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## Urban Vegetation Mitigates Exposure to Extreme Heat

More people die from extreme heat than all other weather-related phenomena combined [1].

- Extreme heat events, defined as sustained high temperatures exceeding the normal range of temperature variability, occur throughout the world and are projected to become more intense, more frequent, and longer lasting over the next century [2].
- Recent studies, however, show that temperatures vary significantly even within the same urban environment and that vegetation plays an important role in mitigating against warm temperatures in some urban areas while bare soil and impervious surfaces store heat, exacerbating high temperatures in other metropolitan areas.

This preliminary study examines human vulnerability to extreme heat in metropolitan Phoenix by quantifying local surface temperature, neighborhood vegetation, and personal experience with heat stress.

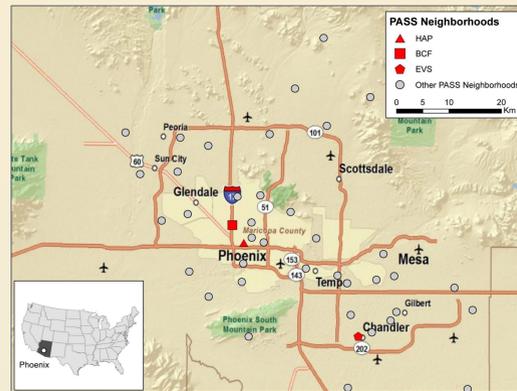
### Research Objectives:

- To explore the spatial distribution of extreme heat throughout diverse neighborhoods in metropolitan Phoenix;
- To assess the spatial relationships between urban land cover, exposure to extreme heat, and heat-related illness.

## Calculating Exposure to Threshold Temperatures

### Study Area

Located in the Sonoran Desert, the Phoenix metropolitan area is ideal for studying human vulnerability to high temperatures. It has a naturally warm climate and over the past 50 years of population growth, the average temperature has increased by more than 3 C.



Metropolitan Phoenix, Arizona

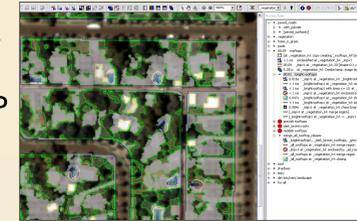
### Methods

#### Weather Research and Forecast (WRF)

This study utilized the WRF mesoscale climate model to simulate local surface temperature for a 2005 four-day heat wave (July 15-19) at a spatial resolution of 1 km.

#### Object-Based Image Analysis (OBIA)

A remote sensing technique which classifies land cover based on objects was used to quantify vegetation. Analyses used NAIP 2007 imagery at a spatial resolution of 1-meter.



#### Phoenix Area Social Survey (PASS)

808 local residents were interviewed across 40 neighborhoods to study experience with climate change. This study examines self-reported illness associated with heat stress.

### Data

#### Census Block Group (2000)

Neighborhood	Socioeconomic Variables			
	Ethnicity	Pop sqmi	HH Inc	Med Age
BCF	Latino	22,489	25,785	22.5
EVS	Mixed	4,441	52,308	33.1
HAP	Anglo	4,088	77,404	37.7

#### Climate Characteristics (WRF)

Neighborhood	Temperature (C)		
	Mean T	Mean H	Mean L
BCF	39.5	46.7	32.1
EVS	37.7	45.2	30.4
HAP	35.9	43.6	28.8

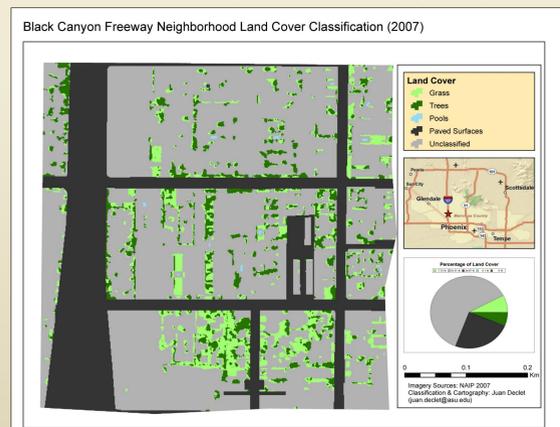
Note: Temperature data reflect a 4-day heat wave

