

## **Introduction**

The objective of this project was to utilize input from campus users to decide on high-traffic areas that could benefit from shade infrastructure. From the results of the survey, we went to the site and collected data using thermal imaging cameras as well as an infrared thermometer. With this data as well as the surrounding area, we would evaluate which site would be the most suitable to shade infrastructure, and give a recommendation to what type of infrastructure. From there, future groups could use our data and recommendations for future implementation or grant applications.

## **Methods**

This study used a mixed-methods approach combining thermal measurement and survey data to evaluate heat conditions and user experience across the University of Arizona campus. The goal was to identify high-heat areas, understand how students interact with these environments, and assess potential improvements related to shading and campus design.

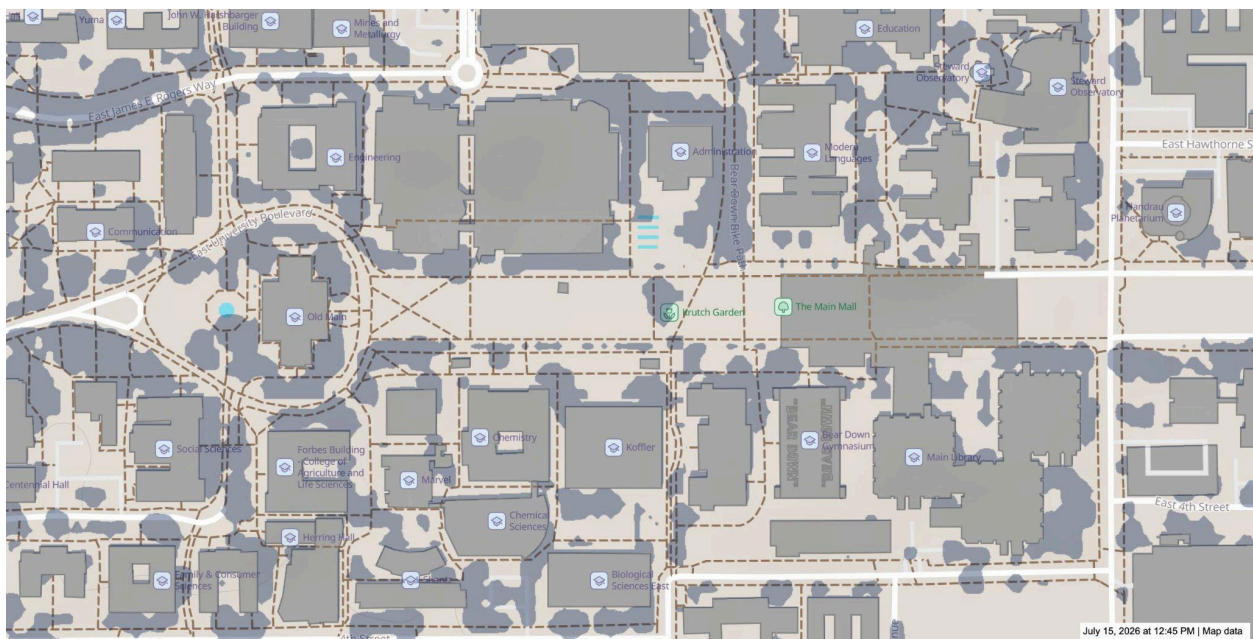
## **Site Selection**

Five campus locations were selected for analysis. These sites were chosen based on two criteria: (1) frequency of student use, focusing on areas with high pedestrian traffic and central campus relevance, and (2) existing shade conditions identified using the Shade Map App, a digital tool that visualizes sun exposure and shade coverage throughout the day. This ensured that selected locations represented a range of thermal conditions and levels of shading, allowing for meaningful comparison across sites.

Below is the link to the website [shademap.app](https://shademap.app) which we used to select based on its visualization of lack of shade in certain areas in conjunction with our knowledge of the campus. This website allows the user to look anywhere on earth and select the month, day, and time of day to view the shadows in that area. As of now, the software only shows shade coming from buildings but soon it will also include trees. The link is below:

[shademap.app](https://shademap.app)

Below is an example of the shade map app website. This shows the amount of shade on campus at 12 PM.



