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# Environmental Justice in Climate Change Adaptation Context: A Case Study in Atlanta, Georgia, Using Local Climate Zones and Sociodemographic Indicators

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► **To cite this version:**

Lily Heidger, François Leconte, Rafael Quirino, Mathieu Petrissans. Environmental Justice in Climate Change Adaptation Context: A Case Study in Atlanta, Georgia, Using Local Climate Zones and Sociodemographic Indicators. American Geophysical Union Fall Meeting, Dec 2021, New Orleans, LA, United States. hal-03519104

**HAL Id: hal-03519104**

**<https://hal.univ-lorraine.fr/hal-03519104>**

Submitted on 10 Jan 2022

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## Introduction

Environmental burdens impact marginalized communities at a greater rate<sup>1</sup>. Urban heat islands provide a great example of this phenomenon.

The **Local Climate Zone (LCZ)** scheme provides 17 classifications for urban areas specified by land cover, vegetation, and building factors<sup>2</sup>. This classification scheme states that particular urban features lead to the development of specific thermal patterns. Some LCZ types favor warmer average temperatures such as LCZs 1-3<sup>1</sup>.

This study aims to further understand how location, specifically LCZs, plays a role in the environmental justice issues in *Atlanta, Georgia*.

## Area of Study

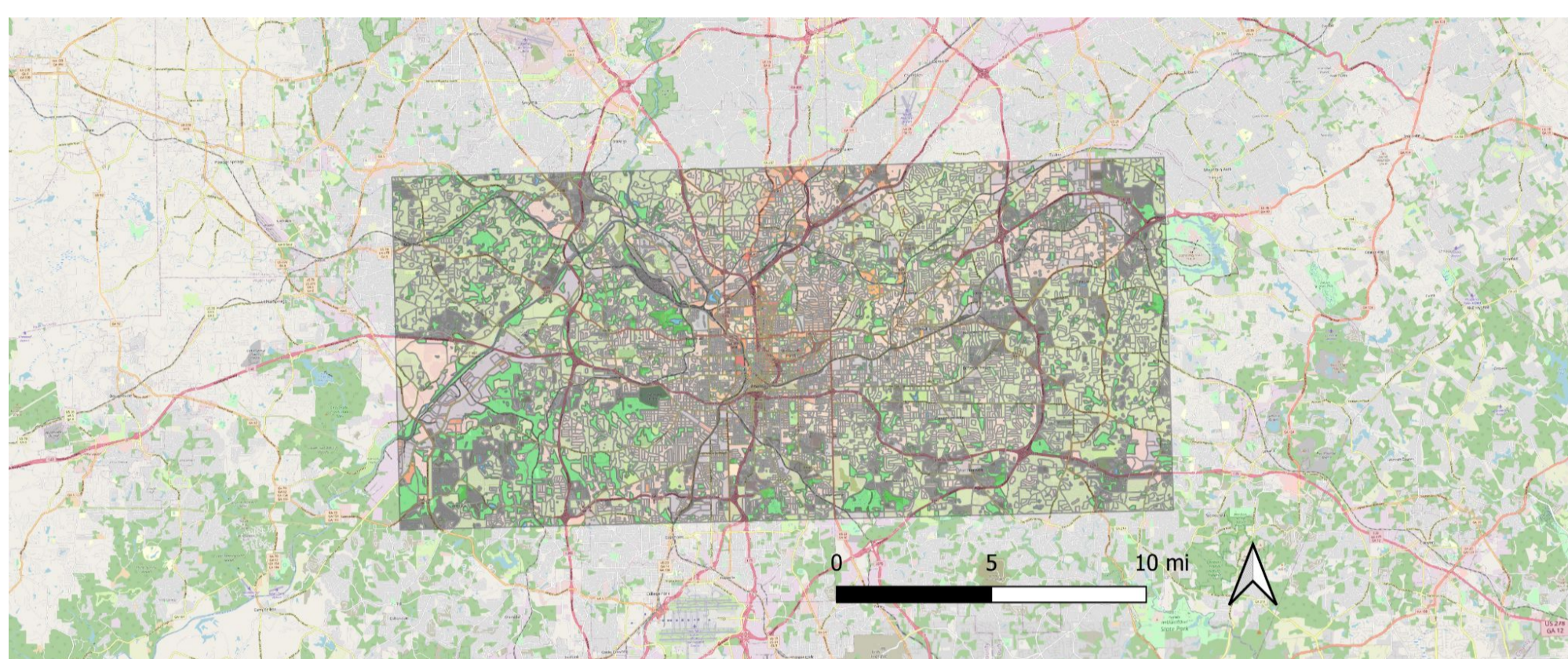


Figure 1. Openstreetmap basemap and area of interest for Atlanta, Georgia.

## Research Questions

What is the relationship between LCZs and 4 factors?

1. LCZs & Percent Minorities
2. LCZs & Percent Low Income
3. LCZs & Percent Less than HS Education
4. LCZs & Tree Equity Score

## Methods

**Geoclimate<sup>3</sup>** is a recently-developed open-source tool used for generating the LCZs of an area. The program uses Openstreetmap data and chosen coordinates to generate a shapefile that classifies each area by LCZ.

**EJScreen** data are provided by the US Environmental Protection Agency's Environmental Justice Screen tool<sup>4</sup>. These sociodemographic data are US Census block data provided in a csv file.

**Tree Equity Score (TES)** data are provided by American Forests from treeequityscore.org<sup>5</sup>. These data originate from US Census block data and Earth Define tree canopy data. The Tree Equity Score is provided for each census block, a number formulated based on tree canopy cover for each area.

All layers have been uploaded to the open source QGIS for analysis. When analyzing the data, the three data layers (LCZ, EJ Screen, and TES) were merged by location. A combined attribute table was produced for further analysis through R. The LCZ layer served as the base layer, to which the other data was then applied.

