**Phoenix Climate**

*Employing NASA Earth Observations to Conduct Site Suitability Analyses on Tree Planting Initiatives in Phoenix, AZ*

**Project Team**

***Project Team:***

Alison Bautista (Project Lead)

Haley Stuckmeyer

Gloria Liu

Ben Schafermeyer

***Advisors & Mentors:***

Lance Watkins (Arizona State University)

Dr. David Hondula (Arizona State University, City of Phoenix)

***Team Contact:*** Alison Bautista, Alisonbautista46@gmail.com

***Partner Contact:*** Dr. David Hondula, david.hondula@phoenix.gov

**Project Overview**

***Project Synopsis:***

The City of Phoenix plans to launch a Residential Tree Planting Program with American Rescue Plan Act (ARPA) funds to reduce Phoenix’s urban heat within its built environment. The Phoenix Climate team employed NASA Earth observations to conduct site suitability analysis to identify residential areas that inequitably lack trees, making them more vulnerable to heat-related illnesses and morbidity. An interactive dashboard was created to aid in the city’s literacy efforts on urban heat islands, recommend residential areas to be recruited for the ARPA tree planting program, and encourage homeowners to take advantage of the residential tree planting program.

***Abstract:***

Phoenix, Arizona is the hottest city in the United States, with daytime summer temperatures consistently reaching upwards of 100°F. As these daytime temperatures continue to climb, heat-related illnesses and morbidity also increase. The City of Phoenix hopes to secure funding to implement the American Rescue Plan Act (ARPA) residential tree equity accelerator program. This funding will be used for targeted investments in underserved neighborhoods to increase tree canopy cover, engaging 5,000 households across selected neighborhoods. By partnering with the City of Phoenix, the Arizona Office of Heat Mitigation, and Arizona State University’s Urban Climate Research Center, our team identified residential neighborhoods, block groups within qualified census tracts, and parcels to be prioritized in the ARPA program. We conducted an analysis using NASA Earth observations, movement and heat exposure data, sociodemographic data, and tree canopy data. For Earth observations, we acquired daytime land surface temperature from the Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) and land cover classification from the United States Geological Survey (USGS) National Land Cover Database (NLCD). The project will support the prioritization of city resources and tree plantings based on community vulnerability, as well as help initiate public engagement efforts and literacy with an interactive dashboard and GIS layers that contribute to the city’s property information portal.

***Key Terms:***

urban heat, environmental justice, LST, tree equity

***National Application Areas Addressed:*** Climate, Urban Development

***Study Location:*** Phoenix, AZ

***Study Period:*** 2015 – 2019

***Community Concerns:***

* The disparities in shade cover between Phoenix neighborhoods means that certain communities are at a distinct disadvantage to respond to heat-related health risks. Long-term maintenance of trees and other cooling infrastructures ensure that communities gain long-term benefits.
* A lack of public engagement efforts means that communities may be unaware of heat-related risks and the programs the city is implementing to combat urban heat.
* Current plans to address shade inequity are focused on larger city streets without a standardized selection criterion, and the shade inequity in other areas is not yet being addressed.

***Project Objectives:***

* Map shade and heat inequity on the neighborhood scale for the City of Phoenix
* Form a heat vulnerability index based on information provided by the Tree Equity Index, the Arizona Department of Health Services, and the Urban Climate Research Center at Arizona State University (ASU)
* Identify land parcels within highlighted block groups suitable for inclusion in the ARPA residential tree planting program
* Write a methodology to identify future land parcels and corridors to be included in both the Cool Corridors Initiative and ARPA tree planting program
* Create a Story Map focused on community education and engagement regarding shade equity

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Phoenix, Office of Heat Response and Mitigation** | Dr. David Hondula, Director | End User | Yes |
| **City of Phoenix, Office of Sustainability** | Mark Hartman, Chief Sustainability Officer | End User | Yes |
| **City of Phoenix, Streets Department** | Erik Wilson, Horticulturist | End User | Yes |
| **Arizona State University, Urban Climate Research Center** | Dr. David Sailor, Director | Collaborator | No |