## Thermal Data Collection

Temperature data were collected using two primary tools: a FLIR thermal imaging camera and a handheld infrared thermometer. The FLIR camera was used to capture

thermal images of surfaces and surrounding environments, providing visual representations of heat distribution, while the infrared thermometer was used to record precise surface temperature readings at specific points.

Data collection was conducted across all sites during peak daytime hours between 11:00 AM and 2:00 PM to capture conditions representative of maximum daily heat exposure. Ambient temperatures during collection ranged from approximately 83°F to 88°F. At each location, multiple measurements were taken across different surface types (e.g., pavement, shaded areas, seating, and building-adjacent zones) to capture variation in heat intensity. Thermal images were documented at each site to support visual comparison of heat concentration patterns.

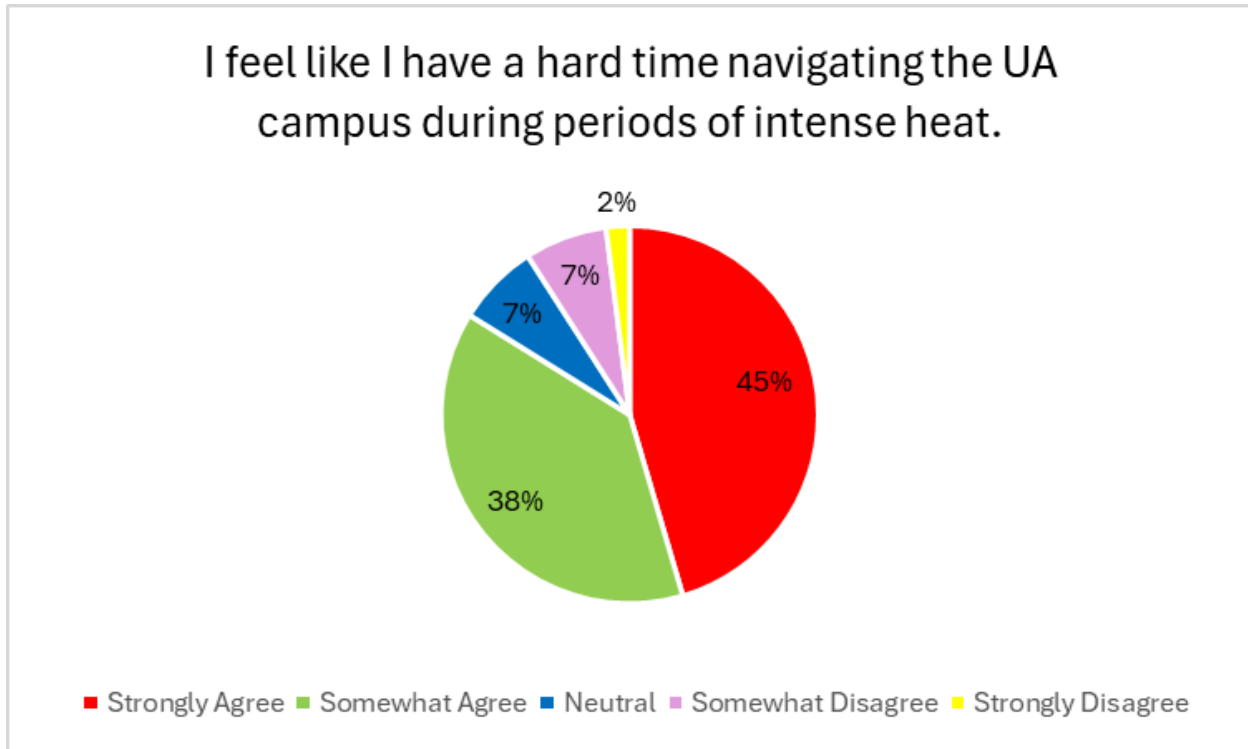
### **Survey Design and Distribution**

A survey was distributed using Qualtrics to gather perception-based data on heat and campus navigation, receiving a total of 84 responses. The survey was shared through multiple channels, including the DIRT newsletter and peer distribution through social networks.