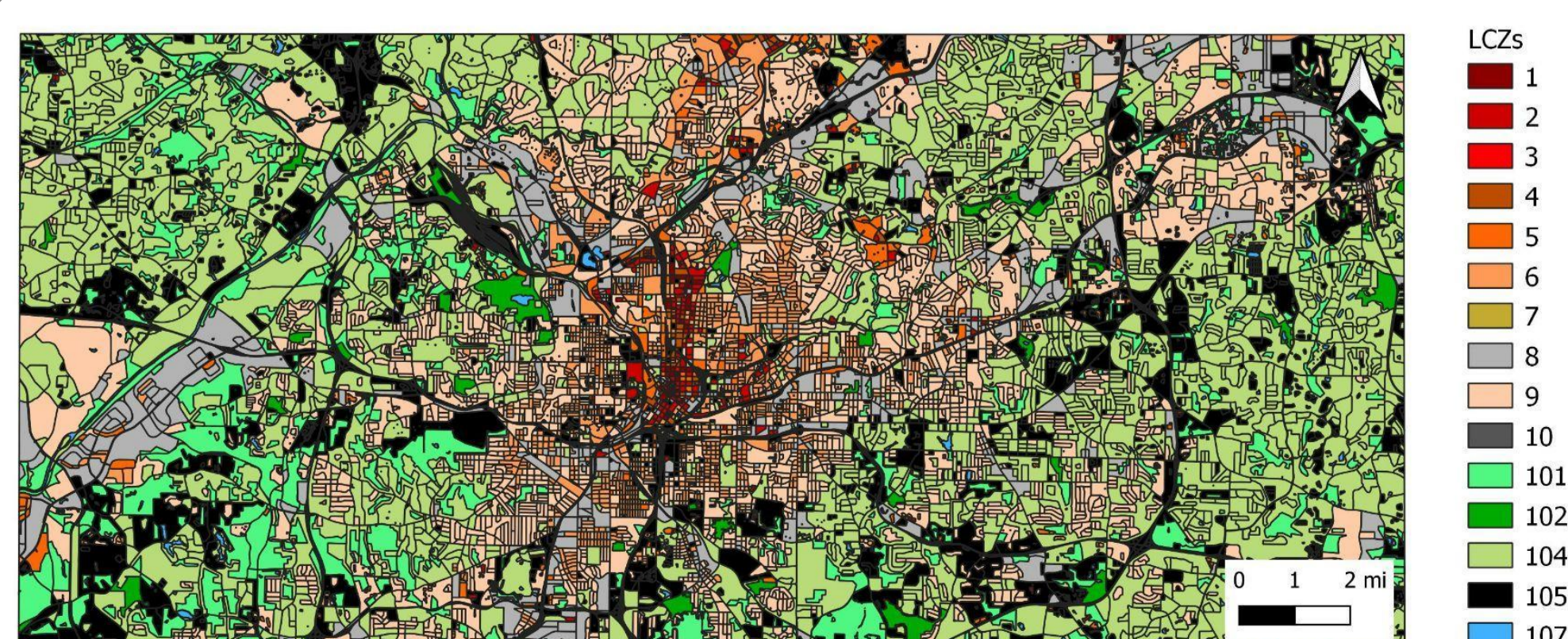
