Heat and Sun Exposure Along Active Transport Pedestrian Pathways

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Introduction

- Heat and ultraviolet (UV) exposure are of public concern in Maricopa County. Active transport commuters display have a higher vulnerability when over-exposed to heat and sun on their active commute.[1]
- Providing thermally comfortable routes can make walking and biking more viable and appealing to individuals who are vehicle-reliant as well as those who depend on active transportation modes.[2]
- Skin cancer is the most common cancer in the United States and costs the country $8.1 billion in average annual treatment costs[3]
- Mitigating heat through shade also has a co-benefit of protecting humans from sunburns and skin cancer.
- **Goal:** The primary goal of this study is to assess the thermal and radiative environments along active transport streets with bus stops in Tempe and Phoenix and identify areas of high and low shade.
- Data were collected in locations that are likely to experience a high amount of walkers using bus and light rail, including the Edison East Lake Neighborhood in Phoenix and University Ave in Tempe.
- **Research Objectives:**
  - Calculate average heat stress conditions along the pedestrian routes.
  - Calculate sun protection along the route using UV measurements.
  - Determine the "Degree minutes" of exposure for the give route, using a wet bulb globe temperature (WBGT) threshold of 87.9°F, multiplied by the ridership at a given bus stop.

Methods and Materials

Data Collection: We utilized a mobile weather station (MaRTy) pulled along the walking routes to simultaneously collect air temperature, humidity, wind speed, latitude, longitude, and solar and infrared radiation from the sky and ground. The ~20-minute transects were segmented into three portions throughout the day (morning, midday, afternoon) to simulate a non-motorized work-day commute and lunch. With this information, urban planners can determine how shade can be utilized along a route and at a bus stop to protect pedestrians from heat stress and overexposure to sunlight during peak foot traffic of the day.

We also attached six ultraviolet dosimeters in a 3D setup, similar to the net radiometers, to monitor the amount of erythemal UV radiation (UV_{Ery}).

Figure 1: Scienterra ultraviolet dosimeter

Figure 2 (above): Sky view factor picture from Casio Elixim Fisheye Lens.

Figure 3 (left): Walking along Edison East Lake transect with MaRTy.

Figure 4: Mobile Human-Biometeorological Platform called MaRTy (main instrument used throughout the study).

Methods and Materials (cont.)

- Ridership of selected bus stops (Figure 5) was utilized for the Edison East Lake location to determine Degree minutes of exposure for pedestrians commuting a normal distance and route of about 20 minutes.

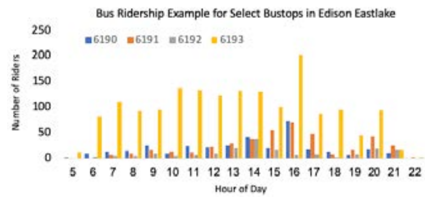

Figure 5: Ridership data average/day at Edison Eastlake bus stops on route.

Results

Figure 6: Transect in Edison East Lake, July 9, 2019, 5-6 pm displaying mean radiant temperature (MRT) results.

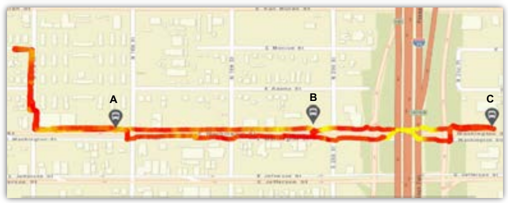

Figure 7: Surface temperature along Edison East Lake transect July 9, 2019, 5-6 pm.

ArcGIS maps created from the data collected at the Edison East Lake transect. The maps were designed with a heat gradient along the transect to represent the fluctuations in mean radiant temperature (Figure 6) or surface temperature (Figure 7) along the route. There is more variability in the gradient in the MRT than surface temperature as more variables are integrated for MRT (includes both solar and infrared radiation).

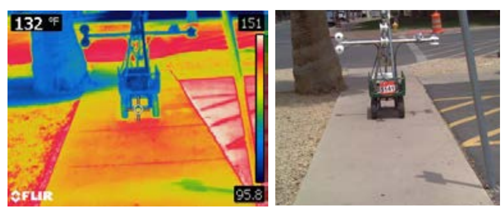

Figure 8: Infrared and visible images taken in Tempe, July 5, 2019, displaying surface temperatures as low at 96°F and up to 151°F. Surface temperatures were also taken with a handheld IRT.

Figure 9: Infrared and visible images taken in Edison East Lake (stop B in Figure 6-7), July 9, 2019, displaying surface temperatures as low at 90°F and up to 141°F.

Results

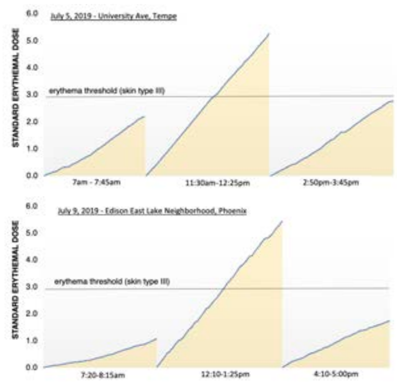

Figure 10: Standard Erythemal Dose (SED) over the course of the segmented transect for July 5 and July 9 morning, midday, and afternoon transects. Horizontal line displays the SED threshold that results in skin reddening / damage for skin type III.

- The Standard Erythemal Dose (or SED) is the result of the UV_{Ery} data collected from the UV dosimeters.
- A quadratic equation is used to calibrate the raw UV data received from the dosimeters initially. Output is in J m^{-2}, where 1 SED=100 J m^{-2}.
- Figure 10 shows the erythema threshold displayed on the graph for skin type III. This threshold signifies the point where one begins to see Erythema, which is the skin beginning of redness and burning.
- Results are similar mid-day in regard increase of the SED for similar durations, yet morning and afternoon SED exposures were lower in Edison Eastlake.
- Next steps include determining the sun protective factor along different routes based on UV information.

Discussion, Conclusions, & Next Steps

- Fine-scale sun and heat data can help urban planners determine where to implement additional shade structures and trees for the health of pedestrians.
- Bus stops and street shading may employ green infrastructure involving ecological processes (e.g., plants, vegetative artwork, bus stop green roofs to attract pollinators; other autotrophs to provide habitats, nutrients, and energy for organisms).
- Collecting heat and UV data can help architects and policy makers can improve upon thermal comfort in heat intensive zones.

Next Steps:

- In addition to UV sun protection factors for each route, the degree minutes of heat exposures will be calculated based on minutes of WBGT > 89.9°F and the ridership at the given bus stops.
- Based on a recent local report,[2] the following standards will be used:

*To achieve a walking route that is safe for **90% of summer afternoon hours**, target shade coverage should be greater than or equal to 20%. This recommendation is based on the necessary fraction of a 20-minute route for the average WBGT to meet the recommended standard of a maximum of 87.9 °F.*

References

[1]Karner, A. (2015). *Journal of Transport & Health*, *2*(4), 451-459.
[2]Shade Design Guidance, Arizona State University and The Nature Conservancy, 2018.
[3]CDC (2018) Skin Cancer Statistics. https://www.cdc.gov/cancer/skin/statistics/index.htm

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