## **Results**

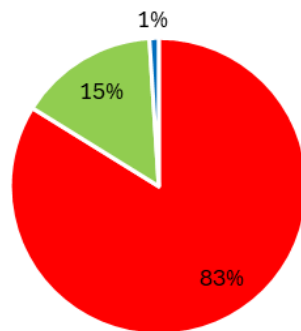
After distributing our survey for 5 weeks, we totalled 84 responses. The survey involved several questions gauging both quantitative and qualitative data with the option for respondents to answer an open-ended question in case the survey did not cover all

areas. The questions are listed below.



Overall, 84% of respondents expressed agreement, indicating that intense heat conditions are widely perceived as uncomfortable.

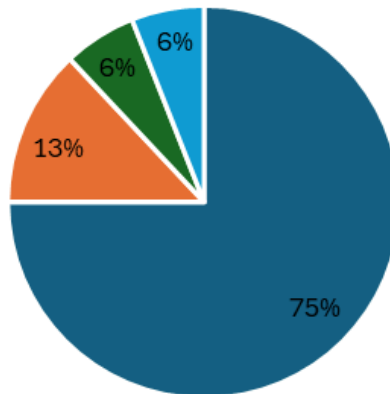
"I believe the UA should increase shade across campus."



■ Strongly Agree ■ Somewhat Agree ■ Neutral

Almost all respondents (99%) indicated agreement, showing that students are in agreement with expanding shading on campus.

How would increased shading best benefit you?



■ Shaded walking paths ■ Shaded green spaces ■ Shaded picnic tables ■ Other

Shaded walking paths are by far the most desired improvement, indicating that mobility

and daily campus movement are the primary concerns. While shaded gathering areas have some value, they are clearly secondary to improving walkability and reducing heat exposure during transit.

Several open-ended questions were included in the survey. These questions included, “How does the heat affect your campus experience?” and “Why did you choose the location and what could be improved about it?” Open-ended responses provide deeper insight into how heat affects daily campus life. Several consistent themes emerged:

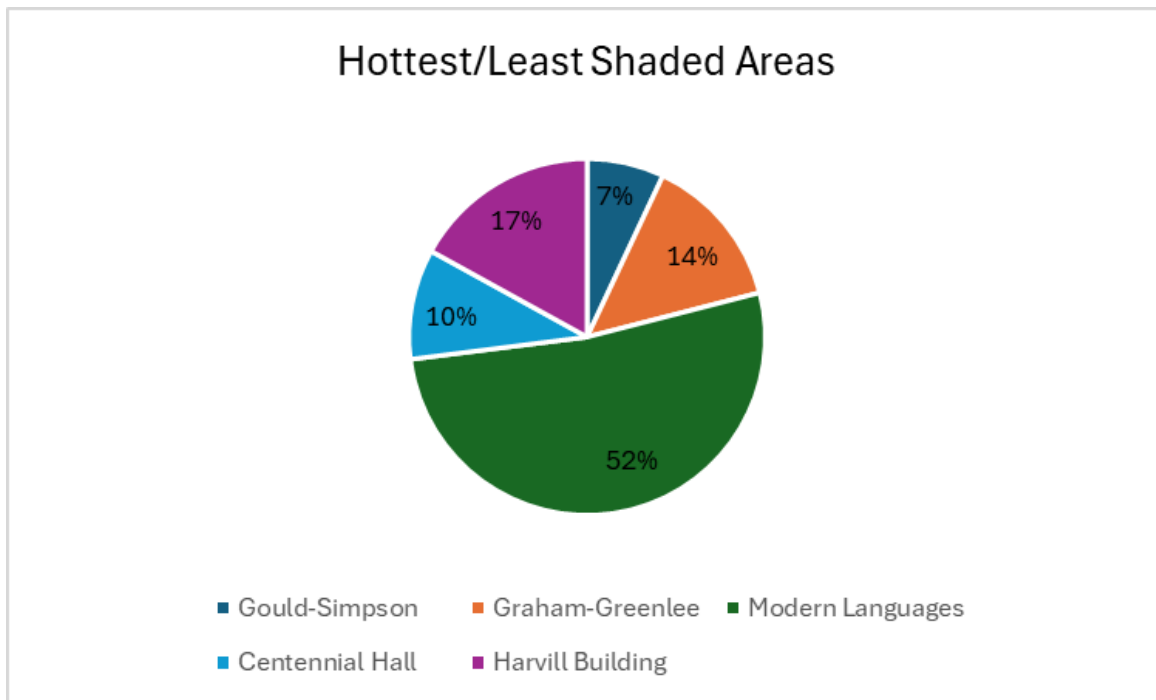
- Reduced mobility: Students frequently reported avoiding walking long distances or limiting movement across campus.
- Behavioral adaptation: Many respondents indicated choosing alternative transportation (Cat Tran, SunLink) or opting for virtual meetings instead of in-person attendance.
- Physical discomfort: Common descriptions included fatigue, sweating, dehydration, and feeling physically drained before arriving at destinations.
- Academic impact: Some students reported decreased engagement, difficulty focusing, and even skipping classes due to heat conditions.
- Environmental concerns: Respondents repeatedly emphasized the lack of shade, tree coverage, and cooling infrastructure, with some identifying heat as a potential health risk.