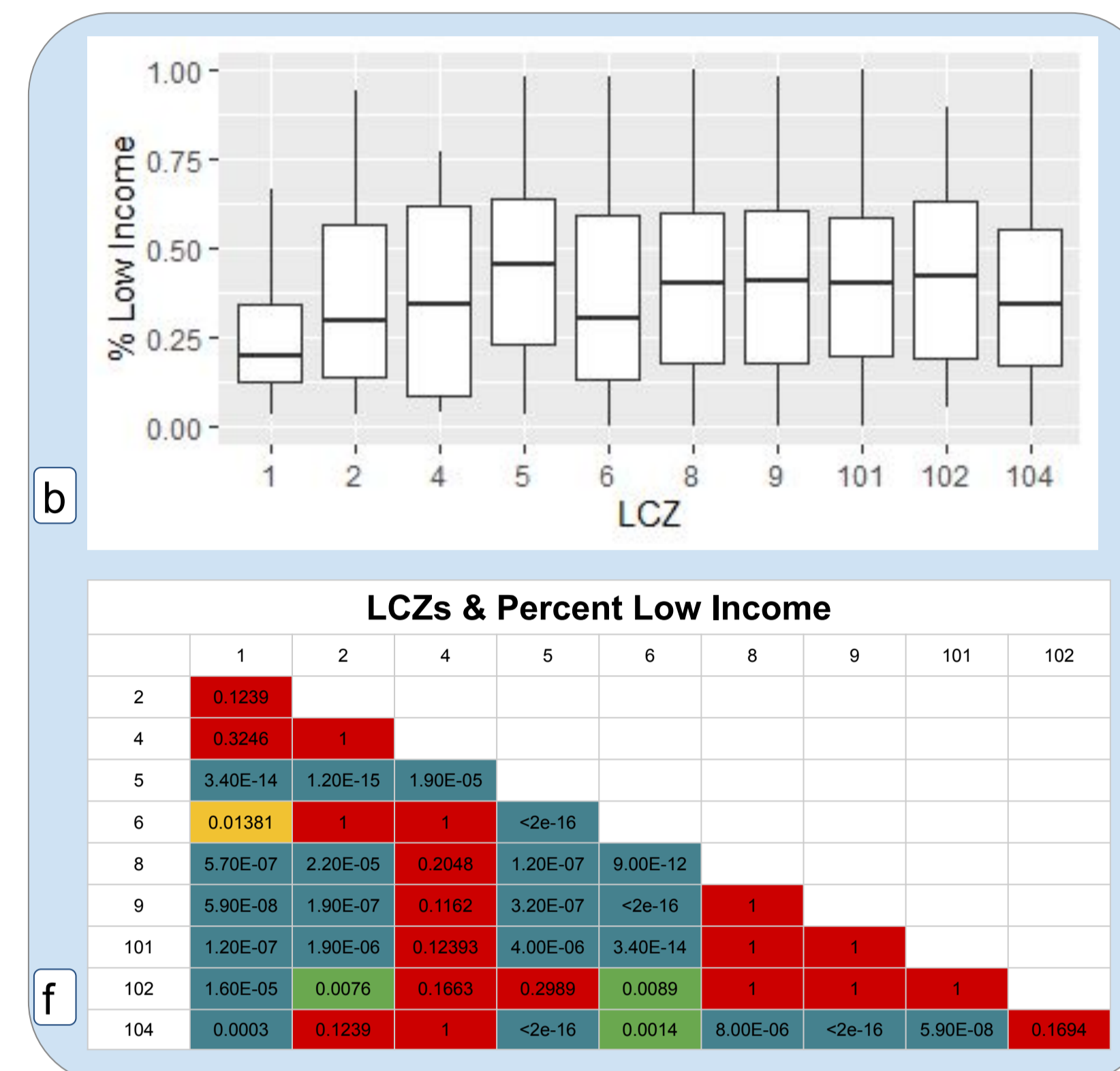
