Investigating contributing and mitigating factors of land surface temperatures in the Los Angeles River Watershed

Riley Blasiak[1,4]; Katie Spahr[2,4], PE, PhD; Anneliese Sytsma [3,4]

University at Buffalo, Department of Civil, Structural and Environmental Engineering, [2]Colorado School of Mines, Department of Civil and Environmental Engineering, [3]University of California, Berkeley, College of Environmental Design, [4]Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)

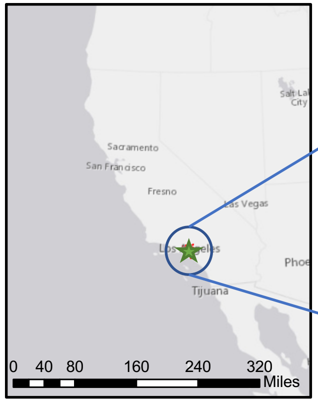
Background

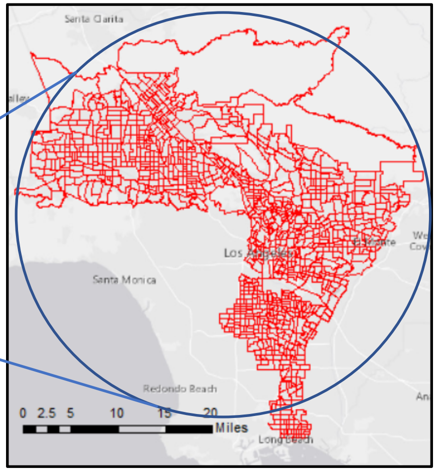
The amount and severity of heat waves are predicted to continue to increase over this century, resulting in higher summer temperatures and lower soil moisture [1]. The increase in extreme heat events has led to higher mortality rates in urban areas around the world: for example, in Berlin, Germany the highest mortality rates occurred within the most densely urbanized sections of the city [2]. Urban heat island (UHI) is the phenomenon that urban areas have higher atmospheric and land surface temperatures than rural areas. These higher temperatures, in turn, increase air conditioning demands and air pollution levels, and modify precipitation patterns [3].

Objectives

This study (1) investigates the relationships between land surface features and land surface temperature (LST), and (2) identifies high priority areas for urban greening within the Los Angeles River (LAR) watershed.

Study Area and Variables





u

- Percent impervious area
- Percent canopy cover
- Percent roof area
- Mean normalized difference vegetative index (NDVI)
- Mean land slope
- Mean stormwater quality
- Percent high risk demographics

Methods

Data acquisition and pre-processing

Data for variables were acquired through the Los Angeles County planning department, California Environmental Data Exchange Network (CEDEN), 2016 American Community Survey, and Landsat 8 imagery processed in Google Earth Engine (GEE)[4]. Variables were aggregated across the LAR subwatersheds.

Regression analysis

Ordinary least squares (OLS) was used to determine the relationships between all the variables and LST. The OLS model originally included all variables: percent impervious, percent canopy cover, and percent roof surfaces (buildings), mean NDVI, and mean land slope. The statistically significant relationships (i.e. $p < 0.01$) were determined and explored with the spatial statistics tools in ArcGIS.

Suitability analysis

A suitability analysis was conducted to prioritize locations for green infrastructure to reduce LST, improve stormwater quality, and benefit high risk demographics. The demographic data included low income households (lower than $54,250 per year[5]), people over the age of 65, and people under the age of five [6]. Thresholds were determined by summarizing the variables for each Census Tract in the LAR and then using the median of the tract values as the cut off value (Table 1). Three screening levels were defined to reduce the number of high priority tracts.

Table 1: Threshold values for each variable with associated screening levels

Variables	Threshold	
LST	>	315.6 K
E. coli	>	3644.1 MPN/100ml
TSS	>	26.34 mg/L
NDVI	<	0.33
Impervious	>	65%
Canopy	<	17%
Parks	<	0.10%
Younger than 5	>	6.10%
Older than 65	>	11.50%
Low income	<	$54,250

Level 1 (LST – TSS)

Level 2 (LST – Canopy)

Level 3 (LST – Low income)

Regression Results

Results of the regression analysis show that NDVI alone accounts for 79% of the variation in LST (*Figure 1*), and adding more variables only marginally improves the explanatory power to 82%. Furthermore, we found that many of the independent variables were related to each other (e.g., NDVI and impervious surfaces), thus, choosing NDVI alone avoids any issues of multicollinearity. Overall, we found that NDVI alone is capable of predicting the spatial distribution of LST, and of identifying locations where UHI phenomenon exists.