Qualitative responses reinforce the quantitative findings, showing that heat is not only an inconvenience but also affects behavior, academic participation, and overall campus engagement.

Across all questions, the data shows a consistent pattern:

- Heat is a major barrier to campus navigation
- Students overwhelmingly support more shade
- The highest-impact intervention is shading along walking routes

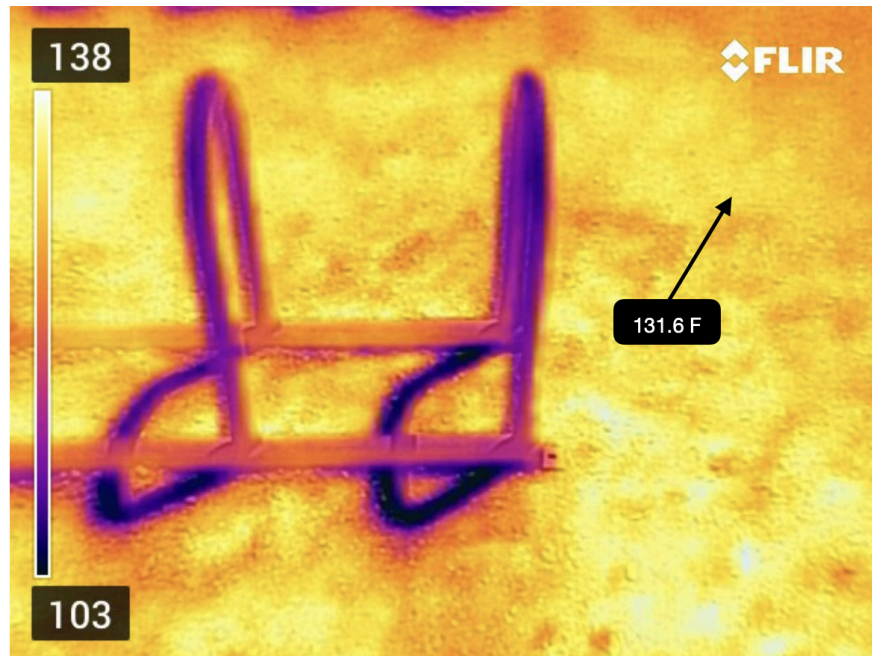
Here are the results from the five selected locations and which area is the hottest or receives the least amount of shade.