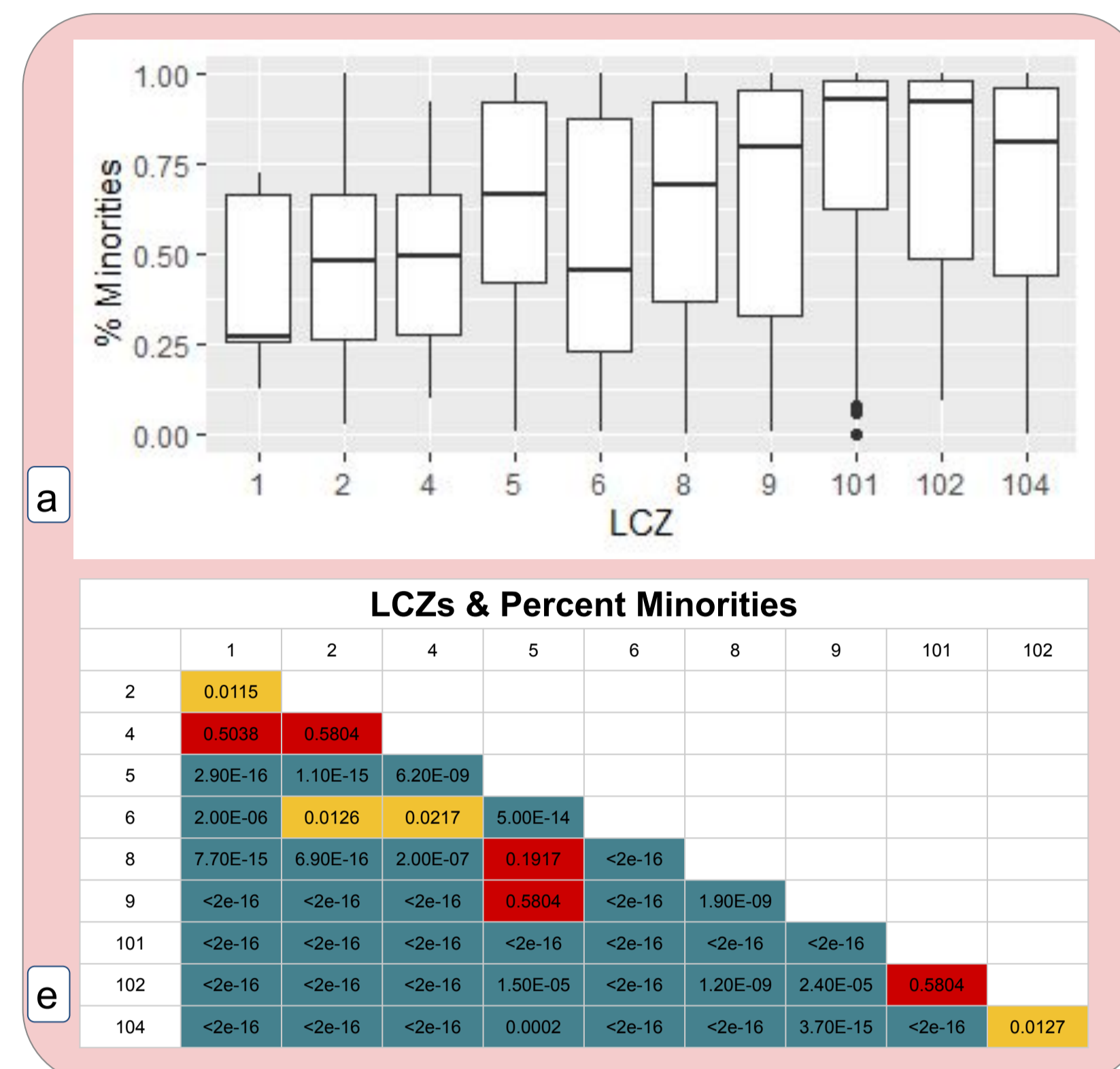


