A Comparison of Yard-Scale Climates in the Phoenix Metro Area

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Central Arizona-Phoenix Long-Term Ecological Research
CAP LTER

Urban Heat Island at the Micro Scale

The urban heat island effect (UHI) is defined as the the difference in temperature between an urban area and the surrounding countryside. Many UHI mitigation scenarios have focused on neighborhood or city units, but few have examined the effects of landscaping on human-scale microclimate and comfort. Because of the small area, slight changes in the yard design can impact how people experience and interact with their environment. This human-environment interaction is an aspect of social and environmental sustainability that is important to consider in a small or multi-scale UHI mitigation scenarios.

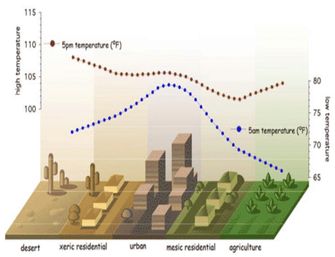


Figure 1: A diagram of the UHI at 5am and 5pm

Research Question: What is the relationship between landscape compositions and yard-scale microclimate effects?

Hypothesis:
a) The maximum air temperature in each yard will be negatively correlated with percent shade.
b) Maximum air temperatures will be lowest in highly shaded, grass-dominated landscapes.

Site Description and Methods

Figure 2: The map of sensor locations in the Phoenix Metro Area

Sensor Installation:
- Starting February, 2013, we hung shielded iButtons (Fig. 3) in each yard.
- The iButtons recorded temperature and relative humidity.

Temperature Analysis:
- I analyzed the June temperature data of 11 houses using R.
- I calculated the mean, minimum, and maximum temperatures according to the average percent canopy cover of each yard.

Figure 3: An iButton in its solar shield.

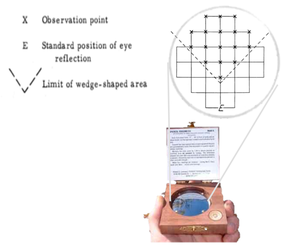


Figure 4: Densiomter with Strickler modifications.

Shade Measurment:
- I used the Strickler densiometer methodology (Fig. 4) to obtain my shade data.
- I split each yard into 9m x 9m plots and took four directional densiometer readings in each plot

Isolating the microclimate:
- Wind speeds ≥1mph cause atmospheric mixing, which masks potential microclimate effects
- I chose 5am and 5pm as the two times at which to analyze the temperature of each yard.
- These times are close to the lowest and highest average wind speed periods (Fig. 5) and also keep their relative positions in the daily cycle throughout the year.

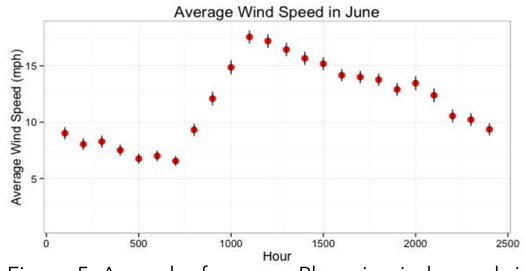
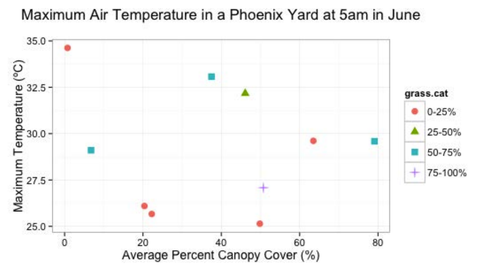


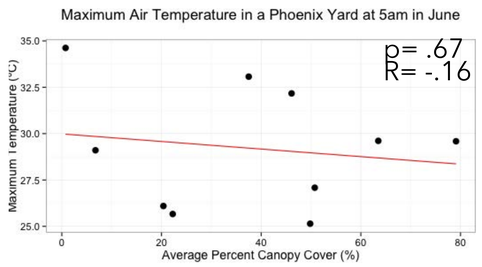
Figure 5: A graph of average Phoenix wind speeds in June

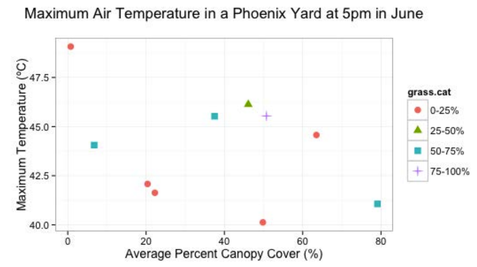
Ground Cover:
- In each yard we estimated the percent of the yard covered by : grass, rock, pavement, dirt
- I calibrated my estimates on several test yards and against a partner to reduce my estimation error.

Figure 6: Examples of some of the yards we analyzed. Many yards had a combination of grass and rock, and all had some pavement in the form of driveways and/or walkways.

Linear Regression Analysis of the Temperature-Shade Relationship







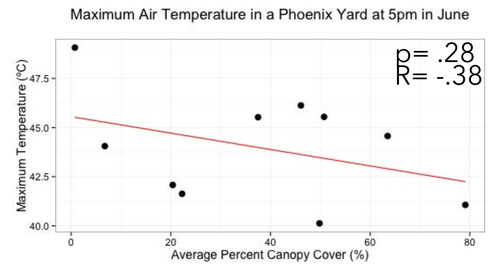


Figure 7a: Graphs of the air temperature in June versus the average percent canopy coverage at periods of low (5am) and high (5pm) wind speeds, with respect to the percentage of grass

Figure 7b: Graphs of the air temperature in June versus the average percent canopy coverage at periods of low (5am) and high (5pm) wind speeds with regression lines shown.

Discussion and Further Research

- I used a linear regression analysis and found that there were no significant relationships between shade and maximum air temperature during either periods of low or high wind speeds.
- This could suggest that a single yard cannot be isolated climatically to any useful degree, or it could suggest that my sample size was too small for any meaningful relationship to be found.
- The similarity between the low and high wind speed times indicates that there was atmospheric mixing occurring at both times, and as such that studying the yard plus the area around it might provide better information.
- The distribution of the colored grass categories suggests that larger amounts of grass do not necessarily create cooler microclimates, although a more extensive sample is needed to examine the potential relationship.
- To complete my project, I plan to compare my findings to larger and/or controlled experiments and apply sustainability concepts to assess the human impacts of landscape composition and the microclimate.

References: Heat island effect. (2013, August 29); Urban Heat Island Comparison [Web Graphic].; Strickler, G.S. (1959). Use of the densiometer to estimate density of forest canopy on permanent sample plots.PNW Old Series Research Notes, (180), 1-5.