#### Vegetation and Human Health

Neighborhood	Percent Vegetation and Illness		
	OBIA		PASS
	Grass	Trees	HH Illness
BCF	7.7	5.9	45
EVS	17.9	5.6	15
HAP	21.1	18.9	33

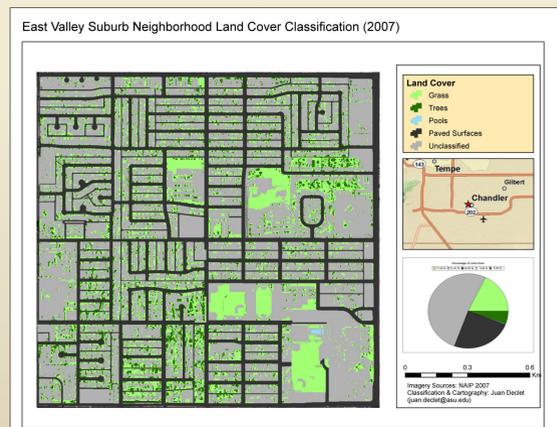
## OBIA Land Cover Classification of Vegetation Correlates with Exposure to Extreme Heat

### Black Canyon Freeway (BCF)



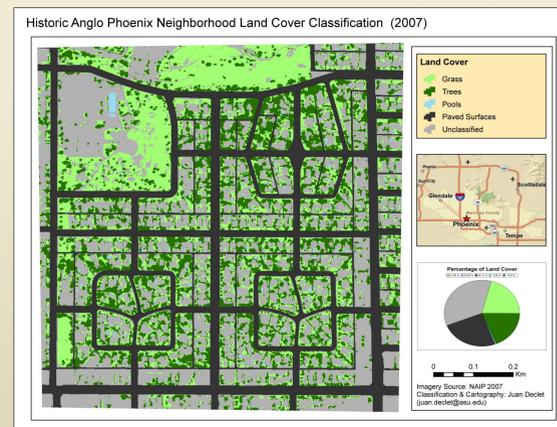
- BCF is located in Phoenix's urban core, and generally speaking, is predominantly Latino, low income, densely populated, and young;
- This industrial neighborhood has sparse vegetation (only 13 percent of land cover) and high temperatures. Almost half (45 percent) of respondents reported an experience with heat stress in the household for the summer of 2005.

### East Valley Suburb (EVS)



- EVS is a typical suburban neighborhood in many ways: mixed ethnicity, medium income, average population density, and middle age;
- EVS has a moderate amount of vegetation (23.5 percent of land cover), and is exposed to moderately warm temperatures. Survey respondents, however, reported a low level of heat-related illnesses (15 percent) during the 2005 summer.

### Historic Anglo Phoenix (HAP)



- An historic urban neighborhood, HAP is a predominately Anglo, upper income neighborhood with a lower population density, and older residents;
- Old-growth mature vegetation accounts for the 40 percent of the land cover classified as vegetation. HAP has cooler temperatures; however, 33 percent of survey respondents reported a 2005 heat-related illness.

## Conclusions

### Research Observations

- There are significant differences in exposure to extreme heat throughout the study area;
- Vegetation (in the form of trees and grass) helps mediate exposure to elevated temperatures among study sites;
- Socio and ecological factors are highly correlated with human vulnerability to heat stress.

### Implications on the Literature

- OBIA land cover classification provides high-resolution data on the urban structure, and illustrates intra-urban variation in land covers;
- Mixed method analysis provides a method for integrating data on physical systems (e.g., temperature) with human experience.

### Future Research

- Classify additional urban land covers (e.g., rooftops, impervious surfaces, buildings);
- Explore adaptation and mitigation initiatives designed to reduce human vulnerability to a changing physical climate.

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### References

- [1] (CDC) Centers for Disease Control and Prevention (2005) Heat-Related Mortality – Arizona, 1993-2002 and United States, 1979-2002. *Morbidity & Mortality Weekly Report* 54(25):628-630.
- [2] Meehl GA & Tebaldi C (2005) More Intense, More Frequent, and Longer Lasting Heat Waves in the 21<sup>st</sup> Century. *Science* 305:994-997.