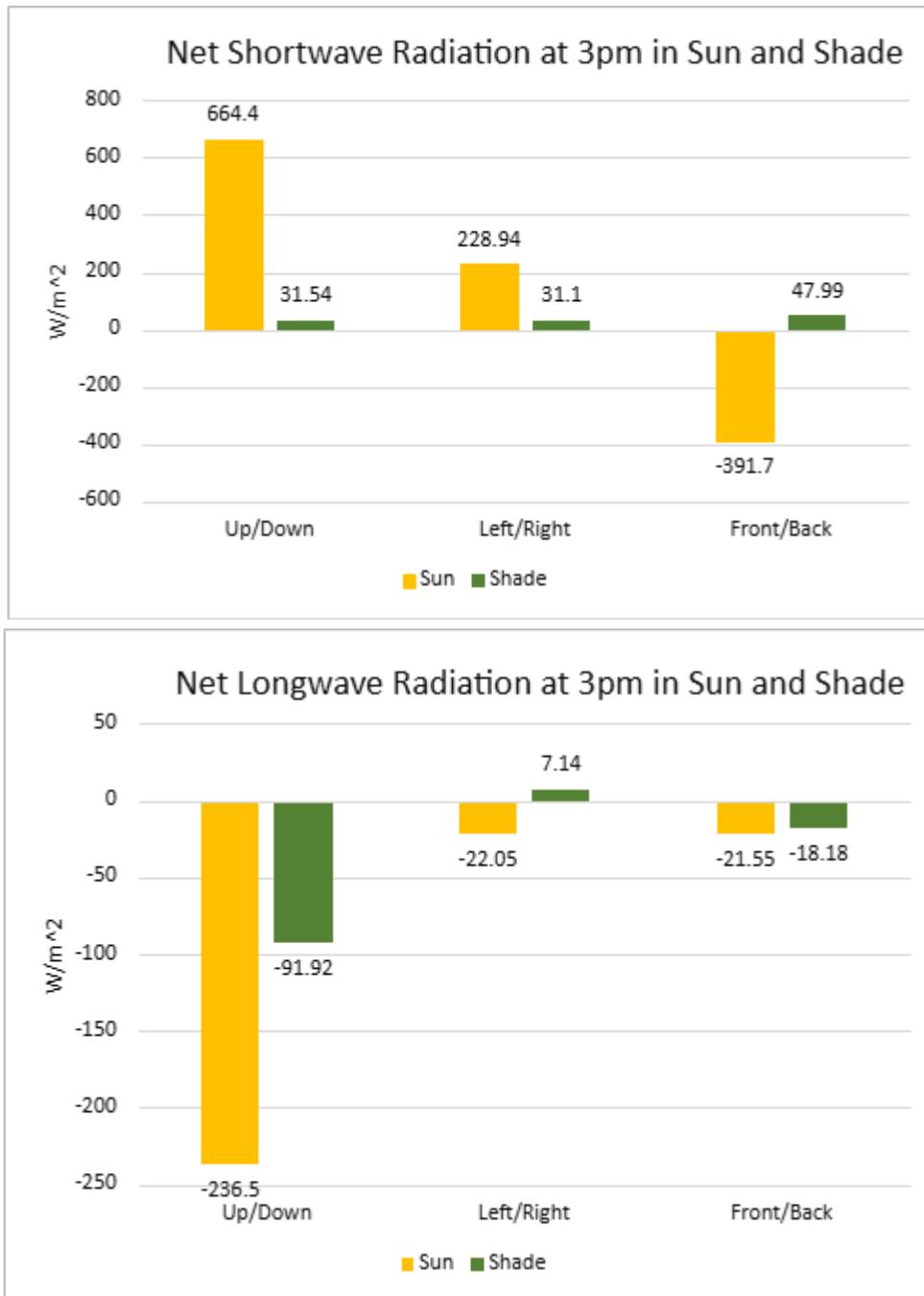
The radiation graphs above provide the measurements of radiation on July 11th from each sensor. The up and down radiometers have the highest values most likely due to the sun position at those times. Net positive SW radiation means that the incoming radiation is larger than outgoing radiation (more going towards the surface); the result was the same for most of the radiometers except the front and back radiometers in the sun. Net LW radiation is negative, meaning more radiation is emitted from the surface than the air. When air is warmer than the surface, the LW radiation is positive, meaning more heat is being absorbed into the surface. The left/right sensor had the only positive LW radiation reading. Also, SW radiation from the up and down sensor is about three times as high as the LW radiation, with a difference of 900.9 W/m^2 (watts per meter squared).This indicates that people typically experience more SW radiation than LW at a given time.