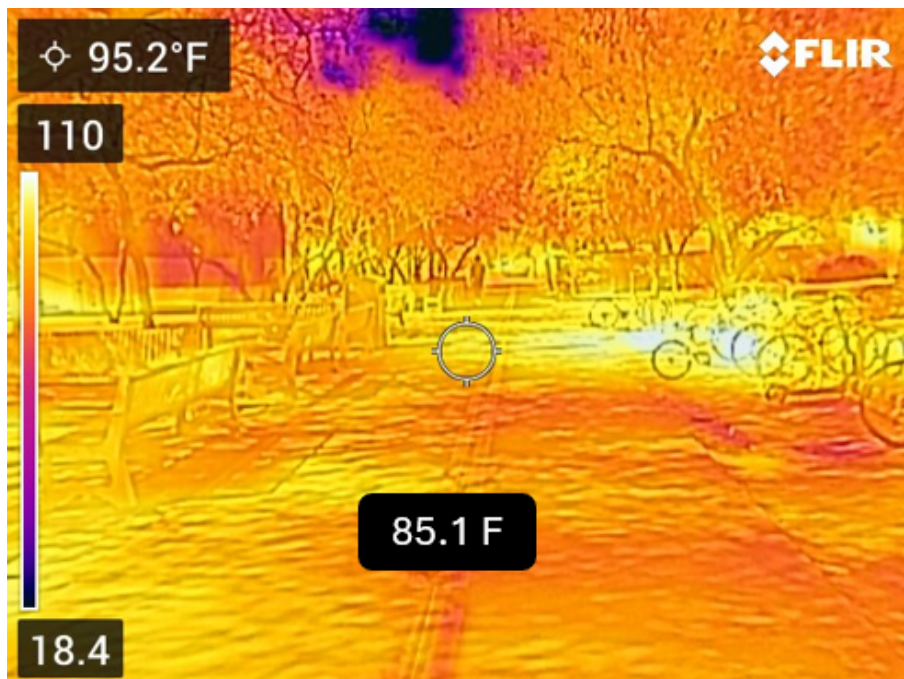
52% of respondents chose the walkway by the Modern Languages Building, demonstrating the need for improved shade at mainly this location.

Here are the results from the thermal camera imaging that was collected at each of the five locations.

### Modern Languages

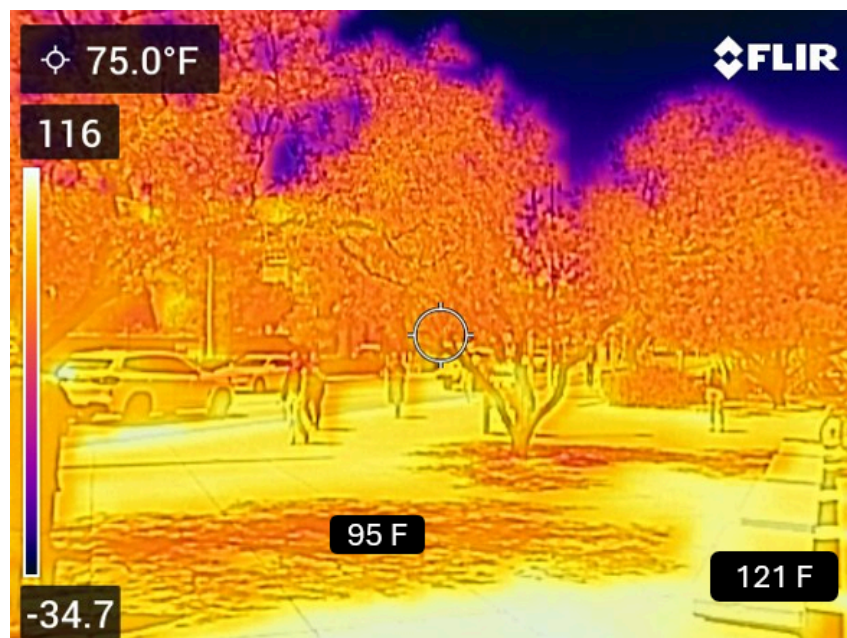
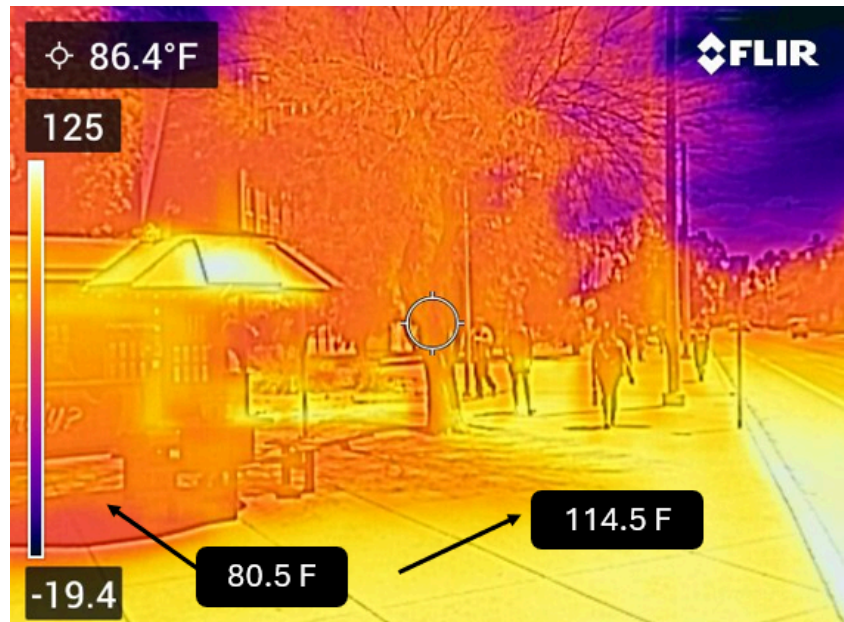


