Modeling Cooling Mitigation Strategies for Model Disadvantaged Communities using the Stanford InVEST Urban Cooling Model

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Introduction

Extreme heat is an escalating global issue driven by climate change, causing higher mortality rates than any other natural disaster and posing serious risks to public health, safety, and quality of life, especially in urban areas with limited vegetation. In Modesto, extreme heat is unevenly distributed. It disproportionately impacts low-income neighborhoods, which often lack tree cover, cooling resources, and access to air conditioning, making heat a critical environmental justice concern. Vulnerable populations, including elders, children, and outdoor workers, face heightened risks of heat-related illness, while both physical and mental health impacts reduce overall community well-being and economic resilience. This project aims to identify the most affected neighborhoods and model equitable mitigation strategies, such as increasing tree canopy coverage and high-albedo surfaces, to reduce heat, improve public health, and strengthen climate resilience.

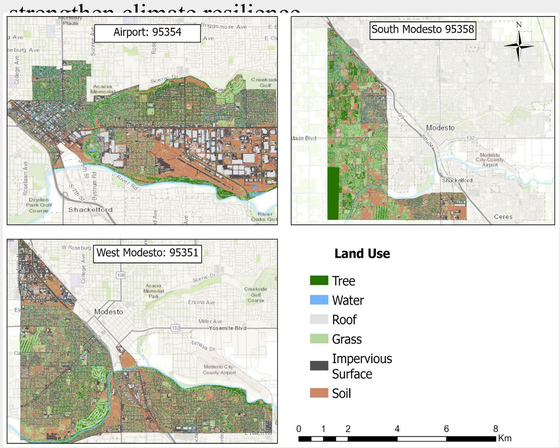

Figure 1. Land Use of Heat Vulnerable Zip Codes in Modesto City

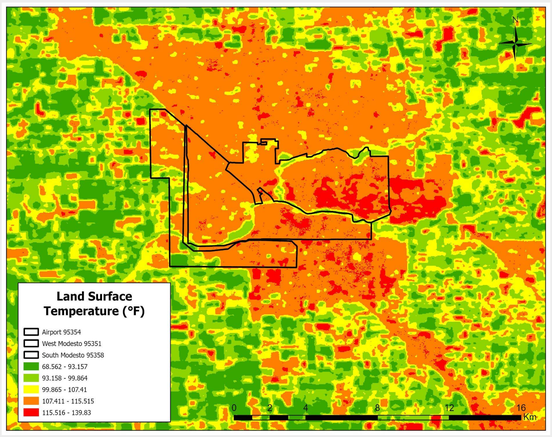

Figure 2. Land Surface Temperature in Modesto City with Areas of Interest, July 2024

Research Questions

1. To what degree do increasing tree canopy coverage and cool roof technology decrease extreme heat in modesto?
2. What percent in increase tree canopy is required to reduce average summer temperatures 1-2°C in Modesto's most heat-vulnerable areas (West Modesto: 95351, South Modesto: 95358, Airport/Downtown: 95354)?
3. How do expanding tree canopy and cool roofs compare in terms of long-term cost efficacy and temperature reduction?

Methods

1. **Data Collection** - This project uses only secondary data from publicly available sources, including peer-reviewed studies, government datasets, institutional reports, and geospatial data from agencies such as Multi-Resolution Land Characteristics Consortium and the U.S. Geological Survey. No primary data collection was conducted.
2. **Software Tools & Instruments** - The primary software used for analysis includes ArcGIS Pro for spatial data visualization, mapping, and geoprocessing; Google Earth Engine for accessing and processing satellite-based environmental data; and the Stanford InVEST Urban Cooling Model for environmental modeling and scenario analysis. No physical instruments or human-subject data were used.
3. **Data Analysis -** Geospatial data was used to examine patterns in land cover, temperature, and urban characteristics across Modesto zip codes, while the InVEST Urban Cooling Model estimated heat mitigation potential. Model results were compared across zip codes and interpreted using existing literature and regulatory frameworks.

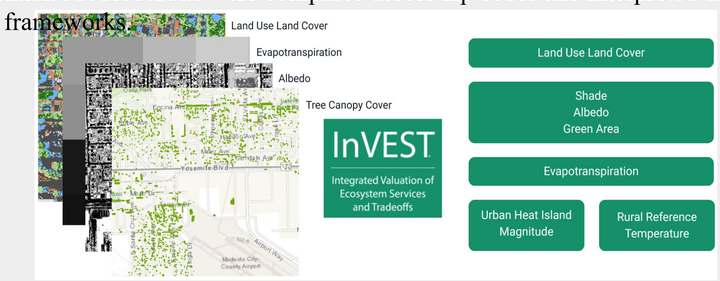

Figure 3. Methodology: InVEST Model

Acknowledgements

Special thanks to Edgar Garibay, Jose Borroel, and Bianca Lopez from Valley Improvement Project for their collaboration over the project. We would also like to thank Jake Dialesandro from Santa Clara University for his guidance and support with our report and geospatial tools.