Summary

All the sites showed a difference in MRT based on whether MaRTy was placed in the shade versus in full sun. The hottest data collection day was July 11th with a high of 100°F and the coolest day was May 28th with a high of 82°C. The days with the most similar conditions are July 11th and August 21st with similar temperatures of around 99°C, but different "feels like" temperatures with a difference of 10°F.

June 17th and July 8th, 11th, and 31st had the most consistent and complete data. They had temperature readings for both times during the afternoon and similar humidity levels.

The day with the most usable data was July 11th (Greenback and Mariposa). This day had the least interference from pedestrians and the most consistent data across all readings.

The preliminary data shows that **MRT is higher in full sun compared to shaded areas**. **The 3:00pm readings show higher MRT than 1:00pm readings. Air temperature shows little difference between sunny and shady locations**.

The highest readings of MRT overall were at 3:00pm. **Arden and Royal Oaks and Greenback and Mariposa had the highest readings of 151.61 and 157.28 °F**. These bus stops all had temperature readings above 90°F. The lowest MRT readings were during the 1:00pm period and occurred in the shade. **The lowest MRT readings in the shade were at Arden and Royal Oaks and the Fair Oaks and Palm bus stops with temperatures of 83 and 82°F**. These areas had temperatures around the low 80s during the shade readings. Additionally, for the four stops with both shade and sun measurements for 1:00pm and 3:00pm, **the average difference in MRT at 1:00pm for sun and shade was 34°F**. **At 3:00pm, the average MRT difference was 44°F. The average percentage differences between shade and sun readings were 25% at 1:00pm and 29% at 3:00pm.**

Recommendations & Conclusion:

Overall, the MRT and thermal data collected provides insight into the benefits of shade under extreme heat conditions and quantifies the impact of providing shade in these areas. The MRT values help determine which sites should be prioritized for the SacRT bus shelter project. By looking at the highest and lowest values, we can prioritize sites that may have a higher heat risk than others. In addition, the heat comfort surveys also provide insight into how the community experiences heat and support the analysis presented in this report. Some days only had two or three survey results. Recommendations include conducting surveys continuously throughout the data collection day to gather more data from transit riders.

Bar graphs are the most accessible depiction of the data from these collection days. This allows us to compare the MRT values and other factors under different sun and shade conditions. Future data analysis may include further programming/Excel statistical analysis to compare MRT values across bus stops or calculating the correlation between variables.

Further site design should consider shade orientation and type of shelters and urban greening. It is recommended that horizontal structures, like bus shelters, be placed in an east-west orientation. This extends the shade provision from the late morning to early afternoon. Green walls and vegetation reduce local temperatures, provide shade, and improve thermal comfort. It is imperative to consider trees as shade infrastructure while also understanding the potential for nighttime heating due to the trapped LW radiation from tree canopies. However,

the benefit of reducing SW radiation through tree shade during the day outweighs the slight impacts of nighttime LW radiation emissions. By considering site design and additional natural shade, the built environment can support cooler urban spaces.

Overall, this data can assist in urban site design and selecting the sites where heat resiliency improvements are necessary and would support the community. More data collection and analysis are planned for summer 2026 to assist with the SacRT Bus Stop Improvement Plan and the installation of the heat-resilient shelters.

Other Resources

Tree Species Suggestions:

The chart below provides information about trees species and characteristics that would be suitable for shade. The trees below are recommended by the Sacramento Tree Foundation in its Shady Eighty Guide.

BVOC: Biogenic volatile organic compounds. These compounds contribute to ozone formation and smog. The trees that release low BVOCs will have a higher rating.

Deciduous: Trees that lose their leaves in the fall and regrow them in the spring.