***Decision-Making Practices & Policies:***

Currently, the City of Phoenix uses some remote sensing data for the Cool Corridors Initiative and has used NASA Earth observations in the past for other urban heat related policy decisions. For Cool Corridor prioritization, the city takes into account neighborhood vulnerability and transit dependency from the most recent 5-year American Community Survey, pedestrian use, shade coverage, and remote sensing temperature data provided by ASU. With these variables, priority streets within each council district are identified and undergo assessment of community engagement and infrastructure conflicts. These proposed locations are constrained to city-managed land on major arterial roads. The city hopes to secure funding for the ARPA residential tree planting program to help further mitigate urban heat throughout residential areas, utilizing similar methodologies to the Cool Corridors Initiative.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | LST | Land Surface Temperature (LST) served as a proxy for urban heat. |
| **Landsat 8 TIRS** | LST | Land Surface Temperature (LST) served as a proxy for urban heat. |

***Ancillary Datasets:***

* US Geological Survey National Land Cover Database (NLCD) – Land cover data for estimating impervious surface cover
* US Geological Survey Phoenix Metro LiDAR (ASU Map and Geospatial Hub) – LiDAR tree point data for performing shadow analysis of residential parcels in Phoenix
* US Census Bureau American Community Survey 2015 to 2019 – Socioeconomic variables for reevaluating heat vulnerability
* Arizona State University, ICARUS: Urban Activity Heat Simulation – Bike and pedestrian simulated travel data and heat exposure
* Valley Metro Open Data, Valley Metro Bus Ridership – Average daily ridership for each bus stop by quarter
* American Forests, Tree Equity Project – Tree canopy percent cover by block group in Phoenix
* Bing Maps Microsoft Building footprints – Mapped buildings used to determine remaining plantable area within parcels
* City of Phoenix City Parcels – City parcels located in Phoenix city limits for parcel analysis
* City of Phoenix Zoning Index – Zoning areas used to filter parcels to include only single-family homes

***Software & Scripting:***

* Google Earth Engine API – NLCD-derived land classification, image processing
* Esri ArcGIS Pro 2.9.2 – Heat vulnerability index visualization across Phoenix, spatial cluster analysis
* Esri ArcGIS Online – StoryMap & Experience Builder creation
* R 4.1.3 – Statistical analysis of demographic variables from US Census
* Python 3.9.7 – Statistical and geospatial analysis
* Kepler.gl – Geospatial visualization

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **ArcGIS Online****Experience Builder with****Proposed****Residential****Project Locations** | Landsat 8 OLILandsat 8 TIRS | The partner will use the online dashboard to explore different aspects of future proposed project locations including heat vulnerability, parcel area, existing tree cover, and demographic variables to aid in decision making.  | N/A |
| **ArcGIS StoryMap** | Landsat 8 OLILandsat 8 TIRS | The partner will use the ArcGIS StoryMap to communicate the need for the ARPA program in Phoenix. This will improve their advocacy efforts to decision makers and funders. | N/A |
| **Ranked List of Block Groups and Parcels for Priority Investment by the ARPA Residential Tree Planting Program** | Landsat 8 OLILandsat 8 TIRS | The analysis of potential future sites will help the partner incorporate EO into the City’s future decisions for additional cooling infrastructure. | I |

***Product Benefit to End User:***

The City of Phoenix Office of Heat Response and Mitigation, as well as other city departments, will use the results from our work to identify block groups and parcels to be prioritized in the ARPA residential tree planting program. In addition to the ranked block groups and parcels we provide, our methodology for our parcel and block group analysis will allow the city to expand to more residential areas that are vulnerable to high heat and suitable for planting. These residential areas found from the analysis are identified according to results from Earth observations, movement and heat exposure data, and sociodemographic variables, allowing the city to focus on areas of shade inequity.

**References**

City of Phoenix. (2022). *Street transportation cool pavement pilot program*. https://www.phoenix.gov/streets/coolpavement

Faragallah, R. N., & Ragheb, R. A. (2022). Evaluation of thermal comfort and urban heat island through cool paving materials using Envi-Met. *Ain Shams Engineering Journal*, *13*(3), Article 101609. https://doi.org/10.1016/j.asej.2021.10.004

Hedquist, B. C., & Brazel, A. J. (2014). Seasonal variability of temperatures and outdoor human comfort in Phoenix, Arizona, U.S.A. *Building and Environment*, *72*, 377–388. https://doi.org/10.1016/j.buildenv.2013.11.018

Zhang, Y., & Turner II, B. (2020). *Land-cover mapping of the central Arizona region based on 2015 National Agriculture Imagery Program (NAIP) imagery* (ver 1) [Data set].Environmental Data Initiative. https://doi.org/10.6073/pasta/e671ed549a55fda3338b177a2ad54487