Results

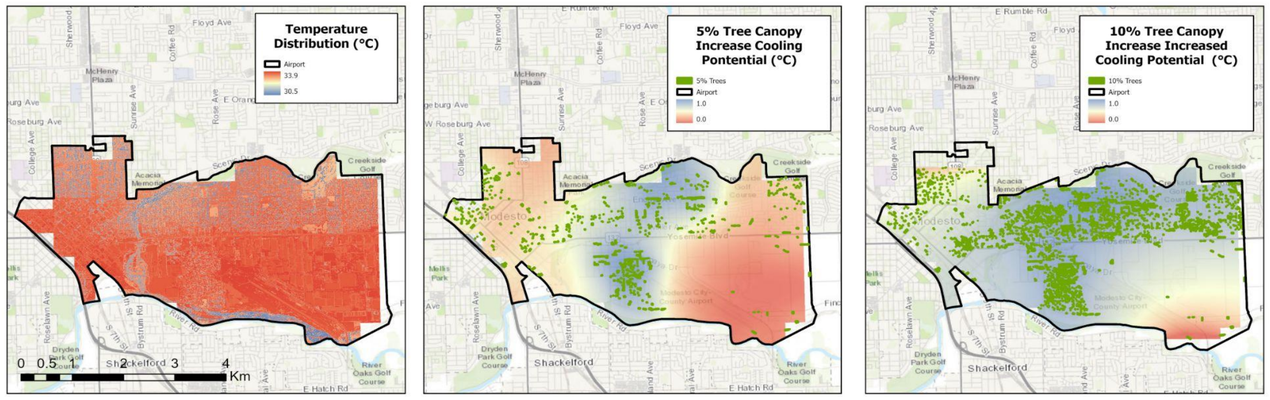

Figure 4. Tree Canopy Increase Scenarios for Airport Neighborhood 95354

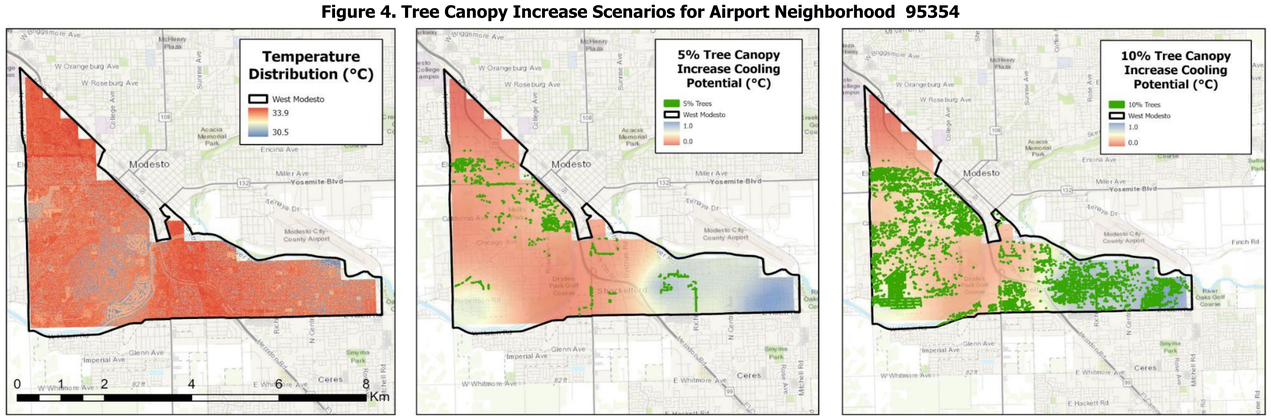

Figure 5. Tree Canopy Increase Scenarios for West Modesto 95351

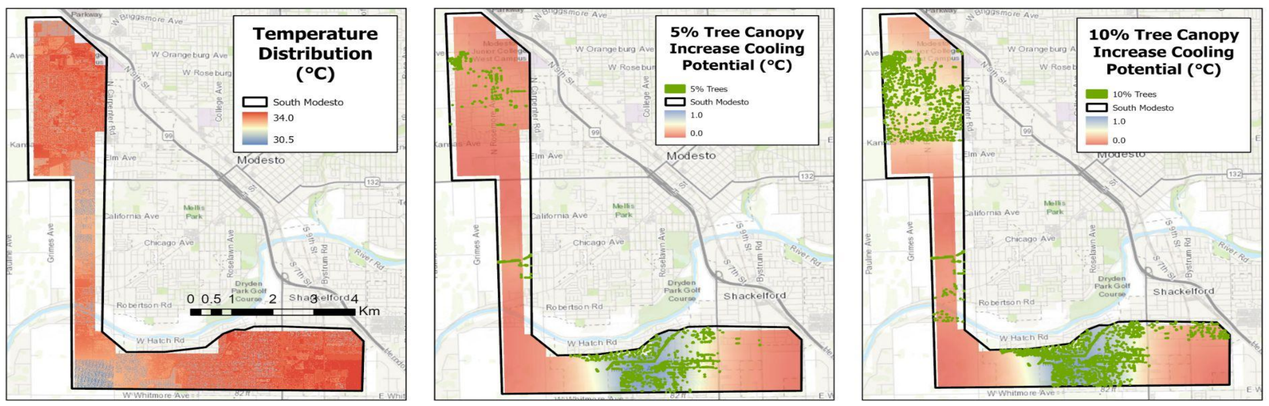

Figure 6. Tree Canopy Increase Scenarios for South Modesto 95358

Conclusions

- We decided to focus solely on increased tree canopy coverage, as we found that it is a productive, cost effective, and long-term heat mitigation practice. After conducting our literature review, we determined that trying to implement cool roof technology in Modesto was not a cost-effect practice for the area.
- Based on our results from the InVEST Cooling Model, we determined that it will take greater than a 10% increase in tree canopy coverage to help reduce average summer temperatures 1-2°C in Modesto's most heat-vulnerable areas.
- Given the maximum cooling potential of increasing tree canopy coverage within the three zip codes, we determined that South Modesto will benefit the most from increased tree canopy.

Neighborhood	Maximum Cooling Potential (° C)	
	5%	10%
Airport	0.045	0.095
West Modesto	0.011	0.099
South Modesto	0.109	0.145

Recommendations

We recommend planting one of the four following tree species: CA Buckeye, Western Redbud, Crepe Myrtle, and California Bay Laurel. Utilizing the research of a past SCU Capstone, we determined these trees would be best as they are California native, require low water use, are good for residential areas, and follow Modesto's ordinance for tree height.