Evergreen: Trees that keep their leaves all year long.

| Small Trees	Size (ft)	Water Use	Shape	Evergreen or Deciduous	Required Distance from Structures	Air Quality (BVOC)	Notes	Picture (Sac Tree Foundation)
Japanese Flowering Crabapple	15-20 for height and crown length	Medium	Spreading	Deciduous	Foundation: 6ft Fences and powerlines: 3ft Between trees: 12ft	★★★	Has flowers and fruit, can be in full sun, can handle more droughts once mature	
Desert Willow	15-25 for height and crown length	Low	Circle	Deciduous	Foundation: 6ft Fences and powerlines: 3ft Between trees: 12ft	★★☆	Pink flowers; prefers well-draining soils, wide spreading low care needs	

Washington Hawthorn	20-35 height 20-25 crown length	Medium	Circle	Deciduous	Foundation: 6ft Fences and powerlines: 3ft Between trees: 12ft	★★★	White flowers, red berries in winter, thorns, SMUD provided, large thorns	
Chinese Fringe Tree	15-25 height 15-20 crown diameter	Very low	Circle	Deciduous	Foundation: 6ft Fences: 3ft Powerlines: 3ft Between trees: 12ft	★★★	SMUD provided, Fragrant, white flowers, peeking bark when mature. Plant female tree together and blue berries that attract birds	
Chaste Tree	10-15 height 15-20 crown diameter	Low	Circle	Deciduous	Foundations: 6ft Hardscape: 5ft Fences and powerlines: 3ft Between trees:12 ft	★☆☆	Wide-spreading trees grow lower branches. Very hardy and drought-tolerant	
Eastern Redbud	20-30 feet height and crown diameter	Medium	Circle	Deciduous	Foundation: 6f Fences: 3ft Power lines: 3ft Between trees: 12 ft	★★★	Low care needed and fast growing, provides dense shade during the summer, SMUD provided	

Medium Trees	Size (ft)	Watering	Shape	Evergreen or Deciduous	Required Distance from Structure	Air Quality	Notes	Picture
Carob Tree	30-40 height 30-35 crown diameter	Low	Circle	Evergreen	Foundation: 15ft Fences: 6ft Powerlines: 20 ft Between trees: 18ft	★☆☆	Dense, green canopy, round leaflets	
Sweet Bay Laurel	30-45 ft height 30-40 crown diameter	Low	Triangle	Evergreen	Foundation: 15ft Fences: 6ft Powerlines: 20 ft Between trees: 18ft	★★☆	Drought-tolerant shade trees, grows at a moderate pace	
Emerald Sunshine Elm	35 ft height 25 feet crown diameter	Very Low	Vase	Deciduous	Foundation: 15ft Fences: 6ft Powerlines: 20 ft Between trees: 18ft	★★★	Resistant to Dutch elm disease and insects, tolerates hot weather	
Shantung Maple	25-30 ft height 20-30ft crown diameter	Low/medium	Circle	Deciduous	Foundation: 10ft Fence: 6ft Powerlines: 20ft Between trees: 15ft	★★☆	Fast growing, dense, round canopy, drought tolerant when mature	

Urban Greening Summary:

Vegetation is a useful tool in reducing heat stress in cities. There are multiple factors to consider when deciding on the best type of vegetation and its placement. Native species thrive best in their original habitat and provide benefits to local wildlife, reduce erosion, and require minimal maintenance. Also, a tree's size and canopy can supply shade. For instance, the leaf area index (LAI) quantifies the amount of leaf material in a canopy. The higher the index, the more leaves in the canopy and the more protection from the sun. Mature trees are also preferred because they have larger canopies.