Here, whether pedestrians are walking on the concrete sidewalk or going into the gravel to retrieve a bike, they are being exposed to extreme heat as there is little to no shade in this entire area. A form of shade infrastructure that could be implemented are a species of tree that has a wide canopy to provide maximum shade. These could be planted in the gravel between the bike racks so that they are providing shade above the bike racks as well as over the walkway.

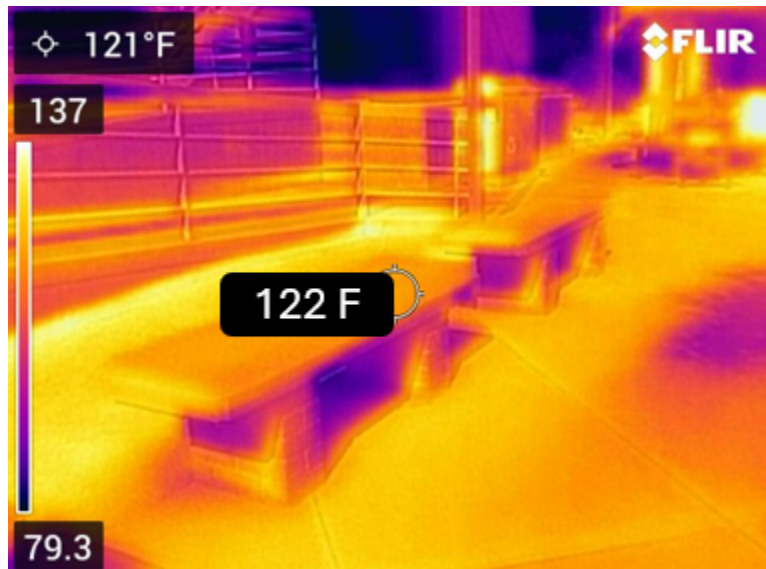
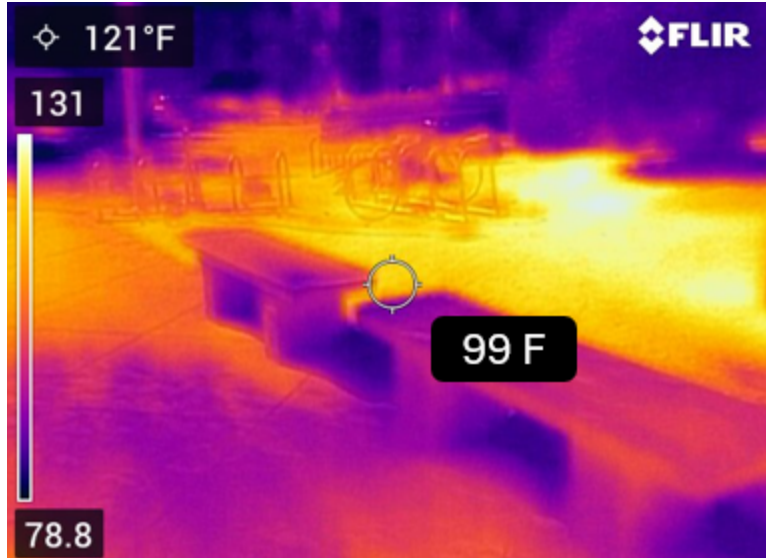


Directly adjacent to the Modern Languages Building there is a shaded walkway. Here we recorded a surface temperature of 85 °F. The unshaded area in the front of the building was recorded at 131.6 °F. This is over a 45 degree difference between the shaded and unshaded area.