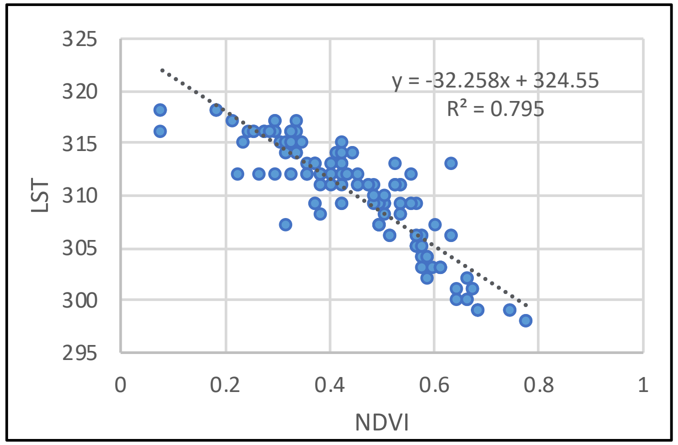


Figure 1: Graph of greenness vs land surface temperature with final regression equation

Suitability Results

Results of the suitability analysis show that of the 1068 total tracts, 215 were identified as level one tracts and 107 as level two tracts. The number of level three tracts, which included the demographic data, physical land characteristics and stormwater quality, was reduced to 57 highest priority tracts. Implementing green infrastructure in these 57 high priority tracts could improve LST, water quality, greenness, and benefit high risk demographics (*Figure 2*).

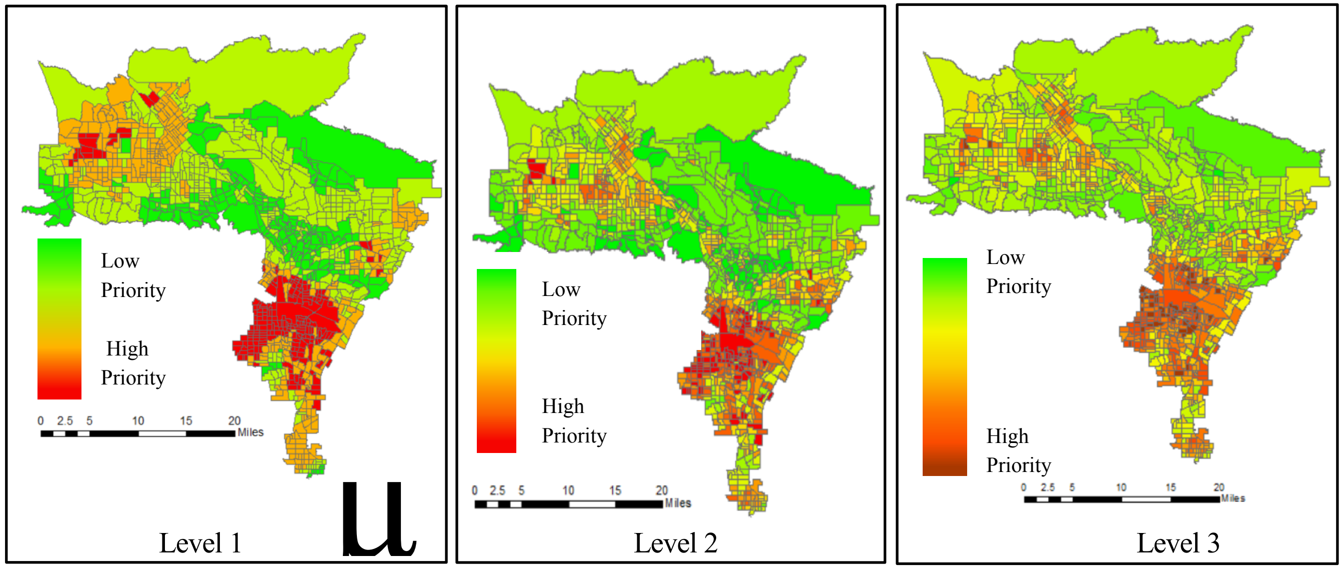


Figure 2: Maps of LAR watershed showing high priority tracts for green infrastructure implementation

Conclusions

This study found that NDVI accounts for 79% of the variation in LST in the LAR watershed. As NDVI (greenness) increases, LST decreases, suggesting that implementing green infrastructure will further reduce LST. We found that 57 tracts should be considered high priority for green infrastructure implementation. Green infrastructure may improve LST as well as stormwater quality, reduce impervious surfaces and vulnerability of populations in these tracts. Future work should collect data to examine how green infrastructure benefits certain tracts and populations in the LAR watershed. Similar studies should be implemented around the US and the world throughout the year to verify the findings outlined above.

Acknowledgements

- Mentor Katie Spahr, PE, PhD
- Mentor Anneliese Sytsma
- PI William Eisenstein, PhD
- Pamela McLeod, PhD Director of Education and Outreach
- Hogue Research Group
- ReNUWIt
- EPA National Priorities: Life Cycle Costs of Water Infrastructure Alternatives (RFP: EPA-G2015-ORD-D1)

Sources

1 NASA. in *Global Climate Change* (2020).

2 Gabriel, K. M. & Endlicher, W. R. Urban and rural mortality rates during heat waves in Berlin and Brandenburg, Germany. *Environmental pollution* **159**, 2044-2050 (2011).

3 Yuan, F. & Bauer, M. E. Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery. *Remote Sensing of environment* **106**, 375-386 (2007).

4 Ermida, S. L., Soares, P., Mantas, V., Göttsche, F.-M. & Trigo, I. F. Google Earth Engine Open-Source Code for Land Surface Temperature Estimation from the Landsat Series. *Remote Sensing* **12**, 1471 (2020).

5 Chiland, E. in *LA Curbed* (2018).

6 CDC. in *Picture of America*.