Regarding placement of vegetation, there are specific requirements for where a tree can go based on other existing infrastructure and permit regulations. This will be a case-by-case basis on what tree fits best for the stop. For bus stops and vegetation, consider whether the species is native to the Sacramento region, size, adaptability to extreme climate, and LAI. Adding a tree as the primary or secondary shade for a bus stop can drastically improve heat comfortability.
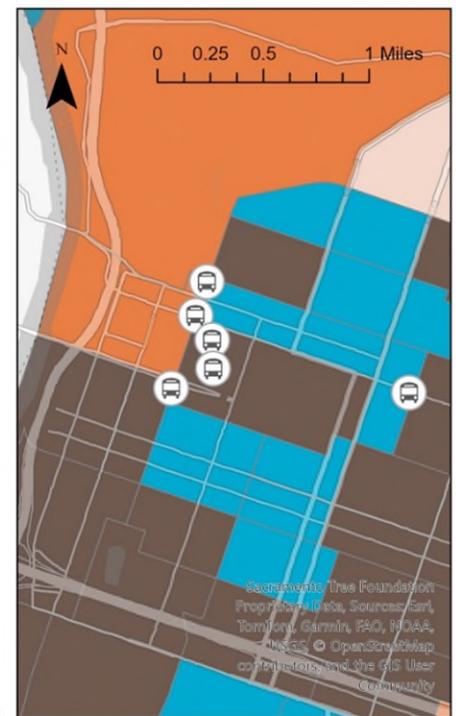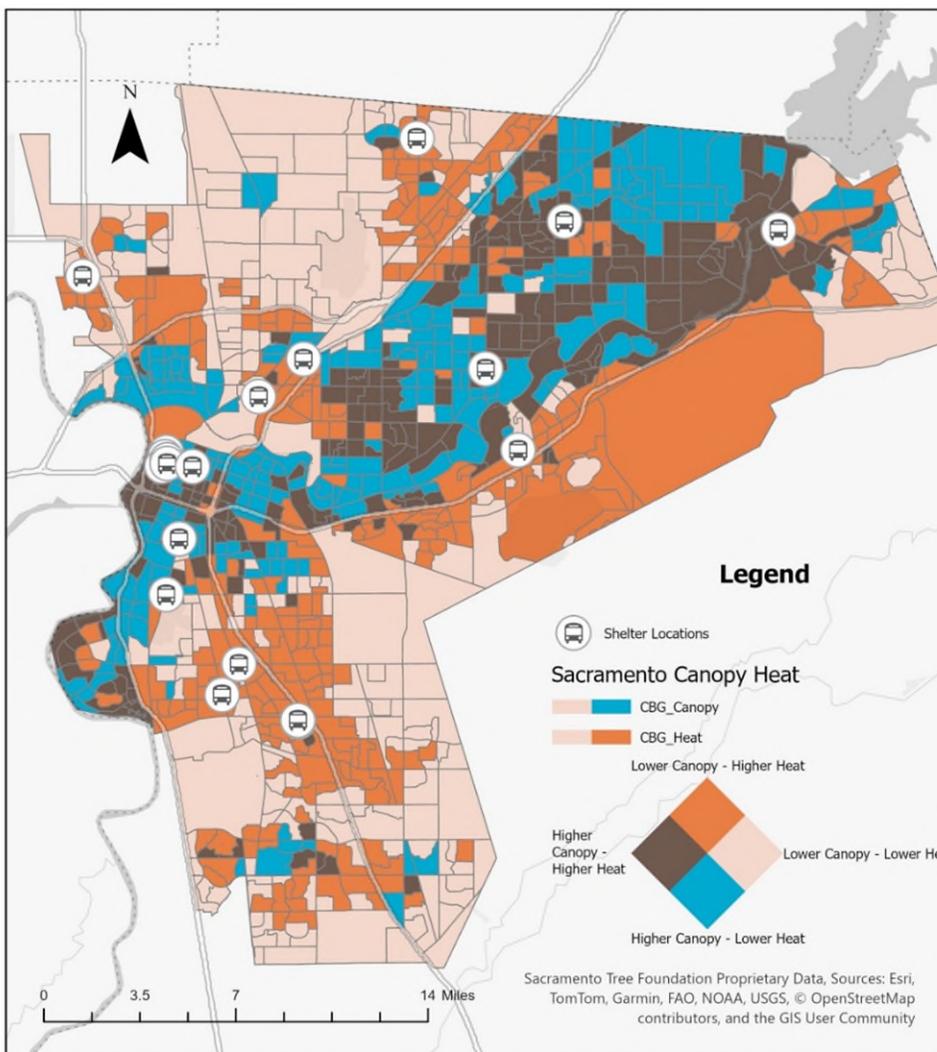
Sacramento Tree Canopy versus Heat Level and Sacramento Regional Transit District's Heat-Resilient Bus Shelters

Heat Comfort Survey

SAC METRO **AIR DISTRICT**

Comfort Survey for Transit Riders

The bus stop that you are standing at is scheduled to receive a shade shelter. We would love to hear from you about your current comfort level and the temperature at this bus stop. Next year, we will ask again to see if the changes worked to make this bus stop feel cooler! Your input is so valuable. All survey responses will remain anonymous, confidential, and the results will inform SacRT bus stop improvement plans.