Figure 2: Geoclimate output showing LCZ classifications in the greater Atlanta area.

## Results

A Kruskal-Wallis test was performed, establishing an initial relationship between the four factors and LCZs. The results of the test provided p-values of  $< 2.2E-16$  for all four factors, indicating a significant difference between the distribution of at least two factors.

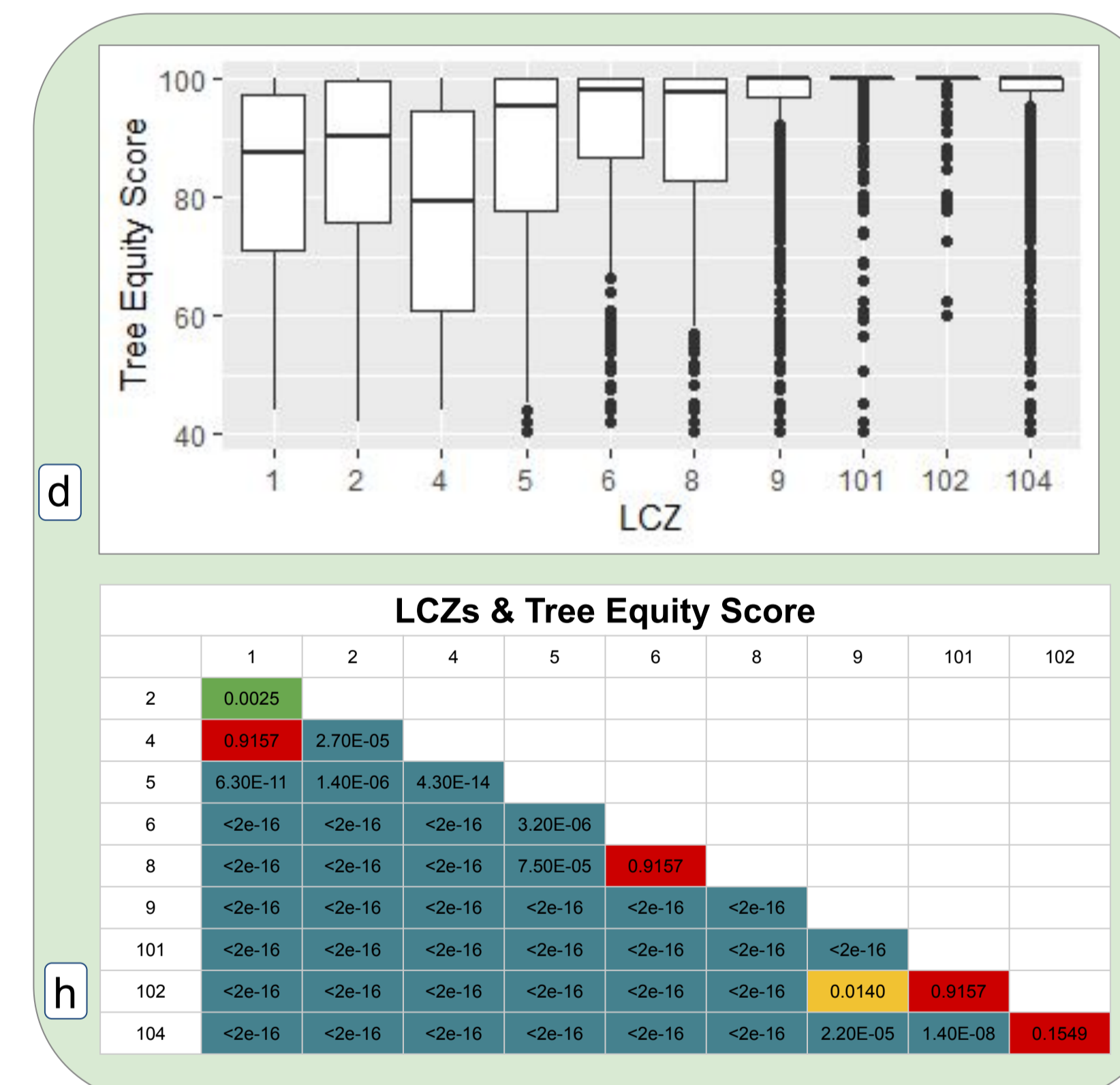
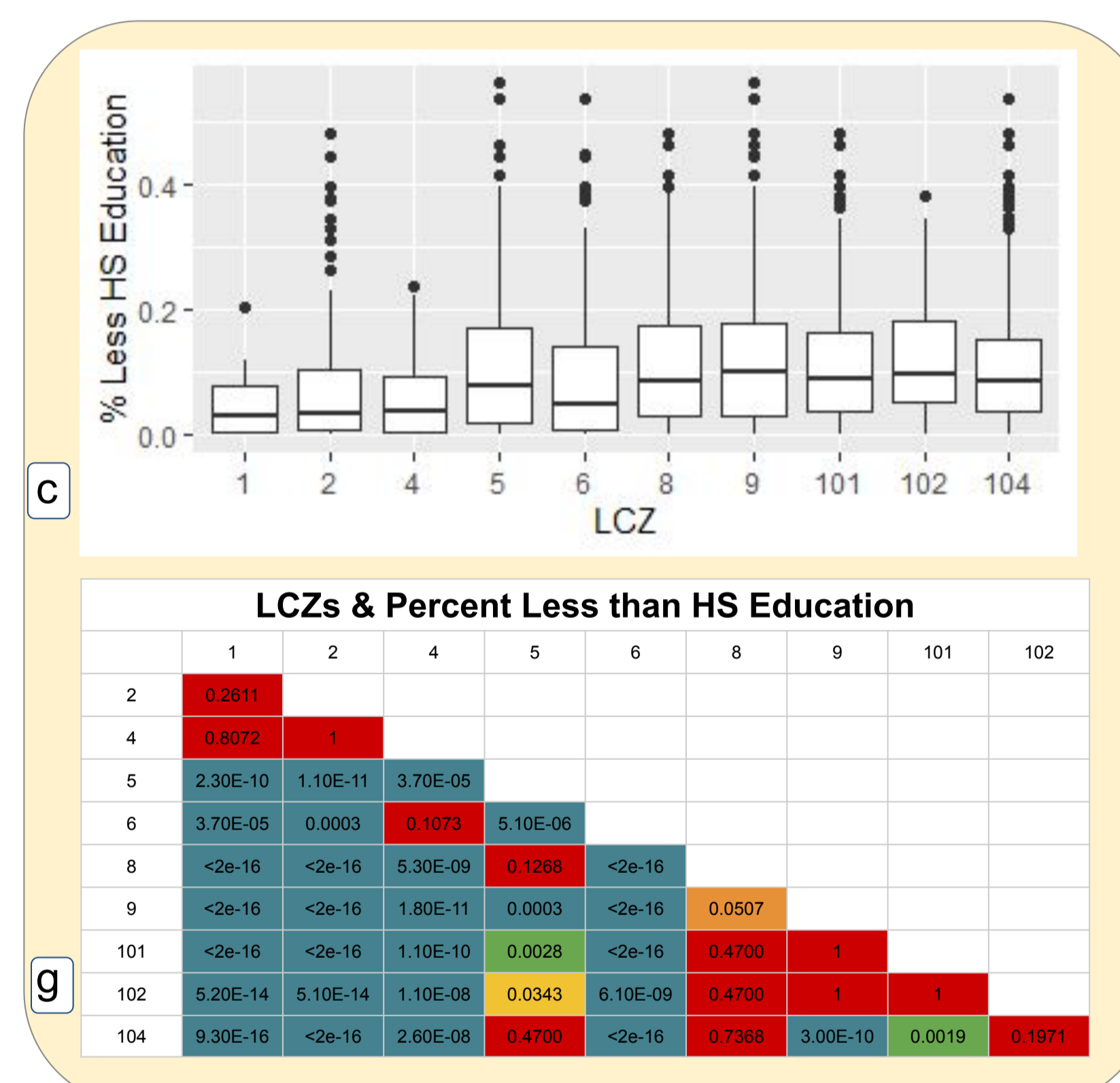
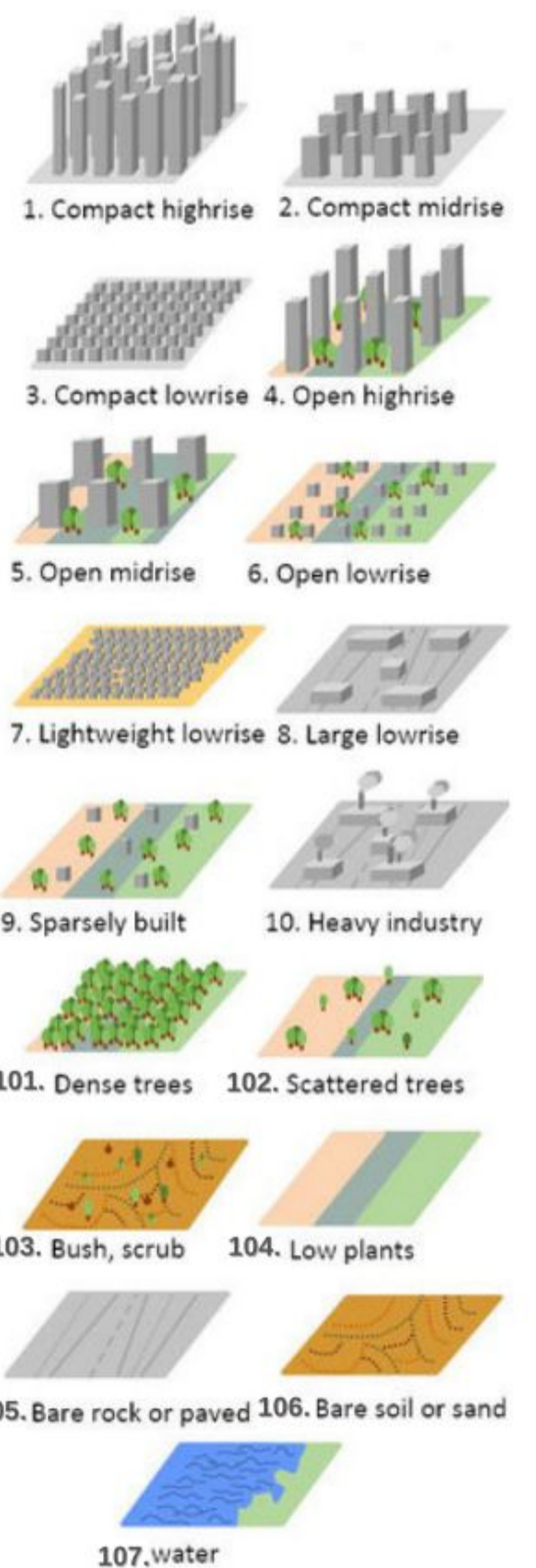
A Dunn's post hoc test was then performed, a pairwise comparison of the distribution of each pair of factors. P-values closer to 1, denoted by red or orange, indicate that the distributions of these two LCZ types are statistically similar. Likewise, p-values closer to 0, denoted by green or blue, indicate that the distributions of two LCZs are statistically different.



