UNDERSTANDING THE ECOLOGICAL DESIGN BENEFITS AND LIMITATIONS OF ROOFTOP GREEN SPACES TO REDUCE HEAT EXPOSURE FOR VULNERABLE RESIDENTS

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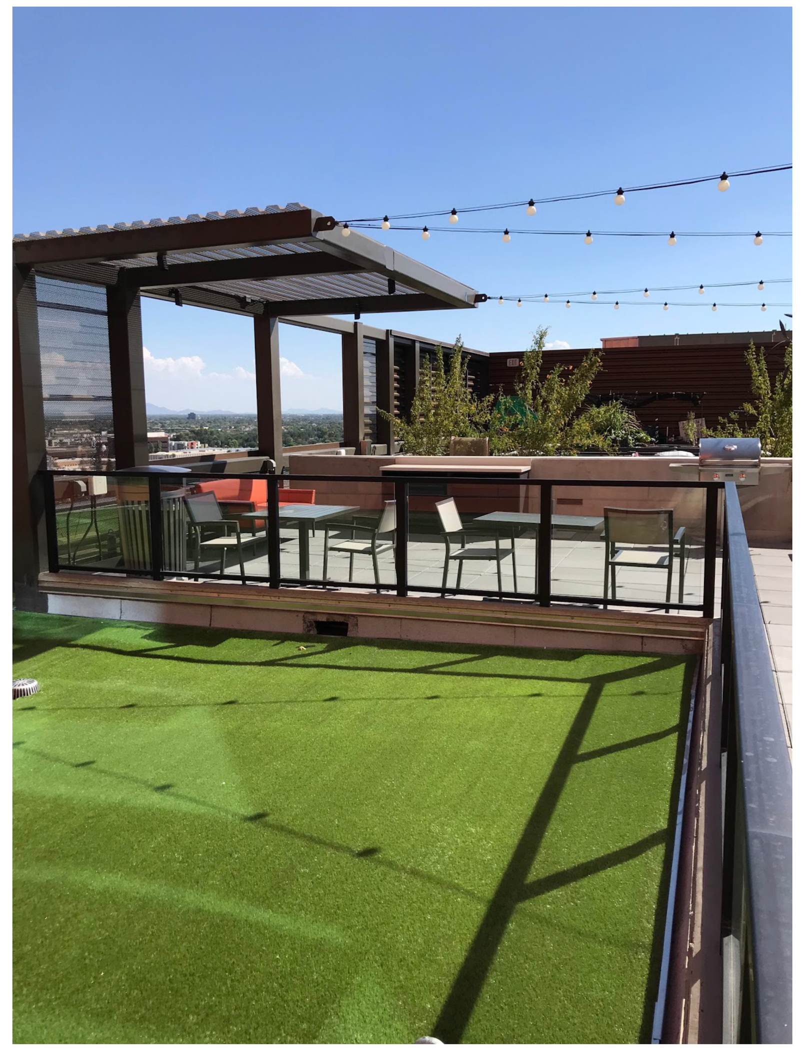
Abstract

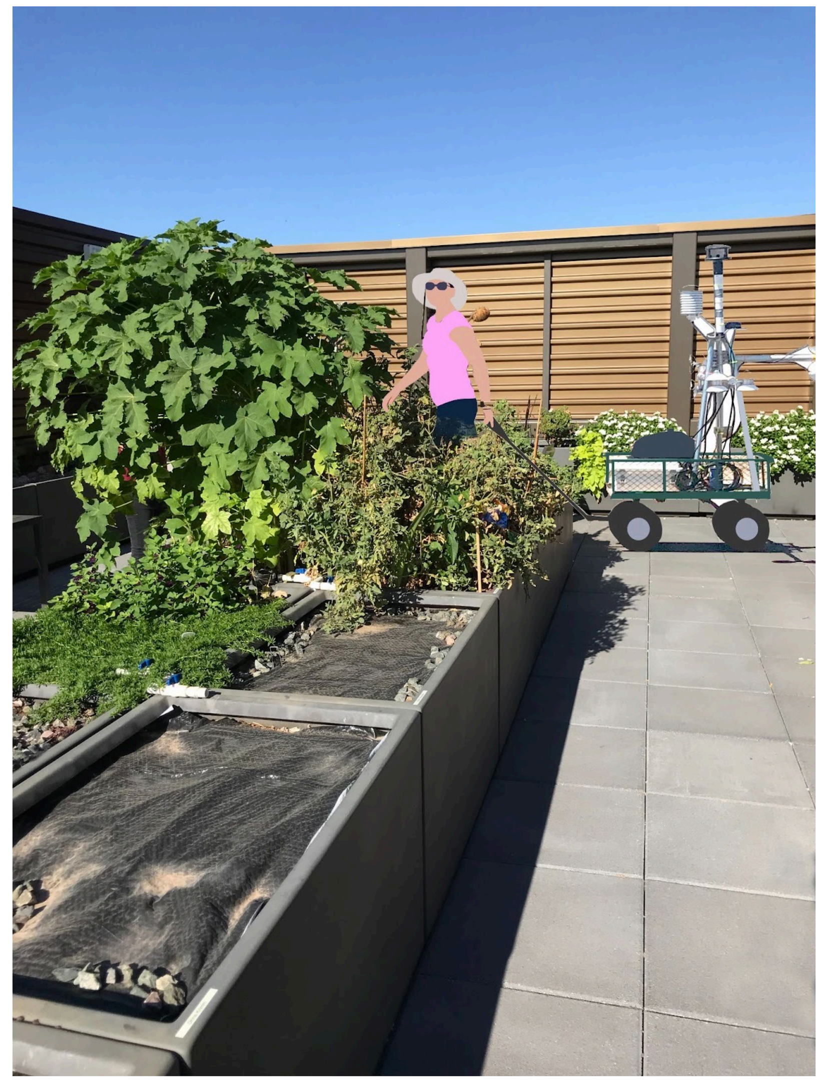
As cities in the Southwest grow and increase in density, designers and property developers are integrating new typologies of vegetated rooftop amenity spaces, which go beyond first-generation green roofs by creating usable outdoor green spaces. Multifamily housing that integrates rooftop green spaces has become common in new urban development in cities like Phoenix and Tempe. Yet, research on these new types of green spaces is limited. These spaces may provide ecosystem service benefits for users such as access to nature and cultural services like community gardens. This study creates an evidenced-based understanding for rooftop green spaces as a nature-based design solution for compact cities. 21st century designers must understand how these novel urban green spaces impact communities' health and well-being. Mirabella at ASU is a compact high-rise residential community adjacent to the ASU Tempe campus that has rooftop green space amenities designed for its resident population of older adults. Older populations have an increased risk of negative health outcomes caused by exposure to high temperatures, but some of the risk may be mitigated by providing access to quality shade and green spaces. This study aims to understand how shade from built structures and plants on the rooftop green space at Mirabella can impact mean radiant temperatures (MRT) and residents' thermal perception. We'll also examine the roles of irrigation and evapotranspiration from plants in reducing MRT, as previous studies have found that shade and evapotranspiration can significantly reduce the MRT experienced by people in green spaces. This study will partner with Mirabella residents to research the benefits and limitations of rooftop community gardens and try to develop design-solution guidance for designers.