1. **On the scale below, how do you feel today, health-wise? (Circle)**

-2	-1	0	+1	+2
Unwell	Bad	Well	Good	Amazing

2. **How familiar are you with Sacramento's summer climate? (Circle)**

   Very familiar   Familiar   Somewhat familiar   Not familiar

3. **What is your reason for taking the bus? (Check)**

   ☐ Work   ☐ School   ☐ Errands   ☐ Fun (meeting up with a friend, going somewhere for fun, etc.)   ☐ Other: _____

4. **Current time:** _____ (This helps us better understand your answers because it tells us roughly how intense the sun is at the current moment.)

   a. **Please indicate how you feel temperature-wise: (Circle)**

-4	-3	-2	-1	0	+1	+2	+3	+4
Very cold	Cold	Cool	Slightly cool	Neutral	Slightly warm	Warm	Hot	Very hot

   b. **Based on your answer above, please indicate your current comfort level: (Circle)**

0	1	2	3
Comfortable	Slightly uncomfortable	Uncomfortable	Very uncomfortable

   c. **Would you prefer the temperature at this location to be... (Circle)**

-3	-2	-1	0	+1	+2	+3
Much cooler	Cooler	Slightly cooler	Neither warmer nor cooler	Slightly warmer	Warmer	Much warmer

5. **Please indicate your current exposure to the sun at this bus stop: (Check all that apply)**

   ☐ Full sun   ☐ Partial shade (under tree)   ☐ Full shade (under tree)

   ☐ Partial shade (under bus shelter)   ☐ Full shade (under bus shelter)

   TURN PAGE →

First Page of Heat Survey

SAC METRO ⌇ AIR DISTRICT

6. **If you HAD to guess, without looking at your phone, what do you think the current temperature is?**

    In the shade: _____ °F   In the sun: _____ °F

7. **We have found that what people were doing just prior to being asked the questions on this survey influences how comfortable they feel in the heat. Where were you/what were you doing... (you may select multiple)**

...5 minutes prior to being here:	...30 minutes prior to being here:
☐ Driving a car	☐ Driving a car
☐ Riding a bike	☐ Riding a bike
☐ Walking around	☐ Walking around
☐ Public transit	☐ Public transit
☐ Exercising	☐ Exercising
☐ Inside with AC (car or building)	☐ Inside with AC (car or building)
☐ Inside with no AC	☐ Inside with no AC
☐ Other: _____	☐ Other: _____

8. **What clothing are you wearing (please check all that apply):** (We know this is specific—it allows us to add this data into a heat index, which tells us a "feels like" temperature of the bus stop given your answers. This data is very useful for advocating for the implementation of more effective shade shelters in the region.)

☐ Short sleeves	☐ Shorts or short skirt	☐ Sweater	☐ Light colored clothes
☐ Long sleeves	☐ Long pants or long skirt	☐ Jacket	☐ Dark colored clothes
		☐ Scarf	☐ Mix of light and dark colored clothes
		☐ Beanie/warm hat	