## Harvill

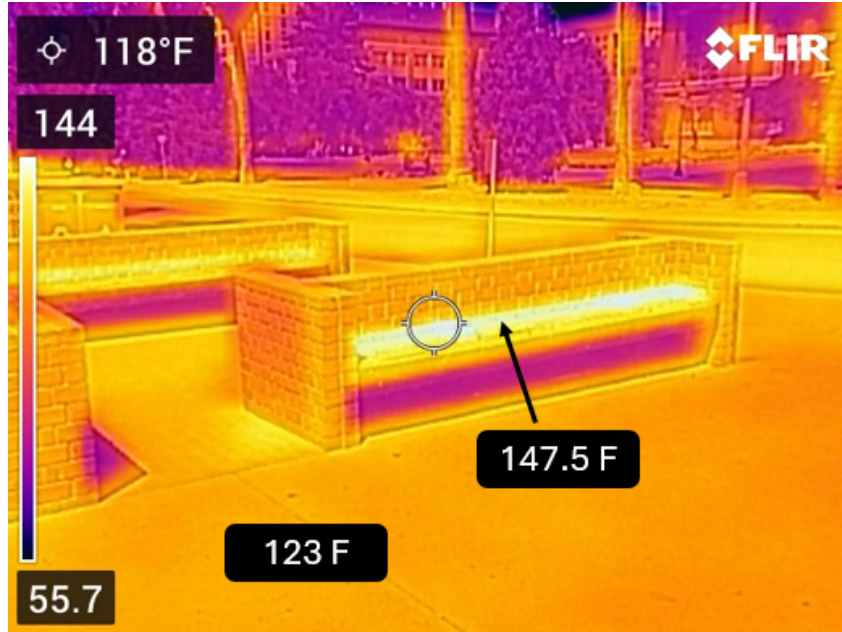


Another trend we noticed was the major disparity between shaded areas and unshaded areas. Here, in front of the Harvill building we can see the area under a shaded picnic table is 80.5 oF and the sunny area nearby is 114.5, a 34 degree difference!



At certain times of day, there is a large disparity between the four benches in front of the Harvill Building. Here, two of the benches covered by shade experienced a surface temperature of 99 degrees, while the unshaded benches experienced a surface temperature of 122 degrees.

### Centennial Hall



Something that we noticed when using FLIR Thermal Imaging Cameras by Centennial Hall was the wooden benches were the hottest temperatures by a significant margin. Here, we can see that the wooden bench was 147.5 °F, much hotter than the surrounding brick and sidewalk. Any efficient solution here could be incorporating umbrellas into the benches, providing a nice shaded area for people to sit.

## Bike Path by Gould Simpson



Another area that could use an improvement is the bike path between Gould-Simpson and Biosciences West. There is already a decent amount of trees and vegetation in certain areas along the bike path, however, the black rubber asphalt the bike path is coated with is much too hot. We observed values of 164.3 on the bike path, alternative surfaces should be looked into. This could be causing major heat effects for users on campus.

A map was created to help visualize the locations that were revealed by the survey as in need of shade infrastructure. It is an interactive map so users can click on specific points and be taken to a popup with some additional information about the location.

[Story Map](#)

## Conclusions

Findings from this study indicate that heat is a significant barrier to campus mobility, comfort, and overall student experience at the University of Arizona. Survey results show that 84% of respondents perceive extreme heat as uncomfortable, while 99% support increasing shade infrastructure, with shaded walking paths identified as the most impactful improvement.

Thermal data supports these perceptions, demonstrating substantial temperature differences between shaded and unshaded areas. Measured surface temperature gaps exceeded 30°F in some locations, and certain materials, such as asphalt and wooden seating, reached temperatures above 140–160°F. These conditions contribute to reduced mobility, behavioral adaptation, and decreased academic engagement.

Based on these results, the most effective intervention is the expansion of shaded pathways in high-traffic areas, particularly near the Modern Languages Building. Additional strategies, including shaded seating and alternative surface materials for high-heat zones such as bike paths, should also be considered.