Proposed Methods

Both objective and subjective methodologies will be used in this proposed research. Our objective measures include observing relevant meteorological data including air temperature, surface temperatures, humidity, wind speed and calculating mean radiant temperature (MRT). We will use stationary and mobile weather instruments. MaRTy mobile biometeorological cart will take transects to observe different portions of the rooftop amenity spaces of Mirabella at ASU. We will also adapt a method called a "heat walk" (Dzyuban et al., 2022) to pair MaRTy with a resident focus group to evaluate the rooftop spaces. A heat walk is a participatory action research data collection event where a community walks with MaRTy while answering focus group questions to identify and reveal new information about hot spots and cool places in their community - in this case a "heat rooftop walk".



Mirabella at ASU Rooftop Amenity Space



Rendering of MaRTy in Rooftop Amenity Space

#	Sensor	Variable(s)	Range	Accuracy	Height
1	HC2S3 Rotronic HygroClip2 T/RH Probe	Temperature	-50° to +100°C	± 0.1°C	1.5 m
		Humidity	0% to 100% RH	± 0.8% RH	
2	Omega Type T Thermocouple	Temperature	-250° to +350°C	± 0.5°C	1.5 m
3	Gill 2D WindSonic	Wind Speed	0 to 60 ms^{-1}	± 2% @12 ms^{-1}	1.7 m
4	GPS16X Garmin GPS	Lat/Lon	-	less than 3m	1.5 m
5	3 Hukseflux 4-Component Net Radiometers	SW Radiation	0 to 2000 Wm^{-2}	± 10%	1.1 m to 1.3 m
		LW Radiation	0 to 1000 Wm^{-2}	± 10%	

Mobile biometeorological weather station ("MaRTy") and sensor specifications (Middel & Krayenhoff 2019)

Proposed Methods (continued)

We will co-research the Mirabella rooftop experience with a focus group. The focus group will be open to the Mirabella residential community. We will co-create a series of community events with a predetermined walk route to meet MaRTy and walk with MaRTy while asking the focus groups questions and create dialog around perceptions of cooling and other ecosystem benefits from their rooftop green space. The featured event is a community walk on a predetermined route that will expose participants to a variety of microclimate conditions, rooftop landscape design features, tree cover, and other rooftop hardscape infrastructure features. During the heat rooftop walk, participants will complete a novel Rooftop Heat Assessment Guide at designated check points. The Guide asks residents to report their perceptions about segments of the Heat Walk, including shade cover, pleasantness, thermal comfort, and safety.

Expected Outcomes

This work will help inform designers of rooftop green spaces in urban compact neighborhoods, where vulnerable populations are most likely to be exposed to dangerous levels of heat. Mirabella residents will benefit directly from more informed understanding of their rooftop heatscape for future cooling design applications. It has broad application outside of the Sonoran Desert. It will advance the collective knowledge about rooftop green spaces, and the potential cooling benefits and limitations they may have for novel urban spaces. Most importantly, this study advances a proof of concept on innovative methods to examine these novel landscapes. These privatized spaces are increasing in numbers and results could have important implications for ecosystem service benefits from these spaces including who benefits and who is excluded.

References

Dzyuban, Y., Hondula, D. M., Coseo, P. J., & Redman, C. L. (2022). Public transit infrastructure and heat perceptions in hot and dry climates. *International journal of biometeorology*, *66*(2), 345-356.

Middel, A., & Krayenhoff, E. S. (2019). Micrometeorological determinants of pedestrian thermal exposure during record-breaking heat in Tempe, Arizona: Introducing the MaRTy observational platform. *Science of the total environment*, *687*, 137-151.