9. **Age group:**

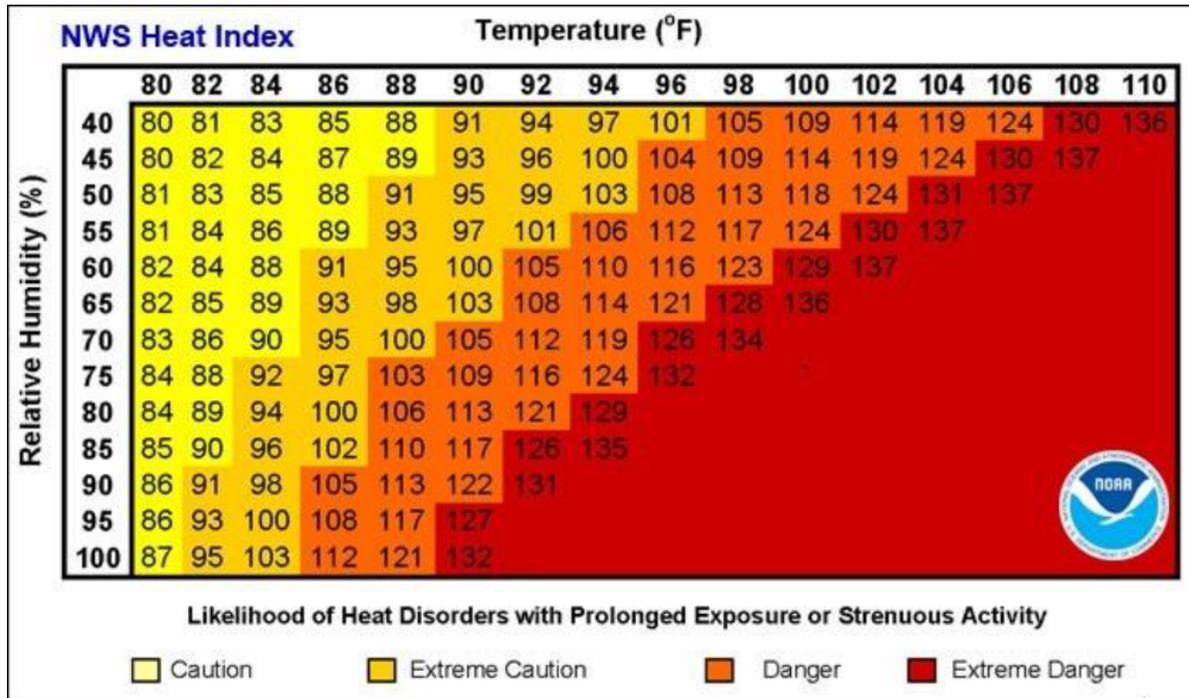 | | | | |
    |---|---|---|---|
    | ☐ Younger than 12 | ☐ 12-18 | ☐ 19-24 | ☐ 25-34 |
    | ☐ 35-44 | ☐ 45-54 | ☐ 55-64 | ☐ 65+ |

Thank you!

For District staff only:

Date: _____ Transit Stop ID: _____

Last Page of Heat Survey

National Weather Service Heat Index and Relative Humidity

At a certain percentage, humidity can influence human thermal comfort. In the summer, relative humidity (RH) affects how one sweats. Since the moisture in the air is so high, one's sweat cannot evaporate. RH has the potential to severely exacerbate how much stress the human body is under. However, according to the National Weather Service's Heat Index, RH levels only have a strong impact on thermal comfort when they are above 40%. In the Sacramento region, the relative humidity is usually below 50% during the summer. Due to the lower humidity, MRT and SW radiation are more influential for thermal discomfort than humidity.

Temp. (F)	Humidity Range	Heat Index Range (F)	Possible Heat Disorder
80°	40 – 100%	79 - 85°	Fatigue possible with prolonged exposure & physical activity
85°	40 – 60%	84 – 90°	Fatigue possible with prolonged exposure & physical activity
85°	60 – 100%	90 – 101°	Sunstroke, heat cramps & heat exhaustion possible
90°	40-70%	90 – 105°	Sunstroke, heat cramps & heat exhaustion possible
90°	70 – 100%	105 -121°	Sunstroke, cramps, and heat exhaustion likely, heat stroke possible.
95°	40 – 50%	98 – 105°	Sunstroke, heat cramps & heat exhaustion possible
95°	50 -80%	105 – 133°	Sunstroke, cramps, and heat exhaustion likely, heat stroke possible.
95°	80 – 100%	133°+	Heat stroke highly likely with continued exposure.
100°	40 – 70%	109 – 142°	Sunstroke, cramps, and heat exhaustion likely, heat stroke possible.
100°	70 – 100%	142°+	Heat stroke highly likely with continued exposure.
105°	40 – 50%	121 – 133°	Sunstroke, cramps, and heat exhaustion likely, heat stroke possible.
105°	50 – 100%	133 – 148°+	Heat stroke highly likely with continued exposure.
110°	40 - 100%	135°+	Heat stroke highly likely with continued exposure.

Link to the data sets: Bus Stop Data Summer 2025.xlsx

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