P-value < 0.001 (different distrib.)  
 0.001 < P-value < 0.01  
 0.01 < P-value < 0.05  
 0.05 < P-value < 0.1  
 0.1 < P-value (similar distrib.)

- Percent Minority :
- Lowest Percent: LCZ 1 (Compact Highrise)
  - Highest Percent: LCZ 101 (Low Plants) and LCZ 102 (Scattered Trees)
  - Distribution appears statistically different for all LCZs except 1-4, 2-4, 5-8, 5-9 and 101-102

- Percent Low Income :
- Lowest Percent : LCZ 1 (Compact Highrise)
  - Highest Percent : LCZ 5 (Open Midrise)
  - Distribution appears statistically different for some LCZs, but statistically similar for many



- Percent Less Than High School Education :
- Lowest Percent : LCZ 1 (Compact Highrise), LCZ 2 (Compact Midrise), and LCZ 4 (Open Highrise)
  - Highest Percent : LCZ 9 (Sparsely Built) and LCZ 102 (Scattered Trees)
  - Distribution appears statistically different for most LCZs, but statistically similar for some

- Tree Equity Score (TES) :
- Lowest TES : LCZ 4 (Open Highrise)
  - Highest TES : LCZs 101 (Low Plants), 102 (Scattered Trees), and 104 (Dense Trees)
  - Distribution appears statistically different for all LCZs except 1-4, 6-8, 101-102 and 102-104.

Figure 3 : Distribution of factors by LCZ types - (a) Percent Minority, (b) Percent Low Income, (c) Percent Less than HS Education (d) Tree Equity Score. Dunn's post hoc test results for the four factors - (e) Percent Minority, (f) Percent Low Income, (g) Percent Less than HS Education (h) Tree Equity Score.

## Conclusion and Future Implications

Preliminary results show that the four factors (race, income level, education, Tree Equity Score) are unequally distributed amongst LCZ types.

Key results :

- Highest percentages of minorities are located in dense vegetation areas (LCZ 101 dense trees and LCZ 102 Scattered Trees) which demonstrate high Tree Equity Score.
- Percentage of Low Income is lower in LCZ 1 Compact Highrise, higher in LCZ 5 Open Midrise.
- Apart from these, low income households seems equally distributed amongst LCZ types.
- Highest percentages of Less than HS Education are situated in non-urbanized LCZ types and low density LCZ types.
- Lowest Tree Equity Score values are found in LCZ 4 Open Highrise

Future work:

- Pair this study with temperature data to understand the implications of extreme heat on the LCZ classifications in Atlanta.
- Investigate neighborhoods with specific sociodemographic profiles.

## Acknowledgments

We would like to thank the I-CEMIITURE (International Collaborative Multidisciplinary Investigations Through Undergraduate Research Experience) REU, the Georgia Southern Department of Chemistry, the National Science Foundation (NSF-IRES 1952402), the College of Coastal Georgia Department of Natural Sciences, and the University of Lorraine.

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